



NEW RESULTS FROM THE SANTONIAN OF THE GOSAU GROUP
HERBERT SUMMERSBERGER (Ed.)

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Cover image:

Texanites quinque nodosus REDTENBACHER
Collection Skoumal: SK/RA/2017/166; Randograben, Rußbach, Salzburg; Gosau-Gruppe, Santonium
Foto: Alice Schumacher, Naturhistorisches Museum Wien

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New results from the Santonian of the Gosau Group (Austria)

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Early and middle Santonian Cephalopods from the Gosau Group (Upper Cretaceous, Austria)

1. Nautiloidea and non-heteromorph Ammonoidea

HERBERT SUMMESBERGER¹, WILLIAM J. KENNEDY² & PETER SKOUMAL³

13 Text-Figures, 16 Tables, 23 Plates

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Abstract

Five taxa of Nautiloidea and 37 taxa of non-heteromorph Ammonoidea are described from the early and middle Santonian part of the Gosau Group of Austria. New for the Gosau are *Angulithes westphalicus* (SCHLÜTER, 1876), *Cymatoceras* cf. *huxleyanum* (BLanford, 1861), *Hyporbulites woodsi* VAN HOEPEN, 1921, *Saghalinites nuperus* (VAN HOEPEN, 1921), *Anagaudryceras* sp., *Jimboiceras* cf. *reyi* COLLIGNON, 1983, *Hauericeras* (*Gardeniceras*) aff. *gardeni* (BAILY, 1855), *Damesites sugata* (FORBES, 1846), *Nowakites carezi* (DE GROSSOURE, 1894), *Nowakites savini* (DE GROSSOURE, 1894), *Patagiosites stobaei* (NILSSON, 1827), *Tragodesmoceras* aff. *clypeale* (SCHLÜTER, 1872), *Pseudoschloenbachia* (*Pseudoschloenbachia*) sp. and *Texasia cricki* (SPATH, 1921). *Muniericeras gosauicum* (HAUER, 1858) and *Hemitissotia randoi* GERTH, 1961, which is shown to be a synonym of *Eulophoceras natalense* HYATT, 1903 are revised.

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Cephalopoden des frühen und mittleren Santoniums der Gosau-Gruppe (Oberkreide, Österreich)

1. Nautiloidea und nicht-heteromorphe Ammonoidea

Zusammenfassung

Es werden fünf taxa Nautiloidea und 37 taxa nicht-heteromorphe Ammonoidea aus dem unteren und mittleren Santonium der österreichischen Vorkommen der Gosau-Gruppe beschrieben. Neu für die Gosau-Gruppe sind: *Angulithes westphalicus* (SCHLÜTER, 1876), *Cymatoceras cf. huxleyanum* (BLANFORD, 1861), *Hyporbulites woodsi* (VAN HOEPEN, 1921), *Saghlinites nuperus* (VAN HOEPEN, 1921), *Anagaudryceras* sp., *Jimboiceras cf. reyi* COLLIGNON, 1983, *Hauericeras* (*Gardeniceras*) aff. *gardeni* (BAILY, 1855), *Damesites sugata* (FORBES, 1846), *Nowakites carezi* (DE GROSSOURE, 1894), *Nowakites savini* (DE GROSSOURE, 1894), *Patagiosites stobaei* (NILSSON, 1827), *Tragodesmoceras* aff. *clypeale* (SCHLÜTER, 1872), *Pseudoschloenbachia* (*Pseudoschloenbachia*) sp. und *Texasia cricki* (SPATH, 1921). *Muniericeras gosauicum* (HAUER, 1858) und *Hemitissotia randoi* GERTH, 1961, die unter die Synonymie von *Eulophoceras natalense* HYATT, 1903 fallen, werden revidiert.

Introduction

Following the description of the late Santonian cephalopods of the Gosau Group from the Schattaugraben outcrops of the Gosau Basin of Salzburg (SUMMESBERGER et al., 2017a; this volume) and Finstergrabenwandl, Upper Austria (WIEDMANN, 1978; SUMMESBERGER, 1979, 1980, 1992), we describe below the early and middle Santonian nautiloids and non-heteromorph ammonites of the Austrian Gosau Group. With the description of the lower and middle Santonian heteromorphs (SUMMESBERGER et al., 2017b; this volume)) the revision of the Austrian Gosau cephalopods will be continued.

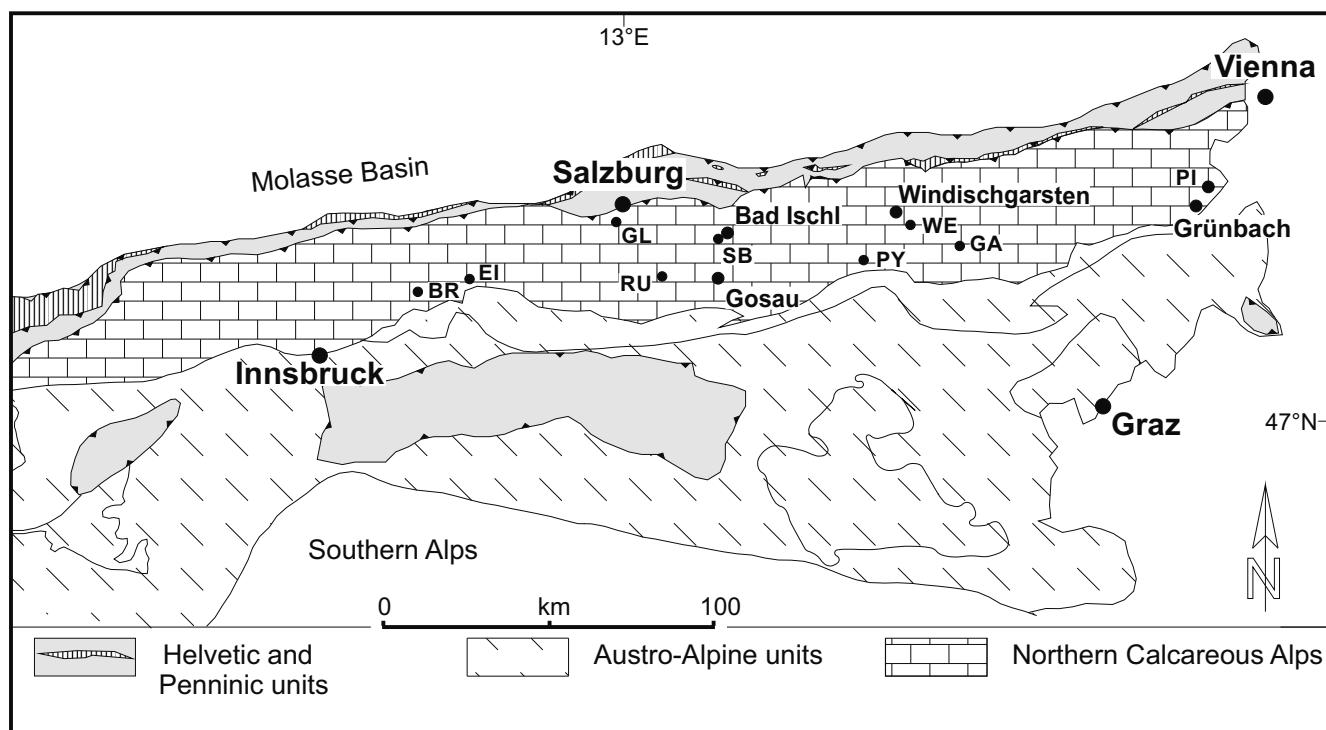
The first ammonites described from the lower Santonian of the Gosau Group were *Ammonites gosauicus* HAUER (1858: 13, Pl. 2, Figs. 7–9) and *Ammonites texanus* ROEMER, 1849 (HAUER, 1858: 10, Pl. 2, Figs. 4–6). REDTENBACHER (1873: 9–140, Pls. 22–30) provided comprehensive descriptions of the cephalopods of the Gosau Group, although dealing with only a few early to middle Santonian localities:

“Gosau” (possibly the Neffgraben and Randograben sections: see below);
“Stöcklwald” (possibly the Randograben);
“Tiefengraben” (possibly Grabenbach);

“St. Wolfgang” (possibly Schneiderwirtsbrücke);
“Strobl-Weißenbach” (possibly also Schneiderwirtsbrücke, as Strobl-Weißenbach is a late Turonian locality: fide SUMMESBERGER & KENNEDY, 1996);
“Weißenbach next Bad Aussee” (Styria) is a Coniacian locality;
“Wolfsbachau next Reifling” (Styria) is possibly Campanian.

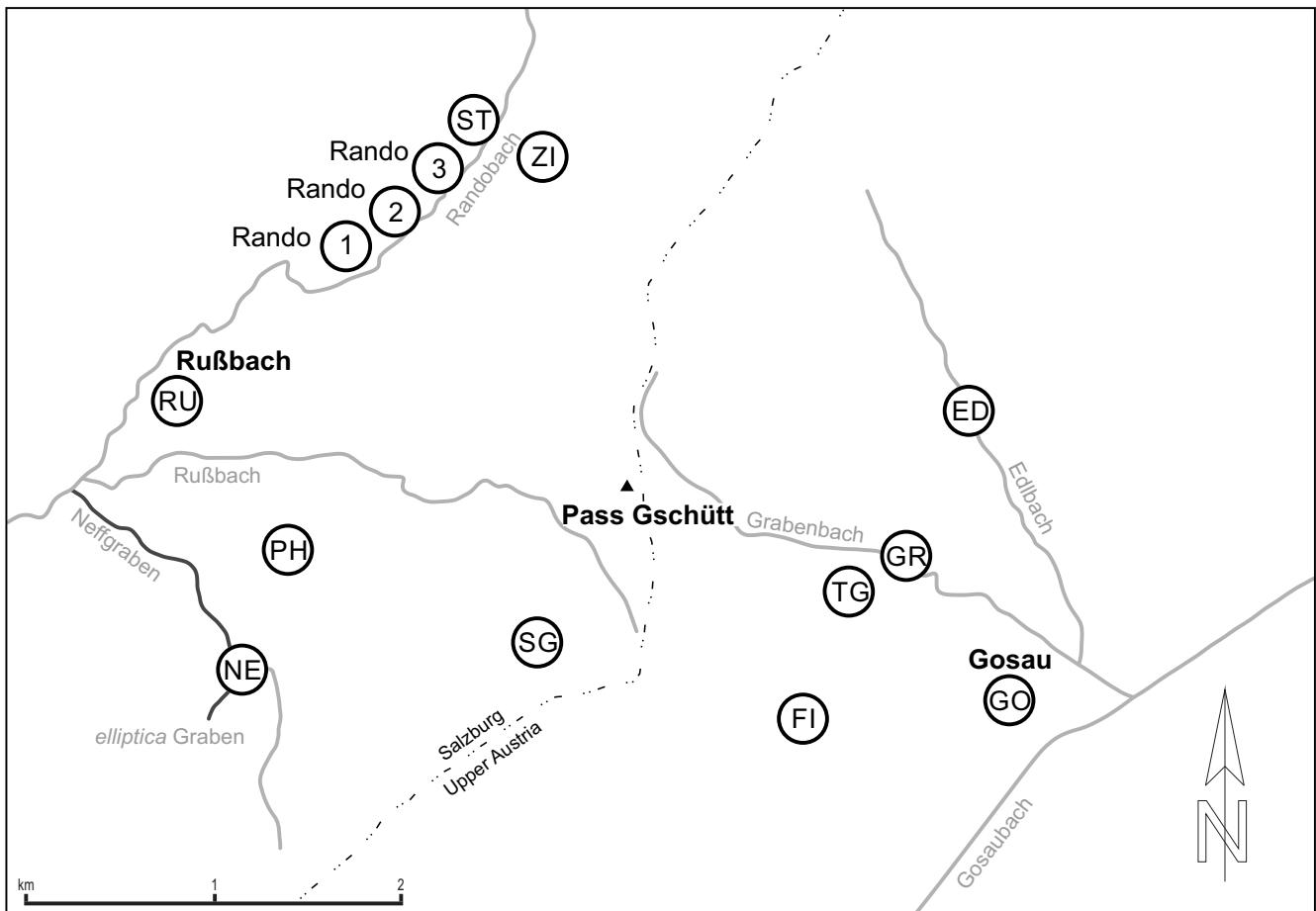
KATSCHTHALER (1935) and BRINKMANN (1935) provided the first list of early Santonian cephalopods from Brandenberg (Tirol). GERTH (1956, 1961) was the first to describe early Santonian ammonites from the Gosau Basin and successfully logged and interpreted the extensive Neffgraben section (Rußbach, Salzburg). A revision of the Austrian Texanitinae was provided by KENNEDY et al. (1981). IMMEL et al. (1982) and IMMEL (1987) gave detailed descriptions of the early Santonian Brandenberg cephalopods.

From 1971 onwards H.A. Kollmann (NHMW) and H. Summesberger (NHMW) ran a stratigraphic program, collected numerous early Santonian fossils and acquired detailed knowledge of the fossil bearing sites of the Gosau Basin itself and the Gosau Group occurrences in the Northern Calcareous Alps (Text-Fig. 1).



Text-Fig. 1.

Distribution of Gosau Group localities mentioned in the text. BR – Brandenberg, EI – Eiberg, GA – Gams, GL – Glanegg, PI – Markt Piesting, PY – Pyhrnpass, RU – Rußbach, SB – Schneiderwirtsbrücke, WE – Weißwasser.



Text-Fig. 2.

Gosau Group localities in the Gosau area (Upper Austria and Salzburg) mentioned in the text: ED – Edlbachgraben, FI – Finstergrabenwandl, GO – Gosau, GR – Grabenbach, NE – Neffgraben, Pass Gschütt, PH – parking site Hornspitz cable-car, Rando (= Randograben) 1–3, RU – Rußbach, SG – Schattaugraben, ST – Stöcklwaldgraben, TG – Tauerngraben, ZI – Zimmergraben.

An account of the late Santonian Schattau locality (= Schattaugraben, Rußbach, Salzburg) with the main focus on biostratigraphy and lithostratigraphy was published by WAGREICH et al. (2010). A detailed description of the Schattaugraben is given in SUMMESBERGER et al., 2017a (this volume).

The base of the Santonian in the Gosau Group is indicated by the appearance of *Texanites quinqueradosus* (REDTENBACHER, 1873) and *Cladoceramus undulatoplicatus* (ROEMER, 1852).

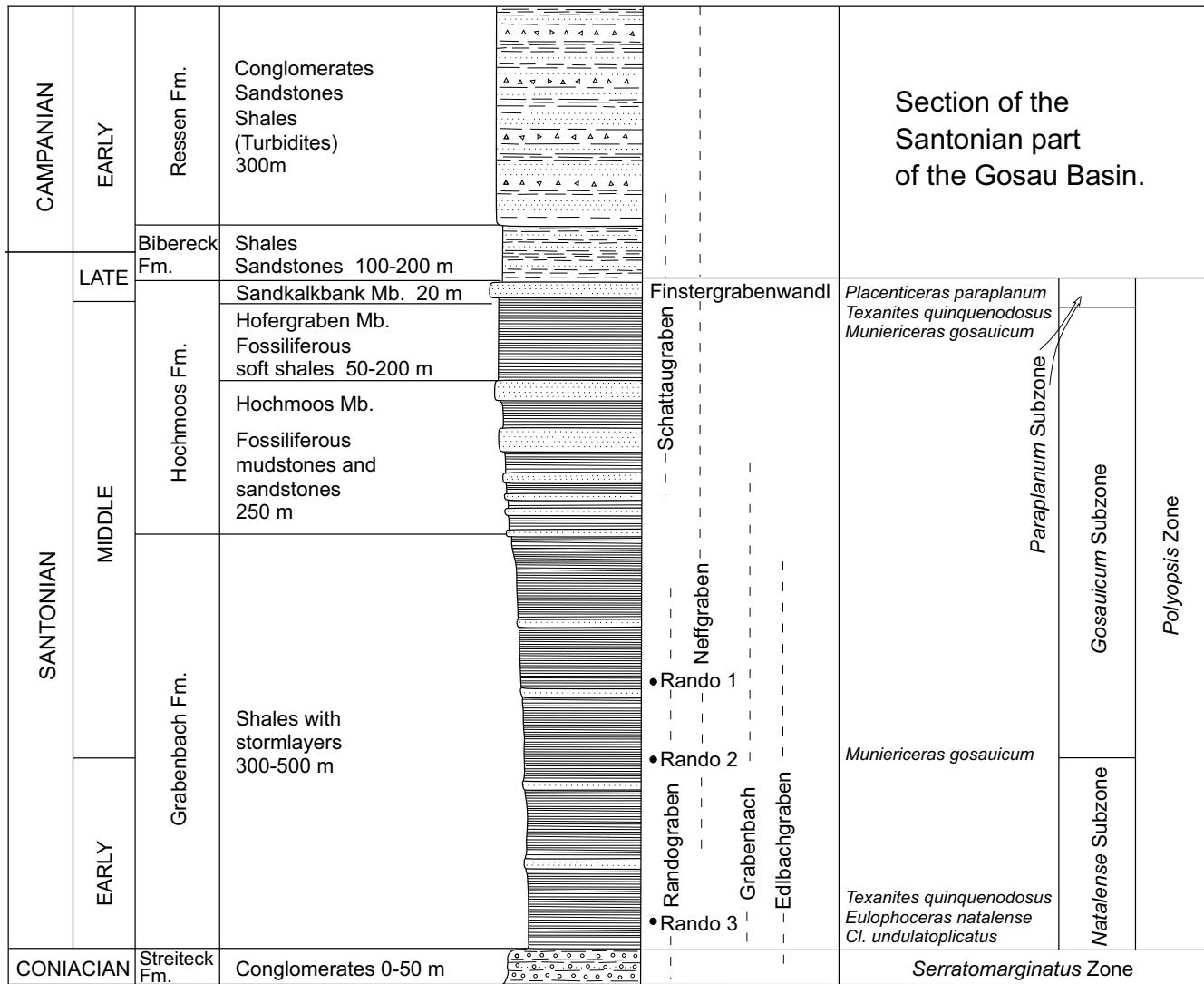
During the present study it also became apparent that the presence of *Eulophoceras natalense* HYATT, 1903 was a distinctive local marker for the base of the Santonian in the Gosau Group (Gosau Basin, Brandenberg, Tyrol, Markt Piesting, Lower Austria). In the present account, the base of the middle Santonian in the Gosau Group is defined by the mass occurrence of *Muniericeras gosauicum* (HAUER, 1858) at the Rando(bach) 1 and 2 sites (Rußbach, Salzburg; Text-Figs. 2, 3). The first appearance of *Placenticeras paraplanum* WIEDMANN 1978 marks the base of the late Santonian, which coincides with the disappearance of *Texanites quinqueradosus* and *Muniericeras gosauicum*. In the field it can be observed in the Neffgraben site at the junction with the «elliptica» Graben (GERTH, 1961: Figs. 3, 4).

Careful collecting over more than 40 years by Kurt and Elisabeth Skoumal (†; Vienna), Josef Kastl (†; Linz, Upper

Austria), Franz and Käthe Böhm (†; Salzburg), Wolf-Peter Maherndl (Bad Ischl, Upper Austria), Odo Mader (†; Brandenberg, Tyrol), Heinz A. Kollmann and two of the authors (P.S., H.S.) provide the basis for an overall revision of the early and middle Santonian cephalopod fauna of the Gosau localities, with a focus on *Muniericeras gosauicum* and *Eulophoceras natalense* (= *Hemitissoita randoi* GERTH, 1961). The rich assemblages of heteromorph ammonites will be described in the subsequent publication (SUMMESBERGER et al., 2017b, this volume).

Repositories of specimens

| | |
|------|--|
| NHMW | Naturhistorisches Museum Wien, Vienna, Austria. |
| GBA | Geologische Bundesanstalt (Geological Survey of Austria, former k. k. Geologische Reichsanstalt), Vienna, Austria. |
| PIUW | Institute of Palaeontology, University of Vienna, Austria. |
| GIUW | Department of Environmental Geosciences, University of Vienna, Austria. |
| OÖLM | Oberösterreichisches Landesmuseum, Linz, Austria. |



Text-Fig. 3.
Composite stratigraphic section of the Santonian parts of the Gosau Group with main focus on the cephalopods described in the text. With alterations after WAGREICH et al. (2010). Cl = *Cladocerasmus*.

| | | | |
|------|--|----------|---|
| GPII | Geologisch-Paläontologisches Institut der Universität Innsbruck, Austria. | CG | Collection Gustav Gapp, Gosau, Austria. |
| TUW | Collection of the Technical University (formerly Technische Hochschule), Vienna, now partly in the collection of PIUW, Vienna. | M | Collection Odo Mader, Rattenberg, Tyrol, Austria. |
| HNS | Haus der Natur, Salzburg, Austria. | MA | Collection Wolf-Peter Maherndl, Bad Ischl, Austria. |
| GPIB | Geologisch-Paläontologisches Institut der Universität Bonn, Germany. | SCH | Collection Schwaighofer, Rußbach, Salzburg, Austria. |
| BSP | Bayerische Staatssammlung für Paläontologie und historische Geologie, Munich, Germany. | SIM | Collection Simonsky, Vienna, Austria. |
| MAD | Collection Odo Mader, Bayerische Staatsammlung für Paläontologie und historische Geologie, Munich, Germany. | SK | Collection Dr. Peter Skoumal, Vienna, Austria. |
| BMNH | British Museum of Natural History, London, UK. | TLMF/SM | Tiroler Landesmuseum Ferdinandeum, Innsbruck, Tyrol, Austria (formerly the Mader Collection). |
| | | SEIDL/CE | Collection Heinz Seidl, Salzburg, Austria. |

Early and middle Santonian nautiloid and ammonite faunas of the Gosau Group (excluding heteromorphs) and key inoceramid bivalve occurrences

Brandenberg (Tyrol), Mühlbach

? *Cimomia* cf. *gosavica* (REDTENBACHER, 1873)

Cymatoceras sp.

Hyporbulites woodsi (VAN HOEPEN, 1921)

Anagaudryceras redtenbacheri (IMMEL et al., 1982), juv.

? *Anagaudryceras* cf. *subtililineatum* (KOSSMAT, 1895)

Gaudryceras mite (REDTENBACHER, 1873)

Gaudryceras ex gr. *denseplicatum* JIMBO, 1894

Gaudryceras sp. indet.

Saghalinites nuperus (VAN HOEPEN, 1921)

Nowakites carezi (DE GROSSOUDRE, 1894)

Nowakites carezi (DE GROSSOUDRE, 1894), juv.

Damesites sugata (FORBES, 1846)

Parapuzosia daubreei (DE GROSSOUDRE, 1894)

Parapuzosia corbarica (DE GROSSOUDRE, 1894)

Parapuzosia sp. indet.

Hauericeras (*Hauericeras*) *pseudogardeni* (SCHLÜTER, 1872)

Hauericeras (*Gardeniceras*) aff. *gardeni* BAILY, 1855

Kossmaticeras (*Kossmaticeras*) cf. *sparsicostatum* (KOSSMAT, 1897)

Patagiosites? sp.

Eupachydiscus isculensis (REDTENBACHER, 1873), microconch

Paratexanites serratomarginatus (REDTENBACHER, 1873)

Texanites quinqueradialis (REDTENBACHER, 1873)

Eulophoceras natalense HYATT, 1903

Cladoceramus undulatoplicatus (ROEMER, 1852)

Eiberg (Kufstein, Tyrol), early to middle Santonian

Ammonite fauna after IMMEL, 1987:

Parapuzosia daubreei (DE GROSSOUDRE, 1894)

Hauericeras sp.

Eupachydiscus isculensis (REDTENBACHER, 1873)

Texanites quinqueradialis (REDTENBACHER, 1873)

Basin of Gosau (Rußbach, Salzburg), early Santonian

Randobach 3

Angulithes westphalicus (SCHLÜTER, 1872)

Hyporbulites woodsi (VAN HOEPEN, 1921)

Nowakites carezi (DE GROSSOUDRE, 1894)

Nowakites savini (DE GROSSOUDRE, 1894)

Parapuzosia daubreei (DE GROSSOUDRE, 1894)

Texania cricki (SPATH, 1921)

Eulophoceras natalense HYATT, 1903

Cladoceramus undulatoplicatus (F. ROEMER, 1852)

Stöcklwaldgraben

Texanites quinqueradialis (REDTENBACHER, 1873)

Eulophoceras natalense HYATT, 1903

Basin of Gosau (Rußbach, Salzburg), middle Santonian

Randobach 1

Angulithes westphalicus (SCHLÜTER, 1872)

Muniericeras gosauicum (HAUER, 1858)

Texanites quinqueradialis (REDTENBACHER, 1873)

Randobach 2

Angulithes westphalicus (SCHLÜTER, 1872)

Gaudryceras mite (HAUER, 1866)

Parapuzosia corbarica (DE GROSSOUDRE, 1894)

Tragodesmoceras aff. *clypeale* (SCHLÜTER, 1872)

Muniericeras gosauicum (HAUER, 1852)

Pseudoschloenbachia (*Pseudoschloenbachia*) sp.

Texanites quinqueradialis (REDTENBACHER, 1873)

Zimmergraben

Texanites quinqueradialis (REDTENBACHER, 1873)

Neffgraben

Damesites sugata (FORBES, 1846)

Nowakites draschei (REDTENBACHER, 1873)

Muniericeras gosauicum (HAUER, 1852)

Texanites quinqueradialis (REDTENBACHER, 1873)

Parking area Hornspitz – cable car, early Santonian

Hauericeras cf. *gardeni* (BAILY, 1855)

Nowakites sp.

Texanites quinqueradialis (REDTENBACHER, 1873)

Eulophoceras sp. indet.

Gosau (Upper Austria), early Santonian

Edlbachgraben

Angulithes westphalicus (SCHLÜTER, 1872)

Hyporbulites woodsi VAN HOEPEN, 1921

Saghalinites nuperus (VAN HOEPEN, 1921)

Nowakites savini (DE GROSSOUDRE, 1894)

Parapuzosia daubreei (DE GROSSOUDRE, 1894)

Hauericeras cf. *gardeni* (BAILY, 1855)

Texanites quinqueradialis (REDTENBACHER, 1873)

Eulophoceras natalense (HYATT, 1903)

Cladoceramus undulatoplicatus (ROEMER, 1852)

Pass Gschütt (forest road Wegscheidgraben; middle Santonian)

(Collection Leibfinger-Prömer)

Muniericeras gosauicum (HAUER, 1852)

Texanites quinqueradosus (REDTENBACHER, 1873)

Grabenbach (p.p. Tiefengraben), early and middle Santonian

Cymatoceras cf. huxleyanum (BLANFORD, 1861)

Muniericeras gosauicum (HAUER, 1852)

Pachydiscidae indet.

Eulophoceras natalense HYATT, 1903 (lowest part of Grabenbach)

Platyceramus cycloides ahsenensis (SEITZ, 1961)

Tauerngraben (middle Santonian)

Muniericeras gosauicum (HAUER, 1852)

Bad Ischl N (Upper Austria)

Schneiderwirtsbrücke, road bridge over the Ischl river near the confluence with the Nussenseebach (middle Santonian)

Saghalinites nuperus (VAN HOEPEN, 1921)

Eupachydiscus isculensis (REDTENBACHER, 1873)

Tragodesmoceras cf. clypeale (SCHLÜTER, 1872)

Muniericeras gosauicum (HAUER, 1852)

Texanites quinqueradosus (REDTENBACHER, 1873), holotype

Kohlbüchl (Upper Austria, Santonian)

Eupachydiscus isculensis (REDTENBACHER, 1873, holotype); Santonian

Weißwasser (Upper Austria), early and middle Santonian

Bergeralm, Breitenberg, Blahberg

Saghalinites nuperus (VAN HOEPEN, 1921)

Muniericeras gosauicum (HAUER, 1858)

Texanites quinqueradosus (REDTENBACHER, 1873)

Eulophoceras natalense HYATT, 1903

Windischgarsten (Upper Austria, Pyhrnpass), early Santonian

Eulophoceras natalense HYATT, 1903

Markt Piesting (Lower Austria), early Santonian

Eulophoceras natalense HYATT, 1903

Conventions

Dimensions are given in millimeters: D = diameter, Wb = whorl breadth, Wh = whorl height, U = umbilicus, c = costal dimension, ic = intercostal dimension. Figures in parentheses are dimensions as a percentage of the diameter. The suture terminology is that of KORN et al. (2003): E = external lobe, A = adventive lobe (= lateral lobe, L, of KULLMANN & WIEDMANN, 1970), U = umbilical lobe, I = internal lobe.

Systematic Palaeontology

Class Cephalopoda CUVIER, 1797

Subclass Nautiloidea AGASSIZ, 1847

Order Nautilida AGASSIZ, 1847

Superfamily Nautilaceae DE BLAINVILLE, 1825

Family Nautilidae DE BLAINVILLE, 1825

Genus *Angulithes* MONTFORT, 1808

Type species: '*Nauillites*' *triangularis* MONTFORT, 1808 by subsequent designation of SPATH (1927: 21).

Angulithes westphalicus (SCHLÜTER, 1876)

(Pl. 1, Figs. 1–3, Pl. 2, Figs. 1–3, Pl. 3, Figs. 4–5, Pl. 4, Figs. 1–3, Tab. 1)

1872 *Nautilus westphalicus* SCHLÜTER: 13.

1876 *Nautilus westphalicus* SCHLÜTER: 175, Pl. 47, Figs. 1, 2.

1906 *Nautilus westphalicus* SCHLÜTER; MÜLLER & WOLLEMANN: 1, Pl. 1, Figs. 1, 2.

1991 *Deltoidonautilus westphalicus* (SCHLÜTER, 1876); RIEGRAF & SCHEER: 426.

1999 *Deltoidonautilus* (sic!) *westphalicus* (SCHLÜTER, 1872c); WITTNER et al.: 37, Figs. 51a, b, 52a, b.

2001 *Angulithes cf. westphalicus* (SCHLÜTER, 1872); FÖZY: 34, Pl. 5.

2010 *Angulithes westphalicus* (SCHLÜTER, 1872); FRANK: 490, Figs. 3A–N (with additional synonymy).

Type: The lectotype by the subsequent designation of FRANK (2010: 490) is GMB 97, the original of SCHLÜTER, 1872 (Pl. 47, Figs. 1, 2) from the lower Campanian *Scaphites binodosus* Zone of Dülmen, Westphalia, Germany, housed in the Goldfuss Museum, Bonn.

Material: Eight specimens: two large individuals (SIM 1996/1, SCH 2012/1) from the early Santonian of the Randobach (Rußbach, Salzburg), three specimens from the early Santonian of the Edlbachgraben (Gosau, Upper Austria): NHMW 2012/1082/0001, SK/EB/1985/10, 11, and two further unregistered specimens in the the Skoumal collection, NHMW 2012/1086/0001.

Description: SIM 1996/1 (Pl. 1, Figs. 1–3) is a large internal mould, with a maximum preserved diameter of 185 mm, with remnants of thick shell adhering. The general shape

is strongly inflated with the greatest breadth at mid-flanks. The outer flanks are slightly convex, converging to the distinctly angular venter. The umbilicus is small with a vertical umbilical wall. The position of the siphuncle cannot be established. Where shell material is absent, the internal mould exposes several slightly flexuous sutures. They are prorsiradiate on the umbilical shoulder and innermost flank, forming a small saddle, sweep back into a large shallow lobe that extends across the middle of the flanks and forwards into a large and shallow saddle (Pl. 1, Fig. 3).

SCH 2012/1 (Pl. 2) is a large internal mould, 200 mm in diameter, with extensive areas of the thick shell (up to 4.7 mm) preserved. *Post mortem* crushing has produced a secondarily deformed discoidal, very compressed shell with an acute 'keel'. The originally narrowly rounded venter is preserved on the penultimate whorl and is visible in the apertural view of the specimen (Pl. 2, Fig. 2). The flanks are slightly convex, converging towards the venter. The umbilicus appears to be closed, probably a result of crushing. The surface of the shell preserves very faint and narrow growth striae, arising at the umbilicus and crossing the flanks in a broad convexity. Eleven sutures cross the flanks parallel to the growth striae. A shallow lobe extends across the flanks and a shallow saddle across the venter. The position of the siphuncle cannot be established.

NHMW 2012/0182/0001 (Pl. 3, Figs. 4, 5) is a large part of the body chamber, retaining the original proportions. The phragmocone is broken away. The umbilicus is missing.

SK/EB/1985/10 (Pl. 4, Figs. 1–3) is an undeformed specimen with extensive areas of the shell preserved. Where the shell is broken away the shape of the aperture is visible; it runs parallel to the growth lines on the shell of the body chamber. These cross the flank in a broad convexity, flexing back in a wide concavity that extends across the angular venter. Very faint growth striae are also visible on NHMW 2012/0182/0001.

Discussion: SCH 2012/1 differs in details only from SIM 1996/1. Its narrow and sharp "keel" is due to *post mortem* crushing. The umbilicus is smaller, which may reflect an original difference, or deformation. We believe the specimens to be conspecific.

There is a difference in sutures between SCHLÜTER's original (1872: Pl. 47, Figs. 1, 2) and the specimens described herein. The sutures of the Gosau specimens are less flexuous. Concerning the variability of the sutures of *Angulithes*

(KUMMEL, 1956: 453–454, Fig. 32) the sutures of the specimens described here are regarded as being within the limits of intraspecific variation.

Occurrence: *Angulithes (A.) westphalicus* (SCHLÜTER, 1872) is said to be an early Campanian species (SCHLÜTER, 1872: 175). It is recorded from the late Campanian of Spain (WILMSEN, 2000: 37). There are also records from the middle Santonian of Westphalia (WITTLER et al., 1999: 41). SIM 1996/1 and SCH 2012/1 are from the Santonian of the Randobach section (Rußbach, Salzburg), from a level above the occurrence of *Texanites (T.) quinqueradosus* at its confluence with the Zimmergraben. NHMW 2012/0182/0001 is from the basal Santonian of the Edlbachgraben (Gosau, Upper Austria), where it co-occurs with *Texanites (T.) quinqueradosus* and *Cladoceras undulatoplicatus*.

Family Cymatoceratidae SPATH, 1927

Genus *Cymatoceras* HYATT, 1883

Type species: *Nautilus pseudoelegans* D'ORBIGNY, 1840 (70, Pls. 8, 9) by the original designation of HYATT (1883: 301).

Cymatoceras sp.

(Pl. 4, Figs. 4–6)

not 1876 *Nautilus Sharpei* SCHLÜTER: 171, Pl. 46, Figs. 4–6

1982 *Cymatoceras sharpei* (SCHLÜTER, 1876); IMMEL et al.: 8, Pl. 1, Figs. 1, 2.

Material: Three specimens: SK/RA/1982/54 from Randobach (Rußbach, Salzburg); M 31, 32 from the Lower Santonian of Brandenberg (Mühlbach, Tyrol).

Description: All of the specimens are strongly deformed internal moulds with areas of adherent shell. The original dimensions and proportions cannot be established. The original diameter of SK/RA/1982/54 (Pl. 4, Figs. 4–6) is estimated as 40 mm approximately. The estimated diameters of the specimens from Mühlbach/Brandenberg (Tyrol) are 52 and 54 mm. The whorl section is depressed and increases rapidly in width. The umbilicus is small and closed by matrix (IMMEL et al., 1982: Pl. 1, Fig. 2a). Where the shell is preserved, all specimens show a distinct pattern of coarse subparallel ribs covering the whole surface. They are prorsiradiate at the umbilical shoulder, cross the flanks in a broad convexity, flex back on the ventrolateral shoulder and cross the venter in a broad, shallow concavity. Some bifurcations occur on the ventrolateral shoulder. The internal mould is smooth. The sutures visible on a specimen from Tyrol (M 32; IMMEL et al., 1982: Pl. 1, Fig. 2a) are near-straight on the flanks, with the shallowest of lobes.

Discussion: IMMEL et al. (1982: 8, Pl. 1, Figs. 1, 2) referred two of the specimens discussed here to *Cymatoceras sharpei* (SCHLÜTER, 1872). The figured syntype (SCHLÜTER, 1872: Pl. 46, Figs. 5–7) is from the Lower Cenomanian of Essen-Altessen in the Münster basin, Westphalia, Germany. It is not the holotype, as stated by IMMEL et al. (1982) as SCHLÜTER (1872: 171) also refers to specimens from 'Tourney' [Tournai] in Belgium. It is much larger than the present

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|---------------------|--------|---------|---------|--------|-------|
| SIM 1996/1 | 185 | 90 | 83 | 15 | 8 |
| SCH 2012/1 | 200 | 115.2 | 64.2 | -- | -- |
| NHMW 2012/0182/0001 | -- | 113 | 66 | -- | -- |
| SK/EB/1985/10 | 132 | 79.1 | 80.1 | 10.4 | 7.9 |
| SK/EB/1985/11 | 114 | 72.8 | -- | 11.5 | 10 |
| SK/EB unreg. | -- | 126 | -- | 18 | -- |

Tab. 1.
Angulithes westphalicus (SCHLÜTER, 1876) from the early to middle Santonian of the Basin of Gosau (Upper Austria and Salzburg). U % of D. unreg. = unregistered.

specimens and differs in its globular shape, closed umbilicus and very widely separated septa. The sutures are prossiradiate at the umbilical shoulder, with a small, very shallow saddle, with a very broad, very shallow lobe that extends across most of the flanks, with the shallowest of lobes that extends across the venter. No shell is preserved and there is no feature that supports reference to *Cymatoceras sharpei* (SCHLÜTER, 1872). KUMMEL (1956: 420) records 64 species of *Cymatoceras*: “All of these are characterised by the ribbing and the slightly sinuous septa.“ This was already mentioned by HYATT (1883: 301). The present specimens are a species of *Cymatoceras* HYATT, 1883 but not *Nautilus sharpei* SCHLÜTER, 1872.

Pseudocenoceras ? *deslongchampsianum* (d'ORBIGNY, 1840: Pl. 20; TINTANT & GAUTHIER, 2006: Pl. 6, Fig. 4) from the Cenomanian of Rouen, Seine-Maritime, France, is a *Cymatoceras* in our view. It differs from the present specimens in its distinctive umbilical edge and conic umbilicus (SCHLÜTER, 1872: Pl. 47, Figs. 7–9; SHARPE, 1853: Pl. 3, Figs. 1, 2). *Deltocymatoceras rugatum* (FRITSCH & SCHLÖNBACH, 1872: 23, Pl. 12, Fig. 2, Pl. 15, Fig. 2), from the Turonian of the Czech Republic is much more coarsely ribbed, and juveniles have a ventral keel (see revision in FRANK et al., 2013: 98, Text-Figs. 6, 8a–i). *Cymatoceras bayfieldi* (FOORD & CRICK, 1890: 405, Text-Fig. 7) from the upper Campanian of England and Northern Ireland is more coarsely ribbed. *Cymatoceras elegans* (d'ORBIGNY, 1840) from the Cenomanian of France (TINTANT & GAUTHIER, 2006: 23, Pl. 6, Figs. 4, 5) and England (KENNEDY in SMITH & BATTEN, 2002: 226, Pl. 43, Figs. 3, 7) is much more finely ribbed and has a larger umbilicus. *Cymatoceras huxleyanum* (BLANFORD, 1861: 19, Pl. 7, Figs. 3, 4, Pl. 8, Figs. 1–3, Pl. 9, Figs. 1–4) is closely related but differs in its rapid increase in whorl width.

Occurrence: Lower to middle Santonian of the Austrian Gosau Group (Randobach; Rußbach, Salzburg); M 31, 32 are from the lower Santonian of Brandenberg (Mühlbach, Tyrol).

Cymatoceras cf. *huxleyanum* (BLANFORD, 1861)

(Pl. 3, Figs. 1–3)

Compare

- 1861 *Nautilus Huxleyanus* BLANFORD, 1861: 19, Pl. 7, Figs. 3, 4, Pl. 8, Fig. 1–3, Pl. 9, Figs. 1–4.
- 1865 *Nautilus Huxleyanus* BLANFORD; STOLICZKA: 205.
- 1891 *Nautilus Huxleyanus* BLANFORD; FOORD: 294.
- ? 1910 *Nautilus Huxleyanus* BLANFORD; SPENGLER: 140, 152, Pl. 12, Figs. 4, 5.
- 1913 *N. Huxleyanus*; SPENGLER, 1913: 118.
- ? 1957 *Cymatoceras huxleyanum* (BLANFORD) 1861; KUMMEL: 425.
- 1975 ? *Cymatoceras huxleyanum* (BLANFORD, 1861); SHIMANSKY: 107, Pl. 24, Fig. 2.

Types: The species is based on numerous syntypes, of which at least five were figured (BLANFORD, 1861: 19, Pl. 7, Figs. 3, 4, Pl. 8, Figs. 1–3, Pl. 9, Figs. 1–4). They come from a variety of localities in Tamil Nadu, South India, and are recorded from both the upper part of the Utatur Group and the Trichinopoly Group, an interval spanning the middle Turonian to middle Coniacian.

Material: A single specimen SK/GR/1983/30 from early to middle Santonian of the Grabenbach (Gosau, Upper Austria).

Description: SK/GR/1983/30 (Pl. 3, Figs. 1–3) is a strongly deformed internal mould with adherent light brownish shell. The whorl section is depressed, the whorl width increasing rapidly, from about 6 mm to about 24 mm within a single whorl. The umbilicus is wide, with steep umbilical wall. The ribbing is very weak and only slightly stronger than growth lines.

Discussion: *Nautilus huxleyanus* is assigned to the genus *Cymatoceras* on the basis of the presence of ribbing, illustrated by both BLANFORD (1861: Pl. 7, Figs. 1, 2) and SPENGLER (1910: 140, Pl. 12, Figs. 4, 5). *C. huxleyanum* differs from *C. deslongchampsianum* in its distinctly larger umbilicus and finer ribbing.

Occurrence: *Cymatoceras huxleyanum* (BLANFORD, 1861) was originally described from the lower Turonian to middle Coniacian of South India. There is a doubtful record from the Turonian to Santonian of the Caucasus (SHIMANSKY, 1975: 108).

Family Hercoglossidae SPATH, 1927

Genus *Cimomia* CONRAD, 1866

Type species: *Nautilus Burtini* GALEOTTI, 1837: 140; from the Eocene of Belgium, by the original designation of CONRAD (1866: 102). We follow KUMMEL (1956: 441) and place *Cimomia* as a distinct genus into the subfamily Hercoglossinae SPATH, 1927.

Cimomia ? cf. *gosavica* (REDTENBACHER, 1873)

(not figured)

Compare

- 1873 *Nautilus gosavicus* REDTENBACHER: 96, Pl. 22, Figs. 2a, b.
- 1982 ?*Eutrephoceras* cf. *gosavicum* (REDTENBACHER, 1873); IMMEL et al.: 8.

Discussion: For description and discussion, see IMMEL et al. (1982: 8), who did not figure the specimen, which we ourselves have not seen. They compared it to *Nautilus gosavicus* (REDTENBACHER, 1873: Pl. 22, Figs. 2a, b), which was assigned to *Cimomia* by SUMMESBERGER et al. (2017b).

Occurrence: *Cimomia gosavica* occurs in the late Santonian of the Finstergrabenwandr (Gosau, Upper Austria). The type specimen is from the Santonian of the Neffgraben (Gosau Group, Rußbach, Salzburg). ?*Eutrephoceras* cf. *gosavicum* (REDTENBACHER, 1873) was described by IMMEL et al. (1982) from the early Santonian Gosau Group of Mühlbach (Brandenberg, Tyrol, Austria).

Nautilidae, gen. et sp. indet., juv.

(Pl. 4, Figs. 7, 8)

Material: SK/1983/15 from the Tauerngraben, a tributary of the Grabenbach (Gosau, Upper Austria).

Discussion: SK/1983/15 (Pl. 4, Figs. 7, 8) is a specifically indeterminate internal mould of a nautiliid 20 mm in diameter that is distinguished from all of the other nautilids from the lower and middle Santonian parts of the Gosau Group on the basis of the very depressed whorl section.

Occurrence: As for material.

Order Ammonoidea ZITTEL, 1884

Suborder Phylloceratina ARKELL, 1950

Superfamily Phylloceratoidea ZITTEL, 1884

Family Neophylloceratidae JOLY, 1993

Subfamily Hyporbultiniae JOLY, 1993

Genus *Hyporbulites* BREISTROFFER, 1947

Type species: *Phylloceras Velledae* var. *Seresitensis* PERVINQUIÈRE, 1907 by original designation.

***Hyporbulites woodsi* (VAN HOEPEN, 1921)**

(Pl. 5, Fig. 1)

- 1906 *Phylloceras* sp. WOODS: 331, Pl. 41, Fig. 4.
1921 *Phylloceras Woodsi* VAN HOEPEN: 3, Pl. 2, Figs. 1–6, Text-Fig. 1.
1977b *Phylloceras (Hypophylloceras) woodsi woodsi* VAN HOEPEN, 1921; KENNEDY & KLINGER: 366, Pl. 13, Figs. 3–5, Text-Figs. 4–6. With synonymy.
1982 *Phylloceras (Hypophylloceras) vellelaeforme* (SCHLÜTER, 1871); IMMEL et al.: 8, Pl. 1, Figs. 3, 4.
1985 *Phylloceras (Hypophylloceras) woodsi woodsi* VAN HOEPEN, 1921; KLINGER: 3, Figs. 2G, H.
1987 *Phylloceras (Hypophylloceras) vellelaeforme* (SCHLÜTER, 1871); IMMEL: 57.
1993 *Hyporbulites woodsi* (VAN HOEPEN); JOLY: 71, Pl. 4, Figs. 3a, b, Pl. 9, Figs. 3–7, Pl. 29, Fig. 4. With synonymy.
2009 *Hyporbulites woodsi* (VAN HOEPEN, 1921); KLEIN et al.: 97 (with additional synonymy).

Types: The holotype is no. 537 in the collections of the Transvaal Museum, the original of VAN HOEPEN (1921: 331, Pl. 41, Figs. 3, 4), refigured by KENNEDY & KLINGER (1977b: Pl. 13, Fig. 6); there are four paratypes, nos. 529, 530, 533, 534 in the same collection. All are from the Santonian to lower Campanian Mzamba Formation at the Mzamba Estuary in north-eastern Eastern Cape Province, South Africa.

Material: Five specimens, two are in the former Mader collection (M 21, 22), one in the collection of Innsbruck University (GPII, P. 8163). Two specimens were figured by

IMMEL et al. (1982: Pl. 1; M 21 is Fig. 3, GPII, P. 8163 is Fig. 4); two further specimens are from the Skoumal Collection (SK/RA/1999/142a, b).

Description: Three specimens from the Mühlbach locality (Brandenberg, Tyrol) are internal moulds lacking any trace of the original shell material. They are flattened as a result of *post mortem* compaction. The original whorl section appears to have been compressed oval. A small specimen, 25 mm in diameter, has an open umbilicus (IMMEL et al., 1982: Pl. 1, Fig. 3), that of the adult phragmocones at diameters of 78 and 52 mm is closed (IMMEL et al., 1982: Pl. 1, Fig. 4). Dense and straight rectiradiate lirae arise at the umbilicus and extend across the flanks and venter. The specimens from the Randobach (Rußbach, Salzburg; SK/RA/1999/142a, b) are fragments, with some original aragonitic shell present. The largest, a body chamber fragment (Pl. 5, Fig. 1), has an estimated diameter of 66 mm and a whorl height of 37.3 mm. The umbilicus is tiny. The ornament of lirae is very fine and crosses the flanks in a very shallow convexity. On the adapertural part of the fragment, the lirae are grouped in narrow bundles. The smallest individual, 33 mm in diameter, is badly crushed; the tiny umbilicus comprises 8.8 % of the diameter.

Discussion: The Campanian/Maastrichtian *Phylloceras (Hypophylloceras) vellelaeforme* (SCHLÜTER, 1972: 60, Pl. 18, Figs. 4, 5, 7, non 6) from Lüneburg (Germany) differs from *Hyporbulites woodsi* in its slightly sinuous lirae. According to the late Tove Birkelund (personal communication to H.C. Klinder, 1982; cited in KLINGER, 1985) *P. (H.) vellelaeforme* is also more inflated. The Campanian *Phylloceras (Neophylloceras) bodei* (MÜLLER & WOLLEMANN, 1906: Pl. 8, Figs. 1, 2) from northern Germany is similar, with flattened flanks, a narrow umbilicus, and more or less straight liration that is delicate on the inner third of the flanks and increases in strength towards the venter. JOLY (1993: 62) regarded *Hyporbulites infundibuliformis* (COLLIGNON, 1956) as close to *Hyporbulites woodsi* (VAN HOEPEN, 1921) whereas KENNEDY & KLINGER regarded *Phylloceras (Hypophylloceras) hoepeni* and its subspecies *P. (H.) hoepeni infundibuliformis* (COLLIGNON, 1956) as synonyms of *P. woodsi* (VAN HOEPEN, 1921).

Occurrence: Brandenberg/Mühlbach, Randobach/Rußbach and Edlbach are the only early Santonian localities of the Gosau Group yielding Phylloceratina. The species also occurs in the Santonian-Lower Campanian of the Western Cape Province in South Africa and in the Santonian of Madagascar.

Suborder Lytoceratina HYATT, 1889
Superfamily Tetragonitoidea HYATT, 1900
Family Gaudryceratidae SPATH, 1927
Genus *Anagaudryceras* SHIMIZU, 1934

Type species: *Ammonites sacya* FORBES, 1846 (113, Pl. 14, Fig. 10) by the original designation of SHIMIZU (1934: 67).

Anagaudryceras redtenbacheri
(IMMEL, KLINGER & WIEDMANN, 1982)
 (not figured)

- 1982 *Gaudryceras* sp., IMMEL et al.: 10, Pl. 1, Fig. 6.
 1982 *Patagiosites redtenbacheri* IMMEL et al.: Pl. 5, Fig. 7, Pl. 6, Figs. 5–7, Pl. 7, Figs. 1a, b.
 1987 *Patagiosites redtenbacheri* IMMEL et al.; IMMEL: 94.
 2017a *Anagaudryceras redtenbacheri* (IMMEL, KLINGER & WIEDMANN, 1982); SUMMESBERGER et al.: 172, Pl. 8, Fig. 1.

Type: The holotype, by original designation is BSP 1982 I9, the original of *Patagiosites redtenbacheri* IMMEL, KLINGER & WIEDMANN, 1982, from the lower Santonian of Brandenberg/Mühlbach.

Material: BSP 1982 I 9; M 13, M 51, M 63, M 64 and M 70 all from the Lower Santonian of Brandenberg/Mühlbach.

Description: The juvenile stage is polygyral with a low expansion rate; this increases in the later growth stages. A detailed description is provided by IMMEL et al. (1982). An increasing number of irregularly spaced collar ribs develop in the later growth stages (e.g. IMMEL et al., 1982: Pl. 6, Figs. 5, 6, Pl. 7, Fig. 1).

Discussion: The specimens described and figured as *Patagiosites redtenbacheri* by IMMEL et al. (1982: Pl. 1, Fig. 6, Pl. 5, Fig. 7, Pl. 6, Figs. 5–7) are clearly Gaudryceratidae. The inner whorls are polygyral (IMMEL et al., 1982: 19, Pl. 5, Fig. 7, Pl. 6, Figs. 5–7, Pl. 7, Fig. 1) and have irregularly spaced collar ribs, crowded at maturity are also a common feature of gaudryceratid ornamentation (see MATSUMOTO, 1995: Text-Figs. 23, 32, 35, 36, 37). As KENNEDY in KENNEDY et al. (1995: 396) noted: “if [Patagiosites redtenbacheri is] not a gaudryceratid, the species is a remarkable homoeomorph of that group”. REDTENBACHER (1873: 125, Pl. 30, Fig. 4) described a specimen from the upper Coniacian of Glanegg as *Ammonites* spec. indet. cfr. *Ammonites Sacya* FORBES, 1846. IMMEL et al. (1982: 19) placed Redtenbacher's specimen in the synonymy of their *Patagiosites redtenbacheri*. We follow KENNEDY in KENNEDY et al. (1995: 395) who assigned Redtenbacher's specimen with a query to *Jimboiceras* MATSUMOTO, 1954. Species referred to the genus *Patagiosites* SPATH, 1953, are more involute, with a smaller umbilicus and a compressed oval whorl section (KAPLAN et al., 1996; KENNEDY & CHRISTENSEN, 1997).

Occurrence: *Anagaudryceras redtenbacheri* occurs in the Austrian Gosau Group at three localities of different age: Glanegg/Salzburg (late Coniacian, *Paratexanites serratomarginatus* Zone); Brandenberg/Tyrol (early Santonian, *Cladoceramus undulatoplicatus* Zone) and the Schattaugraben (late Santonian, *Placenticeras paraplanum* Subzone).

***Anagaudryceras* sp.**

(Pl. 5, Fig. 2, Tab. 2)

Material: A single specimen, OÖLM 2014/10, labelled in the hand of Helmuth Zapfe “angeblich Bad Ischl” (supposedly Bad Ischl). This is a Coniacian locality, but the preservation is such that it may be from some other Santonian locality, and it is on this basis that we include it here.

Description: OÖLM 2014/10 is a partially exfoliated, crushed internal mould with traces of whitish shell material. Coiling appears to have been moderately evolute with a moderate expansion rate. The whorl section has been deformed into an ellipse with flattened flanks and an arched venter. The umbilicus is of moderate size, comprising 25 % approximately of the diameter. The dimensions are as follows:

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|---------------|-----------|------------|------------|-----------|----------|
| OÖLM 2014/10 | 93.5 | 45.2 | 35 | 2.41 | 25.8 |

Tab. 2.
Anagaudryceras sp., OÖLM 2014/10. U % of D.

The umbilical wall is flat to slightly convex. More than 120° of the outer whorl is body chamber. Ornament consists of very fine dense lirae, invisible to the naked eye on all but the last quarter whorl. The lirae are prorsiradiate the innermost flank, feebly convex below and on the mid-flank region and sweep backwards across the outer flank, where they are essentially straight, as they are on the venter. There are delicate, narrow, low, rounded collar-like ribs on the outer whorl, which are parallel to the lirae. They are spaced at regular intervals and presumably mark the site of constrictions on the internal mould; some are followed by a distinct constriction on the partially exfoliated shell. The sutures are not exposed.

Discussion: Proportions, strength and direction of lirae together with the number of ribs suggest this specimen should be referred to *Anagaudryceras*. There are a number of species that have the same style of ornament to a relatively large diameter, before developing the coarse fold-like ribs of the adult. Although specifically indeterminate there are thus comparisons to be made with a number of species reviewed by MATSUMOTO (1995), including *Anagaudryceras yamashitai* (YABE, 1903) (MATSUMOTO, 1995: 62, Figs. 32–34).

Occurrence: As for material.

? *Anagaudryceras* cf. *subtililineatum* (KOSSMAT, 1895)

(not figured)

Compare

- 1895 *Lytoceras* (*Gaudryceras*) *subtililineatum* n.sp.; KOSSMAT: 123, Pl. 19, Figs. 1, 2.
 1979 *Anagaudryceras subtililineatum* (sic) (KOSSMAT); KENNEDY & KLINGER: 155, Text-Fig. 3, Pl. 14, Figs. 3, 12. With synonymy.

- 1982 *Anagaudryceras cf. subtililineatum* (KOSSMAT, 1895); IMMEL et al.: 9, Pl. 1, Fig. 7.
- 1987 *Anagaudryceras cf. subtililineatum* (sic) (KOSSMAT 1895); IMMEL: 64.
- 2009 *Anagaudryceras subtililineatum* (KOSSMAT, 1895); KLEIN et al.: 169 (with additional synonymy).
- 1987 *Gaudryceras glaneggense* (REDTENBACHER 1873), IMMEL: 65.
- 1995 *Gaudryceras mite* (HAUER, 1866); KENNEDY et al.: 390, Pl. 1, Figs. 20, 21.
- 1996 *Gaudryceras mite* (HAUER, 1866); SUMMESBERGER & KENNEDY: 112, Pl. 1, Figs. 1–4. (with synonymy).
- 2000 *Gaudryceras mite* (HAUER); SUMMESBERGER in EGGER et al.: 26.
- 2000 *Gaudryceras mite* (HAUER, 1866); WIESE, 2000: 128, Pl. 1, Fig. 1.
- 2009 *Gaudryceras denseplicatum denseplicatum* (JIMBO, 1894); KLEIN et al.: 177.
- 2009 *Gaudryceras glaneggense* (REDTENBACHER, 1873); KLEIN et al.: 179 (with synonymy).
- 2009 *Gaudryceras mite* (HAUER, 1866); KLEIN et al.: 184 (with additional synonymy).
- 2010 *Gaudryceras mite* (HAUER, 1866); REMIN: 161, Fig. 12 D.
- 2012 *Gaudryceras mite* (HAUER, 1866); SUMMESBERGER & ZORN: 103, Pl. 4, Figs. 4a, b, Pl. 5, Figs. 1a, b.
- 2017a *Gaudryceras mite* (HAUER, 1866); SUMMESBERGER et al.: 172

Type: The lectotype, by the subsequent designation of KENNEDY & KLINGER (1975: 155), is the original of KOSSMAT (1895: Pl. 19, Figs. 1a–c), from the Arialoor Group of South India.

Material: M 18, from the Lower Santonian of Brandenberg/Mühlbach.

Description: M 18 is an internal mould of a phragmocone, 48 mm diameter, with a short sector of the body chamber preserved. The position of the final suture is indicated by an arrow with a query in IMMEL et al. (1982: Pl. 1, Fig. 7). Coiling is gaudryceratid with a low expansion rate. The surface of the mould is smooth; the suture is gaudryceratid (after IMMEL et al., 1982: 9).

Discussion: This poor specimen is said to be a juvenile in the plate explanation of IMMEL et al. (1982: Pl. 1, Fig. 7). It differs from *A. redtenbacheri*, discussed above, in its higher expansion rate. Lack of diagnostic features limits further comparisons.

Occurrence: Early Santonian of Brandenberg/Mühlbach. There are records from South India and Eastern Cape Province, South Africa. The stratigraphic range is Santonian to early Campanian (KENNEDY & KLINGER, 1979: 157).

Types: The holotype, by monotypy, is GBA 1866/01/3, the original of HAUER (1866: Pl. 2, Figs. 3, 4), probably from the late Turonian Gosau Group of Strobl/Weißenbach (Salzburg). It was refigured by KENNEDY & SUMMESBERGER (1979: Pl. 1, Figs. 1–4). The holotype of *Gaudryceras glaneggense* (REDTENBACHER, 1873: 119, Pl. 27, Fig. 3) is no. 6373 in the collections of the Haus der Natur, Salzburg, and from the upper Coniacian Gosau Group of Glanegg, near Salzburg. It was refigured by KENNEDY & SUMMESBERGER (1979: Pl. 3).

Material: GPIB 788, the original of GERTH (1961: Pl. 24, Fig. 10a) from the early Santonian of Edlbachgraben (Gosau, Upper Austria). An unregistered specimen from the early Santonian of Mühlbach/Brandenberg (see IMMEL, 1987: 65); NHMW 1978/1963/0021, the original of SUMMESBERGER (1979: 113, Pl. 1, Fig. 1) and SK/1979/4, the original of SUMMESBERGER (1980: 276, Pl. 1, Fig. 1), both from the late Santonian Sandkalkbank Member (Gosau, Upper Austria).

Discussion: *Gaudryceras mite* (HAUER, 1866) was revised by KENNEDY & SUMMESBERGER (1979: 74). SUMMESBERGER & KENNEDY (1996: 112) pointed out that *Gaudryceras glaneggense* (REDTENBACHER, 1873) is the adult body chamber of *G. mite* and thus a synonym. This view was followed by WIESE (2000). *Gaudryceras denseplicatum* (JIMBO, 1894: 182, Pl. 23, Fig. 1) is a further synonym.

Occurrence: *Gaudryceras mite* (HAUER, 1866) is a long-ranging species occurring in the Gosau Group from the late Turonian of Strobl/Weißenbach and Gams, late Coniacian of Glanegg (IMMEL, 1987: 65), early Santonian of Brandenberg/Mühlbach (IMMEL, 1987) and late Santonian of Gosau (Upper Austria; SUMMESBERGER, 1979, 1980). Elsewhere it ranges into the early Campanian, with records from northern Spain, Romania, Eastern Cape Province and northern KwaZulu-Natal in South Africa, Madagascar, Japan, Sakhalin and California.

Genus *Gaudryceras* DE GROSSOUIRE, 1894

Type species: *Ammonites mitis* HAUER, 1866 (305, Pl. 2, Figs. 3, 4) by the subsequent designation of BOULE, LEMOINE & THÉVENIN (1906: 11).

Gaudryceras mite (HAUER, 1866)

(not figured)

- 1866 *Ammonites mitis* HAUER: 305, Pl. 2, Figs. 3, 4.
- 1873 *Ammonites mitis* HAUER; REDTENBACHER: 119, Pl. 27, Fig. 4.
- 1873 *Ammonites glaneggensis* HAUER; REDTENBACHER: 119, Pl. 27, Fig. 3.
- 1961 *Gaudryceras cf. mite* v. HAUER; GERTH: 120, Pl. 24, Figs. 10a, b.
- 1979 *Gaudryceras mite* (HAUER); SUMMESBERGER: 113, Pl. 1, Fig. 1.
- 1979 *Gaudryceras mite* (HAUER); KENNEDY & SUMMESBERGER: 74, Pls. 1, 2 (with synonymy).
- 1979 *Gaudryceras glaneggense* (REDTENBACHER); KENNEDY & SUMMESBERGER: 76, Pls. 3, 4 (with synonymy).
- 1980 *Gaudryceras mite* (HAUER); SUMMESBERGER: 276, Pl. 1, Fig. 2.
- 1987 *Gaudryceras mite* (HAUER, 1866); IMMEL: 65.

Gaudryceras sp. indet. 1

(not figured)

1982 *Gaudryceras* ex gr. *denseplicatum* YABE 1903 (sic); IMMEL et al.: 9, Pl. 1, Fig. 5.

Material: GPII P.8179 from the early Santonian Mühlbach locality (Brandenberg, Tyrol).

Description: GPII P.8179 is the internal mould of the phragmocone and part of the body chamber 42 mm in diameter (the figure of this specimen in IMMEL et al., 1982: Pl. 1, Fig. 5 is enlarged x 1.5). No trace of the original shell material survives. The surface is covered in straight narrow lirae and more or less regular collar ribs.

Discussion: In our opinion *Gaudryceras* sp. indet. 1 cannot be compared with *Gaudryceras denseplicatum* (JIMBO, 1894). This species was treated as a junior synonym of *Gaudryceras glanneggense* by KENNEDY & SUMMESBERGER (1979), in turn regarded as a junior synonym of *Gaudryceras mite* by SUMMESBERGER & KENNEDY (1996). The Brandenberg specimen has more lirae (about 10) and wider interspaces, than the originals of JIMBO (1894: Pl. 7, Fig. 1) and REDTENBACHER (1873: Pl. 27, Fig. 3), refigured by KENNEDY & SUMMESBERGER (1979: Pl. 3). Ribbing and liration of the Brandenberg specimen are almost straight whereas they are falcoid in the above mentioned examples. The specimen is specifically indeterminate in our view.

Occurrence: Lower Santonian of Brandenberg/Mühlbach.

Gaudryceras sp. indet. 2

(not figured)

1982 *Gaudryceras* sp. indet.; IMMEL et al.: 10, Pl. 1, Fig. 6.

Material: M 51, the original of IMMEL et al. (1982: Pl. 1, Fig. 6), from the early Santonian of the Mühlbach locality (Brandenberg, Tyrol).

Description: M 51 is a small fragment of the phragmocone. Compared to other gaudryceratids the whorl height increases relatively rapidly. The surface is covered with fine, dense, falcoid lirae and some indistinct collar ribs.

Discussion: We follow IMMEL et al. (1982: 10) in regarding this specimen as specifically indeterminate.

Occurrence: As for material

Family Tetragonitidae HYATT, 1900

Subfamily Tetragonitinae HYATT, 1900

Genus *Saghalinites* WRIGHT & MATSUMOTO, 1954

Type species: *Ammonites cala* FORBES, 1846 (104, Pl. 8, Fig. 4), by original designation of WRIGHT & MATSUMOTO (1954: 110).

Saghalinites nuperus (VAN HOEPEN, 1921)

(Pl. 5, Figs. 3–10)

- 1921 *Tetragonites nuperus* VAN HOEPEN: 13, Pl. 3, Figs. 3, 4.
- 1956 *Saghalinites nuperus* (VAN HOEPEN, 1921); COLLIGNON: 81, 95, Pl. 11, Figs. 1, 1a, 1b.
- 1966 *Saghalinites nuperus* VAN HOEPEN; COLLIGNON: 3, Pl. 456, Fig. 1856, 21, Pl. 463, Fig. 1893.
- 1977a *Saghalinites nuperus* (VAN HOEPEN, 1921); KENNEDY & KLINGER: 177, Figs. 16A–E, 17A, B, 18 (with synonymy).
- 1982 *Saghalinites* aff. *wrighti* BIRKELUND; IMMEL et al.: 10, Pl. 2, Figs. 1, 2.
- 1982 *Pseudophyllites latus* (MARSHALL, 1926); IMMEL et al.: 10, Pl. 2, Figs. 3, 4).
- 1985 *Saghalinites nuperus* (VAN HOEPEN, 1921); KLINGER: 4, Figs. 2N–S, 3A–C.
- 1987 *Saghalinites wrighti* BIRKELUND; IMMEL: 67.
- 1987 *Pseudophyllites latus* (MARSHALL, 1926); IMMEL: 67.
- 1995 *Saghalinites nuperus* (VAN HOEPEN, 1921); KENNEDY in KENNEDY et al.: 389, Pl. 3, Figs. 3, 4, 10, 11.
- 2009 *Saghalinites nuperus* (VAN HOEPEN, 1921); KLEIN et al.: 255 (with additional synonymy).

Types: The holotype, by original designation, is no. 532 in the collections of the Transvaal Museum, Pretoria, from the Santonian to early Campanian Mzamba Formation of the Mzamba Estuary in Eastern Cape Province, South Africa, the original of VAN HOEPEN (1921: Pl. 3, Figs. 3, 4), refigured by KENNEDY & KLINGER (1977a: Text-Figs. 1a–c). There are two paratypes from the same unit and locality.

Material: We have eight specimens: NHMW 1982/0035/0001 from the basal Santonian of Edlbachgraben (Gosau, Upper Austria); SK/SB/1989/5 from the middle Santonian of Schneiderwirtsbrücke (bed of the Ischl river, Upper Austria); NHMW 2012/0186/0010 from the middle Santonian of Randobach (Rußbach, Salzburg); NHMW 2013/0015/0004–5 from the early Santonian of Breitenberg near Weißwasser (Upper Austria); NHMW 2013/0015/0003 from the early Santonian of Schwarzenbach near Weißwasser (Upper Austria); GBA 1935 (unregistered) from the middle Coniacian of Nussenseebach; NHMW 2013/0016/0001 from the upper Coniacian of Glanegg.

Description: All of the specimens are preserved as internal moulds with traces of adherent shell material. All are deformed into an ellipse as a result of *post mortem* crushing. As a result, dimensions can only be estimated. The umbilicus comprises 30–40 % of the diameter. The whorl section, so far as can be observed, was rounded-polygonal, with a flattened venter and feebly convex flanks. All specimens retain part of the body chamber. The surface of the internal moulds is smooth, but for more or less distinct constrictions, with an associated adapical collar rib.

In NHMW 2013/0015/0004–5 the projected aperture is well preserved (NHMW 2013/0015/0005: Pl. 5, Figs. 3, 4). Five of the specimens (NHMW 1982/0035/0001, NHMW 2013/0015/0004–5, GBA 1935 (unregistered), SK/SB 1989/5) show a faint mid-ventral ridge and feeble flanking grooves (Pl. 5, Figs. 8, 9). Only traces of the sutures are visible.

The best information about the shell parameters are from the Breitenberg specimens (NHMW 2013/0015/0004–5; Pl. 5, Figs. 3–6), two internal moulds with traces of brownish shell, impregnated with iron-oxide. The general shape is that of a *Saghalinites*, with polygonal whorl section. The outer whorl which seems to be the body chambers shows a lower expanding rate. The weak constrictions are strongly prorsiradiate in NHMW 2013/0015/0004 (Pl. 5, Fig. 5).

Discussion: *Saghalinites nuperus* is described in detail by KENNEDY & KLINGER (1977a: 177), who discuss differences from *Saghalinites wrighti* BIRKELUND, 1965 (30, Pl. 1, Fig. 5, Pl. 2, Figs. 1–5, Pl. 3, Fig. 1, Text-Figs. 14–15) and *Saghalinites cala* (FORBES, 1846: 104, Pl. 8, Fig. 4). A mid-ventral ridge and parallel flanking grooves, as seen in NHMW 1982/0035/0001 (Pl. 5, Figs. 8, 9) are also known in *Tetragonites superstes* VAN HOEPEN, 1921 (KENNEDY & KLINGER, 1977a: Text-Figs. 7D, H) and *Saghalinites cala* (KENNEDY & KLINGER, 1977a: Text-Fig. 13E). The mid ventral ridge and flanking grooves of GII P.8164 suggest that it, together with M 48 and GII P.8164, figured by IMMEL et al. (1982: Pl. 2, Figs. 3, 4) as *Pseudophyllites latus* (MARSHALL) are better assigned *Saghalinites nuperus*. This conclusion is supported by the lower expansion rate of these specimens compared to that of species of *Pseudophyllites* (see: KENNEDY & KLINGER, 1977a: Figs. 25, 26).

Occurrence: Middle Coniacian of Nussenseebach (Salzburg, Austria); late Coniacian of Glanegg (Salzburg, Austria); early Santonian of Brandenberg/Mühlbach (Tyrol); early Santonian of the Edlbachgraben (Gosau, Upper Austria); middle Santonian of the Schneiderwirtsbrücke site (Bad Ischl) and basal Santonian in the case of the Schwarzenbach/Weißwasser specimen, indicated by the presence of co-occurring *Cladoceramus undulatoplicatus*. There are also records from the Corbières in southern France, Eastern Cape Province in South Africa, Madagascar and Japan, with a possible record from northern Spain.

Suborder Ammonitina HYATT, 1889

Superfamily Desmoceratoidea ZITTEL, 1895

Family Desmoceratidae ZITTEL, 1895

Subfamily Puzosiinae SPATH, 1922

(= Hauericeratinae MATSUMOTO, 1938)

Genus *Jimboiceras* MATSUMOTO, 1954

Type species: *Desmoceras planulatiforme* JIMBO, 1894 (27, Pl. 1, Fig. 4) by the original designation of MATSUMOTO (1954: 95).

Jimboiceras cf. reyi COLLIGNON, 1983

(Pl. 6, Figs. 1–4, 6, 7, Text-Fig. 4, Tab. 3)

Compare

1873 *Ammonites* spec. indet. cfr. *Ammonites Sacya* FORBES; REDTENBACHER (1873: 125, Pl. 30, Fig. 4).

1983 ? *Jimboiceras reyi* COLLIGNON; BILOTTE & COLLIGNON: 189, Pl. 2, Fig. 2.

1995 *Jimboiceras ? reyi* COLLIGNON; KENNEDY in KENNEDY et al.: 394, Pl. 4, Figs. 8–11, 15, 16, Pl. 6, Figs. 1, 2.

Material: Four specimens: NHMW 2013/0015/0001–2, two from the early Santonian of Unterlaussa (Weißwasser, Upper Austria), NHMW 2013/0016/0001, an unregistered HNS specimen and the original of *Ammonites* spec. indet. cfr. *Ammonites Sacya* FORBES of REDTENBACHER (1873: Pl. 30, Figs. 4a, b (which could not be traced in the collections of the “Haus der Natur”, Salzburg), both are from the late Coniacian of Glanegg (Salzburg).

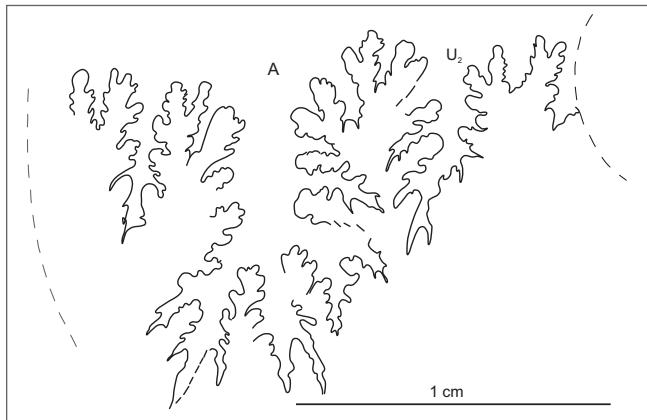
Description: NHMW 2013/0015/0001 (preserved in fine sandstone) and 0002 together with NHMW 2013/0016/0001 are brownish internal moulds. NHMW 2013/0015/0001 and 2 retain traces of shell, partially removed in the latter to expose the suture. Coiling is evolute, the whorls expanding slowly. All specimens are somewhat crushed and deformed into an ellipse by *post mortem* deformation. The original whorl section appears to have been compressed, with a whorl breadth to height ratio of about 0.6. The umbilicus is relatively narrow and shallow with a distinct umbilical edge. The umbilical wall is vertical. The flanks are feebly convex, the maximum breadth at mid-flank, the venter narrowly rounded. NHMW 2013/0015/0001 (Pl. 6, Figs. 6, 7) has about 10 narrow prorsiradiate and biconcave constrictions accompanied by a weak collar rib arising at the umbilical edge with a distinct elongated bulla, strengthening and crossing the venter in a marked convexity. Irregularly spaced short ribs are present on the ventrolateral shoulders between the more or less regularly spaced collar ribs, NHMW 2013/0015/0002 (Pl. 6, Figs. 1, 2) shows a similar but even more irregular style of ribbing, several ribs arising at the umbilical shoulder and crossing the flanks parallel to constrictions and collar ribs. Feeble riblets are visible on the ventrolateral shoulders and venter on a very small area, suggesting that ventrolateral riblets were originally present overall of the specimen. NHMW 2013/0016/0001 (Pl. 6, Figs. 3, 4) has only four constrictions with parallel collar ribs per half whorl. The external suture (Text-Fig. 4) is typically puzosiid, with a more or less regular trifid E/A, deeply incised E and A and narrowly rounded folioles.

Discussion: Despite minor differences the specimens are conspecific in our view. They are assigned with some doubt to *Jimboiceras* cf. *reyi* COLLIGNON, 1981 (sensu KENNEDY in KENNEDY et al., 1995: 394, Pl. 4, Figs. 8–11). They agree in the form of the constrictions, but differ from the French specimens in their more numerous intercalated ribs, more compressed section and smaller umbilicus. *Jimboiceras planulatiforme* (JIMBO, 1894: 173 (27), Pl. 17 (1), Fig. 4); see revision of MATSUMOTO 1988 in MATSUMOTO et al. 1988: 89, Text-Figs. 36–41) is more densely and more evenly ribbed. We confirm the interpretation of KENNEDY in KENNEDY et al. (1995: 394) that *Ammonites* sp. indet. cfr. *sacya*

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|---------------------|-----------|------------|------------|-----------|----------|
| NHMW 2013/0015/0001 | 62 | 26.9 | 15.8 | 13 | 20.9 |
| NHMW 2013/0015/0002 | 39.4 | 18.7 | 11.4 | 8.1 | 20.5 |

Tab. 3.

Jimboiceras cf. reyi COLLIGNON, 1981 from the early Santonian of the Weißwasser area (Unterlaussa, Upper Austria). U % of D.



Text-Fig. 4.
External suture of *Jimboiceras cf. reyi* COLLIGNON, 1983, Unterlaussa, Upper Austria; NHMW 2013/0015/0002.

FORBES from the upper Coniacian of Glanegg (Salzburg, Austria) (REDTENBACHER, 1873: 125, Pl. 30, Fig. 4) may possibly be conspecific with the present material. IMMEL et al. (1982: 19, Pl. 5, Fig. 7 (?), Pl. 6, Figs. 5–7, Pl. 7, Fig. 1) listed *Ammonites* sp. indet. cfr. *sacra* FORBES in the synonymy of “*Patagiosites redtenbacheri*” but this is not a *Patagiosites*, but a gaudryceratid, as already pointed out by KENNEDY in KENNEDY et al. (1995: 396) and noted above.

Occurrence: The Austrian specimens are from the basal Santonian of Unterlaussa (Upper Austria); NHMW 2013/0015/0001 from the early Santonian of the Breitenberg forest road; NHMW 2013/0015/0002 occurs together with *Cladoceramus undulatoplicatus* in the early Santonian of the Blahberg forest road; NHMW 2013/0016/0001 and an unregistered HNS specimen are from the upper Coniacian Gosau Group of Glanegg (Salzburg). The French examples are from the middle and late Coniacian of the Corbières (France).

Genus and Subgenus *Parapuzosia* NOWAK, 1913

Type species: *Sonneratia daubreei* DE GROSSOUIRE, 1894 (154, Pl. 28, Fig. 1) by subsequent designation of SPATH (1922: 126).

Parapuzosia (Parapuzosia) daubreei (DE GROSSOUIRE, 1894)

(not figured)

- 1894 *Sonneratia Daubréei* DE GROSSOUIRE: 154, Pl. 28, Fig. 1.
- 1906 *Sonneratia Daubréei* DE GROSSOUIRE; MÜLLER & WOLLEMANN: 8, Pl. 5.
- 1913 *Parapuzosia Daubréei* DE GROSSOUIRE sp.; NOWAK: 363, Pl. 43, Fig. 32, Pl. 44, Fig. 40.
- 1982 *Parapuzosia daubreei* (DE GROSSOUIRE); KOLLMANN & SUMMERSBERGER: 72.
- 1982 *Parapuzosia daubréei* (DE GROSSOUIRE); IMMEL et al.: 11, Pl. 2, Fig. 9 only, Pl. 3, Figs. 1, 2, Pl. 4, Fig. 2.
- 1987 *Parapuzosia daubreei* (DE GROSSOUIRE 1894); IMMEL: 89.

- 1995 *Parapuzosia (Parapuzosia) daubreei* (DE GROSSOUIRE, 1894); KENNEDY & KAPLAN: 26, Pls. 31, 32.
- 1995 *Parapuzosia (Parapuzosia) daubreei* (DE GROSSOUIRE, 1894); KENNEDY in KENNEDY et al.: 391, Figs. 10, 11 (with synonymy).
- 2010 *Parapuzosia (Parapuzosia) daubreei* (DE GROSSOUIRE, 1894); REMIN: 167, Figs. 8A–D, 9A, 10A, B.

Type: The lectotype, by subsequent designation of KENNEDY in KENNEDY et al. (1995: 391), is the original of DE GROSSOUIRE (1894: 154, Pl. 28).

Material: One specimen from the early Santonian of the Randobach (Rußbach, Salzburg) in the ÖÖLM collection, seven specimens (two of them questionable) from Brandenberg, Mühlbach (IMMEL et al., 1982: 11), one fragment from the Edlbachgraben (Gosau, Upper Austria).

Description and Discussion: See KENNEDY in KENNEDY et al. (1995: 391, Figs. 10, 11). The specimen in the ÖÖLM collection is a phragmocone of about 500 mm diameter (now apparently lost). When complete with body chamber, it must have measured about 900 mm in diameter. *Mesopuzosia yubarensis* (JIMBO) of IMMEL et al. (1982: 12, Pl. 4, Fig. 3) and IMMEL (1987: 89) is a fragment of *Parapuzosia (P.) daubreei* in our view. An almost identical fragment was figured by IMMEL et al. (1982: Pl. 2, Figs. 10a, b) as *P. daubreei*.

Occurrence: The occurrences in the Gosau Group are early Santonian date (IMMEL et al., 1982). In the Corbières it occurs in the Santonian *gallicus* and *paraplanum* Zones (KENNEDY in KENNEDY et al., 1995: 391). MÜLLER & WOLLEMANN (1906: 8, Pl. 5) recorded the species from the early Campanian of Braunschweig, Germany.

Parapuzosia (Parapuzosia) corbarica (DE GROSSOUIRE, 1894)

(Pl. 6, Fig. 9, Pl. 9, Fig. 9)

- 1894 *Puzosia corbarica* DE GROSSOUIRE: 174, Pl. 27, Fig. 1.
- 1982 *Parapuzosia corbarica* (DE GROSSOUIRE 1894); IMMEL et al.: 12, Pl. 3, Fig. 3, Pl. 4, Figs. 1, 3.
- 1982 ? *Mesopuzosia yubarensis* (JIMBO); IMMEL et al.: 12, Pl. 4, Fig. 3.
- 1982 *Parapuzosia daubréei* (DE GROSSOUIRE 1894); IMMEL et al.: 11, Pl. 2, Fig. 10 (only), Pl. 3, Figs. 1, 2.
- 1987 *Parapuzosia corbarica* (DE GROSSOUIRE 1894); IMMEL: 89.
- 1995 *Parapuzosia (Parapuzosia) corbarica* (DE GROSSOUIRE, 1894); KENNEDY & KAPLAN: 27, Pl. 34.
- 1995 *Parapuzosia (Parapuzosia) corbarica* (DE GROSSOUIRE, 1894); KENNEDY in KENNEDY et al.: 391, Pl. 2, Fig. 9, Pl. 5, Figs. 1–3, 12, 13 (with synonymy).
- 2017a *Parapuzosia corbarica* (DE GROSSOUIRE, 1894); SUMMERSBERGER et al.: 174, Pl. 8, Fig. 4, Text-Fig. 14.

Types: The holotype by original designation is the original of DE GROSSOUIRE (1894: Pl. 27, Fig. 1); there are two paratypes and all are from the Santonian of the Corbières in southern France.

Material: M43 and GPII P.8176 from Brandenberg/Mühlbach are early Santonian. SK/RA/2015/165 and SK/RA/1982/78 from the Randobach 2 site (Rußbach, Salzburg) is middle Santonian. NHMW 1978/1955/0003 from the Schattaugraben (Rußbach, Salzburg) is late Santonian age.

Description and Discussion: The species was described and discussed at length by KENNEDY in KENNEDY et al. (1995: 391–393).

Occurrence: Early Santonian of the Gosau Group of Brandenberg/Mühlbach (Tyrol), middle Santonian of Randobach 2 site (Rußbach, Salzburg); late Santonian of Schattau/Rußbach. In the Corbières, in southern France it occurs in the late Coniacian *Serratomarginatus* Zone and in the early Santonian *Gallicus* and *Paraplanum* Zones.

Parapuzosia sp. indet.

(not figured)

? 1982 *Mesopuzosia* sp. indet., IMMEL et al.: 13, Pl. 2, Fig. 8, Text-Fig. 3.

Description and Discussion: The specimen figured and described by IMMEL et al. (1982) differs from *Parapuzosia corbarica* and *P. daubreei* in its very weak ornament and greater rate of increase in whorl height. The well-preserved external suture supports assignment to the Puzosiinae (IMMEL et al., 1982: Text-Fig. 3).

Occurrence: Early Santonian, Gosau Group of Brandenberg/Mühlbach.

Genus and subgenus *Hauericeras* DE GROSSOURE, 1894

Type species: *Ammonites pseudo-gardeni* SCHLÜTER, 1872 by original designation.

Hauericeras (Hauericeras) pseudogardeni (SCHLÜTER, 1872)

(Pl. 6, Fig. 8)

- 1872 *Ammonites pseudo-Gardeni* SCHLÜTER: 54, Pl. 16, Figs. 3–6.
- 1906 *Hauericeras pseudo-Gardeni* SCHLÜTER sp.; MÜLLER & WOLLEMAN: 14, Pl. 4, Figs. 1–4, Pl. 8, Fig. 3.
- 1982 *Desmophyllites* cf. *larteti* (SEUNES); IMMEL et al.: 15, Pl. 4, Fig. 4, Text-Fig. 4.
- 1987 *Desmophyllites larteti* (SEUNES); IMMEL: 91, Pl. 9, Fig. 1.
- 1995 *Hauericeras (Hauericeras) pseudogardeni* (SCHLÜTER, 1872); KENNEDY & KAPLAN: 18, Pls. 1–4, Pl. 5, Figs. 1, 2, 6, Pl. 6, Figs. 1, 7, Pl. 7, Figs. 1–4 (with synonymy).
- 1995 *Hauericeras pseudogardeni* (SCHLÜTER, 1872); LOMMERZHEIM: 53, Pl. 2, Fig. 5, 6 (with additional synonymy).
- 1997 *Hauericeras (Hauericeras) pseudogardeni* (SCHLÜTER, 1872); KENNEDY & CHRISTENSEN: 85, Figs. 5E, 6.
- 1999 *Hauericeras* cf. *pseudogardeni* (SCHLÜTER 1872); SUMMESBERGER et al.: 159, Pl. 1, Fig. 1.

- 2004 *Hauericeras pseudogardeni* (SCHLÜTER, 1872); SUMMESBERGER & KENNEDY: 169, Text-Fig. 2.
- 2005 *Hauericeras pseudogardeni* (SCHLÜTER, 1872); KAPLAN et al.: 52, Pl. 3, Figs. 1–9, Pl. 52, Figs. 1, 2.
- 2006 *Hauericeras (Hauericeras) pseudogardeni* (SCHLÜTER, 1872); KAPLAN et al.: 31, Pl. 1, Figs. 4, 7, 9, 11, 12.

Type: The lectotype, by subsequent designation of MATSUMOTO in MATSUMOTO et al. (1990: 440), is no. 48 in the Schlüter Collection, housed in the Goldfuss Museum, Bonn, the original of *Ammonites pseudo-Gardeni* SCHLÜTER, 1872 (Pl. 16, Figs. 5, 6). It was refigured by KENNEDY & KAPLAN (1995: Pls. 1–3).

Material: Two specimens, M 46, the original of *Desmophyllites* cf. *larteti* (SEUNES) of IMMEL et al. (1982: 15, Pl. 4, Fig. 4, Text-Fig. 4) and MAD 1987 I 11, the original of *Desmophyllites larteti* (SEUNES) of IMMEL (1987: 91, Pl. 9, Fig. 1).

Description: M 46, the original of IMMEL et al. (1982: 15, Pl. 4, Fig. 4, Text-Fig. 4), is an internal mould, lacking any trace of adherent shell material. It is very compressed, high-whorled, with feebly convex flanks, a sharp umbilical edge and a broadly rounded ventrolateral shoulder. The umbilicus is relatively narrow, 20.5 % of the diameter, with a vertical or subvertical umbilical wall. The venter appears to be fastigiated. There are about five shallow fallopoid constrictions per half whorl with faint but distinct ribs between, effacing on the outer flank as size increases.

Discussion: *Hauericeras (Hauericeras) pseudogardeni* from Brandenberg/Mühlbach is very close to specimens with a narrow umbilicus figured by MÜLLER & WOLLEMAN (1906: Pl. 4, Fig. 4) and KENNEDY & KAPLAN (1995: Pl. 5, Fig. 2, Pl. 6, Fig. 1, Pl. 7, Fig. 3). According to KENNEDY & KAPLAN (1995) the umbilicus of smaller (juvenile) specimens from the Münster Basin comprises 17–20 % of the diameter; in larger (adult) specimens, including the lectotype, it is 24–26 % of the diameter.

The specimens from the early Santonian of Brandenberg/Mühlbach were identified as *Desmophyllites* cf. *larteti* (SEUNES) by IMMEL et al. (1982: 15, Pl. 4, Fig. 4) and under *Desmophyllites larteti* (SEUNES) by IMMEL (1987: 91, Pl. 9, Fig. 1). *D. larteti* actually occurs in the late Campanian *Nostoceras hyatti* Zone (e.g. Tercis, France: HANCOCK & KENNEDY, 1993; Gschliefgraben, Austria: KENNEDY & SUMMESBERGER, 1984, 1999) and is also described from the late Maastrichtian of the French Pyrénées (KENNEDY & HANCOCK, 1993). *D. larteti* has a narrow umbilicus, much narrower than the specimen figured by IMMEL et al. (1982) and a broadly rounded umbilical shoulder (e.g. KENNEDY & SUMMESBERGER, 1984: 156, Pl. 2, Figs. 1–3, 5, 6; KENNEDY & HENDERSON, 1992: Pl. 17, Fig. 9, Pl. 18, Figs. 1–6; KENNEDY & HANCOCK, 1993: Pl. 1, Figs. 1–3, 8–10). In contrast the specimen from Brandenberg has a very narrowly rounded umbilical shoulder and an apparently steep umbilical wall. These differences and the considerable age difference between well-dated occurrences of *D. larteti* make the assignment of the Brandenberg specimens to this species unlikely. The specimen figured by IMMEL et al. (1982: Pl. 4, Fig. 4) is closest to one of the narrowly umbilicated representatives of *H. (H.) pseudogardeni* (SCHLÜTER, 1872) figured by MÜLLER & WOLLEMAN (1906: Pl. 4, Figs. 1–4). The specimen figured by IMMEL (1987: Pl. 9, Fig. 1) also appears to belong here. Further

comparable specimens of *H. (H.) pseudogardeni* are figured by KENNEDY & KAPLAN (1995: Pls. 1–4, Pl. 5, Figs. 1, 2, 6, Pl. 7, Figs. 1, 7, Pls. 7, 8). A fine example of *H. (H.) pseudogardeni* (NHMW 2013/0017/0001) from Broitzem, Braunschweig, Germany, is figured here (Pl. 6, Fig. 8) for comparison. For further discussion, see also KENNEDY & CHRISTENSEN (1997).

Occurrence: *Hauericeras (Hauericeras) pseudogardeni* occurs in the late Santonian and early Campanian of Germany (KENNEDY & KAPLAN, 1995: 20) and Sweden (KENNEDY & CHRISTENSEN, 1997). KAPLAN & KENNEDY (2000: Fig. 10) record it from the late Santonian and early Campanian of the Münster Basin (Germany) with rare occurrences in the early Santonian and even late Coniacian. *Hauericeras (Hauericeras) cf. pseudogardeni* (SCHLÜTER, 1872) was described from the Campanian Austrian Gosau Group of Gams (SUMMERSBERGER et al., 1999) and the species is now recorded from the early Santonian of Brandenberg/Tyrol.

Subgenus *Gardeniceras* MATSUMOTO & OBATA, 1955

Type species: *Ammonites gardeni* BAILY, 1855 (450, Pl. 11, Fig. 3), by the original designation of MATSUMOTO & OBATA (1955: 134).

Hauericeras (Gardeniceras) aff. gardeni (BAILY, 1855)

(Pl. 6, Fig. 5, Pl. 7, Figs. 1–3, 6–8, Tab. 4)

- 1855 *Ammonites Gardeni* BAILY: 450, Pl. 11, Fig. 3
 1982 *Hauericeras gardeni* (BAILY, 1855); IMMEL et al.: 16, Pl. 5, Figs. 1–4, Pl. 6, Fig. 1, non Pl. 6, Figs. 2–4.
 1987 *Hauericeras gardeni* (BAILY, 1855); IMMEL: 47.

Material: In addition to the nine specimens in the collections from Brandenberg/Mühlbach (IMMEL et al., 1982: 17), there are eight individuals from the lower Santonian of the Gosau area: NHMW 2010/0355/0027 from the parking site of the cable car (Rußbach, Salzburg), SK/EB/2001/26, SK/EB/2001/27, SK/EB/2010/48, SK/EB/2010/49, 50 from Edlbachgraben (Gosau, Upper Austria) and SK/GR/1983/35 from Grabenbach (Gosau, Upper Austria).

Description: The specimens from Brandenberg (Tyrol) were described by IMMEL et al. (1982: 16, Text-Fig. 5) including a table of measurements in the text.

The largest specimen (Pl. 7, Fig. 1) from Rußbach (NHMW 2010/0355/0027) is preserved on a slab of grey marl. It is flattened and deformed into a feeble ellipse as a result of *post mortem* compaction. The whitish aragonitic shell is almost completely preserved. The coiling is evolute, the umbilicus broad and shallow. Four whorls are visible with 51 % of the previous whorl being covered. The whorl height increases regularly; the whorl breadth to height ratio cannot be measured due to lateral compaction. The umbilical wall is vertical and gently convex, the umbilical shoulder narrowly rounded. In spite of the compaction the flanks are slightly convex, with maximum breadth below mid-flank. The feebly convex ventrolateral shoulders converge towards the fastigate venter and sharp siphon-

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|---------------------|-----------|---------|---------|--------|-------|
| NHMW 2010/0355/0027 | 74 | 31 | -- | 25.6 | 34.5 |
| SK/EB/2010/49 | 83.5 | 33.4 | -- | 26.3 | 31.5 |
| SK/EB/2010/50 | 52.5 | 19.4 | -- | 21.6 | 41.1 |
| SK/EB/2010/48 | 23.8 rest | 10.8 | -- | 11.2 | 37 |
| SK/GR/1983/35 | 53.4 | 26.5 | -- | 18.8 | 35 |

Tab. 4.

Hauericeras (Gardeniceras) aff. gardeni (BAILY, 1855). U % of D. For the measures of the Brandenberg specimens see IMMEL et al. (1982: 17).

nal keel. No ornament is visible on the surface of the shell. Five to six sinuous constrictions per whorl are present on the internal mould. They are feebly concave on the flanks, project strongly forwards on the ventrolateral shoulder and extend forwards subparallel to the ventral keel.

SK/EB/2010/49 from Edlbachgraben is similar. Traces of sutures indicate it to be a phragmocone. The surface is covered by whitish shell and underlying nacreous layer; the keel is narrow and entire. SK/EB/2010/50 also retains the original shell material. The umbilical diameter decreases with increasing total diameter. Only parts of the constrictions are visible on these specimens. SK/EB/2010/48 is a juvenile with most of the original shell material preserved; constrictions cannot be observed. SK/GR/1983/35 (Pl. 7, Fig. 8) is laterally crushed. The constrictions are relatively broad and slightly sinuous, projecting strongly forwards close to the ventral margin.

Discussion: NHMW 2010/0355/0027 from the parking site of the cable car of Rußbach and those from Edlbachgraben and SK/GR/1983/35 from the Grabenbach site are thought to be conspecific with the Brandenberg material on the basis of the form of the constrictions. Three fragmentary specimens, SK/EB/2001/26 (Pl. 7, Fig. 6), SK/EB/2001/27 (Pl. 7, Fig. 7); SK/GR/1983/35, from the early Santonian Gosau Group of Edlbachgraben and Grabenbach (Gosau, Upper Austria) may also belong here. The material is poor and insufficient to establish a new species, hence the present assignation. KENNEDY & KLINGER (2011: 45) excluded the Brandenberg specimens from the synonymy of *H. (G.) gardeni* on the basis of the course of their constrictions: concave in *H. (G.) gardeni* and sinuous in the Brandenberg specimens. *Hauericeras welschi* DE GROSSEVOIRE, 1894 (222, Pl. 35, Fig. 9); see revision in KENNEDY in KENNEDY et al. (1995: 396, Pl. 3, Fig. 12, Pl. 4, Figs. 3–5, Text-Fig. 14) also differs in its sinuous constrictions. *Hauericeras (Gardeniceras) lagarum* (REDTENBACHER, 1873: 112, Pl. 25, Fig. 3) from the Coniacian Gosau beds of Austria, a close ally of *Hauericeras (Gardeniceras) gardeni* and *H. (G.) angustum* (YABE, 1904) from India and Japan, differing in having a wider umbilicus. In *H. angustum* it is 37–44 % after MATSUMOTO in MATSUMOTO et al. (1990: 445).

Occurrence: *Hauericeras (Gardeniceras) aff. gardeni* (BAILY, 1855) occurs in the lower Santonian Gosau Group of Brandenberg/Mühlbach (Tyrol), at the parking site of the Hornspitz cable car at Rußbach (Salzburg) and in the early Santonian at the Edlbachgraben site (Gosau, Upper Austria).

***Hauericeras (Gardeniceras) lagarum*
(REDTENBACHER, 1873)**

(Text-Fig. 5)

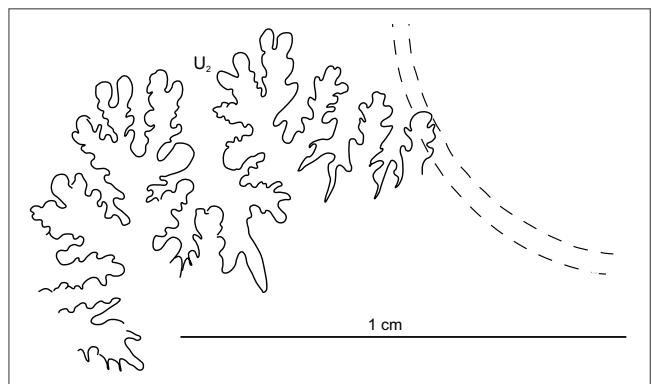
- 1873 *Ammonites lagarus* REDTENBACHER: 112, Pl. 25, Figs. 3a, b.
- 1901 *Hauericeras lagarum* REDTENBACHER; DE GROSSOUVRE: 638.
- 1925 *Hauericeras lagarum* REDTENBACHER; DIENER: 95.
- 1935 *Hauericeras lagarum* REDT.; BRINKMANN: 3.
- 1961 *Hauericeras lagarum* REDTENBACHER; COLLIGNON: 95.
- 1985 *Hauericeras lagarum* (REDTENBACHER); SUMMESBERGER: 152.
- 1995 *Hauericeras (Gardeniceras) lagarum* (REDTENBACHER, 1873); KENNEDY in KENNEDY et al.: 397, Pl. 4, Fig. 17 (with synonymy).
- 2012 *Hauericeras lagarum* (REDTENBACHER, 1873); SUMMESBERGER & ZORN: 106, Pl. 13, Fig. 2.
- 2017a *Hauericeras (Gardeniceras) lagarum* (REDTENBACHER, 1873); SUMMESBERGER et al.: 176, Pl. 8, Figs. 2, 3, Pl. 9, Fig. 7, Text-Fig. 15, Tab. 7.

Types: *Ammonites lagarus* REDTENBACHER (1873: 112, Pl. 25, Figs. 3a, b) was based upon two syntypes combined by Redtenbacher in his original figure. One of the originals, HNS 6391 is designated lectotype by SUMMESBERGER et al. (2017a: 176, Pl. 9, Figs. 7a, b).

The second paralectotype, GBA 1873/001/0007, is an external mould from the middle Coniacian Gosau Group of the Schmolnauer Alpe (Strobl/Weißenbach, Salzburg, housed in the collections of the Geological Survey of Austria in Vienna (SUMMESBERGER & ZORN, 2012: Pl. 13, Fig. 2).

Material: Three specimens from the late Santonian *paraplanum* Subzone of the Hochmoos Formation of the Schattaugraben section (Rußbach, Salzburg): NHMW 1978/1955/0001 without locality details and SK/SG/1984/3 from the *Micraster* Bed. The preservation of NHMW 1978/1955/0001 suggests that it might be from the same level. A juvenile specimen, NHMW 2006/0203/0001, from the *Micraster* Bed is referred with some doubt to the same species.

Description: The whorl section, somewhat deformed by compaction, appears to have been strongly compressed with flattened inner flanks, convergent outer flanks, a sharp and entire siphonal keel. Both specimens from the Schattaugraben section are flattened and deformed into an ellipse by *post mortem* compaction; both are internal moulds with yellowish shell preserved. The umbilical wall is low and distinctly convex, the umbilical edge narrowly rounded. Coiling is evolute, with a very small overlap over the preceding volution, the umbilicus wide and shallow, the expansion rate low. The phragmocones are badly crushed. The Schattaugraben individuals are of equal size, the best-preserved, SK/SG/1984/3, is 59 mm in diameter, with a whorl height of 11.8 mm and a whorl breadth of Wb 7.2 mm. The flanks are smooth except for an estimated 4–5 slightly flexuous constrictions per whorl, projected strongly forwards on the ventrolateral shoulder. These are only visible on the internal mould. The suture is partially visible in NHMW 1978/1955/0001 (Text-Fig. 5).



Text-Fig. 5.
External suture of *Hauericeras lagarum* (REDTENBACHER, 1873), NHMW 1978/1955/0001 from the late Santonian of the Schattaugraben (Rußbach, Salzburg).

HNS 6391, preserved in hard brownish sandstone, compares well with the Schattau specimens, differing only in its more rapidly increasing whorl height.

Discussion: *Hauericeras (Gardeniceras) lagarum* (REDTENBACHER, 1873) is a close ally of *Hauericeras (Gardeniceras) gardeni* (BAILEY, 1855) differing in the smaller overlap between successive whorls and the slightly sinuous rather than concave constrictions. *Hauericeras (Gardeniceras) welschi* (DE GROSSOUVRE, 1894: 222, Pl. 35, Fig. 9) from the French and Austrian Santonian and its ally *H. angustum* (YABE, 1904: 33, Pl. 5, Figs. 5, 6; see revision in MATSUMOTO & OBATA, 1955 (137, Pl. 24, Fig. 6, Pl. 28, Figs. 1, 2, Pl. 29, Figs. 1–5, Text-Figs. 5, 7; MATSUMOTO et al., 1990: 443, Text-Figs. 2–7) from Japan and South India differ in their greater whorl height and sharp umbilical edge. *Hauericeras schlueteri* (REDTENBACHER, 1873: 114, Pl. 26, Fig. 2) from the middle Coniacian of the Schmolnauer Alpe (Strobl/Weißenbach, Salzburg, Austria) is based on a juvenile with a distinctly narrower umbilicus.

Occurrence: *Hauericeras (Gardeniceras) lagarum* ranges from the middle Coniacian of the Corbières (KENNEDY in KENNEDY et al., 1995) and Schmolnauer Alpe, Salzburg, Austria (the paralectotype) through the late Coniacian (Glanegg, Salzburg, the lectotype) and the late Santonian *Paraplanum* Subzone of the Hochmoos Formation (Schattaugraben section). Its presence is to be expected in the early and middle Santonian, although we have found no specimens to date.

Hauericeras (Gardeniceras) sp. indet.

(Pl. 7, Figs. 4, 5)

Material: NHMW 2013/0015/0003 from the early Santonian of Schwarzenbach near Weißwasser, Unterlaussa (Upper Austria).

Description: NHMW 2013/0015/0003 is a fragment with most of the shell preserved. When complete, it would have been about 35 mm in diameter; the Wh_{max} about 19 mm. Coiling is evolute, serpenticone. The umbilical shoulder is rounded, the flanks converging towards the fastigiate venter, forming a sharp siphonal keel. The surface of the shell is smooth, apart from collar-ribs. The sutures are not exposed.

Discussion: Due to its poor preservation the specimen (NHW 2013/0015/0003) cannot be identified to species level and is left in open nomenclature.

Occurrence: As for material.

Subfamily Desmoceratinae ZITTEL, 1895

Genus *Damesites* MATSUMOTO, 1942

Type species: *Desmoceras damesi* JIMBO, 1894 (172, Pl. 1, Figs. 2, 3); ICZN opinion 555, 1959.

Damesites sugata (FORBES, 1846)

(Pl. 8, Figs. 1, 2, 4, 5, Text-Fig. 6, Tab. 5)

- 1846 *Ammonites Sugata* FORBES: 113, Pl. 10, Figs. 2a–c.
- 1865 *Ammonites Sugata* FORBES; STOLICZKA: 60, Pl. 32, Figs. 4–6, Pl. 33, Figs. 1, 2.
- Non 1890 *Desmoceras sugata* FORBES; YOKOYAMA: 185, Pl. 20, Fig. 11 (= *Damesites damesi intermedius* MATSUMOTO, 1942).
- 1898 *Desmoceras Sugata* FORBES; KOSSMAT: 111 (176), Pl. 18 (24), Fig. 11, Pl. 19 (25), Fig. 1.
- 1921b *Hauericeras?* *sugata* (FORBES sp.); SPATH: 46, Pl. 6, Fig. 3.
- 1921 *Desmoceras compactum* VAN HOEPEN: 21, Pl. 4, Figs. 5–7, Text-Fig. 12.
- 1922 *Hauericeras?* *sugata* (FORBES); SPATH: 131.
- 1925 *Latidorsella Sugata* FORBES; DIENER: 126.
- ?1931 *Desmoceras sugata* FORBES; BASSE: 21, Pl. 2, Figs. 19, 20.
- ?1935 *Pachydiscus obscurus* (SCHLÜTER); BRINKMANN: 2.
- 1942 *Damesites sugata* (FORBES); MATSUMOTO: 27, Text-Fig. 1f.
- 1955 *Damesites sugata* (FORBES); MATSUMOTO & OBARA: 128, Pl. 26, Figs. 4, 5, Pl. 27, Figs. 3, 4, Text-Fig. 3.
- 1965 *Damesites sugatus* FORBES; COLLIGNON: 20, Pl. 421, Fig. 1753.
- ?1980 *Damesites compactus* (VAN HOEPEN); SUMMERSBERGER: 278, Pl. 1, Figs. 3, 4, Text-Fig. 4.
- 1983 *Damesites aff. compactus* (VAN HOEPEN); COLLIGNON: 191, Pl. 2, Fig. 3.
- ?1982 *Damesites* sp.; IMMEL et al.: 15, Pl. 2, Fig. 7.
- ?1982 *Damesites cf. compactus* (VAN HOEPEN 1921); IMMEL et al.: 14, Pl. 2, Fig. 6.
- ?1982 *Damesites obscurus* (SCHLÜTER, 1872); IMMEL et al.: 15.
- 1983 *Damesites sugatus* (FORBES); COLLIGNON: 190, Pl. 2, Fig. 4.
- 1983 *Damesites aff. compactus* (VAN HOEPEN); COLLIGNON: 191, Pl. 2, Fig. 3.
- 1987 *Damesites compactus* (VAN HOEPEN 1921); IMMEL: 90, Pl. 8, Fig. 5.

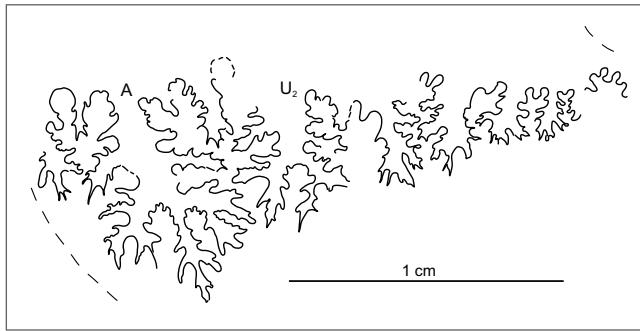
- 1989 *Damesites sugata* (FORBES, 1846); HAGGART: 195, Pl. 8.4, Figs. 14–23 (with additional synonymy).
- ?1991 *Gaudryceras obscurus* (SCHLÜTER, 1872); RIEGRAF & SCHEER: 374 (= SCHLÜTER, 1872: Pl. 22, Figs. 9, 10).
- 1991 *Damesites sugata* (FORBES, 1846); KENNEDY & HENDERSON: 471, Text-Figs. 1, 2.
- 1993 *Damesites sugata* (FORBES, 1846); ALABUSHEV & WIEDMANN: 553, Text-Figs. 1, 2.
- 1995 *Damesites sugata* (FORBES, 1846); KENNEDY in KENNEDY et al.: 398, Pl. 3, Figs. 5, 6, 17, Pl. 4, Fig. 21.
- ?1996 *Damesites damesi* (JIMBO, 1894); COOPER & GREYLING: 19, Figs. 7i–l.
- 1993 *Damesites sugata* (FORBES); ALABUSHEV & WIEDMANN: 22, Pl. 6, Figs. 6, 7, Pl. 11, Fig. 2, Text-Figs. 4a, 7.
- 2000 *Damesites compactus* (VAN HOEPEN, 1921); SUMMERSBERGER in EGGER et al.: 26.
- 2003 *Damesites sugata* (FORBES, 1846); COOPER: 155, Text-Figs. 6e, f, 7d.
- 2013a *Damesites sugata* (FORBES, 1846); KENNEDY & KLINGER: 44, Text-Figs. 7a–j.
- 2017a *Damesites sugata* (FORBES, 1846); SUMMERSBERGER et al.: 177.

Types: The lectotype is BMNH C22647, the original of FORBES (1846: Pl. 10, Figs. 2a–c). It was figured by KENNEDY & HENDERSON (1991: Text-Figs. 1A, B) and KENNEDY & KLINGER (2013a: Text-Figs. 7D, E). There are three paralectotypes, BMNH C22675, of which BMNH C3561a is a further fragment, and BMNH 24196a, b, while BMNH C3561b may be a further paralectotype. The type material is from Vridachellum (Verdachellum), South India.

Material: NHMW 2013/0466/0001 from the top of the middle Santonian of the Neffgraben site (Rußbach, Salzburg); GII P. 8191-2 from the early Santonian of Brandenberg/Mühlbach. SK/1979/7 from the late Santonian Sandkalkbank Member (Hochmoos Formation; Finstergrabenwandl; Gosau, Upper Austria), BSP 1959 VI 39 from Eiberg (Tyrol, Austria); GII P.8192, SK/NE/1991/15 from the middle Santonian Hochmoos Formation of the Neffgraben and SK/SG/1992/15 from the late Santonian Hochmoos Formation of the Schattaugraben (both Rußbach, Salzburg).

Description: NHMW 2013/0466/0001 (Pl. 8, Figs. 1, 2) is an internal mould with partial preservation of the whitish shell. It is slightly deformed into an ellipse. Lateral compaction is negligible. The whorl section is compressed and successive whorls cover the greatest part of the preceding ones. The whorl height increases slowly. The open umbilicus is small. The umbilical wall is convex, the flanks are slightly convex and the umbilical shoulder is narrowly rounded. The flanks are smooth. Delicate growth lines are visible under oblique light only. About six biconvex constrictions per half whorl are distinct on the internal mould and almost invisible on the surface of areas of preserved shell. The entire keel is narrow and sharp. The suture (Text-Fig. 6) is typical for the genus. Crowding of the sutures indicate the adult stage of the specimen.

SK/1979/7, described by SUMMERSBERGER (1980) and SK/NE/1991/15 (Pl. 8, Figs. 4, 5) are internal moulds with ad-



Text-Fig. 6.
External suture of *Damesites sugata* (FORBES, 1846), NHMW 2013/0466/0001.

herent whitish shell fragments. Both specimens are small with almost closed umbilicus and are laterally compressed to a certain degree. SK/NE/1991/15 shows seven slightly falcoid constrictions per whorl, as does BSP 1959 VI 39 from Eiberg, Tyrol (IMMEL, 1987: Pl. 8, Fig. 5), whereas SK/1979/7 has none.

Due to *post mortem* deformation measurements are slightly altered but at least the relations are believed to be meaningful.

Discussion: *Damesites compactus* (VAN HOEPEN, 1921) is a doubtful taxon based upon a very small juvenile. VAN HOEPEN's original (1921: 21, Pl. 4, Figs. 5–7) has a diameter of 18 mm. Comparison with any adult taxon of the genus is problematic and KENNEDY & KLINGER (2013a: 45) regarded it as a synonym of *sugata*. Earlier authors (e.g. COLLIGNON, 1961: 70) noted, that „*plusieurs auteurs (Basse, Matsumoto) ont assimilé [compactus] à Damesites sugatus (sic) Forbes*“. Nevertheless, COLLIGNON (1961: 70–71, Nr. 3335, Pl. 26, Fig. 4, figured apparently erroneously under 2335) maintained *Damesites compactus* as a distinct taxon, whereas KENNEDY in KENNEDY et al., (1995: 398) united all specimens from the Santonian of the Corbières (France) under *Damesites sugata* (FORBES, 1846), due to the lack of correspondence between the Madagascan and the Pondoland representatives of the genus and because of the lack of topotypes from Pondoland.

Ammonites obscurus SCHLÜTER, 1872 was discussed by IMMEL et al. (1982: 15) as a further representative of *Damesites*. KENNEDY & SUMMERSBERGER (1984: 153, Pl. 2, Figs. 10–12) regarded *Ammonites obscurus* SCHLÜTER (1872) as a species of *Tetragonites*, a view which was followed by KENNEDY & KAPLAN (1995: 17), LOMMERZHEIM (1995: 46) and KAPLAN et al. (1996: 26; discussion: 27).

Occurrence: *Damesites sugata* (FORBES, 1846) ranges from the late Coniacian through the Santonian of the Corbières

and in the Circumpacific Realm (KENNEDY in KENNEDY et al., 1995). Furthermore, it occurs in the Coniacian to Santonian of India, Madagascar and South Africa. In Japan and Saghalin it occurs “approximately” (MATSUMOTO & OBATA, 1955: 133, Pl. 26, Figs. 4a, b, 5a, b, Pl. 27, Figs. 3a, b, 4a–d) in the Santonian. NHMW 2013/0466/0001 is from the top of the middle Santonian Hochmoos Formation (Gosau Group) of the Neffgraben site (Rußbach, Salzburg). BSP 1959 VI 39 is possibly from the early Santonian of Eiberg (Tyrol, Austria), GPII P. 8191, 8192 from the early Santonian of Brandenberg/Mühlbach. SK/1979/7 from the late Santonian Sandkalkbank Member (Hochmoos Formation; Finstergrabenwandl; Gosau, Upper Austria); SK/NE/1991/15 from the middle Santonian Hochmoos Formation of the Neffgraben and SK/SG/1992/15 from the late Santonian Hochmoos Formation of the Schattaugraben (both Rußbach, Salzburg).

Damesites sp. indet.

(not figured)

Compare

1982 *Damesites* sp.; IMMEL et al.: 15, Pl. 2, Fig. 7.

Material: Two specimens: GPII P. 8192 from the early Santonian of Brandenberg/Mühlbach and SK/RA/1982/74d from the middle Santonian of Randobach 2 (Rußbach, Salzburg).

Discussion: GPII P. 8192, the specimen figured by IMMEL et al. (1982), is too poorly preserved for specific determination; SK/RA/1982/74 d is a juvenile 9 mm in diameter. It is also specifically indeterminate.

Occurrence: Early Santonian of Brandenberg/Mühlbach (Tyrol, Austria) and middle Santonian of Randobach 2.

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|---------------------|-----------|------------|------------|-----------|----------|
| NHMW 2013/0466/0001 | 63.4 | 32.2 | 19.9 | 8.7 | 13.7 |
| SK/1979/7 | 30 | 14.4 | 10.4 | 2.2 | 7.3 |
| BSP 1959 VI 39 | 34.8 | 22.6 | 10.7 | 1.7 | 4.9 |
| SK/NE/1991/15 | 31 | 19.3 | 10 | 0.9 | 2.9 |

Tab. 5.
Damesites sugata (FORBES, 1846). U % of D.

Family Kossmaticeratidae SPATH, 1922
Subfamily Kossmaticeratiniae SPATH, 1922
Genus and Subgenus *Kossmaticeras*
DE GROSSOUIRE, 1901

Type species: *Ammonites theobaldianus* STOLICZKA, 1865 (161, Pl. 78, Figs. 1–3), by the subsequent designation of DIENER (1925: 96).

Kossmaticeras (Kossmaticeras) cf. sparsicostatum
(KOSSMAT, 1897)
 (not figured)

Compare

- 1865 *Ammonites denisonianus* STOLICZKA: 133, Pl. 66, Figs. 1, 2 only.
- 1897 *Holcodiscus sparsicostatus* KOSSMAT: 38, Pl. 6, Fig. 5.
- 1955 *Kossmaticeras sparsicostatum* KOSSMAT; COLLIGNON: 22, Pl. 3, Fig. 1, Pl. 4, Fig. 1.
- 1982 *Kossmaticeras (Kossmaticeras) cf. sparsicostatum* (KOSSMAT, 1897); IMMEL et al.: 18, Pl. 5, Fig. 5.
- 1985 *Kossmaticeras (Kossmaticeras) sparsicostatum* (KOSSMAT, 1897); KENNEDY & KLINGER: 179, Text-Figs. 7A–E.
- 1987 *Kossmaticeras (Kossmaticeras) cf. sparsicostatum* (KOSSMAT, 1897); IMMEL: 92.

Types: There are two syntypes; the original of *Ammonites denisonianus* STOLICZKA, 1865: 133 (pars), Pl. 66, Fig. 1 only, and the original of KOSSMAT, 1897: Pl. 6 (17), Fig. 5.

Material: A single fragment GPII P.8182, from Brandenberg/Mühlbach (Tyrol).

Description and Discussion: The poor fragment was described and discussed by IMMEL et al. (1982: 18, Pl. 5, Fig. 5).

Occurrence: Early Santonian of Brandenberg/Mühlbach (Tyrol).

Family Pachydiscidae SPATH, 1922
Genus *Nowakites* SPATH, 1922

Type species: *Pachydiscus carezi* DE GROSSOUIRE, 1894 (190, Pl. 25, Fig. 3, Pl. 37, Fig. 5), by the original designation by SPATH (1922: 124).

***Nowakites carezi* (DE GROSSOUIRE, 1894)**

(Pl. 8, Figs. 3, 6, 7, Pl. 9, Figs. 3–5, Tab. 6)

- 1894 *Pachydiscus carezi* DE GROSSOUIRE: 190, Pl. 25, Fig. 3, Pl. 37, Fig. 5.
- 1982 *Eupachydiscus isculensis* (REDTENBACHER, 1873); IMMEL et al.: Pl. 7, Figs. 8, 9 only.
- 1882 *Kitchinites stenomphalus* SUMMESBERGER, 1979; IMMEL et al.: 14, Pl. 2, Fig. 5.
- 1987 *Kitchinites stenomphalus* SUMMESBERGER, 1979; IMMEL: 90.

- 1987 *Eupachydiscus isculensis* (REDTENBACHER, 1873); IMMEL: 94.
- 1995 *Nowakites carezi* (DE GROSSOUIRE, 1894); KENNEDY in KENNEDY et al.: 400, Pl. 6, Figs. 3, 6–8, Pl. 7, Figs. 4, 5, Pl. 8, Figs. 13–15, Pl. 9, Figs. 2–4 (with synonymy).

Type: The holotype, by original designation is the original of DE GROSSOUIRE (1894: Pl. 25, Fig. 3), refigured by KENNEDY in KENNEDY et al. (1995: Pl. 9, Figs. 2–4).

Material: NHMW 1861/0001/0192 and SK/RA/2002/144 from the Randobach and NHMW 2013/0466/0002 from the Neffgraben (Rußbach, Salzburg), both from the middle Santonian, BSP 1974 I. 339 and M 40 and M 47 from the early Santonian of Mühlbach (Brandenberg, Tyrol).

Description: NHMW 1861/0001/0192 (Pl. 8, Figs. 6, 7) is a crushed subadult internal mould with large parts of the aragonitic shell preserved. The specimen is deformed into an ellipse (D_{\max} 41.4 mm). It is moderately involute and shows the change in ornament typical of *carezi*: finely ribbed early whorls (see also Pl. 9, Fig. 5, a juvenile), the ribbing coarsening towards the adult aperture. Narrow ribs arise in groups of two and three from six umbilical bullae. The interspaces are somewhat wider than the ribs, which are generally prorsiradiate, concave or slightly flexuous, sweeping over the venter in a broad convexity. Two indistinct constrictions are visible. In contrast, NHMW 2013/0466/0002 (Pl. 8, Fig. 3), a juvenile, is a smaller internal mould with partially preserved shell. Narrow, slightly flexuous prorsiradiate ribs arise from small bullae, divide into bundles of ribs on the flanks and cross the venter in a distinct convexity. Three narrower constrictions are followed by a much wider one close to the aperture. The body chamber comprises about half a whorl; the last suture is visible through the transparent inner shell layer.

Discussion: NHMW 2013/0466/0002, apparently a juvenile or microconch, is very close to PM G5c5 from the middle Santonian *Gallicus* Subzone of Sougraigne (Corbières) figured by KENNEDY in KENNEDY et al. (1995: Pl. 6, Fig. 3) and also close to the missing paratype (DE GROSSOUIRE, 1894: Pl. 37, Fig. 5; KENNEDY in KENNEDY et al., 1995: 400). NHMW 1861/0001/0192 (Pl. 8, Fig. 6, 7) is interpreted as a subadult individual, the juvenile ornament present on the adapical part of the outer whorl, the change to coarser adult ornament appearing on the adapertural part of the phragmocone. Comparable specimens from the Corbières were figured by KENNEDY in KENNEDY et al. (1995: Pl. 6, Figs. 11, 12, Pl. 7, Figs. 4, 5, Pl. 8, Figs. 13–15, Pl. 9, Fig. 3). We interpret specimens figured by IMMEL et al. (1982: Pl. 2, Fig. 5) as *Kitchinites stenomphalus* SUMMESBERGER, 1979 and as *Eupachydiscus isculensis* (REDTENBACHER, 1873) (IMMEL et al., 1982: Pl. 7, Figs. 8, 9) as juvenile and subadult representatives of *Nowakites carezi*.

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|---------------------|-----------------|---------|------------------|--------|-------|
| NHMW 2013 0466/0002 | D_{\max} 22.1 | 83.2 | Wb_{\max} 61.4 | 4.5 | 20 |

Tab. 6.

Nowakites carezi (DE GROSSOUIRE, 1894), NHMW 2013/0466/0002. \max = maximum. U % of D.

Occurrence: *Nowakites carezi* (DE GROSSOUPRE, 1894) occurs in the lower and middle Santonian *carezi* and *gallicus* sub-zones of the Corbières (KENNEDY in KENNEDY et al., 1995), in the Santonian parts of Gosau Group (this paper) and in the Coniacian of Romania, Bulgaria and Armenia.

Nowakites draschei (REDTENBACHER, 1873)

(Pl. 8, Figs. 8–12, Text-Fig. 7)

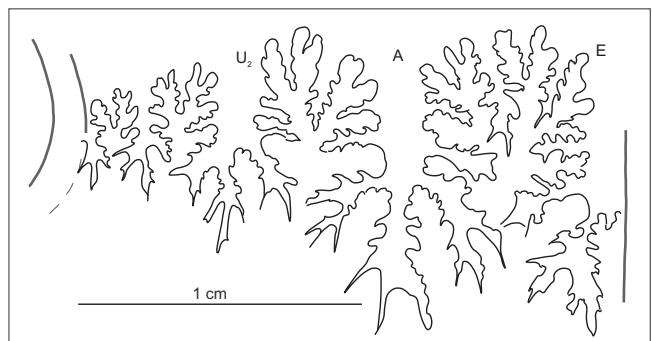
- 1873 *Ammonites Draschei* REDTENBACHER: 123, Pl. 30, Fig. 1.
- 1908 *Puzosia Draschei* REDT.; FELIX: 292.
- 1922 *Nowakites draschei* RDTB. sp.; SPATH: 124.
- 1925 *Nowakites Draschei* REDTENBACHER; DIENER: 113.
- 1935 *Pachydiscus draschei* (REDT.); BRINKMANN: 2, 4.
- 1979 *Eup. draschei* REDT.; WIEDMANN: Fig. 4.
- 1979 *Nowakites draschei* (REDTENBACHER); SUMMESBERGER: 138, Pl. 8, Figs. 33–36, Text-Figs. 23–25 (with synonymy).
- 1982 *Nowakites draschei* (REDTENBACHER); KOLLMANN & SUMMESBERGER: 49.
- 1987 *Nowakites draschei* (REDTENBACHER 1873); IMMEL: 93.
- 2000 *Nowakites draschei* (REDTENBACHER); SUMMESBERGER in EGGER et al.: 26.

Type: The holotype, by monotypy, is the original of *Ammonites Draschei* REDTENBACHER, 1873 (123, Pl. 30, Figs. 1a, b); OÖLM 1938/30, from Neffgraben (Rußbach, Salzburg).

Material: NHMW 2013/0467/0001 (formerly KA/1977/1) and SK/1977/8 from the late Santonian Sandkalkbank Member of the Gosau Basin.

Description: The holotype (Pl. 8, Figs. 10–12) is an imperfectly preserved crushed specimen retaining much of the aragonitic shell. The maximum diameter is 53 mm. Coiling is involute, with a small, deep umbilicus ($U = 23\%$). The umbilical wall is steep and the whorl section was probably depressed, with the greatest breadth at the umbilical bulla, the inner flanks are flattened, with broadly rounded ventrolateral shoulders and venter. There are four strong umbilical bullae on the last half whorl, connected to the umbilical seam by a narrow, rapidly weakening rib. From the bulla a high, narrow, strong rib passes forward across the inner flank, flexing forward to become concave on the outer flank and cross the venter in a broad, shallow convex curve. Between these major ribs are up to seven non-bullate, somewhat weaker ribs of variable length, some extending to the umbilical shoulder, others arising low on the flank. Marked constrictions are present, generally parallel to the major bullate ribs. The incompletely visible suture of NHMW 2013/0467/0001 (Pl. 8, Figs. 8, 9) which is the closest specimen to the holotype is shown in Text-Figure 7. It includes deeply incised lobes and saddles of pachydiscid pattern.

Discussion: Six species of *Nowakites* were described by KENNEDY in KENNEDY et al. (1995: 400–403) from the Corbières. The closest relative of *Nowakites draschei* appears to be *Nowakites carezi*, described above. It is most readily distinguished by the finely ribbed early whorls with distinct constrictions, the ornament coarsening markedly on the adapical part of the phagmocone and the body chamber.



Text-Fig. 7.
External suture of *Nowakites draschei* (REDTENBACHER, 1873), NHMW 2013/0467/0001.

Occurrence: The holotype, OÖLM 1938/30, is from the middle Santonian of the Neffgraben (Rußbach, Salzburg) where it occurs well below the Sandkalkbank Member of the Hochmoos Formation. NHMW 2013/0467/0001 and SK/1977/8 are from the late Santonian Sandkalkbank Member of the Gosau Basin. The stratigraphic position of two specimens of *Pachydiscus draschei* (REDTENBACHER, 1873) from Eiberg (Tyrol) mentioned by BRINKMANN (1935: 2) is uncertain.

Nowakites savini (DE GROSSOUPRE, 1894)

(Pl. 9, Figs. 1, 2, Pl. 10, Fig. 1, Tab. 7)

- 1894 *Sonneratia savini* DE GROSSOUPRE: 152 (pars), Pl. 25, Fig. 4, non Pl. 27, Fig. 4 (= microconch of *Nowakites tallavignesi* (D'ORBIGNY, 1850)).
- 1922 *Nowakites savini* DE GROSSOUPRE; SPATH: 124.
- 1925 *Nowakites savini* DE GROSSOUPRE; DIENER: 113.
- 1939 *Nowakites savini* DE GROSS.; BASSE: 47.
- 1952 *Nowakites savini* DE GROSSOUPRE; COLLIGNON: 29, 85.
- 1955 *Nowakites savini* DE GROSSOUPRE; COLLIGNON: 30, 78.
- 1982 *Nowakites savini* (DE GROSSOUPRE, 1894); TZANKOV: 35, Pl. 27, Fig. 2.
- 1983 *Nowakites savini* (DE GROSSOUPRE); COLLIGNON: 192, Pl. 2, Fig. 6.
- 1983 *Nowakites tallavignesi* (D'ORBIGNY); COLLIGNON: 192 (pars), Pl. 2, Fig. 8.
- 1983 *Nowakites lemarchandi* (DE GROSSOUPRE); COLLIGNON: 193 (pars), Pl. 2, Fig. 9.
- ? 1988 *Nowakites savini thomeli* (COLLIGNON, 1981); THOMEL: 34, Pl. 3, Figs. 1–3, Pl. 4, Fig. 3, Pl. 22, Fig. 1.
- 1995 *Nowakites savini* DE GROSSOUPRE, 1894; KENNEDY et al.: 402, Pl. 8, Figs. 16–23, Pl. 9, Figs. 1, 6, 7, Pl. 19, Fig. 7, Pl. 22, Figs. 1, 2, 4, Text-Fig. 20C.
- 2010 *Nowakites savini*; LUKENEDER et al.: 109, Fig. 1c.
- 2010 *Nowakites savini*; REMIN: 174, Figs. 13A–G.
- 2017a *Nowakites savini* (DE GROSSOUPRE, 1894); SUMMESBERGER et al.: 179, Pl. 8, Fig. 9.

Type: The holotype by original designation is the original of DE GROSSOUPRE (1894: Pl. 25, Fig. 4). It has not been traced (KENNEDY in KENNEDY et al., 1995: 402) and is presumed lost.

| Inventory No. | D _{max} (mm) | Wh _{intercost} (mm) | Wb (mm) | U (mm) | U (%) |
|---------------------|--------------------------|---------------------------------|------------|-----------|----------|
| NHMW 2010/0082/0001 | 105.8 | 51.0 | 31.8 | 24.8 | 23.4 |

Tab. 7.
Nowakites savini (DE GROSSOURE, 1894); NHMW 2010/0082/0001. D_{max} = max. diameter, Wh_{intercost} = intercostal measurement, U % of D.

Material: MA/1982/19 from the Bad Ischl road tunnel section, Upper Austria, middle Coniacian; NHMW 2010/0082/0001 from the early Santonian of the Edlbachgraben and SK/RA/2014/164 from Randobach 3 (Gosau, Upper Austria); NHMW 2010/0081/0001 from the late Santonian *Micraster* Bed of the Schattaugraben.

Description: NHMW 2010/0082/0001 (Pl. 9, Figs. 1, 2, Tab. 7) is an internal mould of a phragmocone with partially preserved body chamber. Whitish shell material is present throughout, the inner layer transparent, rendering the sutures visible, the outer layer brittle and fragmentary. The greater part of the body chamber is broken away. The specimen is distorted into an ellipse as a result of *post mortem* crushing. In spite of this, it is one of the best preserved known individuals of the species.

Coiling is relatively involute, with more than two thirds of the previous whorl covered. The umbilical wall is steep and slightly convex. The umbilical shoulder is narrowly rounded, the flanks are feebly convex, the ventrolateral shoulder broadly rounded, the venter convex. Ornament consists of 11 strong bullae that give rise to very strong, narrow and sharp ribs, either singly or in pairs. Intercalated ribs are somewhat weaker and arise on the inner third of the flanks. Ribbing is more or less regular on the phragmocone, but strengthens on the surviving fragment of the body chamber, the interspaces deepening markedly. There are an estimated 40 ribs on the outer whorl. They are prosiradiate and feebly concave, projecting forwards over the ventrolateral shoulder and crossing the venter in a marked convexity. Occasional interspaces are strengthened into poorly defined constrictions. MA 1982/19 is a very similar but smaller individual with less regular ribbing.

Discussion: *Nowakites carezi* (DE GROSSOURE, 1894), described above, differs in the distinct change in ornament from the finely ribbed inner whorls with occasional constrictions to the coarsely ribbed outer whorls. *Nowakites draschei* (REDTENBACHER, 1873), also described above, is more involute and has less regular ribbing. *Nowakites talavignesii* (D'ORBIGNY, 1850: 212; see revision by KENNEDY in KENNEDY et al. (1995: 401; Pl. 6, Figs. 15–19, Pl. 8, Figs. 1–5, 8–12, Pl. 10, Fig. 16)) is a small, relatively evolute, relatively sparsely ribbed species with fewer umbilical bullae. *Nowakites pailletteanus* (D'ORBIGNY, 1841: 339, Pl. 102, Figs. 3, 4; KENNEDY in KENNEDY et al., 1995: 401, Pl. 6, Figs. 20, 21, 24, Pl. 7, Figs. 1–3, 6–12, Pl. 9, Fig. 8, Pl. 10, Fig. 16) and its synonym *Nowakites lemarchandi* (DE GROSSOURE, 1894: 173, Pl. 22, Fig. 5), a Coniacian species, is a larger, less evolute species with less pronounced even ornament.

Occurrence: NHMW 2010/0082/0001 is from the basal Santonian of the Edlbachgraben (Gosau, Upper Austria) and SK/RA/2014/164 is from Randobach, where they co-occur with *Cladoceramus undulatoplicatus* and *Eulophoceras na-*

talense. MA 1982/19 is from the middle Coniacian of the road tunnel section north of Bad Ischl, where it co-occurs with *Peroniceras tridorsatum* (SCHLÜTER, 1867) and *Forresteria (F.) alluaudi* (BOULE et al., 1907). It also occurs in the lower and middle Santonian *carezi* and *gallicus* Zones in the Corbières, southern France.

Genus *Patagiosites* SPATH, 1953

Type species: *Ammonites patagiosus* SCHLÜTER, 1867 (22, Pl. 4, Figs. 4, 5) by the original designation of SPATH (1953: 38) = *Ammonites stobaei* NILSSON (1827: 5, Pl. 1, Figs. 1, 2 (see KENNEDY & CHRISTENSEN, 1997: 95)).

Patagiosites? sp.

(not figured)

- 1867 *Ammonites patagiosus* SCHLÜTER: 22, Pl. 4, Figs. 4–5.
- 1872 *Ammonites patagiosus* SCHLÜTER: 66, Pl. 20, Figs. 7–8.
- 1982 *Patagiosites patagiosus* (SCHLÜTER, 1867); IMMEL et al.: 18, Pl. 5, Fig. 6.
- 1982 *Menuites sturi* (REDTENBACHER, 1873); IMMEL et al.: 21, Pl. 7, Figs. 6, 7.

Material: M 25, the original of *Patagiosites patagiosus* (SCHLÜTER) of IMMEL et al. (1982: Pl. 5, Fig. 6) and two doubtful specimens, M 23 and M 55, the originals of *Menuites sturi* (REDTENBACHER 1873) of IMMEL et al. (1982: Pl. 7, Figs. 6, 7) from the early Santonian of Brandenberg, Tyrol.

Description: M 25 is a crushed internal mould 20 mm in diameter, described and figured by IMMEL et al. (1982: 18, Pl. 5, Fig. 6) as *Patagiosites patagiosus* (SCHLÜTER, 1867). It is characterised by involute coiling and a narrow umbilicus. Five deep constrictions are flanked by weak collar-ribs. Two further crushed specimens (M 23 and M 55) described and figured as *Menuites sturi* (REDTENBACHER, 1873) by IMMEL et al. (1982: 21, Pl. 7, Figs. 6, 7) are also characterised by involute coiling, five constrictions per whorl on the internal mould, flanked by collar ribs. There are occasional ribs between the successive groups of constrictions plus collar ribs. One such rib in M 55 (IMMEL et al., 1982: Pl. 7, Fig. 6) is strengthened markedly on the ventrolateral shoulder.

Discussion: The specimens referred by IMMEL et al. (1982: 18, Pl. 5, Fig. 6; 21, Pl. 7, Figs. 6, 7) to the Campanian *Patagiosites patagiosus* (SCHLÜTER, 1867) (a synonym of *Ammonites stobaei* (NILSSON, 1827); see KENNEDY & CHRISTENSEN, 1997: 95, Text-Figs. 13–17) and the Maastrichtian *Menuites sturi* (REDTENBACHER, 1873) are, in our view, conspecific. The former appear to be microconchs; the latter (M 25) appears to be a juvenile of a presumed macroconch. The age difference between the Austrian early Santonian specimens and the type material of the species they were referred to by IMMEL et al. (1982) is such that we doubt their assignations. The material appears to be a species of the early Santonian to Maastrichtian *Patagiosites*.

Occurrence: As for material.

Genus *Eupachydiscus* SPATH, 1922

Type species: *Ammonites isculensis* REDTENBACHER, 1873 (122, Pl. 29, Fig. 1) by the original designation of SPATH (1922: 124).

Eupachydiscus isculensis (REDTENBACHER, 1873)

(Pl. 9, Figs. 6–8, Pl. 10, Fig. 3)

- 1873 *Ammonites isculensis* REDTENBACHER: 122, Pl. 29, Fig. 1.
- 1894 *Pachydiscus isculensis* (REDTENBACHER, sp.); DE GROSSOUVRE: 185, Pl. 22, Fig. 2, Pl. 37, Fig. 1, Text-Fig. 66.
- 1922 *Eupachydiscus isculensis* (REDTENBACHER); SPATH: 124.
- 1925 *Eupachydiscus isculensis* (REDTENBACHER); DIEDERER: 110.
- 1935 ? *Scaphites* sp.; KATSCHTHALER: 178.
- 1935 *Pachydiscus isculensis* (REDT.); BRINKMANN: 4.
- 1957 *Eupachydiscus isculensis* (REDTENBACHER, 1873); WRIGHT: 380, Fig. 295,2.
- 1961 *Eupachydiscus isculensis* (REDTB.); GERTH: 124, Pl. 24, Fig. 7.
- 1964 *Scaphites* sp.; FISCHER: 131.
- 1966 *Eupachydiscus isculensis* REDT.; COLLIGNON: 90, Pl. 492, Fig. 1977.
- 1979 *Eupachydiscus isculensis* (REDTENBACHER); WIEDMANN in HERM et al.: 49, Pl. 8A.
- 1979 *Eupachydiscus isculensis* (REDTENBACHER); SUMMESBERGER: 136, Pl. 7, Figs. 30, 31, Pl. 8, Fig. 32, Text-Figs. 20–22.
- 1982 *Eupachydiscus isculensis* (REDTENBACHER); MARTINEZ: 64, Pl. 7, Fig. 3.
- 1982 *Eupachydiscus isculensis* (REDTENBACHER); KOLLMANN & SUMMESBERGER: 49.
- 1982 *Eupachydiscus isculensis* (REDTENBACHER); IMMEL, KLINGER & WIEDMANN: 22, Pl. 7, Figs. 8–11, non Figs. 8, 9 (= *N. carezi* GROSS., see above).
- 1982 *Pseudomenites katschthaleri* IMMEL et al.: 20, Pl. 7, Figs. 2–5.
- 1986 *Eupachydiscus isculensis* (REDTENBACHER, 1873); KENNEDY: 52, Text-Fig. 19 (with synonymy).
- 1987 *Pseudomenites katschthaleri* IMMEL et al.: IMMEL: 96.
- 1987 *Eupachydiscus isculensis* (REDTENBACHER, 1873); IMMEL: 94.
- ? 1995 *Nowakites* ? aff. *katschthaleri* (IMMEL, KLINGER & WIEDMANN, 1982); KENNEDY in KENNEDY et al.: 403, Pl. 6, Figs. 4, 5.
- 1995 *Eupachydiscus isculensis* (REDTENBACHER, 1873); KENNEDY in KENNEDY et al.: 404, Text-Fig. 18 (with full synonymy).
- ? 1998 *Eupachydiscus isculensis* (REDTENBACHER); KÜCHLER: Pl. 13, Figs. 7, 8.
- 2000 *Eupachydiscus isculensis* (REDTENBACHER); SUMMESBERGER in EGGER et al.: 26.
- ? 2000 *Pseudomenites katschthaleri* IMMEL et al.; KENNEDY & KAPLAN: 60.

- 2000 *Eupachydiscus isculensis* (REDTENBACHER, 1873); KENNEDY & KAPLAN: 60, Pls. 5–7.
- 2006 *Eupachydiscus isculensis* (REDTENBACHER, 1873); KENNEDY & KLINGER: 34, Figs. 15, 16 (with additional synonymy).
- 2010 *Eupachydiscus isculensis* (REDTENBACHER, 1873); REMIN: 175, Figs. 14 F, 17 I.
- 2017a *Eupachydiscus isculensis* (REDTENBACHER, 1873); SUMMESBERGER et al.: 179, Pl. 8, Fig. 7

Type: The holotype, by monotypy, is the original of REDTENBACHER (1873: Pl. 29, Fig. 1) from the Santonian Gosau Group of Kohlbüchl, ENE of Bad Ischl, Upper Austria, preserved in the ÖÖLM collections. It was refigured by WRIGHT (1957: Fig. 495, 2a), KENNEDY (1986: Text-Fig. 19), KENNEDY in KENNEDY et al. (1995: Text-Fig. 18), WRIGHT et al. (1996: Fig. 77/3) and KENNEDY & KAPLAN (2000: Pls. 6, 7).

Material: About 24 individuals from the early Santonian of Mühlbach (Brandenberg, Tyrol); four specimens listed by SUMMESBERGER (1979: 136) are from the late Santonian of Finstergrabenwandl (Gosau, Upper Austria). The holotype (ÖÖLM 1938/30) is from a stratigraphically uncertain horizon. SK/SB/1989/6 is from the middle Santonian of Schneiderwirtsbrücke (bridge over the Ischl river). Additional unregistered specimens, including those in private collections, make *Eupachydiscus isculensis* one of the most common ammonites in the Santonian part of the Gosau Group.

Description and Discussion: The much-figured and described holotype of the type species is a macroconch. A further macroconch is SK/RA/1983/84 from the middle Santonian of Randobach 2. A macroconch and a microconch were described from the Santonian part of the Mzamba Formation of South Africa (KENNEDY & KLINGER, 2006: 34, Figs. 15, 16). The earliest interpretation of *Pseudomenites katschthaleri* IMMEL et al. (1982) from the early Santonian of Brandenberg (Tyrol) as the microconch of *Eupachydiscus isculensis* (REDTENBACHER, 1873) was given by KENNEDY (1986: 52–54) and repeated by KENNEDY & KLINGER (2006: 34–36). An additional individual (SK/SB/1989/6) also interpreted as a microconch, from the middle Santonian of Schneiderwirtsbrücke (Pl. 10, Fig. 3) supports this interpretation.

Occurrence: *Eupachydiscus isculensis* co-occurs with *Texanites quinqueradosus* and *Cladoceramus undulatoplicatus* in the early Santonian part of the Austrian Gosau Group. It is also present in the late Santonian Gosau Group of the Finstergrabenwandl locality (Gosau, Upper Austria; SUMMESBERGER, 1979) together with *Placenticeras paraplanum* and *Boehmoceras*. South African representatives are also of Santonian date. Elsewhere, there are records from the Santonian of Germany, France, Spain, Romania and from the Santonian and Campanian of Madagascar.

Family Muniericeratidae WRIGHT, 1952

Genus *Tragodesmoceras* SPATH, 1922

Type species: *Desmoceras clypealoides* LEONHARD, 1897 (57, Pl. 6, Fig. 2) by original designation by SPATH (1922: 127).

Tragodesmoceras aff. *clypeale* (SCHLÜTER, 1872)

(Pl. 10, Figs. 2, 5, Text-Fig. 8, Tab. 8)

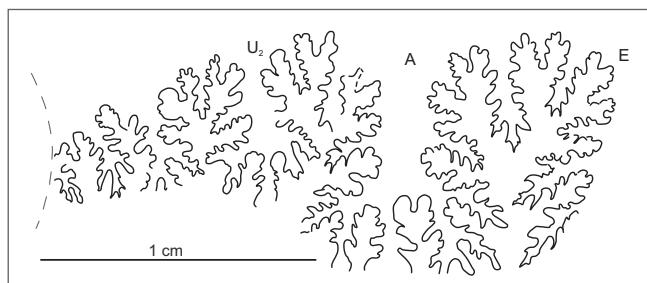
Compare

- 1872 *Ammonites clypealis* SCHLÜTER: 51, Pl. 15, Figs. 9–14.
- 1931 *Hauericeras clypeale* SCHLÜTER; RIEDEL: 693, Pl. 79, Fig. 1.
- ? 1995 *Tragodesmoceras clypeale* (SCHLÜTER, 1872); LOMMERZHEIM: Pl. 4, Figs. 2, 3. non 1995 *Tragodesmoceras clypeale* (SCHLÜTER, 1872); LOMMERZHEIM: Pl. 3, Fig. 8.
- 2000 *Tragodesmoceras* aff. *clypeale* (SCHLÜTER, 1872); KENNEDY & KAPLAN: 68, Pl. 12, Fig. 2, Pl. 13, Figs. 1, 2 (with synonymy).
- 2003 *Tragodesmoceras* aff. *clypeale* (SCHLÜTER, 1872); KENNEDY & KAPLAN: 312, Fig. 5 (with synonymy).

Types: Schlueter mentioned five specimens in the Ewald Collection in Berlin and two in the Witte Collection in Hanover that are the syntypes of *clypeale*. KENNEDY & KAPLAN (2003: 312) designated specimen C. 609.2 in the Collections of the Museum für Naturkunde, Berlin, lectotype. They state, in error, that this is the original of SCHLÜTER (1872: Pl. 15, Figs. 9, 10); it is in fact the original of SCHLÜTER (1872: Pl. 15, Figs. 11, 12). They figure C. 609.2 and refer to it as lectotype in the explanation of their Text-Figures 2a, b. They also describe the surviving paralectotypes.

Material: Two specimens of the Skoumal collection, SK/RA/1999/140 from the middle Santonian of the Randobach (Rußbach, Salzburg), SK/SB/1989/4 (Pl. 10, Figs. 2, 5) from the middle Santonian of Schneiderwirtsbrücke (Bad Ischl, Upper Austria).

Description: Both specimens are crushed internal moulds with extensive areas of shell preserved, nacreous aragonite in the case of SK/SB/1989/4. Both are flattened as a result of *post mortem* crushing. The original whorl section was high oval, the whorl height increasing rapidly, the coiling involute, with an estimate 80 % of the preceding whorl being covered. The umbilicus comprises 27 % of the diameter and is shallow, partially the result of crushing. The umbilical wall is low, subvertical with a narrowly rounded umbilical shoulder. The flanks are slightly convex, the ventrolateral shoulder gently rounded, the venter, where preserved, is narrowly rounded. Ornament consists of low ribs



Text-Fig. 8.

External suture of *Tragodesmoceras* aff. *clypeale* (SCHLÜTER, 1872); SK/RA/1999/140.

and constrictions. Single ribs arise close to the umbilicus, some of them bifurcate on the inner third of the flanks; short intercalated ribs arise on the outer third. The primary ribs are concave at mid-flank and project strongly forward on the outer flank. There are a total of 50 ribs at the ventrolateral shoulder of the outer whorl. Eight deep constrictions per whorl are succeeded by strong collar ribs that strengthen markedly over the venter. The suture line of SK/RA/1999/140 (Text-Fig. 8) is deeply incised with a large trifid A. The dimensions, given in Table 8 have been modified by *post mortem* distortion.

Discussion: *Hauericeras clypeale* SCHLÜTER of RIEDEL (1931: Pl. 79, Fig. 1) has about 32 narrow concave ribs on the outermost flank, ventrolateral shoulders and venter, and very feeble constrictions. The umbilicus comprises 20 % approximately of the diameter and differs from that of the present one in the shape of the umbilical shoulder recalling *Hauericeras*. *Tragodesmoceras clypealoides* (LEONHARD, 1897: 57, Pl. 6, Fig. 2) differs in its crowded sinuous ribbing without the marked projection on the outermost flank shown by the present material. The Gosau specimens match well with specimens referred to as *T. aff. clypeale* by KENNEDY & KAPLAN (2000: Pl. 12, Fig. 2, Pl. 13, Fig. 1; 2003: Fig. 5), although these have a wider umbilicus. *Tragodesmoceras* (?) *mengedene* (SCHLÜTER, 1876: 154, Pl. 40, Fig. 9) from the Coniacian to Santonian of Westphalia (Germany) is a close ally. Its ribbing (KAPLAN & KENNEDY, 1994: 40, Pl. 6, Figs. 1–3, 7) is weaker and more flexuous. Differences in shape and ornamentation between the type material of *clypeale* and material from the middle Santonian of the Münster Basin led KENNEDY & KAPLAN (2000: 68, Pl. 12, Fig. 2, Pl. 13, Figs. 1, 2; 2003: 316, Fig. 5) to refer to their material as *Tragodesmoceras* aff. *clypeale*; the present material is clearly conspecific and their terminology is used here.

Occurrence: In Westphalia (Germany), *Tragodesmoceras* aff. *clypeale* (SCHLÜTER, 1876) occurs in the middle Santonian. This dating agrees well with that of the specimens from the Gosau Group of the Randobach 2 site where it is found with the mass occurrence of *Muniericeras gosauicum*, with which it also co-occurs at the Schneiderwirtsbrücke locality in the Bad Ischl area.

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|----------------|--------|---------|---------|--------|-------|
| SK/RA/1999/140 | 93.8 | 36.6 | ---- | 25.4 | 27 |
| SK/SB/1989/4 | 98.1 | 37 | ---- | 26.4 | 26.9 |

Tab. 8.
Tragodesmoceras aff. *clypeale* (SCHLÜTER, 1872). U % of D.

Genus *Muniericeras* DE GROSSOUIRE, 1894

Type species: *Muniericeras lapparenti* DE GROSSOUIRE, 1894 (158, Pl. 29, Figs. 1, 5, Pl. 35, Fig. 3) by the original designation of DE GROSSOUIRE (1894: 185).

Muniericeras gosauicum (HAUER, 1858)

- (Pl. 11, Figs. 1–13, Pl. 12, Figs. 1–11, Pl. 13, Figs. 1–8, Pl. 14, Figs. 1–3, Pl. 15, Figs. 1–8, Pl. 16, Figs. 1–7, Pl. 17, Figs. 1, 3–9, Text-Figs. 9–11, Tab. 9, 10)
- 1858 *Ammonites Gosauicus* HAUER: 13, Pl. 2, Figs. 7–9.
 1873 *Ammonites Gosauicus* HAUER; REDTENBACHER: 124.
 1894 *Am. gosavicus*; DE GROSSOUIRE: 156.
 1894 *Ammonites gosaviclus* HAUER; DE GROSSOUIRE: 158, Text-Fig. 66.
 1894 *M. gosaviculum* HAUER; DE GROSSOUIRE: 159.
 1925 *M. gosaviculum* v. HAUER; DIENER: 154.
 1935 *Muniericeras gosauicum* (HAUER); BRINKMANN: 4.
 non 1935 *Muniericeras gosauicum* v. HAUER; BRINKMANN: 5, 7 (= *Barroisiceras minimus* (HAYASAKA & FUKADA 1951); fide SUMMESBERGER & KENNEDY, 1996).
 1961 *Muniericeras cf. gosauicum* (HAUER); GERTH: 127, Pl. 24, Fig. 3.
 1961 *Barroisiceras cf. haberfellneri* (HAUER); GERTH: 130, Pl. 24, Fig. 5.
 ? 1963 *Muniericeras aff. gosauicum* (HAUER); FABRE-TAXY: 8, Pl. 1, Fig. 2.
 non 1982 *Muniericeras gosauicum* (HAUER); KOLLMANN & SUMMESBERGER: 31 (= *Barroisiceras minimus* (HAYASAKA & FUKADA 1951), fide SUMMESBERGER & KENNEDY, 1996).
 non 1987 *Muniericeras gosauicum* (v. HAUER 1858); IMMEL: 96, Pl. 9, Fig. 5 (= *Barroisiceras minimus* (HAYASAKA & FUKADA, 1951), fide SUMMESBERGER & KENNEDY, 1996).
 1994 *Muniericeras gosauicum* (HAUER); TRÖGER & SUMMESBERGER: 185.
 1995 *Muniericeras gosauicum* (HAUER, 1858); KENNEDY in KENNEDY et al.: 408.
 2000 *Muniericeras gosauicum* (HAUER); SUMMESBERGER in EGGER et al.: 23, Fig. 13/2.
 2012 *Muniericeras gosauicum* (HAUER 1858); SUMMESBERGER & ZORN: 102, Pl. 2, Fig. 1.

Type: HAUER's original specimen (1858: Pl. 2, Figs. 7–9 from Gosau is lost (SUMMESBERGER & ZORN, 2012: 102). We designate as neotype NHMW 2013/0581/0001 (Pl. 11, Figs. 1–3; formerly SK/RA/1997/133). It is from the Santonian Grabenbach Formation of Randobach 2 (Rußbach, Salzburg) which is believed to be the source of Hauer's specimen.

Material: 109 specimens, mostly in the Skoumal Collection, all from the middle Santonian of the Grabenbach and Hochmoos Formations of the Gosau Group. All are from five localities in the Gosau type region (Randobach 1, 2), Grabenbach, Neffgraben and Schneiderwirtsbrücke (Bad Ischl).

Skoumal Collection

- Randobach 1, 2* (SK/RA):
 SK/RA/1981/4–6, 10–14, 20 (2), 21–27, 34, 35, 40–42
 SK/RA/1982/46–51, 53, 56, 57, 77, 79, 80
 SK/RA/1983/81, 83, 85, 94a, 97(2); SK/RA/1984/101, 102, 104, 106, 107, 109, 110
 SK/RA/1986/111; SK/RA/1988/115, 116; SK/RA/1989/120;
 SK/RA/1990/121–123; SK/RA/1995/126, 127; SK/RA/1996/128, 129;
 SK/RA/1997/131, 132; SK/RA/1998/138; SK/RA/1999/139, 141, 142;
 SK/RA/2003/147–149; SK/RA/2004/151, 152

Neffgraben (SK/NE); SK/NE/1989/1, 3, 5, 6 (2 specimens), 7, 8, 9; SK/NE/1990/13, SK/NE/2001/16;
Grabenbach (SK/GR): SK/GR/1981/1, 15, 16, 19, 21, 25; SK/GR/1983/26; SK/GR/1993/43, 44; SK/GR/2002/47 (Pl. 15, Fig. 7);
Schneiderwirtsbrücke (Ischl river; SK/SB), SK/SB/1989/1–3;
NHMW Collection (16 specimens): NHMW 1982/0028, NHMW 1982/0029; NHMW 2012/0186/0004–0009, 00013, NHMW 2013/0472/0001–2 (Neffgraben), NHMW 2013/0473/0001–2; NHMW 2013/0581/0001 (neotype ex coll. Skoumal);
Maherndl Collection: MA 1977/10 (Randobach, 70 m “after the first bridge” = Randobach 2 of this paper);
GIUW Collection: Gosau, Stöckl (2 specimens), unregistered;
PIUW Collection: Gosau, OÖ (1 specimen), unregistered;
OÖLM Collection: OÖLM 36/1938, 1 specimen, probably Randobach, erroneously labelled: St. Wolfgang;
GBA Collection: The holotype, by monotypy, of *Ammonites gosauicus* HAUER, 1858 apparently lost (SUMMESBERGER & ZORN, 2012).

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|--------------------------------|--------------------|---------|---------|--------|-------|
| NHMW 2013/0581/0001 | 45.6 | 20.5 | 11.5 | 9.5 | 20.8 |
| NHMW 2013/0472/0001 | 27 | 13.2 | 11.9 | 7.1 | 26.3 |
| NHMW 2013/0472/0002 | 61.5 | 27.8 | 11.6 | 13.5 | 21.9 |
| NHMW 2012/0186/0004 | 24.9 | 13.6 | 8.6 | 4.9 | 19.6 |
| NHMW 2013/0473/0001 | 65.5 | 27.3 | 12.1 | 13.6 | 20.7 |
| NHMW 2013/0473/0002 | 59.8 | 22 | 7.2 | 12 | 20 |
| GBA (lost holotype) | 25.4 | 12.2 | 7.6 | 5.6 | 22 |
| GIUW _{not reg.} | 52.2 | 22.8 | 15 | 10.8 | 20.7 |
| PIUW/ _{not reg.} | 26.6 | 12.6 | 6.1 | 6 | 22.5 |
| MA 1977/10 | 49.9 | 23.8 | 15 | 11.9 | 23.8 |
| MA 1977/10 _{max} | 61.5 | 26.2 | 12.9 | 16 | 26.1 |
| SK/GR/1981/1 | 38.7 | 18.2 | 5.5 | 8.4 | 21.7 |
| SK/GR/1981/16 | 51.3 | -- | -- | 11 | 21.5 |
| SK/GR/1981/16 _{max} | 83 | 34.8 | 10.6 | 20.3 | 24.51 |
| SK/GR/1981/21 | 43.2 | 26.3 | 7.8 | 10.2 | 23.6 |
| SK/RA/1981/4 | 18.8 | 10.5 | 10.9 | 3.4 | 18.1 |
| SK/RA/1981/5 | 32.6 | 15.9 | 16.4 | 5.2 | 15.9 |
| SK/RA/1981/10 | 100 _{est} | 39.6 | 15.7 | 18.3 | 18.3 |
| SK/RA/1981/13 | 52.3 | 28.1 | 12.9 | 8.14 | 15.6 |
| SK/RA/1981/13 _{max} | 60.4 | 30.7 | 11.9 | 12.9 | 21.3 |
| SK/RA/1981/14 | 49.9 | 23.6 | 12.3 | 12 | 24 |
| SK/RA/1981/14 _{max} | 78.4 | 26.4 | 12.4 | 16.4 | 20.9 |
| SK/RA/1981/20/a _{est} | 22 | 11 | 7 | 5 | 22.7 |
| SK/RA/1981/22 _{max} | 36.4 | 14.2 | 5.8 | 8.3 | 22.8 |
| SK/RA/1981/22 | 25.6 | 11.8 | 4.6 | 5.1 | 20 |
| SK/RA/1982/48 | 57 | 25.8 | 15.1 | 14.1 | 24.7 |
| SK/RA/1982/57 | 25.3 | 8.8 | 6.2 | 4.8 | 18.3 |
| SK/RA/1982/79 | 45.8 | 19.3 | 16.8 | 10.3 | 22.4 |
| SK/RA/1983/94a | 23 | 12.6 | 6.5 | 4.5 | 19.5 |
| SK/RA/1990/121 | 72.9 | 37.7 | 12.2 | 15.3 | 20.9 |
| SK/RA/1996/128 | 62 | 31.5 | -- | 12 | 19.3 |
| SK/RA/1997/132 | 76.3 | 31.5 | 12.5 | 14.8 | 19.4 |
| SK/RA/1998/138 _{max} | 63.7 | 37.3 | 17.4 | 18.3 | 28.7 |
| SK/RA/1998/138 | 47.8 | 23.6 | -- | 11.6 | 24.3 |
| SK/RA/1999/142 | 90.5 | 41.8 | 19.2 | 28.7 | 31.7 |
| SK/RA/2003/147 | 55.5 | 25.4 | -- | 13.5 | 24.3 |
| SK/RA/2003/148 _{max} | 65.8 | 33.1 | 17.9 | 12.9 | 19.6 |
| SK/RA/2003/148 | 39.5 | 20.8 | 15.3 | 9.2 | 23.3 |

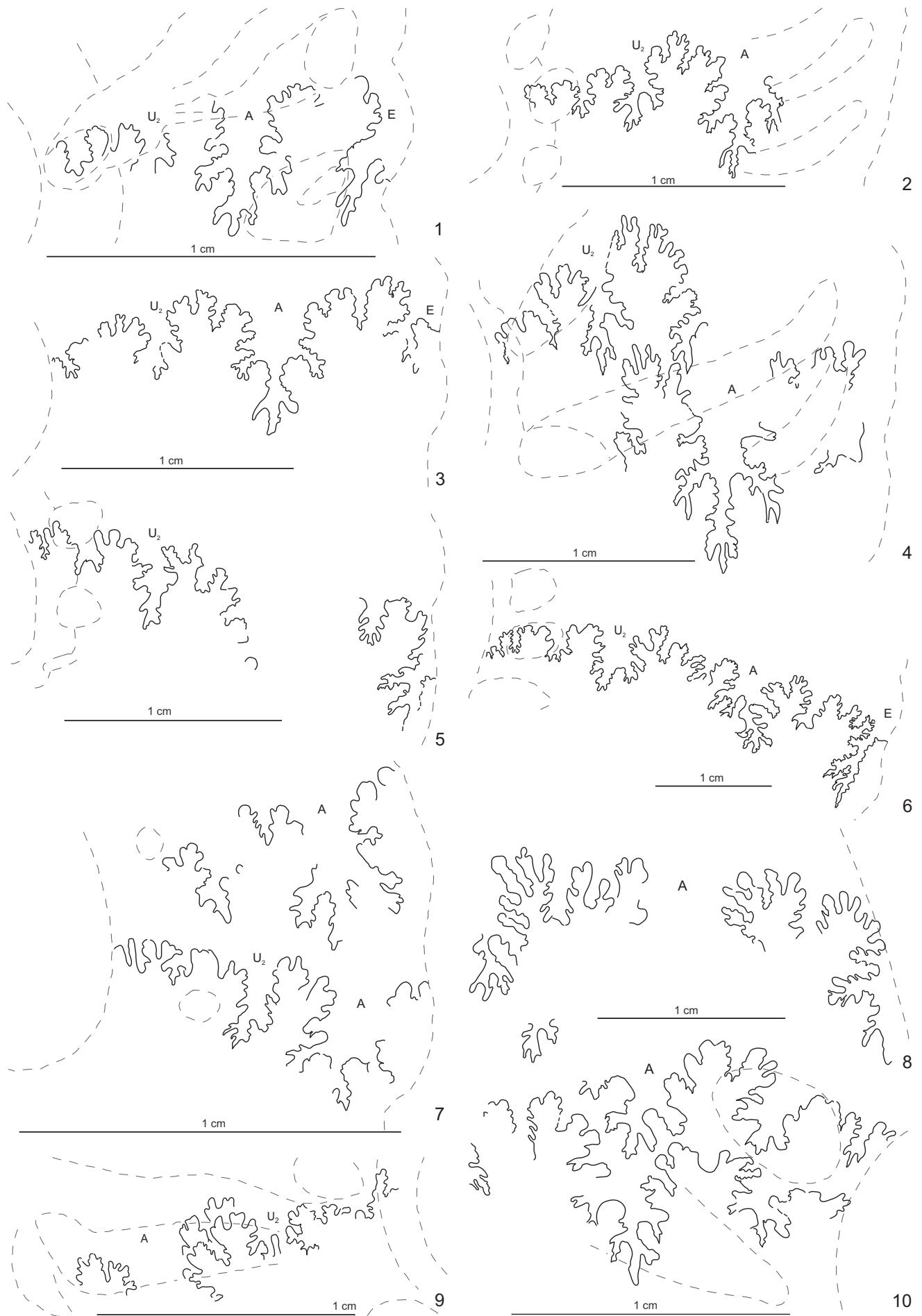
Tab. 9.

Muniericeras gosauicum (HAUER, 1858). Measurements of microconchs from the middle Santonian Gosau Group of the Gosau area (Rußbach, Salzburg; Gosau, Upper Austria). _{est} = estimated average, _{max} = measured maximum, _{fragm} = fragment, _{not reg.} = not registered, U % of D. NHMW 2013/0581/0001 is the neotype. The measurements of the lost holotype are recalculated following HAUER (1858: 13).

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|-------------------------------|-------------------|---------|---------|-------------------|-------|
| NHMW 2012/0186/0007 | 27.8 | 13.3 | 7.1 | 5.7 | 20.5 |
| NHMW 2013/0472/0002 | 46.2 | 25.7 | 8.1 | 11 | 23.8 |
| PIUW/TUW/1884 | 26.5 | 12.2 | 7.8 | 6.3 | 23.8 |
| SK/SB/1989/2 | 60 | 22.7 | 11.2 | 12.2 | 20.3 |
| SK/GR/1981/19 | 69.3 | 35.6 | -- | 16.1 | 23.2 |
| SK/GR/1981/19 _{max} | 108.5 | 55.9 | -- | 25 _{est} | 23 |
| SK/GR/2002/47 | 70.3 | 33.4 | -- | 22.5 | 32 |
| SK/GR/2002/47 _{max} | 121.5 | 53 | -- | 29.7 | 24.4 |
| SK/NE/1989/5 _{max} | 52.7 | 25 | 10.2 | 10.3 | 19.5 |
| SK/NE/2001/16 | 46.4 | 22.2 | 8.7 | 8.3 | 17.9 |
| SK/RA/1981/6 | 65.7 | 39.7 | 11.6 | -- | -- |
| SK/RA/1981/11 | 145 | 56.4 | -- | 38.1 | 26.2 |
| SK/RA/1981/34 | 63.3 | 31.4 | 14.2 | 14.3 | 22.6 |
| SK/RA/1981/35 | 37.5 | 20 | 8.4 | 8.2 | 21.8 |
| SK/RA/1981/35 _{max} | 47.9 | 21.9 | 8 | 10.3 | 21.5 |
| SK/RA/1981/41 | 30.6 | 15.6 | 7.7 | 5.7 | 18.6 |
| SK/RA/1981/41 _{max} | 51.2 | 22.2 | 10.3 | 10.2 | 19.9 |
| SK/RA/1982/50 | 37.3 | 19.4 | 9.7 | 8 | 21.4 |
| SK/RA/1982/50 _{max} | 75.7 | 33.8 | 11.9 | 15.3 | 18.9 |
| SK/RA/1982/51 | 52.2 | 23.1 | 12.4 | 12.5 | 23.9 |
| SK/RA/1982/51 _{max} | 74.9 | 28.9 | 22 | 19.2 | 25.6 |
| SK/RA/1982/53 | 43.5 | 24.3 | 10.4 | 9 | 20.6 |
| SK/RA/1982/53 _{max} | 90.6 | -- | -- | 16.3 | 18 |
| SK/RA/1982/77 _{max} | 75.8 | 35.6 | 11.8 | 11.3 | 14.9 |
| SK/RA/1982/80 | 50.8 | 30.6 | 12.4 | 9.4 | 18.5 |
| SK/RA/1983/81 | 89 _{est} | 43.7 | 20 | 20.6 | 23 |
| SK/RA/1983/97 | 114.1 | 43.4 | 19.4 | 25 _{est} | 21.9 |
| SK/RA/1984/107 | 44.8 | 20 | 10.9 | 12.4 | 27.6 |
| SK/RA/1984/109 | 53.4 | 24.8 | 12 | 10.2 | 19.1 |
| SK/RA/1984/109 _{max} | 69.1 | 30.1 | 11.5 | 14.6 | 21.1 |
| SK/RA/1988/115 _{max} | 67.5 | 30 | 11.8 | 12 | 17.98 |
| SK/RA/1988/115 | 33.9 | 19.3 | 8.3 | 7.1 | 20.9 |
| SK/RA/1997/131 | 93.2 | 41.7 | -- | 20.3 | 21.8 |

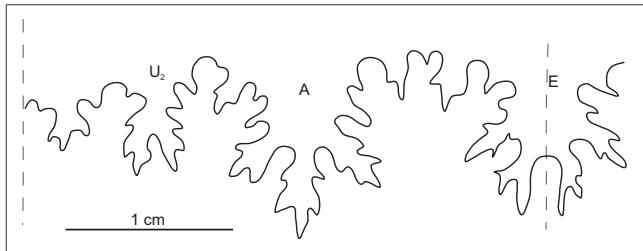
Tab. 10.

Muniericeras gosauicum (HAUER, 1858). Measurements of macroconchs from the middle Santonian Gosau Group of the Gosau area (Rußbach, Salzburg; Gosau, Upper Austria). _{est} = estimated average, _{max} = measured maximum, U % of D.



◀ Text-Fig. 9.

External sutures of *Muniericeras gosauicum* (HAUER, 1858). Fig. 1: NHMW 2013/0581/0001 (neotype), Fig. 2: SK/RA/1986/107, Fig. 3: GLÜW Stöckl 2, Fig. 4: SK/RA/1989/120, Fig. 5: NHMW 2013/0472/0002, Fig. 6: SK/RA/1981/11, Fig. 7: SK/RA/1981/22, Fig. 8: SK/RA/1997/131, Fig. 9: SK/RA/1997/132, Fig. 10: SK/RA/1999/142.



Text-Fig. 10.
External suture of Hauer's lost specimen; after HAUER (1858: Pl. 2, Fig. 9).

Description: *Muniericeras gosauicum* (HAUER, 1858) is a highly variable, dimorphic species. All variants are moderately involute and, with a few exceptions, have a compressed, lanceolate whorl section and a high expansion rate. The umbilicus typically comprises about 20 % of the diameter; the range is 15–31 %. A keel is present throughout ontogeny and extends as a rostrum at the adult aperture (Text-Fig. 11). All variants are characterised by falcoid ribbing. All individuals are internal moulds, in many cases preserved with parts of the whitish shell. Some show remains (e.g. the neotype, Pl. 11, Figs. 1–3) of a thin layer of unknown composition between the shell and the internal mould. This broadens with the growth of the individual. Most individuals are more or less crushed and deformed into an ellipse by *post mortem* crushing. Body chambers are commonly preserved and extend to over half of the outer whorl, and an adult aperture with rostrum is preserved in several individuals (Pl. 15, Fig. 8, Pl. 16, Fig. 3, Pl. 11, Fig. 10, Text-Fig. 11). The umbilical shoulder is narrowly rounded. The flanks are slightly convex, converging towards the ventrolateral shoulder; the venter is fastigate. A common feature of all variants is the falcoid ribbing, arising at the umbilical shoulder with or without developing an umbilical bulla, straight and prorsiradiate on the inner flank, flexing back and feebly convex at mid-flank, flexing forwards and concave on the outer flank and projected strongly forwards on the ventrolateral shoulders and venter, where they strengthen into a strongly prorsiradiate incipient bulla. The suture is visible in some specimens (Text-Figs. 9, 10).

Microconchs (for dimensions see Table 9) are characterised by coarser ornament and an undulose to serrate keel. Most of the microconchs are smaller than the macroconchs. Seven to 14 prominent umbilical tubercles give rise to from 26 to 40 falcoid ribs, arising at the umbilical shoulder in bundles of twos and threes and terminating, together with some intercalatories, in a marginal swelling at the ventrolateral shoulder, close to the serrate keel. In some cases the keel becomes entire as in macroconchs. In a few individuals the ribs weaken at mid-flank. Umbilical tubercles are strong. The neotype NHMW 2013/0581/0001 (formerly SK/RA/1997/133) (Pl. 11, Figs. 1–3; for the suture see Text-Figure 10) is a microconch. The umbilicus comprises about 20 % of the diameter and is shallow, with

a vertical wall. The ribs are almost completely effaced at mid-flank, before strengthening again at the ventrolateral shoulder.

Some macroconchs are quite large (108, 114, 121, 108 mm in diameter), some are of medium size (50–70 mm, for the whole range see Table 10). The ornament is weaker than that of typical microconchs, the ribs effacing on the inner flanks. Umbilical tubercles are of moderate strength, number about 13 per whorl, and give rise to falcoid ribs in groups of two or three. In some individuals the umbilical tubercles are very small, or are not developed. The primary ribs weaken or efface on the inner third of the flanks, before strengthening on the outer flanks, where additional ribs intercalate to give a total of 30–40 ribs per whorl. The ribs strengthen into an incipient bulla close to the typically entire, undulose or irregular keel. Some body chambers are ornamented by falcoid growth lines only (Pl. 14, Fig. 1, Pl. 15, Fig. 7, Pl. 16, Figs. 1, 4, Pl. 17, Figs. 5, 7).

Discussion: HAUER's lost holotype of *Ammonites gosauicus* (1858: 13, Pl. 2, Figs. 7–9) matches well with specimens in the new collections from the Gosau Group. It is highly likely that the few meters of the Grabenbach Formation at the Randobach 2 locality (Rußbach, Salzburg) is the source of this specimen (SUMMESBERGER & ZORN, 2012). The specimens from this section (Pls. 11–17, all Figs., but Pl. 17, Fig. 2) thus rank as topotypes. DE GROSSOUVRE (1894: 156) recognised *Ammonites gosauicus* as a close ally of *Muniericeras*



Text-Fig. 11.
Muniericeras gosauicum (HAUER, 1858); SK/RA/1998/138; ventral view of the broken aperture with rostrum and keel.

lapparenti (DE GROSSOUPRE, 1894: 158, Pl. 29, Figs. 1, 5, Pl. 35, Fig. 3), the type species of *Muniericeras*.

Within the present collection of variable topotypes of *M. gosauicum*, some specimens approach *Texasia* (e.g. SK/RA/1997/132: Pl. 13, Figs. 2, 3; SK/RA/1981/10: Pl. 17, Fig. 9). *Muniericeras lapparenti* (DE GROSSOUPRE, 1894) differs in its somewhat larger umbilicus (25.8 to 28.03 % after KENNEDY in KENNEDY et al., 1995: 407), fewer umbilical tubercles (5–9 per whorl) and less markedly falcoid ribs (KENNEDY in KENNEDY et al., 1995: Pl. 16, Figs. 4–7). *Muniericeras triplicatum* (COLLIGNON, 1966: 41, Pl. 422, Fig. 1924) is a synonym of *M. rectecostatum* COLLIGNON (1966: 40, Pl. 472, Fig. 1919) (teste KENNEDY in WALASZCZYK et al., 2014: 119) and differs in its obtusely fastigiate venter without an entire or serrate keel (KENNEDY et al., 2008: 287). '*Praemuniericeras' boriesi* COLLIGNON (1981: 195, Pl. 3, Fig. 1) is the microconch of *Texasia cricki* (SPATH, 1921) (KENNEDY & KLINGER, 2013b: 39); it differs from *M. gosauicum* in its broad and shallow ribs that efface on the inner third of the flank. *Muniericeras bilottei* (COLLIGNON, 1981: 195, Pl. 3, Figs. 2–4; KENNEDY in KENNEDY et al., 1995: 407, Pl. 13, Figs. 2, 4, 10, Pl. 14, Figs. 2, 3, 10, 11, Pl. 17, Fig. 1) differs in its moderate to weak sculpture and more numerous (10–16) umbilical bullae (KENNEDY in KENNEDY et al. (1995: 408)). *Muniericeras rennense* (DE GROSSOUPRE, 1894: 160, Pl. 35, Fig. 2) was interpreted by KENNEDY in KENNEDY et al. (1995: 415) as a *Pseudobarroisiceras* SHIMIZU, 1932, and *Muniericeras inconstans* DE GROSSOUPRE (1894: 159, Pl. 35, Figs. 4, 5) as a *Pseudoschloenbachia* (*Pseudoschloenbachia*) SPATH, 1921. The Lower Santonian *Texasia cricki* (SPATH, 1921) and all of its synonyms listed by KENNEDY & KLINGER (2013b) differ in their coarser sculpture and a somewhat wider umbilicus.

Occurrence: *Muniericeras gosauicum* appears in a mass occurrence in the middle Santonian in its presumed type area (Randobach 2, Rußbach, Salzburg) in the Gosau Basin, where it co-occurs with baculitids, *Parapuzosia corbarica* (DE GROSSOUPRE, 1894) and *Tragodesmoceras* aff. *clypeale* (SCHLÜTER, 1872). It is not present in the early Santonian of the Randobach 3 locality that yields *Parapuzosia daubreei*, *Eulophoceras natalense* (HYATT, 1903) and *Cladoceramus undulatoplatus*. It is present in the middle Santonian of the Schneidewirtsbrücke locality (Bad Ischl, Upper Austria). In the nearby Neffgraben section it extends into higher parts of the middle Santonian, close to the first occurrence of *Placenticeras paraplanum*. *Muniericeras gosauicum* has not been recognised from outside the Gosau occurrences and has not been found in the early Santonian of Brandenberg (Mühlbach, Tyrol).

Genus *Texasia* REESIDE, 1932

Type species: *Ammonites dentato-carinatus* ROEMER, 1852 by subsequent designation of WRIGHT (1957: Part L, 432).

Texasia cricki (SPATH, 1921)

(Pl. 18, Fig. 2, Tab. 11)

- 1921b Gen. nov. (*Muniericeras?*) *cricki* SPATH: 44, Pl. 7, Figs. 4a, b.
 1966 *Lehmaniceras sornayi* COLLIGNON: 50, Pl. 475, Fig. 1933.
 1968 *Barroisiceras umzambiense* VAN HOEPEN: 161, Pl. 6.
 2013b *Texasia cricki* (SPATH, 1921); KENNEDY & KLINGER: 34, Figs. 1 A–E; ?G, I–L, 2 A, B, ? C, D–F, 3 A–G; with complete synonymy.

Types: The holotype of Gen. nov. (*Muniericeras?*) *cricki* SPATH, 1921 is an unregistered specimen in the Durban Museum. The holotype of *Barroisiceras umzambiense* VAN HOEPEN 1968 (a synonym) is SAM-PCP022448 (see KENNEDY & KLINGER, 2013b: 36).

Material: A single specimen, SEIDL/CE 00002 from Rußbach (Salzburg) in the Seidl collection.

Description: SEIDL/CE 00002 (measurement Table 11) is a laterally crushed internal mould with the original aragonitic shell preserved. The whorl height increases rapidly, covering about 60 % of the preceding whorl, the umbilicus of about 30 % of the diameter is relatively shallow, the umbilical wall is convex, the umbilical shoulder narrowly rounded. The flanks are dominated by an extremely coarse ornament. Eight umbilical tubercles give rise to broad and coarse pairs or single ribs which diminish about midflanks, recovering in the outer third of the flank and culminating in about 16 elongated bullae. Some of the ribs are prorsiradiate. At the end of what we believe to be the body chamber they are rectiradiate. They end at the ventrolateral shoulder corresponding with about 16 undulated clavi forming a relatively broad keel.

Discussion: A detailed discussion of *Texasia cricki* (SPATH, 1921) was given by KENNEDY & KLINGER (2013b: 36). SEIDL/CE 00002 is very close to the coarser ornamented variants of *T. cricki* (e.g. *Barroisiceras umzambiensis* VAN HOEPEN, 1968, refigured by KENNEDY & KLINGER, 2013b: Figs. 1E, F; or *Lehmaniceras sornayi* COLLIGNON, 1966, refigured by KENNEDY & KLINGER, 2013b: Fig. 2A).

Differences to *Texasia dentatocarinata* from the late Santonian of the Schattaugraben (Rußbach, Salzburg) were discussed by SUMMERSBERGER et al. (2017a; this volume).

Occurrence: The holotype is imprecisely located within the Santonian Mzamba Formation of Eastern Cape Province, South Africa. Material from Madagascar referred to the

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|----------------|--------|---------|-------------------|--------|-------|
| SEIDL/CE 00002 | 50 | 24.3 | 13 _{est} | 12.3 | 24.6 |

Tab. 11.

Texasia cricki (SPATH, 1921) (SEIDL/CE 00002). _{est} = estimated; U % of D.

species by KENNEDY & KLINGER comes from the Niveau à *Lehmaniceras* of COLLIGNON (1966: 50), some way above the base of the stage. The present specimen is from the lower Santonian of Randobach 3 (Rußbach, Salzburg).

Genus and Subgenus *Pseudoschloenbachia* SPATH, 1921

Type species: *Ammonites umbulazi* BAILY, 1855 (456, Pl. 11, Fig. 4).

Pseudoschloenbachia (Pseudoschloenbachia) sp. (Pl. 18, Fig. 1)

Compare

- 1894 *Muniericeras inconstans* DE GROSSOURE: 159, Pl. 35, Figs. 4, 5.
- 1981 *Pseudoschloenbachia inconstans* (DE GROSSOURE); COLLIGNON: 197, Pl. 4, Figs. 1–5.
- 1995 *Pseudoschloenbachia (Pseudoschloenbachia) inconstans* (DE GROSSOURE, 1894); KENNEDY in KENNEDY et al.: 409, Pl. 14, Figs. 7, 8, 12, 13, Pl. 15, Figs. 1–6, 13–16, Pl. 16, Figs. 3, 8, 9.

Material: NHMW 1982/0031/0001, a single specimen.

Description: NHMW 1982/0031/0001 is a fragment of an internal mould of a body chamber with traces of the original aragonitic shell material. The aperture is well preserved. Wh is 31.1, Wb is 23.9, the umbilicus is not preserved. The diameter must have measured about 90 mm. The whorl section is lanceolate, the flanks are feebly convex, passing gradually into the ventrolateral shoulder. The entire keel is sharp and narrow. There are an estimated 40 shallow falcoid ribs per whorl correct, prorsiradiate on the inner flank, they flex back at mid-flank, and are concave on the outer flank, sweeping forwards to the siphonal keel. The course of the aperture parallels that of the ribs, the keel projected forwards as a short rostrum.

Discussion: The specimen is closest to adult individuals of *P. (P.) inconstans* (DE GROSSOURE, 1894) from the Santonian of the Corbières (KENNEDY in KENNEDY et al., 1995: Pl. 14, Figs. 10–13, Pl. 15, Fig. 13), but is too fragmentary for confident assignation to the species. It is also comparable to macroconchs of *Muniericeras gosauicum* (HAUER, 1858) from the Randogaben with which it co-occurs.

Occurrence: NHMW 1982/0031/0001 is from the Randobach 2 locality.

Superfamily Hoplitoidea H. DOUVILLÉ, 1890

Family Placenticeratidae HYATT, 1900 Genus *Placenticeras* MEEK, 1876

Type species: *Ammonites placenta* DEKAY, 1828 (278, Pl. 5, Fig. 2) by the original designation of MEEK (1876: 442).

Placenticeras paraplanum WIEDMANN, 1978

(Pl. 10, Fig. 4, Tab. 12)

- 1978 *Placenticeras paraplanum* WIEDMANN: 666, Pl. 1, Figs. 3, 4, Text-Fig. 2a.
- 1979 *Placenticeras paraplanum* WIEDMANN; SUMMESBERGER: 152, Pl. 13, Figs. 53–57.
- 1983 *Placenticeras paraplanum* WIEDMANN, 1978; KENNEDY & WRIGHT: 866.
- 1985 *Placenticeras aff. paraplanum* WIEDMANN; AMEDRO & HANCOCK: 24, Text-Figs. 11a–c, f, g.
- 1987 *Placenticeras paraplanum* WIEDMANN 1978; IMMEL: 98.
- 1987 *Placenticeras paraplanum* WIEDMANN, 1978; KENNEDY: 769, Pl. 80, Figs. 1–3, 8–10.
- 1989 *Placenticeras paraplanum* WIEDMANN; KLINGER & KENNEDY: 268.
- 1995 *Placenticeras paraplanum* WIEDMANN, 1978; KENNEDY in KENNEDY et al.: 411, Pl. 17, Figs. 11, 12, Pl. 18, Figs. 1–4.
- 2017a *Placenticeras paraplanum* WIEDMANN, 1978; SUMMESBERGER et al.: 183, Pl. 9, Fig. 5.

Type: The holotype, by the original designation of WIEDMANN (1978: 666) is no. CG 01 in the Gapp Collection, the original of WIEDMANN (1978: Pl. 1, Figs. 3, 4, Text-Fig. 2A), from the late Santonian of the Gosau Basin, Upper Austria.

Material: NHMW 2014/0090/0001 and a fragment, NHMW 2014/0090/0002, from the base of the late Santonian of the Hochmoos Formation (Gosau Group) of the Neffgraben site (Rußbach, Salzburg).

Description: NHMW 2014/0090/0001 (Pl. 10, Fig. 4, Tab. 12) is an internal mould of an adult individual with large areas of the aragonitic nacreous layer of the shell preserved. The last suture is partially visible: the body chamber extends over half of the outer whorl. The proportions of the specimen are close to those of the holotype, with slowly increasing whorl height and whorl breadth. The umbilicus is deep, with a slightly oblique umbilical wall. The growth lines are well-preserved and are rursiradiate on the umbilical wall with a deep concavity, sweeping back over the flank in a shallow convexity parallel to the ribs. These arise from faint bullate swellings on the umbilical shoulder and are single, feebly rursiradiate and feebly concave across the flanks, and are separated by shallow, broad interspaces. They link to well-developed inner ventrolateral tubercles. The venter bears outer ventrolateral clavi that alternate in position on either side of a broad, shallow midventral depression. The incompletely exposed suture line is typical for the genus.

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|---------------------|-----------|------------|------------|-----------|----------|
| NHMW 2014/0090/0001 | 106.8 | 43 | 27.6 | 24.3 | 22.7 |

Tab. 12.

Placenticeras paraplanum WIEDMANN, 1978. U % of D.

Discussion: *Placenticeras paraplanum* WIEDMANN, 1978, from the late Santonian “Sandkalkbank Member” of the Fins-tergrabenwandl site (Gosau, Upper Austria) is a distinctly dimorphic species. It was originally based upon a single specimen (WIEDMANN, 1978: 666, Pl. 1, Figs. 3, 4, Text-Fig. 2A). SUMMESBERGER (1979: 153), on the basis of four additional specimens, distinguished two characteristic forms: “Form A” interpreted as the macroconch and “Form B” interpreted as the microconch. The holotype (WIEDMANN, 1978: Pl. 1, Figs. 3, 4) and the present specimen from the Neffgraben site (Rußbach, Salzburg) are macroconchs, SK/1977/13 (SUMMESBERGER, 1979: Pl. 13, Figs. 53, 54) is a microconch. SUMMESBERGER (1979: 154) discussed the evolutionary lineage from the late Santonian *P. paraplanum* to the early Campanian *P. bidorsatum*. KENNEDY (1987: 770) concluded *P. bidorsatum* was “a hypermorphic giant derivative of *paraplanum*”. This was followed by KLINGER & KENNEDY (1989: 268). The predecessors of *P. paraplanum* may be seen the fragments of smooth forms from the middle Santonian part of the Gosau Group.

Occurrence: NHMW 2014/0090/0001 is from the base of the late Santonian Hochmoos Formation of the Neffgraben site, approximately 20 meters below the base of the Sandkalkbank Member in the section. Accordingly, *Placenticeras paraplanum* is the earliest strongly ornamented placenticeratid in the Gosau Group, succeeding compressed and smooth predecessors (see below) in the middle Santonian, and giving rise the three dimorphic species present in the “Sandkalkbank Member”. Furthermore the present specimens are from below the last occurrence of *Texanites quinqueradosus* in the Neffgraben (see page 37). *Placenticeras paraplanum* occurs in the late Santonian Paraplanum Subzone of the Corbières and in the Santonian of Aquitaine (France; KENNEDY, 1984; KENNEDY in KENNEDY et al., 1995).

Placenticeras sp. indet.

(not figured)

Discussion: Poor fragments of compressed, high-whorled, unornamented *Placenticeras*, recognisable by their distinctive sutures, occur in the middle Santonian part of the Gosau Group in the Grabenbach and Neffgraben sections, where they overlap with the occurrence of *Muniericeras*.

Superfamily Acanthoceratoidea DE GROSSOURE, 1894

Family Collignoniceratidae WRIGHT & WRIGHT, 1951

Subfamily Texanitinae COLLIGNON, 1948

Genus and Subgenus *Texanites* (*Texanites*) SPATH, 1932

Type species: *Ammonites texanus* ROEMER, 1852 (31, Pl. 3, Fig. 1) by the original designation of SPATH (1932: 379).

Texanites (*Texanites*) *quinqueradosus* (REDTENBACHER, 1873)

(Pl. 18, Figs. 3–7, Text-Fig. 12, Tab. 13)

- 1854 *Ammonites texanus*?; REUSS: 24, 41.
- 1858 *Ammonites texanus* HAUER (non RÖMER, 1852): 10, Pl. 2, Figs. 4–6.
- 1873 *Ammonites quinqueradosus* REDTENBACHER: 108, Pl. 24, Fig. 3.
- 1925 *Mortoniceras quinqueradosum* REDTENBACHER; DIERNER: 147.
- 1935 *Mortoniceras texanum* ROEM. var. *quinqueradosum* REDT.; BRINKMANN: 3, 4.
- 1935 *Mortoniceras quinqueradosum* REDT.; BRINKMANN: 6.
- 1948 *Texanites quinqueradosus* (REDT.); COLLIGNON: 69.
- 1966 *Texanites quinqueradosus* (REDT.); COLLIGNON: 128, Pl. 510, Fig. 2021.
- 1970 *Texanites* (*Texanites*) *quinqueradosus* (REDTENBACHER); MATSUMOTO: 273.
- 1979 *Texanites quinqueradosus* (REDTENBACHER); WIEDMANN in HERM et al.: 48, Pl. 7, Figs. C, D.
- 1980 *Texanites quinqueradosus* (REDTENBACHER, 1873); KLINGER & KENNEDY: 135, Figs. 102, 103.
- 1981 *Texanites quinqueradosus* (REDTENBACHER, 1873); KENNEDY et al.: 126, Figs. 8–16 (with synonymy).
- 1982 *Texanites* (*Texanites*) *quinqueradosus* (REDTENBACHER 1873); IMMEL et al.: 23, Pl. 9, Fig. 1.
- 1987 *Texanites quinqueradosus* (REDTENBACHER 1873); IMMEL: 112.
- 1994 *Texanites quinqueradosus* (REDTENBACHER); TRÖGER & SUMMESBERGER: 185.
- 1995 *Texanites* (*Texanites*) *quinqueradosus* (REDTENBACHER); KENNEDY et al.: 420, Pl. 22, Figs. 8, 10, Pl. 23, Figs. 3–5, Text-Fig. 26.
- 1998 *Texanites quinqueradosus* (REDTENBACHER, 1873); KÜCHLER: Pl. 14, Figs. 7a, b.
- 2000 *Texanites quinqueradosus* (REDTENBACHER); SUMMESBERGER in EGGER et al.: 22.
- 2000 *Texanites* (*Texanites*) *quinqueradosus* (REDTENBACHER, 1873); KENNEDY & KAPLAN: 88, Pl. 24.
- 2012 *Texanites quinqueradosus* (REDTENBACHER, 1873); SUMMESBERGER & ZORN: 6–7, Pl. 15, Fig. 1, Pl. 16, Fig. 1.
- 2017c *Texanites* (*Texanites*) *quinqueradosus* (REDTENBACHER, 1873); SUMMESBERGER et al.: 125.

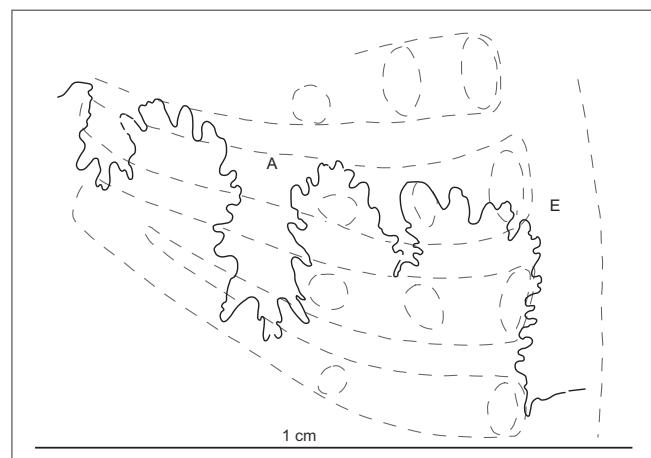
Type: The lectotype by the subsequent designation of MATSUMOTO (1970: 273) is GBA 1873/01/13/1, the original of REDTENBACHER (1873: Pl. 24, Fig. 3) from the middle Santonian Gosau Group of Schneiderwirtsbrücke, between Bad Ischl (Upper Austria) and Strobl (Salzburg). There are two paralectotypes, GBA 1873/01/13/2 and OÖLM/41/1938, from the Schneiderwirtsbrücke (road bridge) over the Ischl river (Bad Ischl, Upper Austria).

Material: NHMW 1935/0003/0039–40 from the Grabenbach Formation of Grabenbach (Gosau, Upper Austria), NHMW 1926/0002/2469 and NHMW 2014/0104/0002 (former Böhm Collection) from the Hochmoos Formation of Neffgraben (Rußbach, Salzburg); NHMW 2012/0186/0016 from Zimmergraben (Rußbach, Salzburg; former collection Kastl). NHMW 2015/0031/0001 (Pl. 18, Fig. 7), NHMW/1864/0730 from Hofergraben (Gosau, Upper Austria); an unregistered fragment in the GBA collection; TLMF/SM 596, 597 from the Lower Santonian of Brandenberg/Mühlbach and TLMF/SM 598 from the confluence of Mühlbach and Brandenberger Ache (WIEDMANN in HERM et al., 1979).

Other specimens are GPII P.8161 (the original of WIEDMANN in HERM et al., 1979: 48, Pl. 7, Figs. C, D) and M 20 (IMMEL et al., 1982: 23, Pl. 9, Fig. 1) from the early Santonian of Brandenberg/Mühlbach; one specimen from Wolfsbachau, an additional one from Weißenbach near Bad Aussee (both Steiermark, not seen) and from Unterlaussa (Upper Austria; coll. Schüssler, pers. comm.). 14 specimens from the Skoumal collection: SK/RA/1981/15, 16, 17, 19; SK/RA/1982/45, 55, 58; SK/RA/1983/82; SK/RA/2009/155; SK/GR/1981/13, 18, 22; SK/NE/1990/14; SK/EB/2008/45.

Discussion: A revision of the Austrian material was given by KENNEDY et al. (1981: 126). The lectotype (GBA 1873/01/13/1) was refigured by KENNEDY et al. (1981: Figs. 8, 9); KENNEDY in KENNEDY et al. (1995: Fig. 26); KENNEDY & KAPLAN (2000: Pl. 24) and SUMMESBERGER & ZORN (2012: Pl. 15, Fig. 1). Paralectotype GBA 1873/01/13/2 was figured by KENNEDY et al. (1981: Figs. 9 A–D) and by SUMMESBERGER & ZORN (2012: Pl. 16, Figs. 1 a–d). An additional paralectotype (OÖLM/LL 41/1938) was figured by KENNEDY et al. (1981: Figs. 15, 16).

Texanites collignonii KLINGER & KENNEDY, 1980: 126, Text-Figs. 95, 96a, 97, 98, 99b–c, 100, 101) from the early Santonian of Madagascar, Santonian I and Santonian II of northern KwaZulu-Natal (South Africa) and Japan, is similar but differs in its rounded tubercles. KLINGER & KENNEDY (1980: 135) discuss the possibility that *Texanites oliveti* (BLANCKENHORN, 1905: 10) might be a junior synonym of *T. quinqueradosus*.



Text-Fig. 12.
External suture of *Texanites (T.) quinqueradosus* (REDTENBACHER, 1873), SK/RA/1981/17.

Occurrence: The type locality of the lectotype of *Ammonites quinqueradosus* was stated by REDTENBACHER (1873: explanation of Pl. 24, Fig. 3) to be St. Wolfgang in Upper Austria, but the species has not in fact been found in this area. As discussed by SUMMESBERGER & ZORN (2012: 107) it is probably from the middle Santonian of Schneiderwirtsbrücke (road bridge) in the bed of the Ischl river close to the confluence with the Nussenseebach. The species is also recorded from Gosau (Upper Austria), Rußbach (Salzburg), Unterlaussa (Upper Austria) and from the early Santonian of Brandenberg/Mühlbach (Tyrol; IMMEL et al., 1982).

T. quinqueradosus appears together with *Cladoceramus undulatoplicatus* in the early Santonian Grabenbach Formation. Its local range extends upwards and it overlaps with the first occurrence of the late Santonian *Placenticeras paraplanum* in the Neffgraben and Rußbach sections, and in the Hochmoos Formation below the Sandkalkbank Member. Elsewhere it occurs in France, Spain, Japan and possibly Angola and Madagascar. Higher in the section (e.g. Neffgraben (Rußbach) or Finstergrabenwandl (Gosau, Upper Austria)) *Reginaites gappi* WIEDMANN, 1978 is the only Gosau representative of the Texanitidae.

Family Sphenodiscidae HYATT, 1900

Subfamily Lenticeratiniae HYATT, 1900

Genus *Eulophoceras* HYATT, 1903

Type species: *Eulophoceras natalense* HYATT, 1903 by original designation.

Eulophoceras natalense HYATT, 1903

(Pl. 17, Fig. 2, Pl. 19, Figs. 1–5, Pl. 20, Figs. 1–8, Pl. 21, Figs. 1–11, Pl. 22, Figs. 1–6, Pl. 23, Figs. 1–19, Text-Figs. 13a, b, Tabs. 14–16)

- | Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|------------------------------------|--------|---------|---------|--------|-------|
| NHMW 1935/0003/0040 _{max} | 118.5 | 40 | 32 | 51 | 43 |
| NHMW 2012/0186/0016 | 102 | 34.3 | 24 | 44.6 | 43.7 |
| SK/RA/1981/17 _{est} | 23 | 7.8 | 11.4 | 9.5 | 41.3 |
- Tab. 13.
Texanites (T.) quinqueradosus (REDTENBACHER, 1873). _{max} = maximum, _{est} = estimated; U % of D.

1903

Eulophoceras natalense HYATT: 86, Pl. 11, Figs. 2–6.

1906

Eulophoceras natalense HYATT; Woods: 337, Pl. 42, Fig. 3.

| | | | |
|----------|---|-------|---|
| 1921 | <i>Eulophoceras natalense</i> HYATT; VAN HOEPEN: 47, Pl. 6, Figs. 2, 3. | 1995 | <i>Hemitissotia randoi</i> GERTH, 1961; KENNEDY et al.: 412, Pl. 14, Fig. 9, Pl. 15, Fig. 9. |
| 1921 | <i>Pelecodiscus umzambiensis</i> VAN HOEPEN: 30, Pl. 5, Fig. 10, Pl. 6, Fig. 1. | 2000 | " <i>Hemitissotia</i> " <i>randoi</i> GERTH; SUMMESBERGER in EG-GER et al.: 23, Fig. 13/1. |
| 1921 | <i>Pelecodiscus capensis</i> VAN HOEPEN: 32, Pl. 5, Fig. 11. | 2012a | <i>Eulophoceras natalense</i> HYATT, 1903; KENNEDY & KLINGER: 33, Figs. 5–11, 12A–C, (with synonymy). |
| 1921 | <i>Pelecodiscus amapondensis</i> VAN HOEPEN: 33, Pl. 7, Figs. 1, 2. | | |
| 1921a | <i>Eulophoceras natalense</i> HYATT; SPATH: 242, Text-Fig. C 2. | | |
| 1921a | <i>Spheniscoceras africanum</i> (Crick MS); SPATH: 242, Fig. C 1a. | | |
| 1921a | <i>Spheniscoceras tenue</i> (Crick MS); SPATH: 242, Text-Fig. C 1e. | | |
| 1921a | <i>Spheniscoceras minor</i> (Crick MS); SPATH: 242, Text-Fig. C 1b. | | |
| 1921b | <i>Eulophoceras natalense</i> HYATT; SPATH: table opposite page 50. | | |
| 1921b | <i>Spheniscoceras africanum</i> (Crick MS); SPATH: table opposite page 50. | | |
| 1921b | <i>Spheniscoceras tenue</i> (Crick MS); SPATH: table opposite page 50. | | |
| 1921b | <i>Spheniscoceras minor</i> (Crick MS); SPATH: table opposite page 50. | | |
| 1922 | <i>Eulophoceras natalense</i> HYATT; SPATH: 142. | | |
| 1922 | <i>Spheniscoceras africanum</i> (Crick MS); SPATH: 143, Pl. 6, Fig. 1. | | |
| 1922 | <i>Spheniscoceras tenue</i> (Crick MS); SPATH: 144, Pl. 8, Fig. 3. | | |
| ? 1922 | <i>Spheniscoceras tenue</i> (Crick MS); SPATH: 144, Pl. 7, Fig. 3. | | |
| 1922 | <i>Spheniscoceras minor</i> (Crick MS); SPATH: 144, Pl. 6, Fig. 2. | | |
| 1922 | <i>Spheniscoceras amapondense</i> (v. HOEPEN); SPATH: 144, Pl. 7, Fig. 2. | | |
| 1922 | <i>Spheniscoceras umzambicense</i> (v. HOEPEN); SPATH: 145. | | |
| 1961 | <i>Hemitissotia randoi</i> GERTH: 131, Pl. 24, Figs. 1, 2. | | |
| 1982 | <i>Eulophoceras natalense</i> HYATT 1903; IMMEL et al.: 24, Pl. 8, Fig. 5 (with synonymy). | | |
| 1982 | <i>Hemitissotia</i> ; SUMMESBERGER in KOLLMANN & SUMMESBERGER: 59. | | |
| ? 1982 | <i>Tissotia</i> ; SUMMESBERGER in KOLLMANN & SUMMESBERGER: 59. | | |
| 1982 | <i>Hemitissotia randoi</i> GERTH, 1961; SUMMESBERGER in KOLLMANN & SUMMESBERGER: 68, 69, 72. | | |
| 1985 | <i>Hemitissotia randoi</i> GERTH; SUMMESBERGER: 156, Tab. 3. | | |
| 1987 | <i>Hemitissotia randoi</i> GERTH 1961; IMMEL: 114. | | |
| 1988 | <i>Eulophoceras natalense</i> HYATT, 1903; COOPER: 209, Figs. 1 A, B (with synonymy). | | |
| 1994 | " <i>Hemitissotia</i> " <i>randoi</i> GERTH; TRÖGER & SUMMESBERGER: 185, Text-Fig. 4. | | |
| non 1995 | <i>Eulophoceras cf. natalense</i> HYATT, 1903; KENNEDY et al.: 425, Pl. 26, Figs. 3, 4, 7, Text-Fig. 32 (= <i>Eulophoceras losaense</i> SANTAMARIA ZABALA, 1995). | | |

Types: The holotype of *Eulophoceras natalense* HYATT, 1903, is no. 956 in the collections of the Peabody Museum of Yale University, the original of HYATT (1903: 86, Pl. 11, Figs. 2–6). The lectotype of *Hemitissotia randoi* GERTH, 1961, by subsequent designation of KENNEDY in KENNEDY et al., (1995: 412) is the original of GERTH (1961: Pl. 24, Fig. 2), the paralectotype is the original of GERTH (1961: Pl. 24, Fig. 1). Both of Gerth's originals (GPIB 408a, b) are apparently lost.

Material: 26 registered macroconchs, eight registered subadults, 61 registered microconchs and many unregistered specimens from the Gosau Basin (Salzburg, Upper Austria; Edlbachgraben, Randobachgraben, Schattaugraben, parking site of the Hornspitz cable car), Markt Piesting (Lower Austria), Brandenberg (Mühlbach locality, Tyrol) were available for study.

Description: *Eulophoceras natalense* HYATT, 1903 is a highly variable dimorphic species. Macroconchs are described below as *natalense* type, microconchs as "*Hemitissotia randoi*" type.

Macroconchs (*natalense* type)

Macroconchs are large oxycone shells 63 to 136 mm in diameter, with a tiny umbilicus. The venter is narrow, with an entire keel on the phragmocone, becoming rounded on the body chamber in large adults (e.g. Pl. 19, Fig. 4, Pl. 20, Figs. 3, 8). The whorl height increases rapidly, the whorls overlapping almost completely. Adult ornament, where present, consists in 1–5 low, broad, straight or slightly fallopoid undulations on the adapertural part of the body chamber, often visible under oblique light only (Pl. 19, Fig. 3; NHMW 2014/0139/0001). Many adult macroconchs are completely smooth (e.g. MA/1975/0001, Pl. 20, Figs. 2, 4, Pl. 19, Fig. 4). The umbilicus is deep with a steep subvertical umbilical wall, passing into the flank with a narrowly rounded umbilical shoulder. The flanks are gently inflated or subparallel, converging towards the ventrolateral region and passing into the feebly convex ventrolateral shoulder. Inner whorls of macroconchs are identical to those of juvenile microconchs. As diameter increases, the umbilical diameter decreases, from 7–10 % in juveniles to about 4 % in adults. The suture is often irregular, moderately incised, with short folioles. E is wide and shallow, E/A large and shallow, A is moderately deep. In many cases whitish or iridescent shell is preserved. Specimens from the Gosau area are preserved in marlstone to siltstone, those from Windischgarsten (Upper Austria) in hard black limestone.

Microconchs ("*Hemitissotia randoi*" type)

The microconchs of *Eulophoceras natalense* from the Randobach and Edlbach sites are internal moulds preserved with areas of adherent whitish shell, some with the original nacreous layer. Four specimens from downstream of

| Inventory No. | D (mm) | Wb (mm) | Wh (mm) | Wb/Wh | U (mm) | U (%) |
|---------------------|-------------------|---------|---------------------|-------|--------|-------|
| SK/EB/1987/11 | 92.5 | 16.8 | 50 | 0.33 | 4.5 | 4.8 |
| SK/EB/1987/13a | 106 | 21.4 | 58.6 | 0.36 | 4.2 | 3.9 |
| SK/EB/1987/13b | 81.7 | 11.1 | 49 | 0.22 | 3.7 | 4.5 |
| SK/EB/1992/14 | 91.8 | 20.8 | 50.1 | 0.41 | 2.6 | 2.8 |
| SK/EB/2000/18 | 83.3 | 16.6 | 45.8 | 0.36 | 4.8 | 5.7 |
| SK/EB/2000/19 | 93 | 16.4 | 57.8 | 0.28 | 4.4 | 4.7 |
| SK/EB/2000/25 | 65.9 | 15 | 43.2 | 0.35 | 4.4 | 6.7 |
| SK/EB/2004/35 | 75.3 | 10.4 | 44.6 | 0.23 | 3 | 4 |
| SK/EB/2004/37 | 81.6 | -- | 44.8 | -- | 4.4 | 5.4 |
| SK/EB/2005/39 | 76.9 | 18.9 | 48.2 | 0.39 | 3.4 | 4.4 |
| SK/EB/2005/40 | 80.9 | -- | 46.9 | -- | 2.9 | 3.1 |
| SK/EB/2007/43 | 88.6 | 14.3 | 55.9 | 0.25 | 3 | 3.4 |
| SK/EB/2011/51 | 136 | 28.4 | 75.9 | 0.37 | 5.6 | 4.1 |
| SK/EB/2013/63 | 76.1 | 14.7 | 40.9 | 0.36 | 2.9 | 3.8 |
| SK/EB/2013/71 | 87 | 11.6 | 46.6 | 0.25 | 3.6 | 4.1 |
| SK/EB/2013/73 | 75 | -- | 48 | -- | 3.5 | 4.7 |
| SK/RA/1981/9 | 70.2 | 9.7 | 34.3 | 0.28 | 3.1 | 4.4 |
| SK/RA/1981/7 | 63.1 | 13.1 | 32.4 | 0.4 | 2.5 | 3.9 |
| NHMW 2014/0206/0001 | 90.4 | 10 | 52 | 0.19 | 4.7 | 5.2 |
| NHMW 2014/0139/0001 | 91 | -- | 50 | -- | 2.1 | 2.3 |
| NHMW 2014/0139/0002 | 93 _{est} | 13.2 | 53.8 _{est} | 0.25 | 2.8 | 3 |
| NHMW 2014/0139/0003 | 70.2 | 18.6 | 42.4 | 0.43 | 4.6 | 6.5 |
| MA/1975/1 | 93.3 | 18.8 | 50 | 0.37 | -- | -- |
| BSP 1981 I 109 | 77 | 13 | 43 | 0.3 | 4 | 5.2 |

Tab. 14.

Adult macroconchs of *Eulophoceras natalense* HYATT, 1903. U % of D; Dimensions of BSP 1981 I 109 after IMMEL et al. (1982).

| Inventory No. | D (mm) | Wb (mm) | Wh (mm) | Wb/Wh | U (mm) | U (%) |
|---------------------|-------------------|---------|---------|-------|--------|-------|
| NHMW 1983/0034/0002 | 45.2 | 5.3 | 27.4 | 0.19 | 1.9 | 4.2 |
| NHMW 2014/0206/0001 | 41.3 | -- | 22.3 | -- | 2.2 | 5.3 |
| SK/EB/1985/1a | 45.8 | 9.1 | 25.9 | 0.35 | 1.4 | 3.1 |
| SK/EB/2000/21 | 31.8 | -- | 18.9 | -- | 1.2 | 3.8 |
| SK/EB/2000/22 | 40.4 | 10.9 | 18.3 | 0.59 | 1.6 | 3.9 |
| SK/EB/2013/68 | 37.4 | -- | 21.4 | -- | 2.2 | 4.6 |
| SK/RA/1981/31 | 60 _{est} | 9 | 35.5 | 0.25 | 2.4 | 4 |
| SK/RA/1983/86 | 47.9 | 7 | 29.5 | 0.23 | 2.1 | 4.3 |
| SK/SG/2000/31a | 40 _{est} | 9.4 | 21.7 | 0.43 | 2.2 | 5.5 |

Tab. 15.

Subadults of *Eulophoceras natalense* HYATT, 1903. U % of D. for NNMW 2014/0206/0001, see adults.

| Inventory No. | D (mm) | Wb (mm) | Wh (mm) | Wb/Wh | U (mm) | U (%) |
|----------------------|---------------------|--------------------|---------------------|---------------------|---------------|--------------|
| SK/RA/1981/1a | 21.5 | 4.3 | 14.2 | 0.3 | 2 | 9.3 |
| SK/RA/1981/1b | 27.8 | 4.4 | 17.8 | 0.24 | 2.6 | 9.3 |
| SK/RA/1981/1c | 24.8 | 4 | 16 | 0.25 | 2 | 8 |
| SK/RA/1981/1d | 28 | 4.2 | 18 | 0.23 | 1.9 | 6.8 |
| SK/RA/1981/1e | 21.6 | 3.7 | 12.5 | 0.29 | 2 | 9.2 |
| SK/RA/1981/1f | 27.4 | 3.9 | 16.1 | 0.24 | 2.1 | 7.6 |
| SK/RA/1981/1g | 3 | 3.7 | 14.3 | 0.26 | 2 | 8.7 |
| SK/RA/1981//28b | 21 | 4 | 10.7 | 0.37 | 2.1 | 10 |
| SK/RA/1981/43 | 35 _{est} | 9.9 | 16.3 | 0.6 | -- | -- |
| SK/RA/1981/44 | 27.7 | 4.1 | 16.8 | 0.24 | 2.8 | 10.1 |
| SK/RA/1982/65 | 14.4 | -- | 9.6 | -- | 1.4 | 9.7 |
| SK/RA/1982/73 | 24.9 | 7 | 14.3 | 0.49 | 2.1 | 8.4 |
| SK/RA/1982/73a | 22.3 | 5.9 | 13.1 | 0.45 | 2 | 8.9 |
| SK/RA/1982/73b | 22.9 | 5.2 | 13.6 | 0.38 | 2.1 | 9.1 |
| SK/RA/1982/73c | 19.4 | 4.2 | 8.1 | 0.51 | 2.1 | 10.8 |
| SK/RA/1982/74a | 21.6 | 4 | 12.5 | 0.32 | 2 | 9.2 |
| SK/RA/1982/74b | 24.7 | -- | 15.1 | -- | 1.9 | 7.7 |
| SK/RA/1982/74c | 20 _{est} | 5.9 | 13 _{est} | 0.45 _{est} | 1.7 | 8.5 |
| SK/RA/1982/76 | 34.9 | 4 | 20 | 0.2 | 2.3 | 6.6 |
| SK/RA/1984/103 | 29.9 | 3.6 | 16.4 | 0.22 | 2 | 6.7 |
| SK/RA/2000/143b | 31.9 | 4.6 | 13.8 | 0.33 | 2.8 | 8.8 |
| SK/EB/1985/3 | 22.5 | 5.6 | 15.6 | 0.36 | 2 | 8.9 |
| SK/EB/1985/4a | 27 | 3.4 | 16.1 | 0.21 | 1.6 | 5.9 |
| SK/EB/1985/4b | 15.9 | 2.5 _{est} | 9 | 0.28 | 1.3 | 8.2 |
| SK/EB/1985/6 | 25.5 | -- | 15.9 | -- | 1.8 | 7 |
| SK/EB/2000/23 | 35.4 | 5.7 | 19.7 | 0.29 | 1.6 | 5.9 |
| SK/EB/2000/24 | 30 | -- | 18.2 | -- | 2.2 | 7.3 |
| SK/EB/2003/28 | 37.5 | -- | 23.2 | -- | 2.5 | 6.7 |
| SK/EB/2003/29 | 16.2 | 3.4 | 9.4 | 0.36 | 1.2 | 7.4 |
| SK/EB/2009/46 | 26.2 | -- | 14.2 | -- | 1.8 | 6.8 |
| SK/EB/2011/53 | 31.5 | 5.8 | 18.8 | 0.31 | 1.8 | 5.7 |
| SK/EB/2012/55 | 29.6 | -- | 17.1 | -- | 2 | 8.8 |
| SK/EB/2012/56 | 21.9 | 3.4 | 11.5 | 0.29 | 1.3 | 5.9 |
| SK/EB/2013/57 | 27.8 | 6.5 | 15.5 | 0.41 | 1.3 | 4.6 |
| SK/EB/2013/63 | 38.2 | -- | 20.3 | -- | 2.2 | 5.7 |
| SK/EB/2013/70 | 24.2 | 5.3 | 13.1 | 0.4 | 1.3 | 5.4 |
| SK/EB/2013/74 | 50.2 | 3.4 | 21 | 0.16 | 3.8 | 7.6 |
| NHMW 1982/0032/0001 | 27.0 _{est} | -- | 16.0 _{est} | -- | 2.2 | 8.1 |
| NHMW 1982/0036/0001 | 26.7 | 4.1 | 15.3 | 0.26 | 2 | 7.5 |
| NHMW 1983/0034/0002 | 25.7 | 4.1 | 16.6 | 0.24 | 2 | 7.8 |

| | | | | | | |
|---------------------|------|-----|------|------|-----|-----|
| NHMW 1983/0035/0001 | 31.6 | 3.7 | -- | -- | -- | -- |
| NHMW 2010/0355/0030 | 26.2 | -- | 14.8 | -- | 2.2 | 8.4 |
| NHMW 2014/0138/0001 | 45 | 6.3 | 25.5 | 0.24 | 2.8 | 6.2 |
| NHMW 2014/0138/0002 | 26.9 | -- | 15 | -- | 2.4 | 8.9 |
| NHMW 2010/0300/0030 | 25.1 | -- | 15.1 | -- | 2.3 | 9.1 |

Tab. 16.

Eulophoceras natalense HYATT, 1903. U % of D. Microconchs.

the Randobach site (SK/RA/1982/73a-d: Pl. 23, Fig. 14) are pyritised. Parts of the sutures are frequently exposed. Specimens from Lower Austria (Markt Piesting, Thalgasse) are preserved with brittle yellowish or rusty shell without sutures in shaly sandstone (there are no macroconchs from Piesting).

Microconchs and juvenile macroconchs of *Eulophoceras natalense* generally measure between 20 and 30 mm (see Table 16) in diameter and are coarsely ornamented. The general outline is discoidal, compressed or highly compressed. The venter is fastigiate with an entire sharp keel which continues to the aperture. The whorls overlap almost completely leaving a very small umbilicus which decreases in diameter through ontogeny. The steep umbilical wall passes without a distinct umbilical edge into the flank. The flanks are gently convex with the greatest breadth at mid-flank. The ventrolateral margin is markedly accentuated by the ornament. Body chambers are preserved in many cases. The sculpture of the adult microconchs weakens or is lost on the adult body chamber. Despite minor *post mortem* deformation measurements (Tabs. 14–16) are still valid.

Microconch ("*Hemitissotia randoi*" type) ornament is variable and dominated by approximately 16 or more strongly bi-convex ribs per whorl. They arise at the umbilical shoulder singly or in pairs with or without an incipient bulla. They strengthen progressively across the flanks, are feebly concave and prorsiradiate on inner flanks, flexing back in a 90° geniculation at mid-flank and are markedly concave on the outer flank, projecting forwards and strengthening on the outermost flank and linking to a low, flat, more-or-less triangular ventrolateral tubercle. Ribbing weakens and is lost in most individuals at a diameter of 27–30 mm. Some juvenile individuals appear to have smooth or near smooth flanks, anticipating the adult ornament.

Change of ornament during ontogeny

Change of ornament from "*Hemitissotia randoi*" type to *Eulophoceras natalense* type during the ontogeny of single individuals can be observed in a number of specimens: SK/RA/1983/86 (Pl. 22, Figs. 1, 2), or SK/RA/1981/31 (Pl. 22, Fig. 4) and NHMW 1983/0034/0002 (Pl. 22, Fig. 5) at a diameter of approximately 27–30 mm (Pl. 21, Figs. 3, 11); others are poorly ornamented throughout ontogeny (Pl. 23, Fig. 12).

The external sutures are characterised by a wide E/A and elongate folioles (for the sutures see Text-Figures 13a, b).

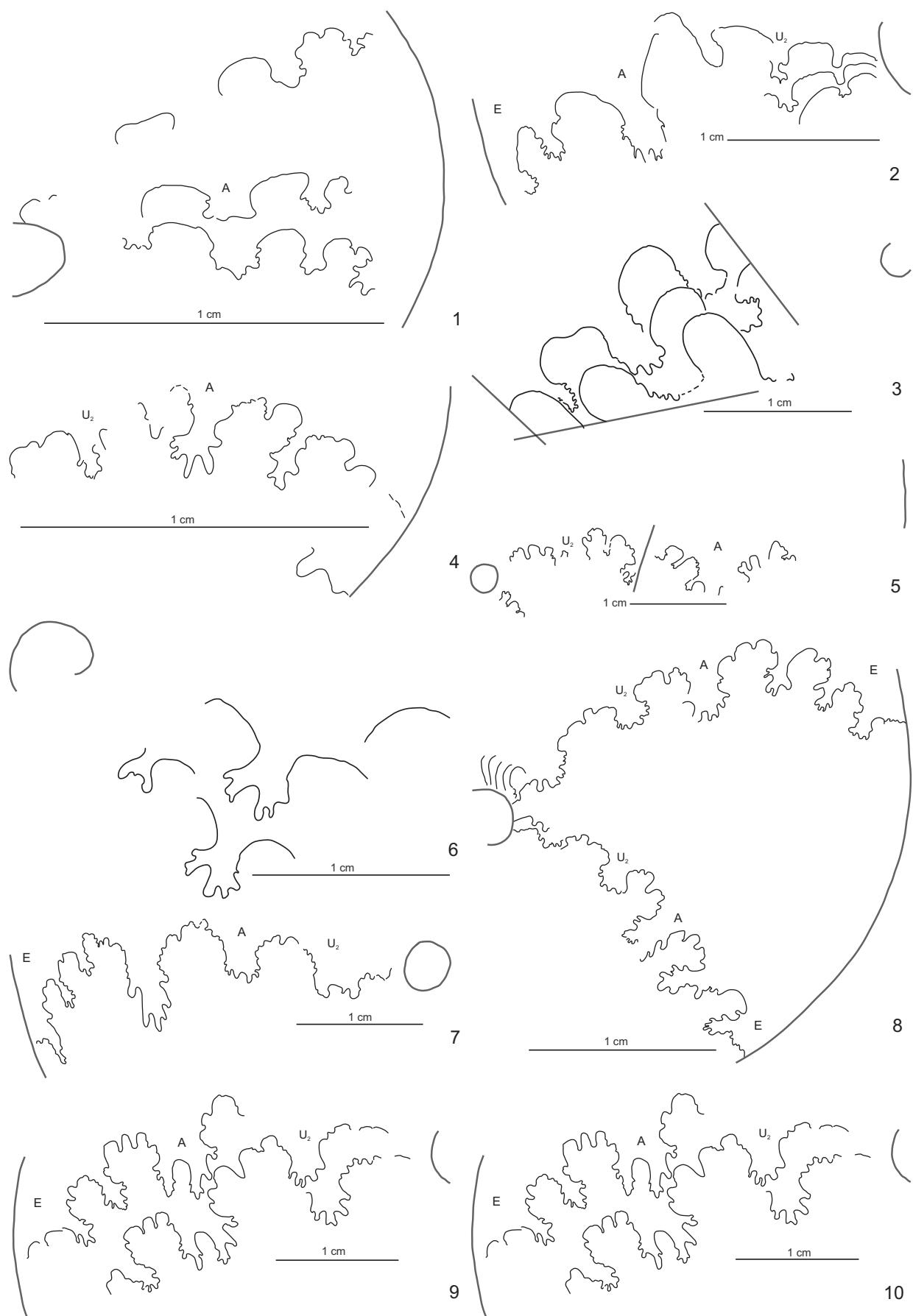
Discussion: *Hemitissotia randoi* (microconch) and *Eulophoceras natalense* (macroconch) is thus a dimorphic pair. Their spe-

cific identity based upon morphological details is supported by the co-occurrence of macroconchs, microconchs and subadult macroconchs at several localities. All of the South African representatives of *Eulophoceras* described to date are macroconchs, in marked contrast to the Austrian occurrences. They were discussed recently by KENNEDY & KLINGER (2012a). As they noted, *Eulophoceras* species have been differentiated chiefly on the basis of minute differences in the sutures. SPATH (1922: 145) expressed his doubts concerning VAN HOEPEN's 'species' of *Pelecodiscus* (= *Eulophoceras*); in spite of this, he went on to introduce several new species of *Sphenodiscoceras* (= *Eulophoceras*), based on a manuscript by the late G.C. Crick. YOUNG (1963: 126) noted the variability of sutures (see Text-Figures 13a, b) within species or even within individuals (see Text-Figures 13a, b). COOPER (1988: 209–210) placed all of the South African 'species' in the synonymy of *Eulophoceras natalense*, as did KENNEDY in KENNEDY et al. (1995: 426) and KENNEDY & KLINGER (2012a: 33, Figs. 5–11, 12A–C). Differences between *E. natalense*, *E. jacobi* HOURCQ, 1949, *E. bererense* HOURCQ, 1949, *E. vautrini* BASSE 1954, *E. wollmanae* YOUNG 1963, and *E. losaense* SANTAMARIA ZABALA, 1995, are discussed in detail by KENNEDY & KLINGER (2012a: 35). *E. natalense* from the Lower Santonian of Brandenberg (BSP 1981 I 109: IMMEL et al., 1982: Pl. 8, Fig. 5) can best be compared with the specimens from Windischgarsten (Austria; Pl. 19, Fig. 3) and the Gosau Basin (Pl. 19, Fig. 4).

The late Santonian *Diaziceras austriacum* (SUMMESBERGER, 1979) (= *Skoumalia austriaca*, form A of SUMMESBERGER, 1979), (see KENNEDY & KLINGER (2012b) differs from *Eulophoceras natalense* in its wider umbilicus and the presence of small, widely separated bullae on the ventrolateral shoulders, whereas co-occurring *Eulophoceras jacobi* HOURCQ, 1949 (= *Skoumalia austriaca* SUMMESBERGER, 1979, form B), also of late Santonian age and originally thought to be the dimorphic partner of *Diaziceras austriacum* differs from *E. natalense* in its tiny and prorsiradiate ventrolateral bullae.

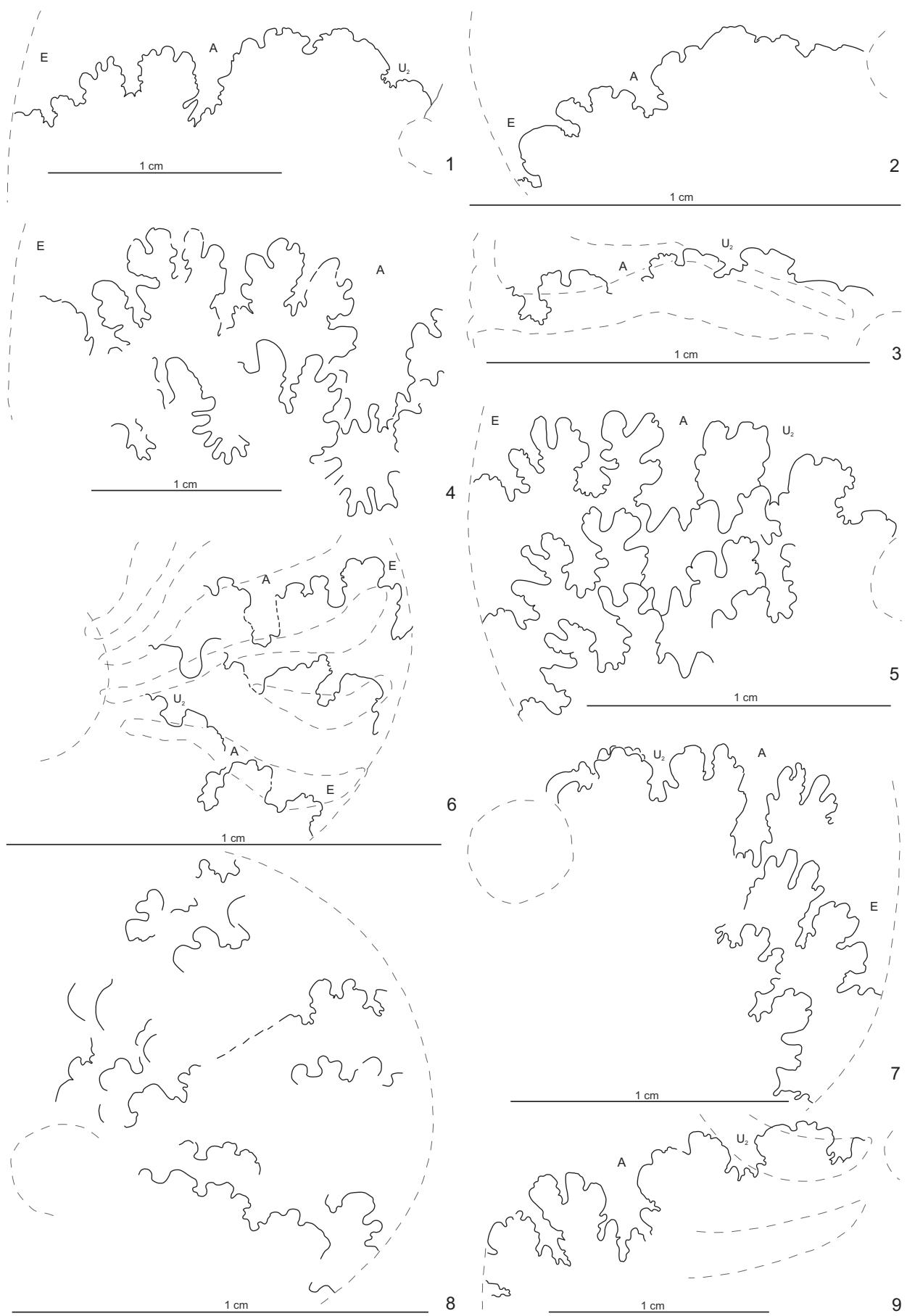
Eulophoceras wollmanae YOUNG, 1963 (Pl. 72, Fig. 5, Pl. 74, Figs. 1, 3–6) differs in its greater whorl breadth and occluded umbilicus.

Occurrence: All Austrian Gosau Group occurrences of *Eulophoceras natalense* HYATT, 1903 are of early Santonian date: Brandenberg (Tyrol; IMMEL et al., 1982), Windischgarsten (Upper Austria), Edlbachgraben (Gosau, Upper Austria) and Grabenbach (Gosau, Upper Austria). Randobach 3, the type area of "*Hemitissotia randoi*" GERTH, 1961 and the Stöcklwaldgraben, a tributary of the Randobach (TRÖGER & SUMMESBERGER, 1994), are located in Rußbach (Salzburg). The occurrence of Markt Piesting (Lower Austria) is equally of early Santonian age. Elsewhere in Europe *E. natalense*



Text-Fig. 13a.

External sutures of *Eulophoceras natalense* HYATT, 1903. Fig. 1: NHMW 1982/0032/0001, Fig. 2: NHMW 2014/0105/0001, Fig. 3: NHMW 2014/0139/0001, Fig. 4: SK/EB/1985/1, Fig. 5: NHMW 2014/0139/0002, Fig. 6: NHMW 2014/0139/0003, Fig. 7: SK/EB/1987/13a, Fig. 8: SK/EB/2000/13b, Fig. 9: SK/EB/2000/18, Fig. 10: SK/EB/2000/19.



Text-Fig. 13b.

External sutures of *Eulophoceras natalense* HYATT, 1903: Fig. 1: SK/EB/2000/22, Fig. 2: SK/RA/1981/1c, Fig. 3: SK/RA/1981/1e, Fig. 4: SK/RA/1981/29, Fig. 5: SK/RA/1982/73a, Fig. 6: SK/RA/1981/31, Fig. 7: SK/RA/1983/86, Fig. 8: SK/RA/1982/74a, Fig. 9: SK/SG/2000/31a.

is described from the Santonian of the Corbières in southern France (KENNEDY in KENNEDY et al., 1995). In Africa *E. natalense* occurs in the late Santonian to early Campanian Mzamba Formation of the Mzamba Estuary in Eastern Cape Province and northern KwaZulu-Natal in South Africa and in the early Campanian of Angola (COOPER, 1988). The stratigraphic range of *Eulophoceras natalense* is thus from the early Santonian through early Campanian, with an acme in the Santonian.

Biostratigraphical subdivision of the Santonian Gosau Group

The Santonian part of the Gosau Group corresponds to the *Placenticeras polyopsis* Zone. It can be divided into three sub-zones as follows:

1) *Eulophoceras natalense* Subzone (early Santonian).

Eulophoceras natalense HYATT, 1903 appears together with *Nowakites savini* DE GROSSOUPRE, 1894, *Texanites quinqueradialis* (REDTENBACHER, 1873) and *Cladoceramus undulatoplicatus* (ROEMER, 1852).

Texanites quinqueradialis appears at the base of the Santonian and extends, together with *M. gosauicum*, from Randobach 2 to about 20 m below the base of the Sandkalkbank Member in the Neffgraben. The highest specimen was found above the confluence of the „Elliptica“ Graben with the Neffgraben (GERTH, 1961: Figs. 3, 4). *Texanites quinqueradialis* does not occur in the Sandkalkbank Member. Texanitids are represented in the Sandkalkbank Member by *Reginaites gappi* WIEDMANN, 1978. The absence of Campanian members of the family (e.g. *Submortoniceras*) in the Gosau Group may be a reflection of facies changes (see WAGREICH & MARSCHALKO, 1995).

2) *Muniericeras gosauicum* Subzone (middle Santonian).

Muniericeras gosauicum (HAUER, 1852) occurs abundantly together with *Texanites quinqueradialis* (REDTENBACHER, 1873), *Parapuzosia corbarica* (DE GROSSOUPRE, 1894) and *Baculites* sp. at the Randobach 2 site and extends through the Grabenbach Formation (Neffgraben/Rußbach) together with *Texanites quinqueradialis*.

3) *Placenticeras paraplanum* Subzone (late Santonian).

Placenticeras paraplanum (WIEDMANN, 1978) occurs together with abundant *Placenticeras polyopsis* (DUJARDIN, 1837), *Boehmoceras krekelei* (WEGNER, 1905) and *Boehmoceras arculus* (MORTON, 1834) (see SUMMESBERGER, 1979, 1980).

Systematic conclusions

Hauericeras (*Gardeniceras*) aff. *gardeni* is described and is a close relative of *Hauericeras* (*G.*) *gardeni* (BAILY, 1855). We follow KENNEDY (1986) and KENNEDY & KLINGER (2006) in the interpretation of *Pseudomenuites katschthaleri* IMMEL et al. (1982) from the early Santonian of Brandenberg (Tyrol) as the microconch of *Eupachydiscus isculensis* (REDTENBACHER, 1873). An additional microconch individual from the middle Santonian of Schneiderwirtsbrücke (Pl. 10, Fig. 3) confirms this interpretation. The dominating faunal element *Muniericeras gosauicum* (HAUER, 1858) is redescribed and shown to be a highly variable dimorphic species. *Hemitissotia randoi* GERTH, 1961 is shown to be based on the microconch of *Eulophoceras natalense* HYATT, 1903.

Revised list of Nautiloids and non-heteromorph Ammonites described by IMMEL et al. (1982) and IMMEL (1987) from the early Santonian of Mühlbach/Brandenberg (Tyrol)

? *Cimomia* cf. *gosavica* (REDTENBACHER, 1873)

Cymatoceras sp.

Hyporbulites woodsi (VAN HOEPEN, 1921)

Gaudryceras mite (REDTENBACHER, 1873)

Gaudryceras ex gr. denseplicatum JIMBO, 1894

Gaudryceras sp. indet.

Anagaudryceras redtenbacheri (IMMEL et al., 1982), juv.

? *Anagaudryceras* cf. *subtililineatum* (KOSSMAT, 1895)

Saghalinites nuperus (VAN HOEPEN, 1921)

Parapuzosia (*Parapuzosia*) *daubreei* (DE GROSSOUPRE, 1894)

Parapuzosia (*Parapuzosia*) *corbarica* (DE GROSSOUPRE, 1894)

Parapuzosia sp. indet.

Damesites sugata (FORBES, 1846)

Hauericeras (*Hauericeras*) *pseudogardeni* (SCHLÜTER, 1872)

Hauericeras (*Gardeniceras*) aff. *gardeni* BAILY, 1855

Kossmaticeras (*Kossmaticeras*) cf. *sparsicostatum* (KOSSMAT, 1897)

Nowakites carezi (DE GROSSOUPRE, 1894)

Nowakites carezi (DE GROSSOUPRE, 1894), juv. (REDTENBACHER, 1873)

Patagiosites stobaei (NILSSON, 1827)

Eupachydiscus isculensis (REDTENBACHER, 1873), microconch

Texanites (*Texanites*) *quinqueradialis* (REDTENBACHER, 1873)

Paratexanites serratomarginatus (REDTENBACHER, 1873)

Eulophoceras natalense HYATT, 1903

Revised plate explanations for IMMEL et al. (1982: Pls. 1–11), excluding the heteromorphs

Plate 1

- Figs. 1, 2: *Cymatoceras sharpei* (SCHLÜTER) → *Cymatoceras* sp.
 Figs. 3, 4: *Phylloceras* (*Hypophylloceras*) *velledaeforme* (SCHLÜTER) → *Hyporbulites woodsi* (VAN HOEPEN, 1921).
 Fig. 5: *Gaudryceras* ex gr. *denseplicatum* (YABE) → *recte*:
Gaudryceras ex gr. *denseplicatum* JIMBO, 1894.
 Fig. 6: *Gaudryceras* sp. → *Gaudryceras* sp. indet.
 Fig. 7: *Anagaudryceras* cf. *subtililineatum* (KOSSMAT) → ?
Anagaudryceras cf. *subtililineatum* (KOSSMAT, 1895).

Plate 2

- Figs. 1, 2: *Saghalinites* aff. *wrighti* BIRKELUND → *Saghalinites* *nuperus* (VAN HOEPEN, 1921).
 Figs. 3a, b,
 4a, b: *Pseudophyllites latus* (MARSHALL) → *Saghalinites* *nuperus* (VAN HOEPEN, 1921).
 Fig. 5: *Kitchinites stenomphalus* SUMMESBERGER → *Nowakites carezi* (DE GROSSOUPRE, 1894).
 Fig. 6: *Damesites* cf. *compactus* (VAN HOEPEN) → *Damesites* *sugata* (FORBES, 1846).
 Fig. 7: *Damesites* sp. → *Damesites* *sugata* (FORBES, 1846).
 Fig. 8: ?*Mesopuzosia* sp. indet. → *Parapuzosia* sp. indet.
 Fig. 9: *Parapuzosia daubreei* (DE GROSSOUPRE) → *Parapuzosia* (*P.*) *daubreei* (DE GROSSOUPRE, 1894).
 Fig. 10: *Parapuzosia daubreei* (DE GROSSOUPRE) → *Parapuzosia* (*P.*) *corbarica* (DE GROSSOUPRE, 1894).

Plate 3

- Figs. 1, 2: *Parapuzosia daubreei* (DE GROSSOUPRE) → *Parapuzosia* (*P.*) *daubreei* (DE GROSSOUPRE, 1894).
 Fig. 3: *Parapuzosia corbarica* (DE GROSSOUPRE) → *Parapuzosia* (*P.*) *corbarica* (DE GROSSOUPRE, 1894).

Plate 4

- Fig. 1: *Parapuzosia corbarica* (DE GROSSOUPRE) → *Parapuzosia* (*P.*) *corbarica* (DE GROSSOUPRE, 1894).
 Fig. 2: *Parapuzosia daubreei* (DE GROSSOUPRE) → *Parapuzosia* (*P.*) *daubreei* (DE GROSSOUPRE, 1894).
 Fig. 3: ?*Mesopuzosia yubarensis* (JIMBO) → *Parapuzosia* (*P.*) *daubreei* (DE GROSSOUPRE, 1894).
 Fig. 4: *Desmophyllites* cf. *larteti* (SEUNES) → *Hauericeras* (*H.*) *pseudogardeni* (SCHLÜTER, 1872).

Plate 5

- Figs. 1–4: *Hauericeras gardeni* (BAILY) → *Hauericeras* (*Gardericeras*) aff. *gardeni* (BAILY, 1855).
 Fig. 5: *Kossmaticeras* (*Kossmaticeras*) cf. *sparsicostatum* (KOSSMAT) → *Kossmaticeras* (*Kossmaticeras*) cf. *sparsicostatum* (KOSSMAT, 1897).
 Fig. 6: *Patagiosites patagiosus* (SCHLÜTER) → *Patagiosites* sp.
 Fig. 7: *Patagiosites redtenbacheri* n. sp. → *Anagaudryceras redtenbacheri* (IMMEL et al., 1982), juv.

Plate 6

- Fig. 1: *Hauericeras gardeni* (BAILY) → *Hauericeras* (*Gardericeras*) aff. *gardeni* (BAILY, 1855).
 Figs. 2–4: *Hauericeras gardeni* (BAILY) → *Hauericeras* (*Gardericeras*) aff. *gardeni* (BAILY, 1855).
 Figs. 5–7: *Patagiosites redtenbacheri* n. sp. → *Anagaudryceras redtenbacheri* (IMMEL et al., 1982).

Plate 7

- Fig. 1: *Patagiosites redtenbacheri* n. sp. → *Anagaudryceras redtenbacheri* (IMMEL et al., 1982).
 Figs. 2–5: *Pseudomenites katschthaleri* n. sp. → *Eupachydiscus isculensis* (REDTENBACHER, 1873), microconch.
 Figs. 6, 7: *Menites sturi* (REDTENBACHER) → *Patagiosites strobæi* (NILSSON, 1827).
 Fig. 8: *Eupachydiscus isculensis* (REDTENBACHER) → *Nowakites carezi* (DE GROSSOUPRE, 1894), juv.
 Figs. 9–11: *Eupachydiscus isculensis* (REDTENBACHER) → *Eupachydiscus isculensis* (REDTENBACHER, 1873).

Plate 8

- Figs. 1–4: *Eupachydiscus isculensis* (REDTENBACHER) → *Eupachydiscus isculensis* (REDTENBACHER, 1873), macroconch.
 Fig. 5: *Eulophoceras natalense* HYATT → *Eulophoceras natalense* HYATT, 1903.
 Fig. 6: *Paratexanites serratomarginatus* (REDTENBACHER) → *Paratexanites serratomarginatus* (REDTENBACHER, 1873).

Plate 9

- Fig. 1: *Texanites quinquerodatus* (REDTENBACHER) → *Texanites* (*T.*) *quinquerodatus* (REDTENBACHER, 1873).
 Fig. 2: *Neocrioceras* (*Neocrioceras*) *maderi* n. sp.; not revised.
 Fig. 3: *Neocrioceras* (*Schlüterella*) *compressum* KLINGER; not revised.
 Figs. 4, 5: *Diplomoceras* (*Glyptoxoceras*) *subcompressum* (FORBES); not revised.

Plate 10

- Figs. 1–4: *Neocrioceras* (*Schlüterella*) *compressum* KLINGER; not revised.
 Figs. 5, 6: *Diplomoceras* (*Glyptoxoceras*) *indicum* (FORBES) → *Glyptoxoceras crispatum* (MOBERG, 1885).
 Fig. 7: *Diplomoceras* (*Glyptoxoceras*) *subcompressum* (FORBES); not revised.

Plate 11

- Figs. 1, 2: *Neocrioceras* (*Neocrioceras*) *maderi* n. sp. → not revised.
 Fig. 3: *Neocrioceras* (*Neocrioceras*) *compressum* KLINGER; not revised.
 Fig. 4: *Diplomoceras* (*Glyptoxoceras*) *subcompressum* (FORBES); not revised.
 Figs. 5–7: *Baculites incurvatus* DUJARDIN; not revised.
 Fig. 8: *Baculites fuchsii* REDTENBACHER; not revised.

List of early and middle Santonian Nautiloids and non-heteromorph Ammonoids from the Austrian Gosau Group

| | | |
|--|----|--|
| <i>Angulithes westphalicus</i> (SCHLÜTER, 1876) | 10 | Pl. 1, Figs. 1–3, Pl. 2, Figs. 1–3, Pl. 3, Figs. 4–5, Pl. 4, Figs. 1–3, Tab. 1 |
| <i>Cymatoceras</i> sp. | 11 | Pl. 4, Figs. 4–6 |
| <i>Cymatoceras cf. huxleyanum</i> (BLANFORD, 1861) | 12 | Pl. 3, Figs. 1–3 |
| ? <i>Cimomia</i> cf. <i>gosavica</i> (REDTENBACHER, 1873) | 12 | not figured |
| <i>Nautilidae</i> , gen. et sp. indet., juv. | 13 | Pl. 4, Figs. 7, 8 |
| <i>Hyporbulites woodsi</i> (VAN HOEPEN, 1921) | 13 | Pl. 5, Fig. 1 |
| <i>Anagaudryceras redtenbacheri</i> (IMMEL et al., 1982) | 14 | not figured |
| <i>Anagaudryceras</i> sp. | 14 | Pl. 5, Fig. 2, Tab. 2 |
| ? <i>Anagaudryceras</i> cf. <i>subtililineatum</i> (KOSSMAT, 1895) | 14 | not figured |
| <i>Gaudryceras mite</i> (HAUER, 1866) | 15 | not figured |
| <i>Gaudryceras</i> sp. indet. 1 | 16 | not figured |
| <i>Gaudryceras</i> sp. indet. 2 | 16 | not figured |
| <i>Saghalinites nuperus</i> (VAN HOEPEN, 1921) | 16 | Pl. 5, Figs. 3–10 |
| <i>Jimboiceras</i> cf. <i>reyi</i> COLLIGNON, 1983 | 17 | Pl. 6, Figs. 1–4, 6, 7, Text-Fig. 4, Tab. 3 |
| <i>Parapuzosia</i> (<i>Parapuzosia</i>) <i>daubreei</i> (DE GROSSOUVRE, 1894) | 18 | not figured |
| <i>Parapuzosia</i> (<i>Parapuzosia</i>) <i>corbarica</i> (DE GROSSOUVRE, 1894) | 18 | Pl. 6, Fig. 9, Pl. 9, Fig. 9 |
| <i>Parapuzosia</i> sp. indet. | 19 | not figured |
| <i>Hauericeras</i> (<i>Hauericeras</i>) <i>pseudogardeni</i> (SCHLÜTER, 1872) | 19 | Pl. 6, Fig. 8 |
| <i>Hauericeras</i> (<i>Gardeniceras</i>) <i>aff. gardeni</i> (BAILY, 1855) | 20 | Pl. 6, Fig. 5, Pl. 7, Figs. 1–3, 6–8, Tab. 4 |
| <i>Hauericeras</i> (<i>Gardeniceras</i>) <i>lagarum</i> (REDTENBACHER, 1873) | 21 | Text-Fig. 5 |
| <i>Hauericeras</i> (<i>Gardeniceras</i>) sp. indet. | 21 | Pl. 7, Figs. 4, 5 |
| <i>Damesites sugata</i> (FORBES, 1846) | 22 | Pl. 8, Figs. 1, 2, 4, 5, Text-Fig. 6, Tab. 5 |
| <i>Damesites</i> sp. indet. | 23 | not figured |
| <i>Kossmaticeras</i> (<i>Kossmaticeras</i>) cf. <i>sparsicostatum</i> (KOSSMAT, 1897) | 24 | not figured |
| <i>Nowakites carezi</i> (DE GROSSOUVRE, 1894) | 24 | Pl. 8, Figs. 3, 6, 7, Pl. 9, Figs. 3–5, Tab. 6 |
| <i>Nowakites draschei</i> (REDTENBACHER, 1873) | 25 | Pl. 8, Figs. 8–12, Text-Fig. 7 |
| <i>Nowakites savini</i> (DE GROSSOUVRE, 1894) | 25 | Pl. 9, Figs. 1, 2, Pl. 10, Fig. 1, Tab. 7 |
| <i>Patagiosites?</i> sp. | 26 | not figured |
| <i>Eupachydiscus isculensis</i> (REDTENBACHER, 1873) | 27 | Pl. 9, Figs. 6–8, Pl. 10, Fig. 3 |
| <i>Tragodesmoceras</i> aff. <i>clypeale</i> (SCHLÜTER, 1872) | 28 | Pl. 10, Figs. 2, 5, Text-Fig. 8, Tab. 8 |
| <i>Muniericeras gosauicum</i> (HAUER, 1858) | 29 | Pl. 11, Figs. 1–13, Pl. 12, Figs. 1–11, Pl. 13, Figs. 1–8, Pl. 14, Figs. 1–3, Pl. 15, Figs. 1–8, Pl. 16, Figs. 1–7, Pl. 17, Figs. 1, 3–9, Text-Figs 9–11, Tab. 9, 10 |
| <i>Texania cricki</i> (SPATH, 1921) | 34 | Pl. 18, Fig. 2, Tab. 11 |
| <i>Pseudoschloenbachia</i> (<i>Pseudoschloenbachia</i>) sp. | 35 | Pl. 18, Fig. 1 |
| <i>Placenticeras paraplanum</i> WIEDMANN, 1978 | 35 | Pl. 10, Fig. 4, Tab. 12 |
| <i>Placenticeras</i> sp. indet. | 36 | not figured |
| <i>Texanites</i> (<i>Texanites</i>) <i>quinquenodosus</i> (REDTENBACHER, 1873) | 36 | Pl. 18, Figs. 3–7, Text-Fig. 12, Tab. 13 |
| <i>Eulophoceras natalense</i> HYATT, 1903 | 37 | Pl. 17, Fig. 2, Pl. 19, Figs. 1–5, Pl. 20, Figs. 1–8, Pl. 21, Figs. 1–11, Pl. 22, Figs. 1–6, Pl. 23, Figs. 1–19, Text-Fig. 13, Tab. 14–16 |

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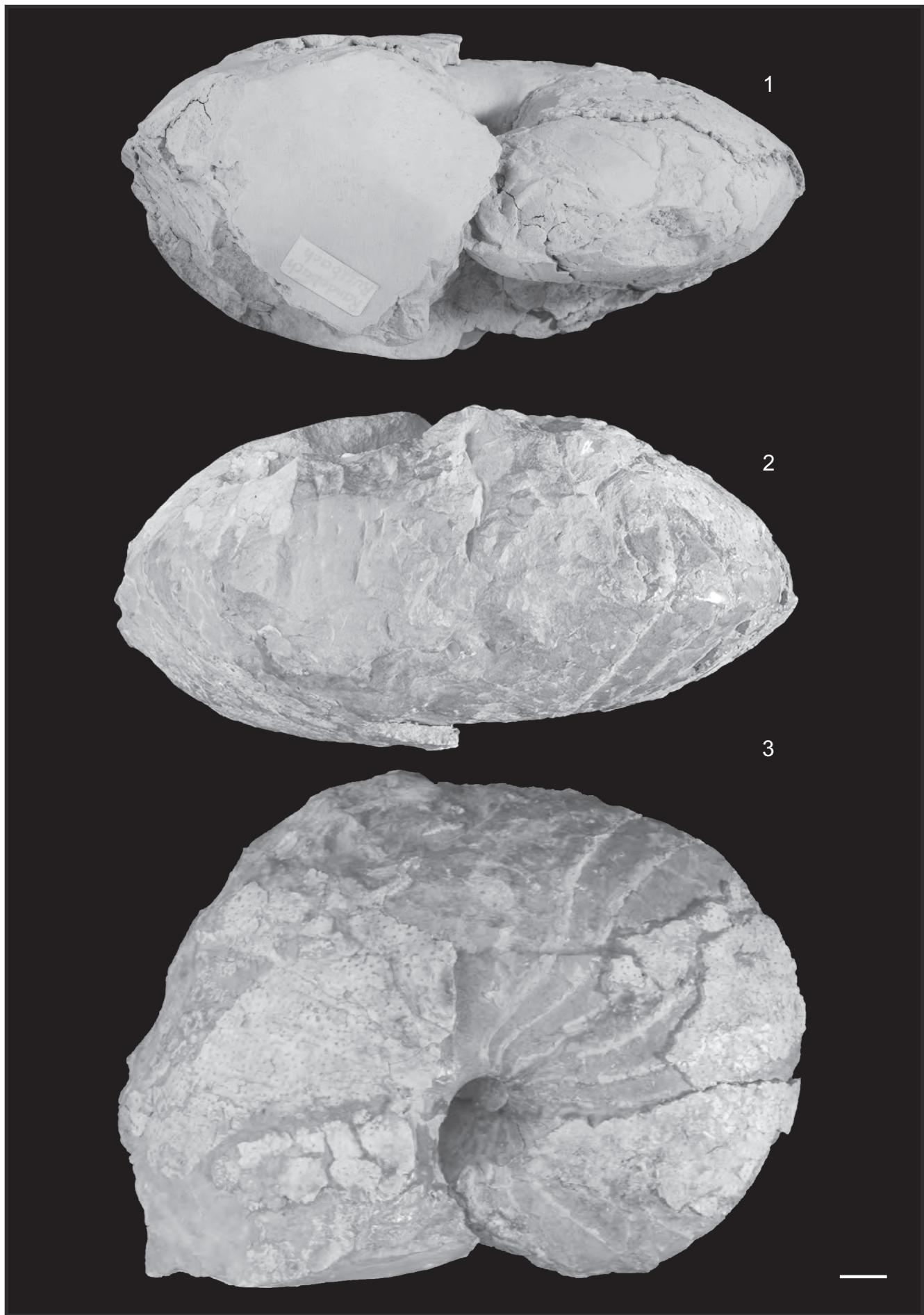
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Plates

Plate 1

Figs. 1–3: *Angulithes westphalicus* (SCHLÜTER, 1876); SIM 1996/1; Randobach, Rußbach, Salzburg. x 0.9

Specimen coated with ammonium chloride.



1

2

3

Plate 2

Figs. 1–3: *Angulithes westphalicus* (SCHLÜTER, 1876); SCH 2012/1; Randobach, Rußbach, Salzburg. x 0.9

Specimen coated with ammonium chloride.



Plate 3

Figs. 1–3: *Cymatoceras cf. huxleyanum* (BLANFORD, 1861); SK/GR/1983/30; Grabenbach, Gosau, Upper Austria. x 2

Figs. 4, 5: *Angulithes westphalicus* (SCHLÜTER, 1876); NHMW 2012/0182/0001; Edlbach, Gosau, Upper Austria. x 0.9

All specimens coated with ammonium chloride.



Plate 4

Figs. 1–3: *Angulithes westphalicus* (SCHLÜTER, 1876); SK/EB/1985/10; Edlbach, Gosau, Upper Austria. x 0.9

Figs. 4–6: *Cymatoceras* sp.; SK/RA/1982/54; Randobach, Rußbach, Salzburg. x 1

Figs. 7, 8: Nautilidae, gen. et sp. indet., juv.; SK/1983/15; Grabenbach, Tauerngraben, Upper Austria. x 2

All specimens coated with ammonium chloride.

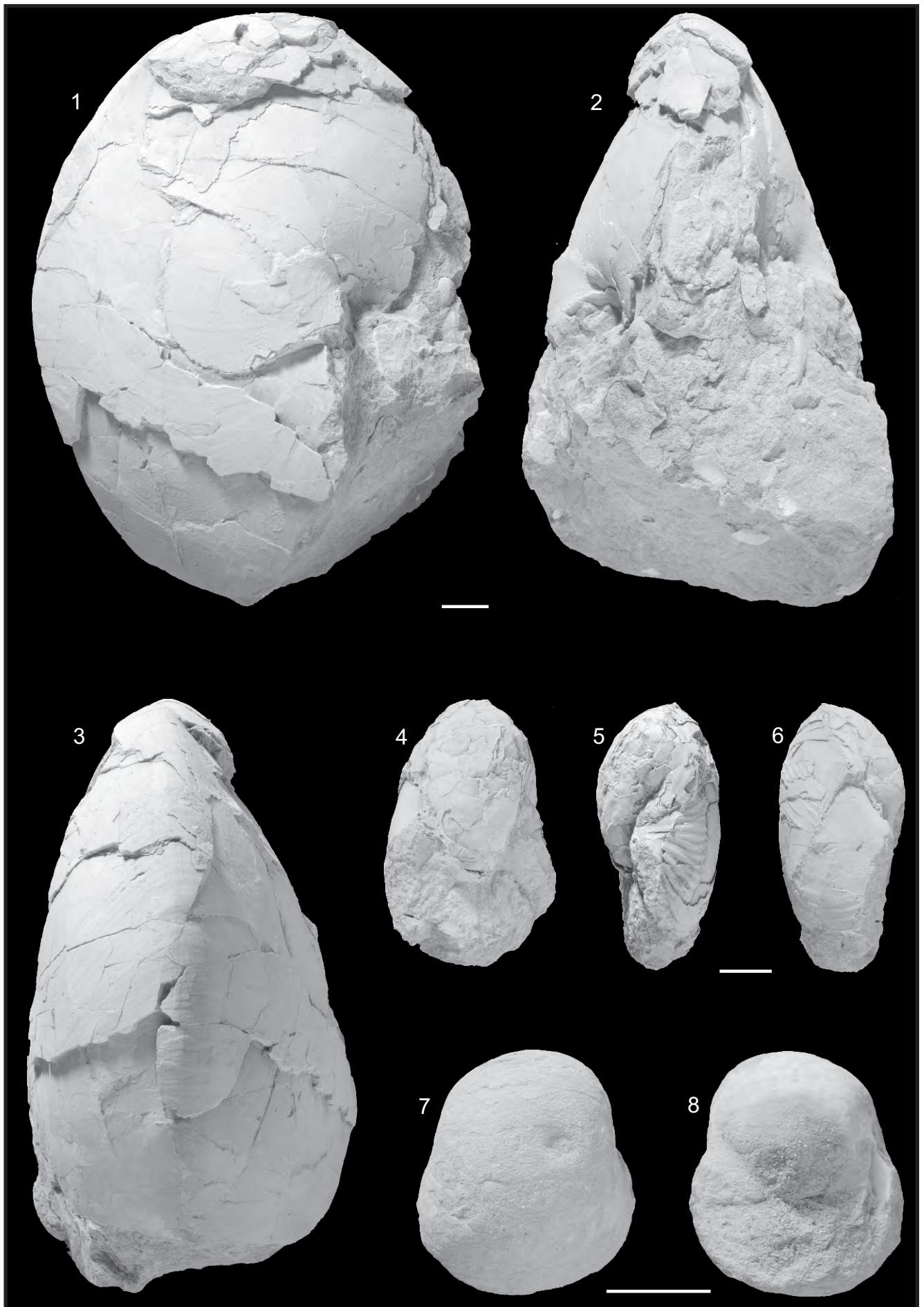


Plate 5

- Fig. 1: *Hyporbulites woodsi* (VAN HOEPEN, 1921); SK/RA/1999/142; Randobach, Rußbach, Salzburg. x 1
- Fig. 2: *Anagaudryceras* sp.; ÖÖLM 2014/10; Gosau Group; no locality details. x 1
- Figs. 3, 4: *Saghalinites nuperus* (VAN HOEPEN, 1921); NHMW 2013/0015/0005; Weißwasser, Unterlaussa, Upper Austria. x 1
- Figs. 5, 6: *Saghalinites nuperus* (VAN HOEPEN, 1921); NHMW 2013/0015/0004; Weißwasser, Unterlaussa, Upper Austria. x 1
- Figs. 7, 10: *Saghalinites nuperus* (VAN HOEPEN, 1921); NHMW 2012/0186/0010; Randobach, Rußbach, Salzburg. x 1
- Figs. 8, 9: *Saghalinites nuperus* (VAN HOEPEN, 1921); NHMW 1982/0035/0001; Edlbach, Gosau, Upper Austria. x 2
- All specimens coated with ammonium chloride.

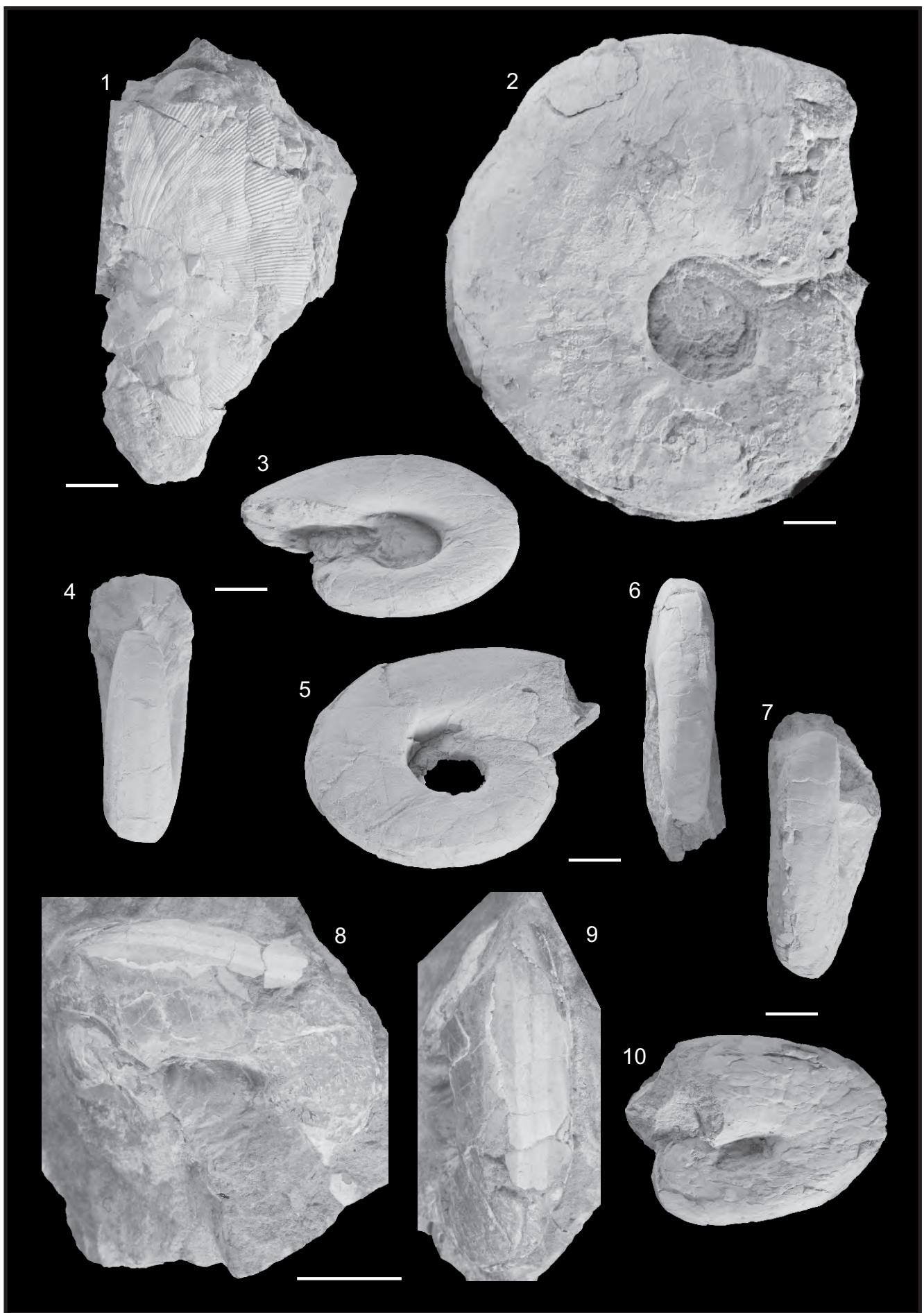


Plate 6

- Figs. 1, 2: *Jimboiceras cf. reyi* COLLIGNON, 1983; NHMW 2013/0015/0002; Blahberg, Unterlaussa, Upper Austria. x 1
- Figs. 3, 4: *Jimboiceras cf. reyi* COLLIGNON, 1983; NHMW 2013/0016/0001; Glanegg castle, Grödig, Salzburg; late Coniacian. x 1
- Fig. 5: *Hauericeras (Gardeniceras) aff. gardeni* (BAILY, 1855); SK/EB/2010/48; Edlbachgraben, Gosau, Upper Austria. x 2
- Figs. 6, 7: *Jimboiceras cf. reyi* COLLIGNON, 1983; NHMW 2013/0015/0001; Breitenberg, Unterlaussa, Upper Austria. x 1
- Fig. 8: *Hauericeras (Hauericeras) pseudogardeni* (SCHLÜTER, 1872); NHMW 2013/0017/0001; Broitzem, Germany; early Campanian. x 1
- Fig. 9: *Parapuzosia (Parapuzosia) corbarica* (DE GROSSOUVRE, 1894); SK/RA/2015/165; Randobach 2, Rußbach, Salzburg; middle Santonian. x 1

All specimens coated with ammonium chloride.

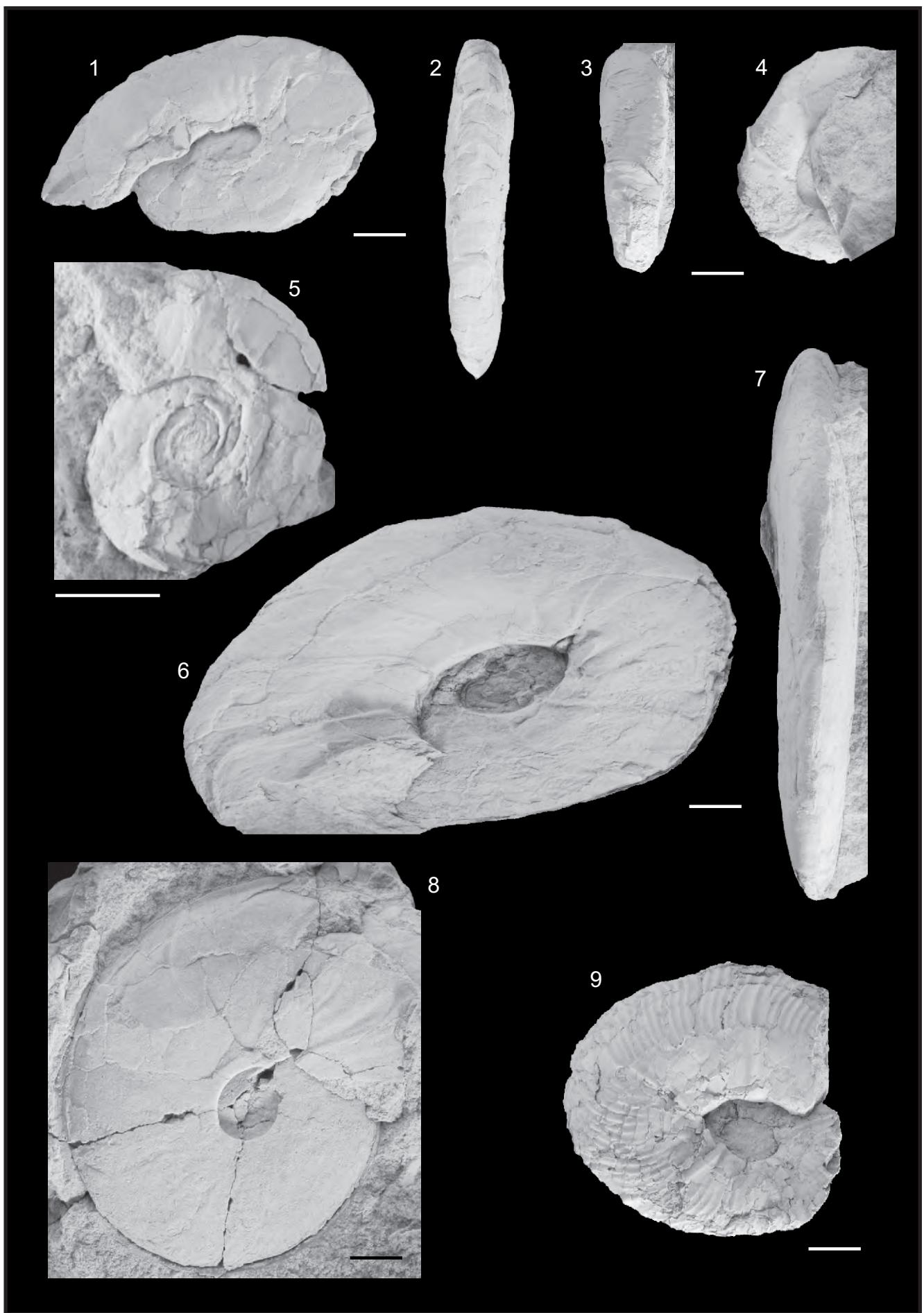


Plate 7

- Fig. 1: *Hauericeras (Gardeniceras) aff. gardeni* (BAILY, 1855); NHMW 2010/0355/0027; Parking area, Hornspitz cable car, Rußbach, Salzburg. x 1
- Fig. 2: *Hauericeras (Gardeniceras) aff. gardeni* (BAILY, 1855); SK/EB/2010/50; Edlbachgraben, Gosau, Upper Austria. x 1
- Fig. 3: *Hauericeras (Gardeniceras) aff. gardeni* (BAILY, 1855); SK/EB/2010/49; Edlbachgraben, Gosau, Upper Austria. x 1
- Fig. 4: *Hauericeras (Gardeniceras)* sp. indet.; NHMW 2013/0015/0003; Weißwasser, Unterlaussa, Upper Austria; Gosau Group, early Santonian. x 1
- Fig. 5: *Hauericeras (Gardeniceras)* sp. indet.; NHMW 2013/0015/0003; Weißwasser, Unterlaussa, Upper Austria; Gosau Group, early Santonian. x 2
- Fig. 6: *Hauericeras (Gardeniceras) aff. gardeni* (BAILY, 1855); SK/EB/2001/26; Edlbachgraben, Gosau, Upper Austria. x 1
- Fig. 7: *Hauericeras (Gardeniceras) aff. gardeni* (BAILY, 1855); SK/EB/2001/27; Edlbachgraben, Gosau, Upper Austria. x 1
- Fig. 8: *Hauericeras (Gardeniceras) aff. gardeni* (BAILY, 1855); SK/GR/1983/35; Grabenbach, Gosau, Upper Austria. x 1

All specimens coated with ammonium chloride.

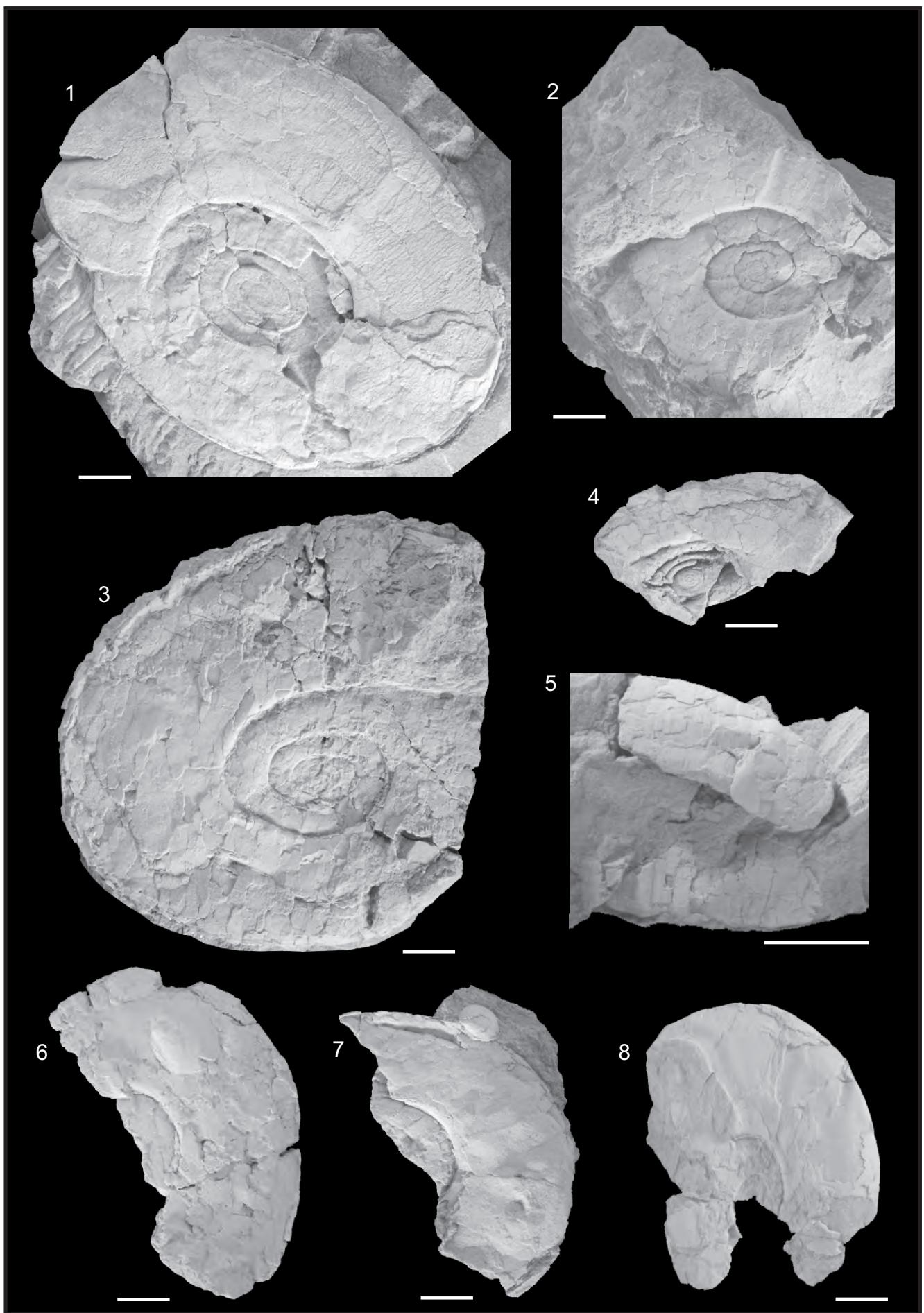


Plate 8

- Figs. 1, 2: *Damesites sugata* (FORBES, 1846); NHMW 2013/0466/0001; Neffgraben, Rußbach, Salzburg; middle Santonian. x 1
- Fig. 3: *Nowakites carezi* (DE GROSSOUVRE, 1894), juv.; NHMW 2013/0466/0002; Neffgraben, Rußbach, Salzburg; middle Santonian. x 1
- Figs. 4, 5: *Damesites sugata* (FORBES, 1846); SK/NE/1991/15; Neffgraben, Rußbach, Salzburg; middle Santonian. x 2
- Figs. 6, 7: *Nowakites carezi* (DE GROSSOUVRE, 1894); NHMW 1861/0001/0192; Randobach, Rußbach, Salzburg. x 1
- Figs. 8, 9: *Nowakites draschei* (REDTENBACHER, 1873); NHMW 2013/0467/0001; Finstergrabenwandl, Gosau, Upper Austria; Hochmoos Formation, late Santonian. x 1
- Figs. 10–12: *Nowakites draschei* (REDTENBACHER, 1873); holotype; OÖLM 1938/30; Neffgraben, Rußbach, Salzburg; middle Santonian. x 1
- All specimens coated with ammonium chloride.

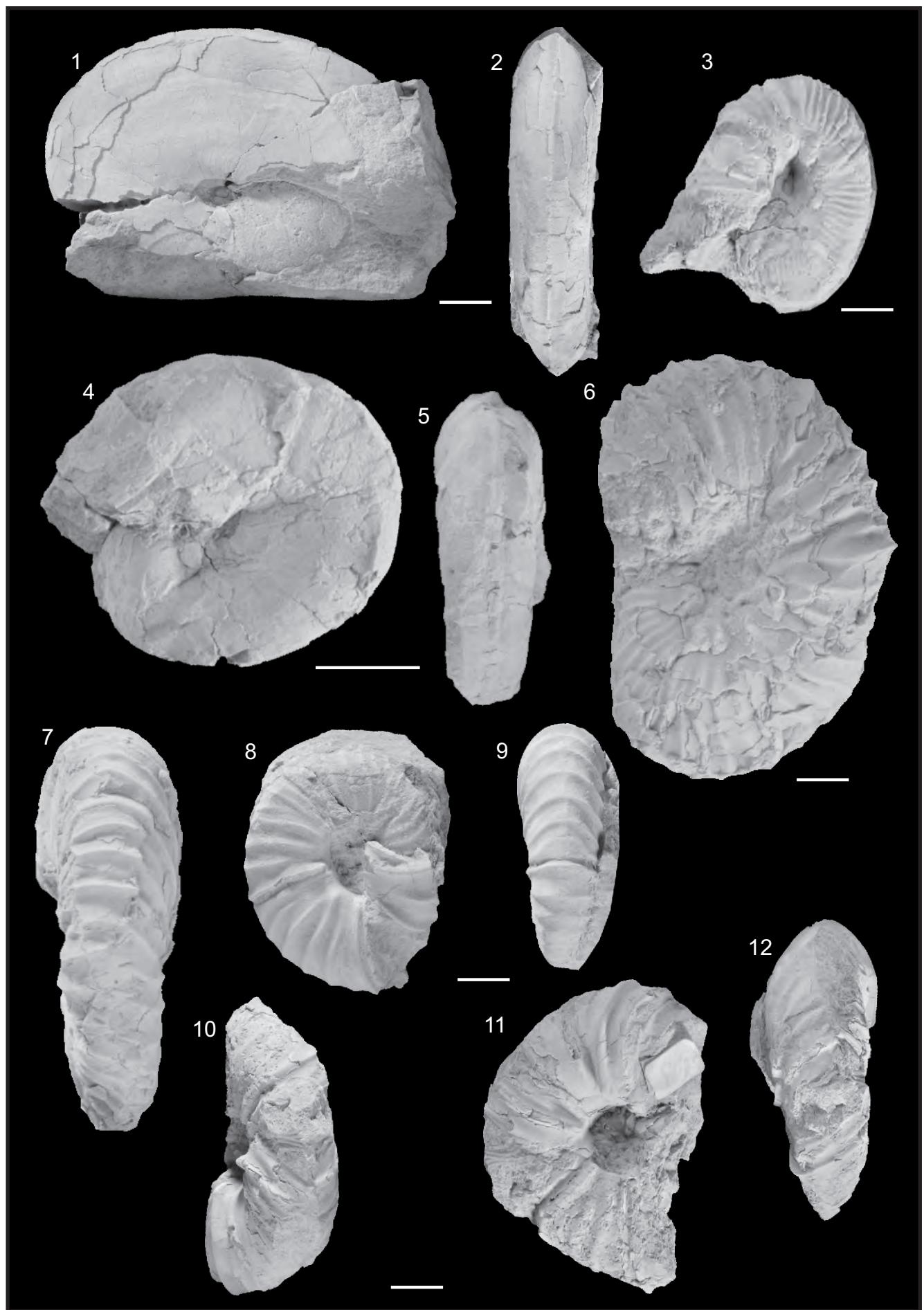


Plate 9

- Figs. 1, 2: *Nowakites savini* (DE GROSSOUPRE, 1894); NHMW 2010/0082/0001; Edlbachgraben, Gosau, Upper Austria; early Santonian. x 1
- Figs. 3, 4: *Nowakites carezi* (DE GROSSOUPRE, 1894); SK/RA/2002/144; Randobach 3, Rußbach, Salzburg; early Santonian. x 1
- Fig. 5: *Nowakites carezi*, juv. (DE GROSSOUPRE, 1894); SK/GR/1993/45; Tauernbach, Gosau, Upper Austria; Santonian. x 2
- Figs. 6–8: *Eupachydiscus isculensis* (REDTENBACHER, 1873); SK/RA/1983/84; Randobach 2, Rußbach, Salzburg; middle Santonian. x 1
- Fig. 9: *Parapuzosia (Parapuzosia) corbarica* (DE GROSSOUPRE, 1894); SK/RA/1982/78; Randobach 2, Rußbach, Salzburg; middle Santonian. x 2

All specimens coated with ammonium chloride.

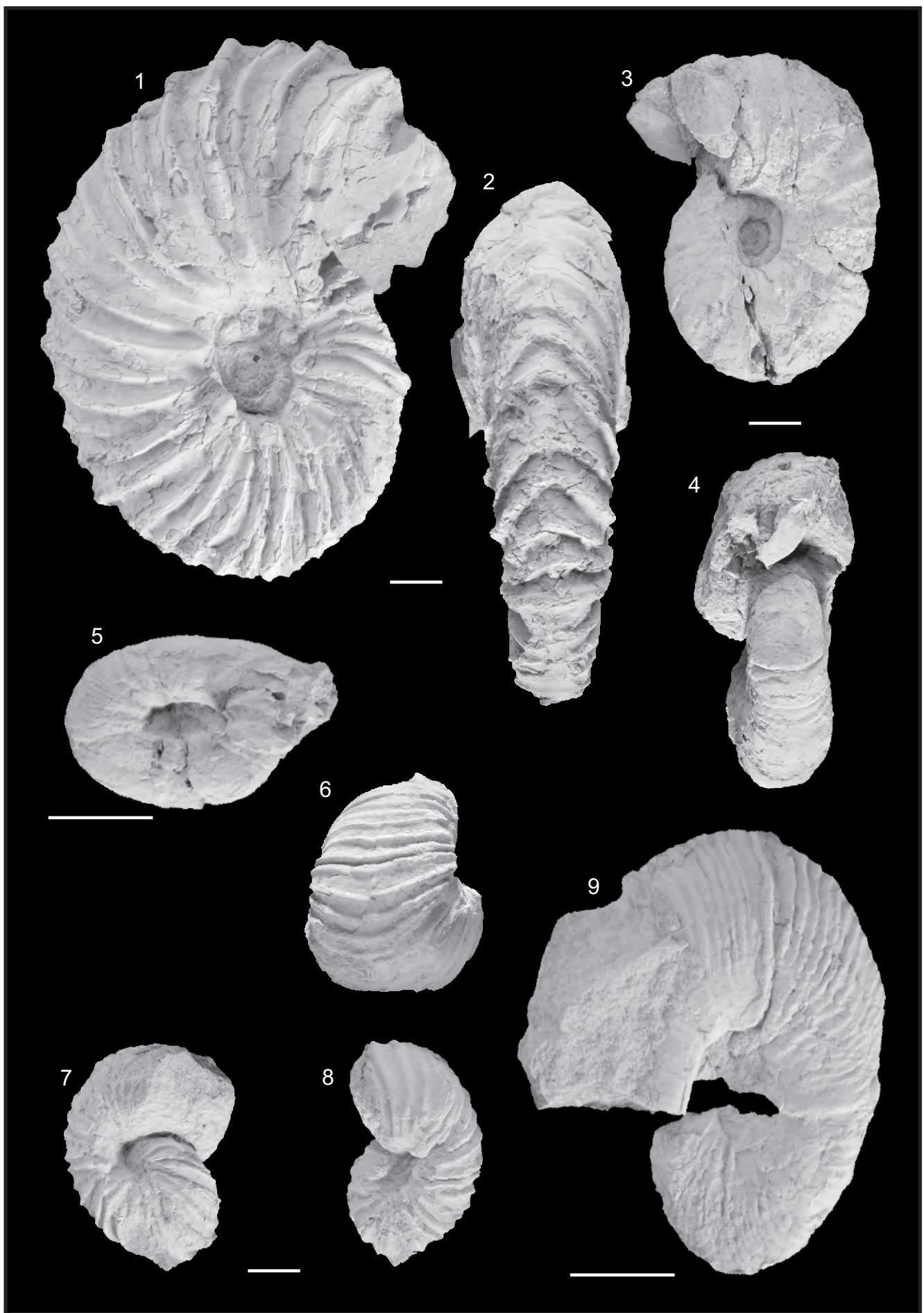


Plate 10

- Fig. 1: *Nowakites savini* (DE GROSSOUIRE, 1894); SK/RA/2014/164; Randobach 3, Rußbach, Salzburg; basal Santonian. x 1
- Fig. 2: *Tragodesmoceras aff. clypeale* (SCHLÜTER, 1872); SK/SB/1989/4; Schneiderwirtsbrücke, Nussenseebach, Salzburg; middle Santonian. x 1
- Fig. 3: *Eupachydiscus isculensis* (REDTENBACHER, 1873); microconch; SK/SB/1989/6; Schneiderwirtsbrücke, Nussenseebach, Salzburg; middle Santonian. x 2
- Fig. 4: *Placenticeras paraplanum* WIEDMANN, 1978; NHMW 2014/0090/0001; Neffgraben, Rußbach, Salzburg; late Santonian, *Paraplanum Zone*. x 1
- Fig. 5: *Tragodesmoceras aff. clypeale* (SCHLÜTER, 1872); SK/RA/1999/140; Randobach 1, Rußbach, Salzburg; middle Santonian. x 1
- All specimens coated with ammonium chloride.

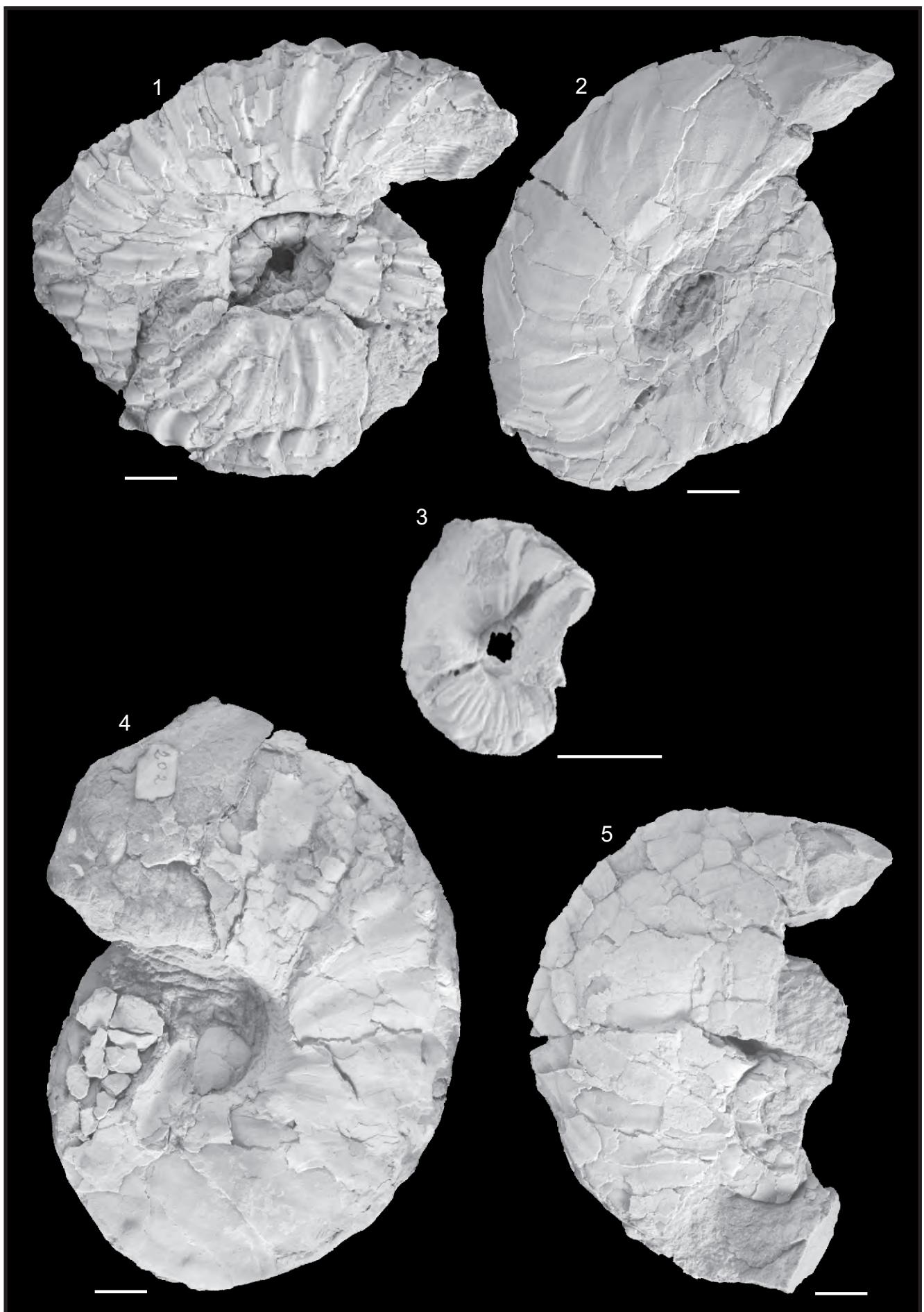


Plate 11

Microconchs of *Muniericeras gosauicum* (HAUER, 1858)

Figs. 1–3: *Muniericeras gosauicum* (HAUER, 1858); neotype; NHMW 2013/0581/0001; ex Coll. Skoumal; Randobach 2, Rußbach, Salzburg; middle Santonian. x 1

Figs. 4, 7, 8: GIUW not registered; Stöckl (Grabenbach 2), Rußbach, Salzburg. x 1

Figs. 5, 6: PIUW not registered; Gosau (possibly Randobach 2), Rußbach, Salzburg; Santonian. x 2

Figs. 9, 11, 12: MA/1977/1; Randobach 2, Rußbach, Salzburg. x 1

Fig. 10: NHMW 2013/0472/0002; Neffgraben, Rußbach, Salzburg. x 1

Fig. 13: SK/GR/1981/15; Grabenbach, Gosau, Upper Austria; middle Santonian. x 1

Figs. 1–3 are uncoated, Figs. 4–13 are coated with ammonium chloride.

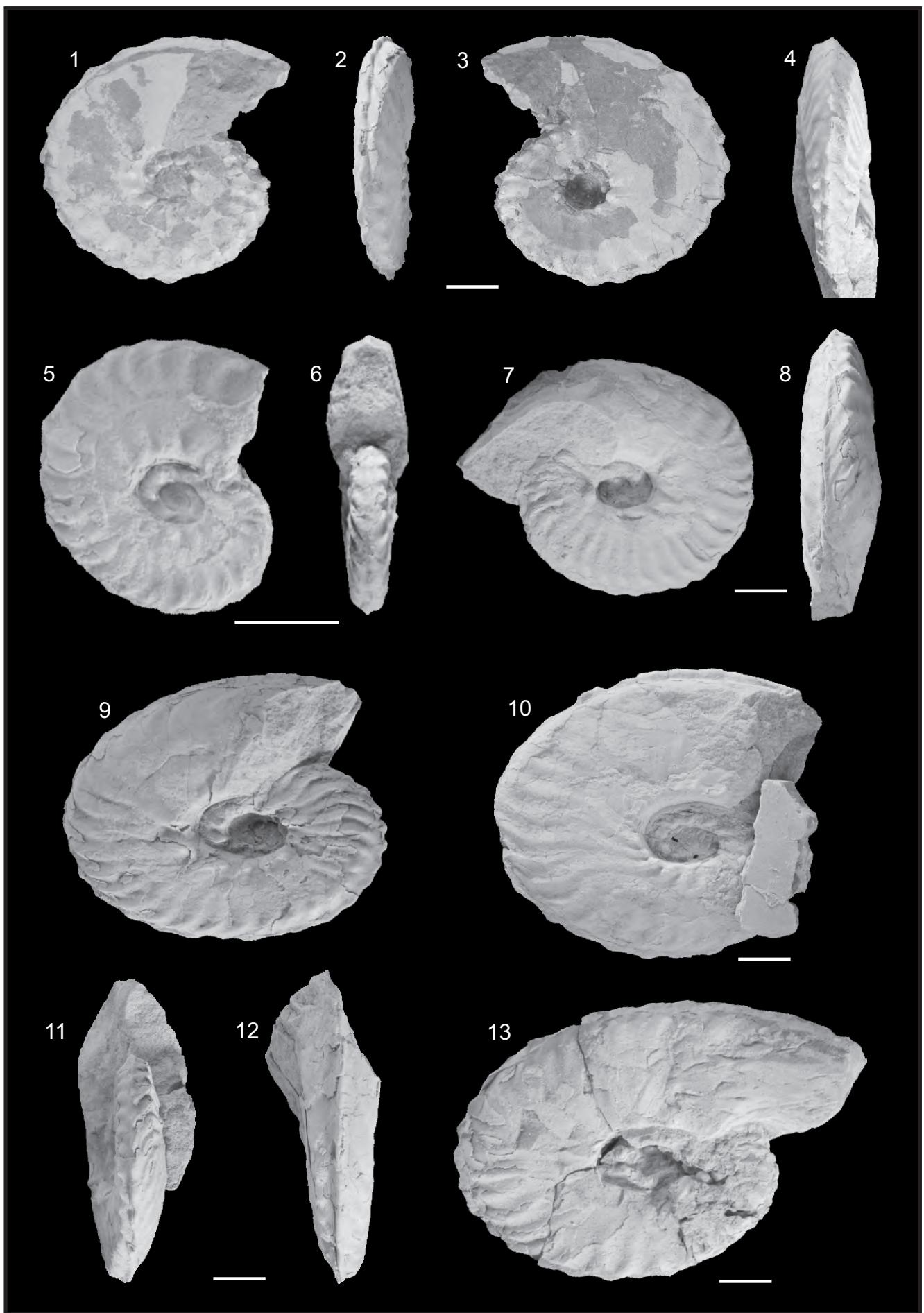


Plate 12

Microconchs of *Muniericeras gosauicum* (HAUER, 1858)

Figs. 1, 2: NHMW 2013/0472/0001; Neffgraben, Rußbach, Salzburg; middle Santonian. x 2

Figs. 3, 6: SK/RA/1981/5; Randobach 2, Rußbach, Salzburg; middle Santonian. x 2

Figs. 4, 5: SK/RA/1981/4; Randobach 2, Rußbach, Salzburg; middle Santonian. x 2

Fig. 7: SK/RA/1981/22; Randobach 1, Rußbach, Salzburg; middle Santonian. x 1

Fig. 8: SK/RA/1982/57; Randobach 2, Rußbach, Salzburg; middle Santonian. x 2

Figs. 9, 10: NHMW/ 2012/0186/0004; Randobach 2; Rußbach, Salzburg; middle Santonian. x 2

Fig. 11: SK/GR/1981/16; Tiefengraben, Gosau, Upper Austria; middle Santonian. x 1

All specimens coated with ammonium chloride.

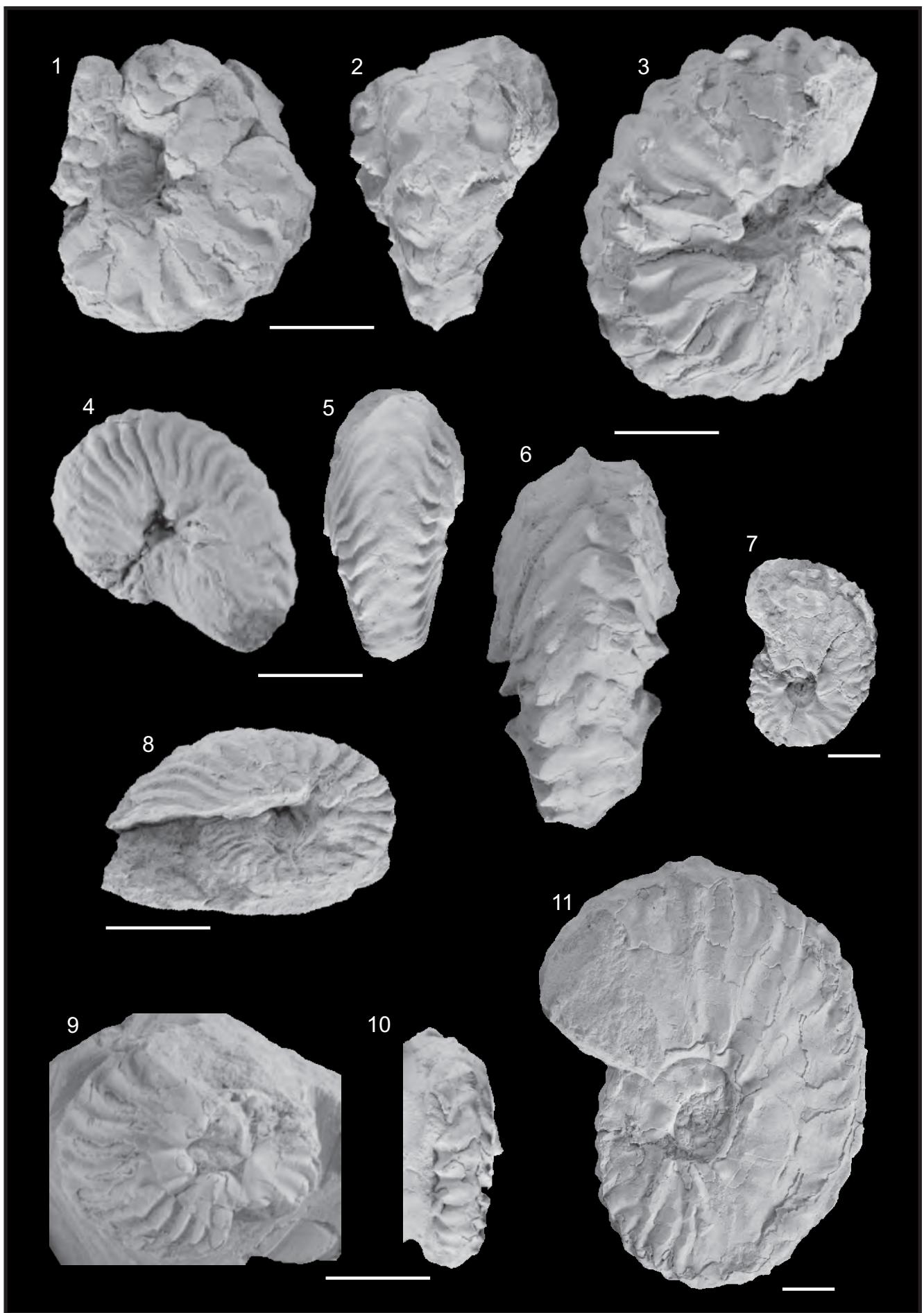


Plate 13

Microconchs of *Muniericeras gosauicum* (HAUER, 1858)

- Fig. 1: SK/NE/1989/9; Neffgraben, 20 m below "elliptica" Graben, Rußbach, Salzburg. x 2
- Figs. 2, 3: SK/RA/1997/132; Randobach 1, Rußbach, Salzburg. x 1
- Figs. 4, 5: SK/RA/1999/142; Randobach 1, Rußbach, Salzburg. x 1
- Fig. 6: SK/RA/2003/147; Randobach 2, Rußbach, Salzburg. x 1
- Fig. 7: SK/RA/1982/48; Randobach 2, Rußbach, Salzburg. x 1
- Fig. 8: SK/RA/1990/121; Randobach 1, Rußbach, Salzburg. x 1

All specimens are from the middle Santonian and coated with ammonium chloride.



Plate 14

Macroconchs of *Muniericeras gosauicum* (HAUER, 1858)

Fig. 1: SK/RA/1981/11; lateral view, coated with ammonium chloride.

Fig. 2: SK/RA/1981/11; lateral view, last whorl partially removed, uncoated to show sutures and change of keel ornament.

Fig. 3: SK/RA/1981/11; ventral view, coated with ammonium chloride.

All specimens are from middle Santonian, from the Randobach 1 site and figured x 0.9.



Plate 15

Macroconchs of *Muniericeras gosauicum* (HAUER, 1858)

- Fig. 1: SK/RA/1982/51; Randobach 1, Rußbach, Salzburg.
- Fig. 2: SK/RA/1982/56; Randobach 2, Rußbach, Salzburg.
- Fig. 3: SK/RA/1982/50; Randobach 1, Rußbach, Salzburg.
- Fig. 4: SK/RA/1981/34; Randobach 1, Rußbach, Salzburg.
- Fig. 5: SK/RA/1981/34; Randobach 1, Rußbach, Salzburg.
- Fig. 6: SK/RA/1986/107; Randobach 1, Rußbach, Salzburg.
- Fig. 7: SK/GR/2002/47; Grabenbach, Gosau, Upper Austria.
- Fig. 8: SK/GR/1981/19; Grabenbach, Gosau, Upper Austria.

All specimens are from the middle Santonian, coated with ammonium chloride and figured x 1.



Plate 16

Macroconchs of *Muniericeras gosauicum* (HAUER, 1858)

Figs. 1, 2: SK/RA/1983/81; Randobach 2, Rußbach, Salzburg.

Figs. 3, 6: SK/RA/1982/77; Randobach 2, Rußbach, Salzburg.

Figs. 4, 7: SK/RA/1982/53; Randobach 2, Rußbach, Salzburg.

Fig. 5: SK/RA/1997/131; Randobach 2, Rußbach, Salzburg.

All specimens are from the middle Santonian, are coated with ammonium chloride and figured x 1.



Plate 17

Fig. 1: SK/NE/1989/5; Neffgraben, Rußbach, Salzburg. x 1

Fig. 2: NHMW 2010/0300/0030; parking site, Rußbach, Salzburg. x 2

Figs. 3, 4, 6: SK/RA/1984/109; Randobach 2, Rußbach, Salzburg. x 1

Fig. 5: SK/RA/1982/80; Randobach 2, Rußbach, Salzburg. x 1

Fig. 7: SK/RA/1982/46; Randobach 2, Rußbach, Salzburg. x 1

Fig. 8: SK/RA/1988/115; Randobach 1, Rußbach, Salzburg. x 1

Fig. 9: SK/RA/1981/10; Randobach 1, Rußbach, Salzburg. x 1

Figs. 1, 3–9 are macroconchs of *Muniericeras gosauicum* (HAUER, 1858), Fig. 2 is a juvenile of *Eulophoceras natalense* HYATT, 1903.
All specimens are coated with ammonium chloride.

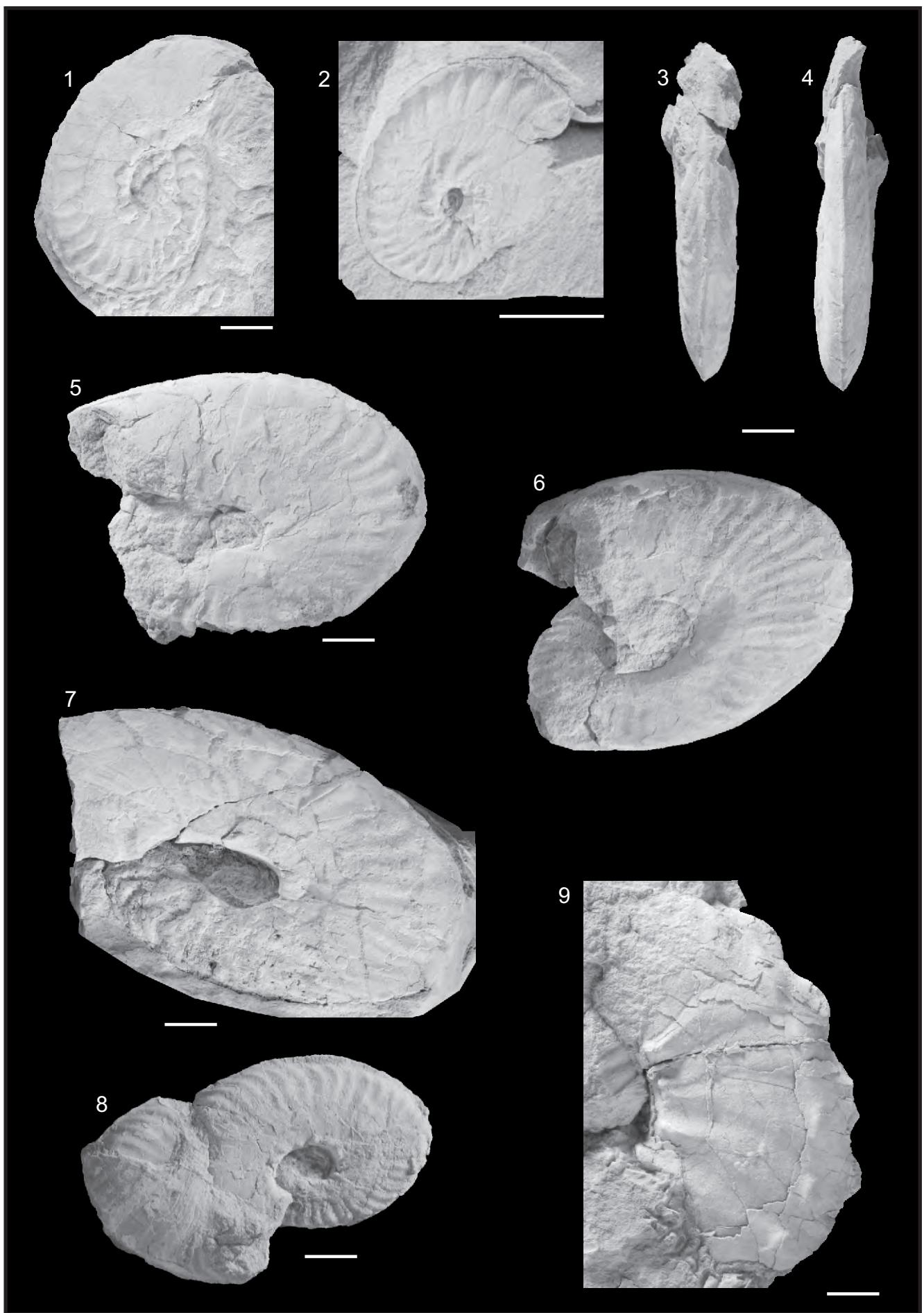


Plate 18

- Fig. 1: *Pseudschloenbachia (Pseudschloenbachia)* sp. NHMW 1982/0031/0001; Randobach 2, Rußbach, Salzburg. x 1
- Fig. 2: *Texasia cricki* (SPATH, 1921); SEIDL/CE 00002; Randobach 3, Rußbach, Salzburg; early Santonian. x 1
- Figs. 3–5: *Texanites quinque nodosus* (REDTENBACHER, 1873); SK/NE/1990/14; Neffgraben, Rußbach, Salzburg; middle Santonian. x 1
- Fig. 6: *Texanites (T.) quinque nodosus* (REDTENBACHER, 1873), juv.; SK/RA/1981/19; Randobach 1, Rußbach; middle Santonian. x 1.5
- Fig. 7: *Texanites (T.) quinque nodosus* (REDTENBACHER, 1873); NHMW 2015/0031/0001; Neffgraben, Rußbach, Salzburg; middle Santonian. x 1

All specimens are coated with ammonium chloride.

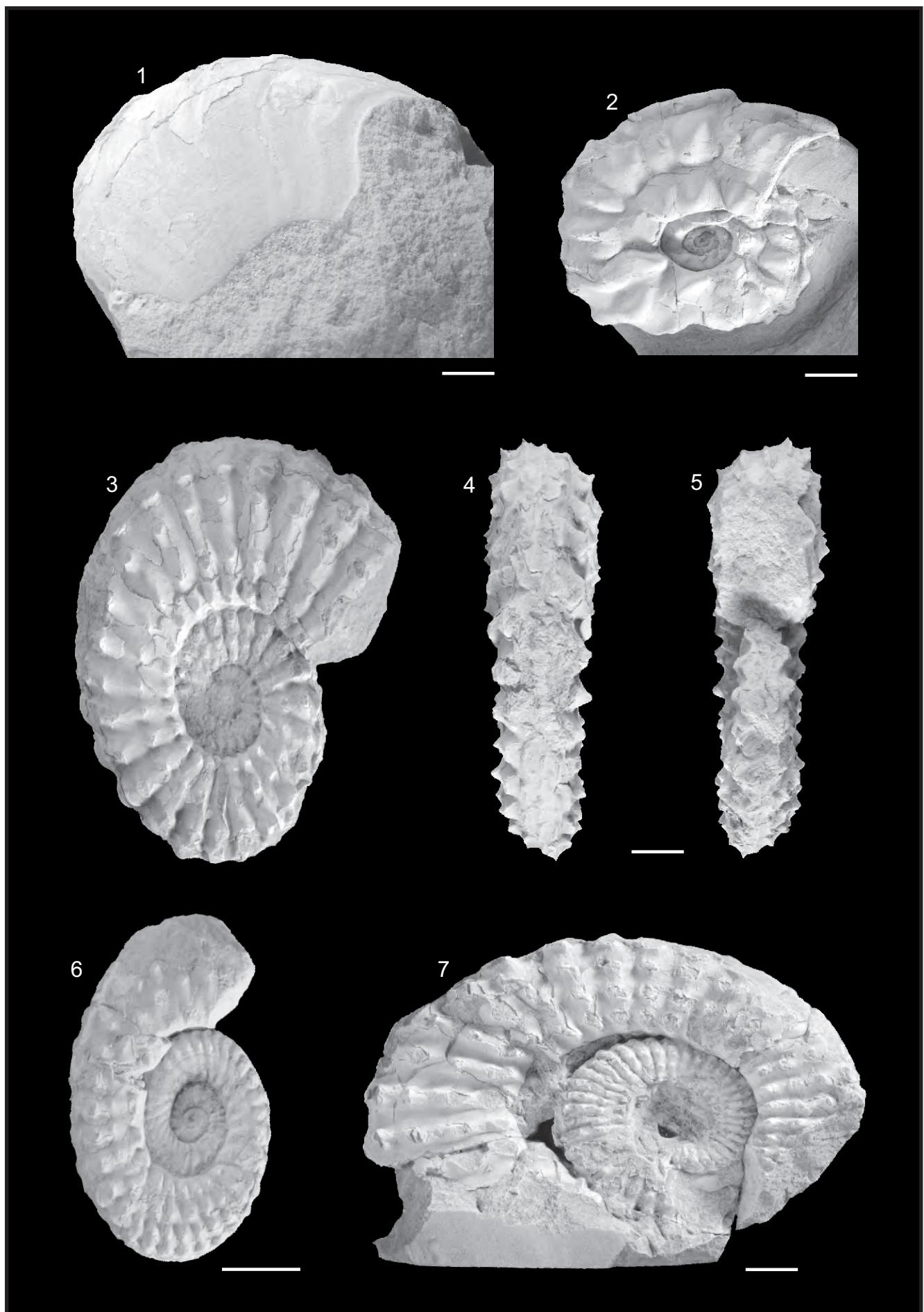


Plate 19

Eulophoceras natalense HYATT, 1903

Fig. 1: SK/EB/1987/13b; Edlbachgraben, Gosau, Upper Austria. x 1

Fig. 2: SK/RA/1981/31; Randobach, Rußbach, Salzburg. x 2

Fig. 3: NHMW 2014/0139/0001; Windischgarsten, Upper Austria. x 1

Fig. 4: SK/EB/2011/51; Edlbachgraben, Gosau, Upper Austria. x 1

Fig. 5: SK/EB/2013/70; Edlbachgraben, Gosau, Upper Austria. x 2

All specimens are early Santonian. Figs. 1 and 2 are uncoated, Figs. 3–5 are coated with ammonium chloride.

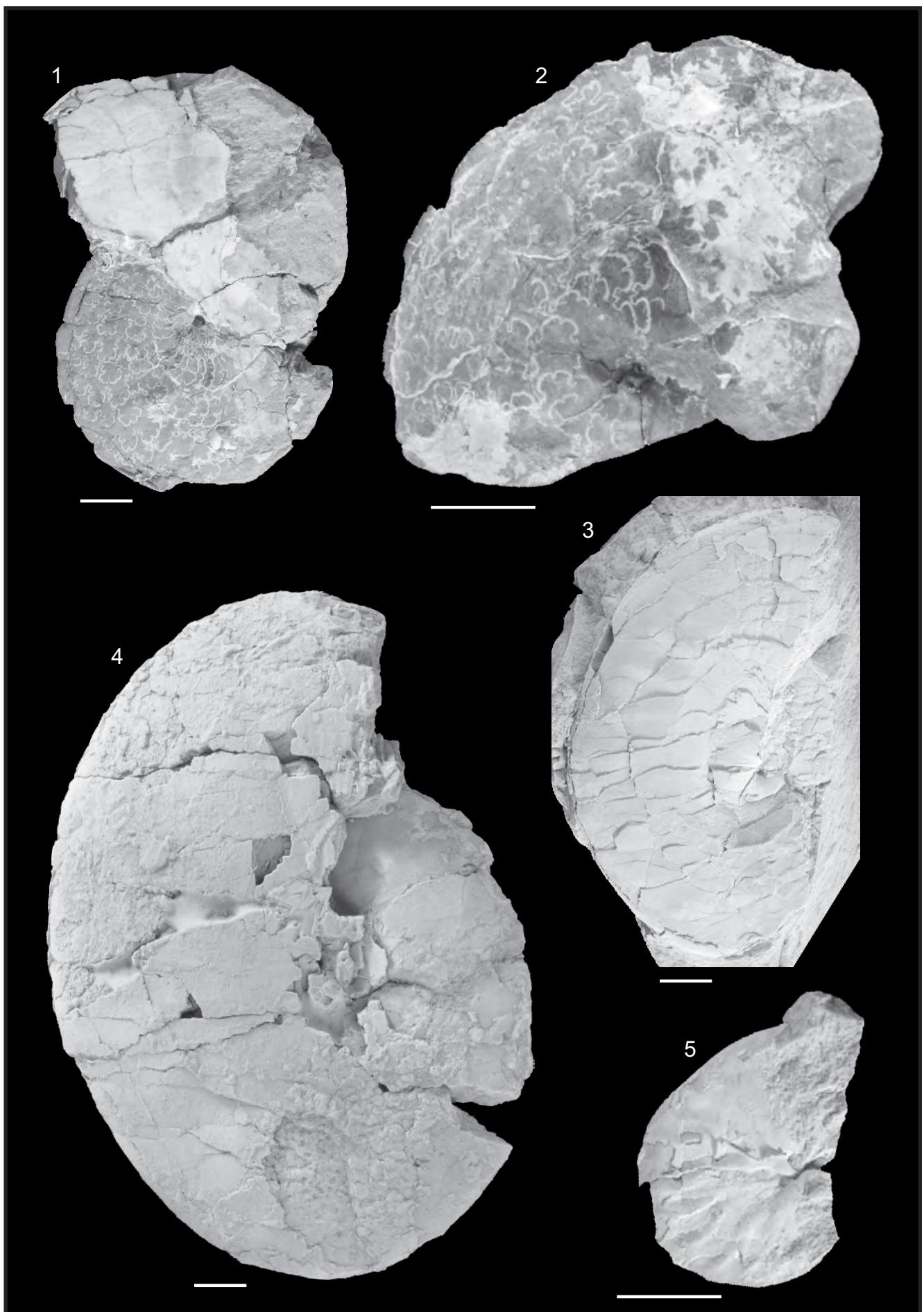


Plate 20

Eulophoceras natalense HYATT, 1903

- Fig. 1: SK/EB/2004/35; Edlbachgraben, Gosau, Upper Austria.
- Fig. 2: MA/1975/1; Edlbachgraben, Gosau, Upper Austria.
- Figs. 3, 4: SK/EB/1987/13a; Edlbachgraben, Gosau, Upper Austria.
- Fig. 5: NHMW 1983/0034/0002; Randobach, Rußbach, Salzburg.
- Fig. 6: SK/EB/2000/21; Edlbachgraben, Gosau, Upper Austria.
- Figs. 7, 8: SK/EB/1992/14; Edlbachgraben, Gosau, Upper Austria.

All specimens are early Santonian, are coated with ammonium chloride and figured x 1.

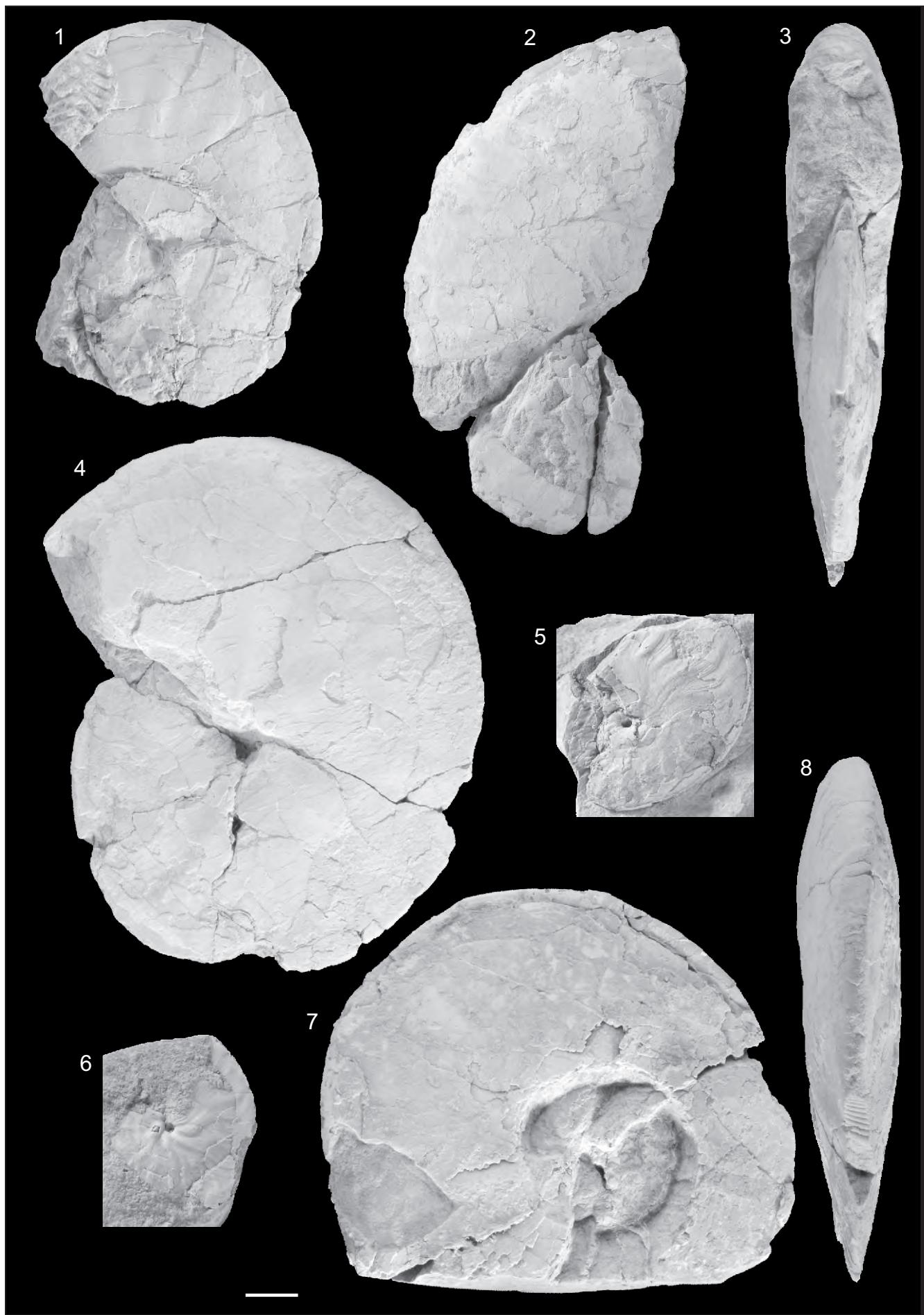


Plate 21

Eulophoceras natalense HYATT, 1903

- Figs. 1, 5: SK/EB/2013/63; Edlbachgraben, Gosau, Upper Austria. x 1
- Fig. 2: SK/EB/2000/24; Edlbachgraben, Gosau, Upper Austria. x 2
- Fig. 3: SK/EB/2012/55; Edlbachgraben, Gosau, Upper Austria. x 2
- Fig. 4: SK/RA/1982/76; Randobach, Rußbach, Salzburg. x 2
- Fig. 6: SK/RA/1981/29; Randobach, Rußbach, Salzburg. x 1
- Fig. 7: SK/EB/2009/46; Edlbachgraben, Gosau, Upper Austria. x 2
- Fig. 8: SK/EB/2012/55; Edlbachgraben, Gosau, Upper Austria. x 2
- Fig. 9: SK/EB/1985/2; Edlbachgraben, Gosau, Upper Austria. x 2
- Fig. 10: SK/EB/2003/29; Edlbachgraben, Gosau, Upper Austria. x 2
- Fig. 11: SK/RA/2000/143b; Randobach, Rußbach, Salzburg. x 2

All specimens are early Santonian and are coated with ammonium chloride.

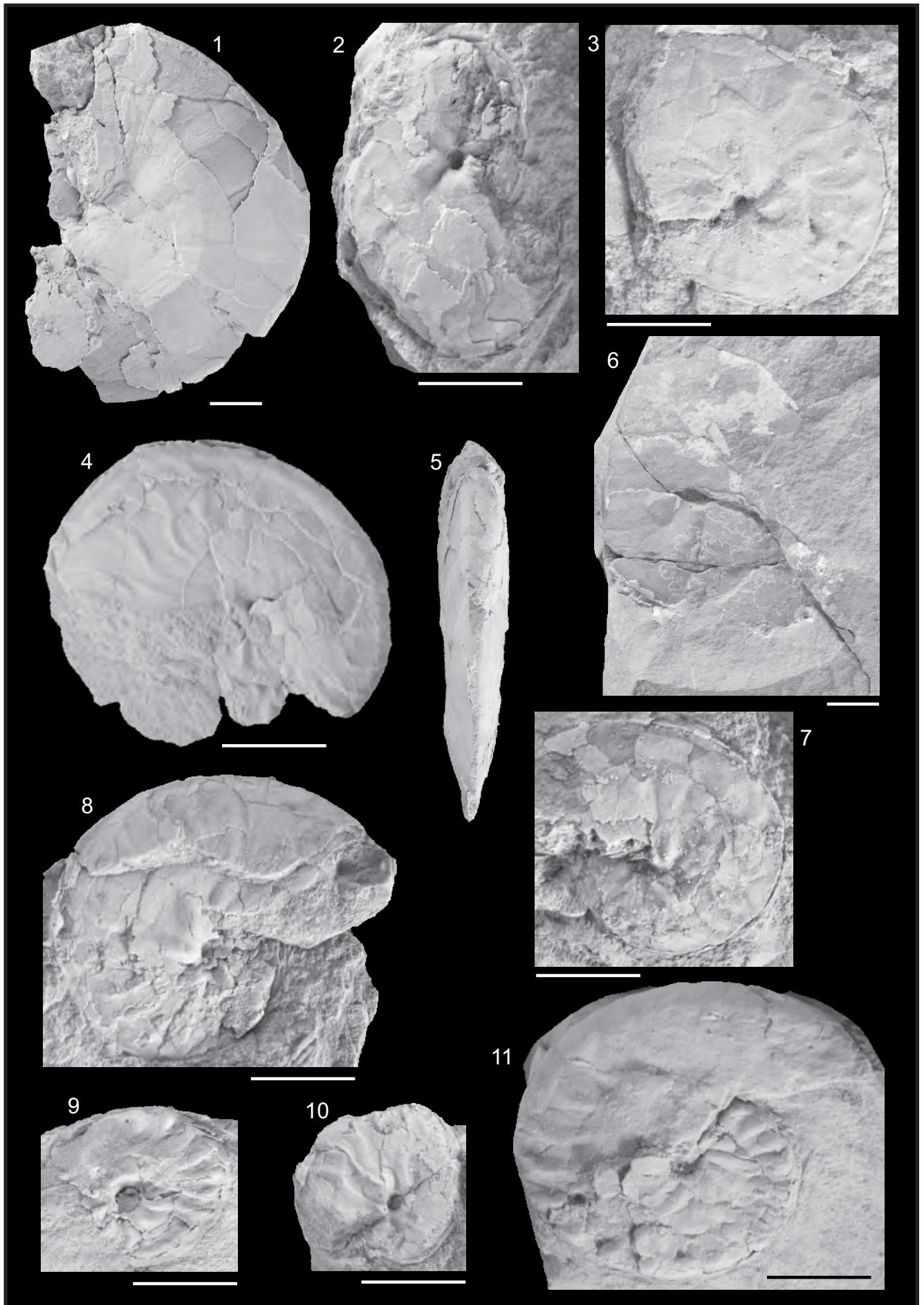


Plate 22

Eulophoceras natalense HYATT, 1903

Figs. 1, 2: SK/RA/1983/86; Randobach, Rußbach, Salzburg.

Fig. 3: SK/EB/2003/28; Edlbachgraben, Gosau, Upper Austria.

Fig. 4: SK/RA/1981/31; Randobach, Rußbach, Salzburg.

Fig. 5: NHMW 1983/0034/0002; Randobach, Rußbach, Salzburg.

Fig. 6: NHMW 2014/0138/0002; Markt Piesting, Lower Austria.

All specimens are early Santonian, coated with ammonium chloride and figured x 2.

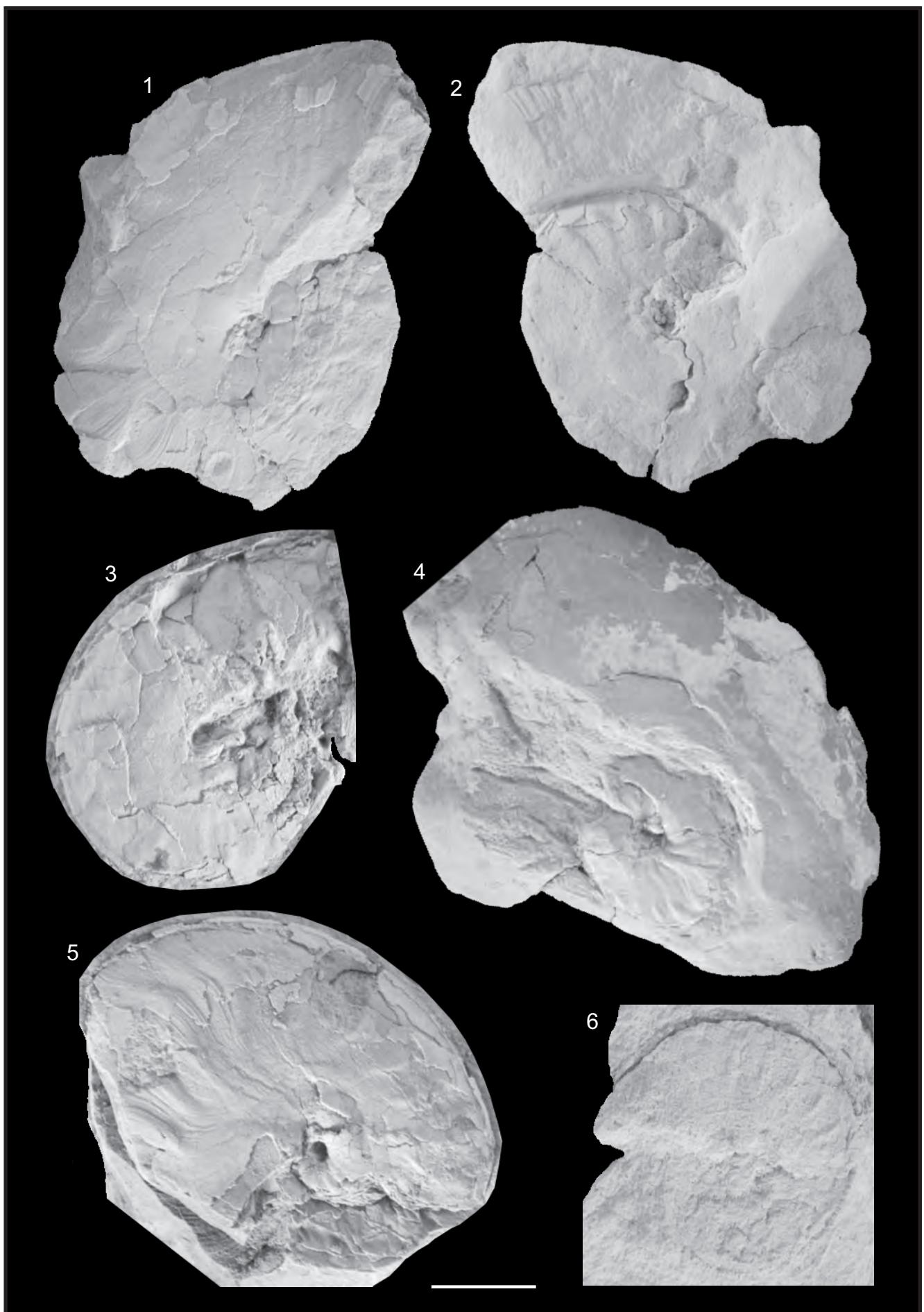
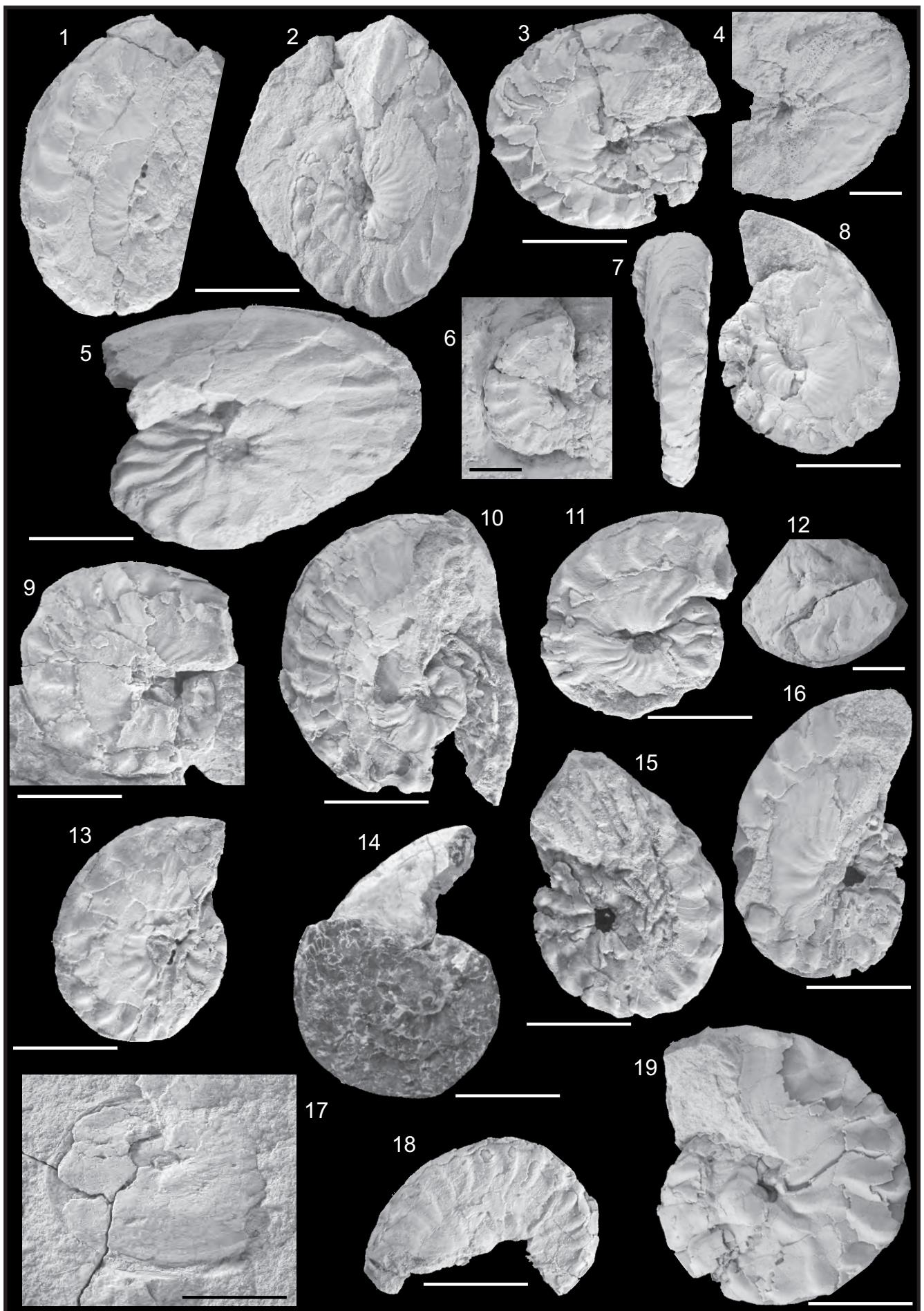


Plate 23

Eulophoceras natalense HYATT, 1903

- Figs. 1, 2: SK/RA/1984/103; Randobach 3, Rußbach, Salzburg. x 2
- Figs. 3, 7: SK/RA/1982/74a; Randobach 3, Rußbach, Salzburg. x 2
- Fig. 4: NHMW 2014/0138/0001; Markt Piesting, Lower Austria. x 1
- Fig. 5: NHMW 2014/0137/0001a; Unterlaussa, Upper Austria. x 2
- Fig. 6: NHMW 1982/0036/0001; Stöcklwaldgraben, Randobach, Rußbach, Salzburg. x 1
- Fig. 8: SK/RA/1981/28; Randobach 3, Rußbach, Salzburg. x 2
- Fig. 9: SK/EB/1985/3; Edlbachgraben, Gosau, Upper Austria. x 2
- Fig. 10: SK/RA/1981/1b; Randobach 3, Rußbach, Salzburg. x 2
- Fig. 11: SK/RA/1981/1g; Randobach 3, Rußbach, Salzburg. x 2
- Fig. 12: NHMW 1983/0034/0001; Randobach 3, Rußbach, Salzburg. x 1
- Fig. 13: SK/RA/1981/1c; Randobach 3, Rußbach, Salzburg. x 2
- Fig. 14: SK/RA/1982/73; Randobach 3, Rußbach, Salzburg. x 2
- Fig. 15: SK/RA/1981/1e; Randobach 3, Rußbach, Salzburg. x 2
- Fig. 16: SK/RA/1981/1d; Randobach 3, Rußbach, Salzburg. x 1
- Fig. 17: NHMW 1982/0032/0001; Grabenbach, Gosau, Upper Austria. x 2
- Fig. 18: SK/RA/1981/1h; Randobach 3, Rußbach, Salzburg. x 2
- Fig. 19: SK/RA/1981/44; Randobach 3, Rußbach, Salzburg. x 2

All specimens are microconchs and are early Santonian; all but Fig. 14 are coated with ammonium chloride.



**Early and middle Santonian Cephalopods from the Gosau Group
 (Upper Cretaceous, Austria)
 2. Heteromorph Ammonoidea**

HERBERT SUMMESBERGER¹, WILLIAM J. KENNEDY² & PETER SKOUMAL³

6 Text-Figures, 7 Tables, 11 Plates

Österreichische Karte 1:50.000

BMN / UTM

89 Angath / NL 32-03-18 Kundl

90 Kufstein / NL 33-01-13 Kufstein

95 Sankt Wolfgang im Salzkammergut / NL 33-01-17 Hallstatt

120 Wörgl /

/ NL 33-01-11 Bad Ischl

Heteromorph Ammonites

Gosau Group

Santonian

Biostratigraphy

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Abstract

A total number of 24 taxa of heteromorph ammonites are described from the lower and middle Santonian parts of the Gosau Group of Austria: *Eubostrychoceras salisburgense* sp. nov.; *Didymoceras* (*Didymoceras*) sp.; *Hyphantoceras plicatum* (d'ORBIGNY, 1842); *Muramotoceras costatum* sp. nov.; *Scalarites cingulatus* (SCHLÜTER, 1872); *Glyptoxoceras crispatum* (MOBERG, 1885); *Glyptoxoceras retrorsum* (SCHLÜTER, 1872); *Glyptoxoceras* sp.; *Neocrioceras* (*Neocrioceras*) *maderi* (IMMEL et al., 1982); *Neocrioceras* (*Neocrioceras*) *gosaviense* sp. nov.; *Neocrioceras* (*Neocrioceras*) sp. indet.; *Schlüterella compressa* KLINGER, 1976; *Pseudoxybeloceras* (*Pseudoxybeloceras*) *quadrinodosum* (JIMBO, 1894); *Pseudoxybeloceras* (*Parasolenoceras*) *splendens* COLLIGNON, 1969; *Polyptychoceras* sp. juv.; *Polyptychoceras* sp., form 1; *Polyptychoceras* sp., form 2; *Polyptychoceras* sp., form 3; *Baculites incurvatus* DUJARDIN, 1837; *Baculites brevicosta* SCHLÜTER, 1876; *Baculites fuchsii* REDTENBACHER, 1873; *Baculites* sp.; *Scaphites leei* REESIDE, 1927, form II (COBBAN, 1969); *Scaphites* sp.

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Cephalopoden des frühen und mittleren Santoniums der Gosau-Gruppe (Oberkreide, Österreich) 2. Heteromorphe Ammonoidea

Zusammenfassung

Es werden insgesamt 24 Taxa heteromorpher Ammoniten aus dem unteren und mittleren Santonium der österreichischen Gosau-Gruppe beschrieben: *Eubostrychoceras salisburgense* sp. nov.; *Didymoceras* (*Didymoceras*) sp.; *Glyptoxoceras plicatum* (d'ORBIGNY, 1842); *Muramotoceras costatum* sp. nov.; *Scalarites cingulatus* (SCHLÜTER, 1872); *Glyptoxoceras crispatum* (MOBERG, 1885); *Glyptoxoceras retrorsum* (SCHLÜTER, 1872); *Glyptoxoceras* sp.; *Neocrioceras* (*Neocrioceras*) *maderi* (IMMEL et al., 1982); *Neocrioceras* (*Neocrioceras*) *gosavicense* sp. nov.; *Neocrioceras* (*Neocrioceras*) sp. indet.; *Schlüterella compressa* KLINGER, 1976; *Pseudoxybeloceras* (*Pseudoxybeloceras*) *quadrinodosum* (JIMBO, 1894); *Pseudoxybeloceras* (*Parasolenoceras*) *splendens* COLLIGNON, 1969; *Polyptychoceras*, sp. juv.; *Polyptychoceras* sp., Form 1; *Polyptychoceras* sp., Form 2; *Polyptychoceras* sp., Form 3; *Baculites incurvatus* DUJARDIN, 1837; *Baculites brevicosta* SCHLÜTER, 1876; *Baculites fuchsii* REDTENBACHER, 1873; *Baculites* sp.; *Scaphites leei* REESIDE, 1927, form II (COBBAN, 1969); *Scaphites* sp.

Introduction

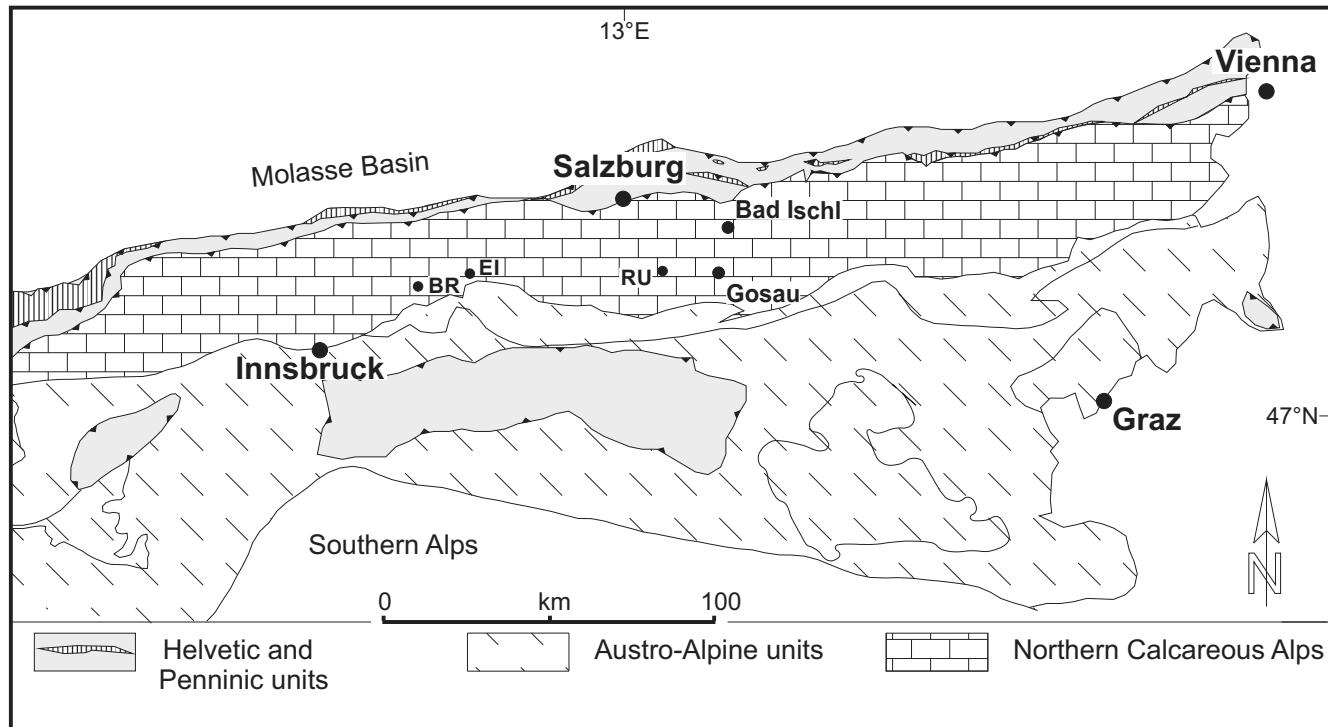
Following the account of the lower and middle Santonian nautiloids and non-heteromorph ammonites of the Gosau Group (SUMMESBERGER et al., 2017a, this volume), the heteromorphs are described below. The revision of the lower Santonian ammonite fauna of Brandenberg (Tyrol; IMMEL et al., 1982) is completed. Previous accounts of the heteromorph ammonites from the early and middle Santonian parts of the Gosau began with that of REDTENBACHER (1873), followed by KATSCHTHALER (1935), BRINKMANN (1935), GERTH (1956, 1961), IMMEL et al. (1982), IMMEL (1987) and KOLLMANN et al. (2000).

Beginning in 1971, H.A. Kollmann (NHMW) and H. Summesberger (NHMW) ran a stratigraphic program, collected numerous lower Santonian fossils, and acquired detailed knowledge of the fossil bearing sites of the Gosau Basin itself and the Gosau Group occurrences of the Northern Calcareous Alps (SUMMESBERGER et al., 2017a:

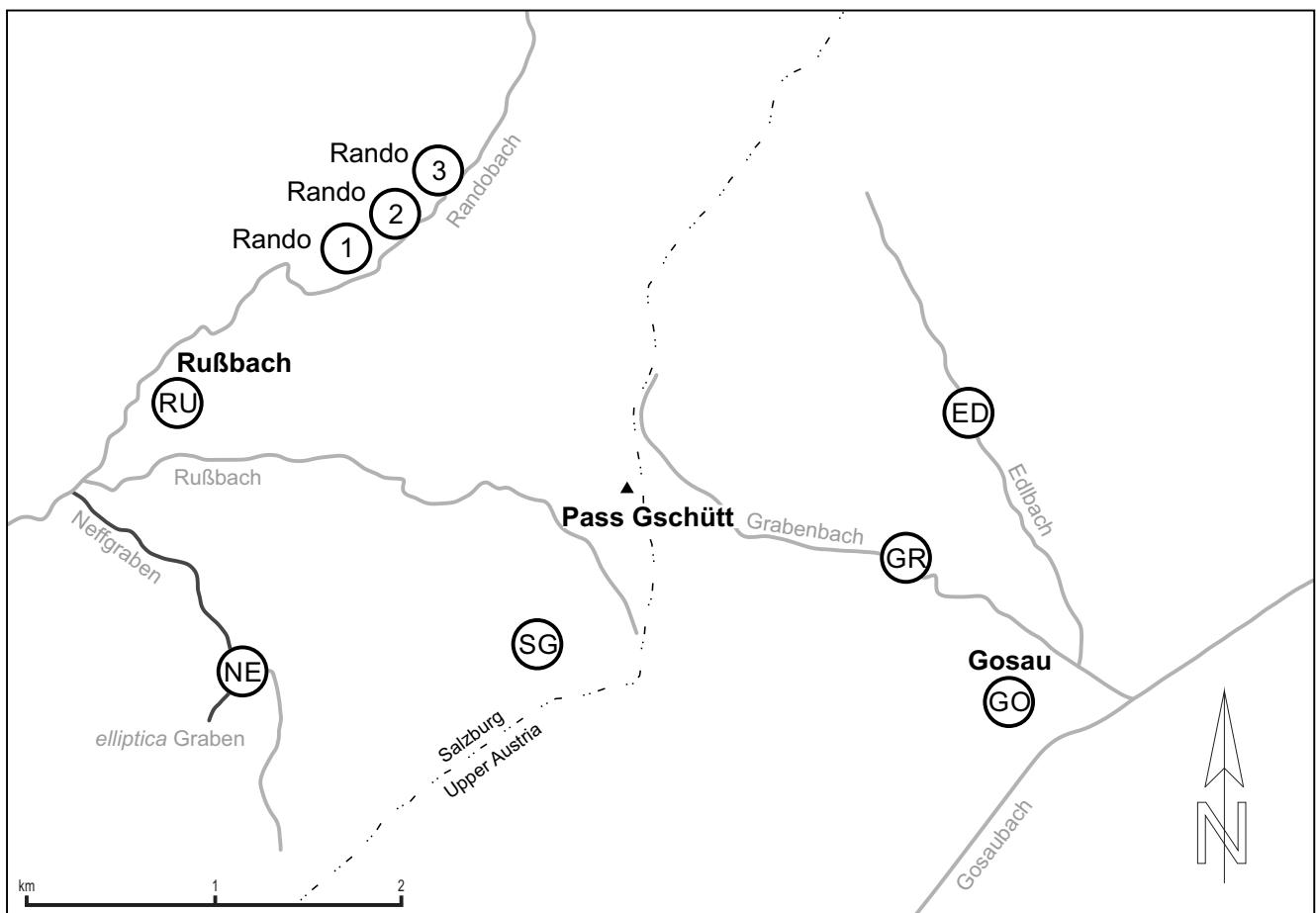
Text-Fig. 1). The most important fossil collection, including heteromorph ammonites, is that of the Skoumal family (Vienna), brought together over a period of 40 years. Additional collections were made by Wolf-Peter Maherndl (Bad Ischl, Upper Austria), Franz Klotz (Rum, Tyrol), Alfred Leiblfinger (Golling, Salzburg), Heinz Seidl (Salzburg), and Michael Wagreich and students (Vienna). Text-Figures 1 and 2 show the position of localities mentioned in the text.

Repositories of specimens

| | |
|------|--|
| NHMW | Museum of Natural History Vienna, Austria. |
| GBA | Geologische Bundesanstalt (Geological Survey of Austria, former k. k. Geologische Reichsanstalt), Vienna, Austria. |
| OÖLM | Oberösterreichisches Landesmuseum, Linz, Austria. |



Text-Fig. 1.
Distribution of Gosau Group localities mentioned in the text. BR – Brandenberg, EI – Eiberg, RU – Rußbach.



Text-Fig. 2.

Gosau Group localities in the Gosau area (Upper Austria and Salzburg) mentioned in the text: ED – Edlbachgraben, GO – Gosau, GR – Grabenbach, NE – Neffgraben, Rando (= Randograben) 1–3, RU – Rußbach, SG – Schattaugraben.

| | |
|----------|---|
| GPII | Geologisch Paläontologisches Institut der Universität Innsbruck, Austria. |
| HNS | Haus der Natur, Salzburg. |
| GPIB | Geologisch-paläontologisches Institut der Universität Bonn, Germany. |
| BSP | Bayerische Staatssammlung für Paläontologie und historische Geologie, München, Germany. |
| LE GO | Leiblfinger collection, Golting, Salzburg. |
| KL | Franz Klotz collection, Rum, Tyrol, Austria. |
| M | Odo Mader collection, Rattenberg, Tyrol, Austria. |
| MA | Wolf-Peter Maherndl collection, Bad Ischl, Austria. |
| MM | University Museum, Tokyo, Japan. |
| SK | Dr. Peter Skoumal collection, Vienna, Austria. |
| TLMF/SM | Tiroler Landesmuseum Ferdinandeum, Innsbruck, Tyrol, Austria (former Mader collection, Rattenberg). |
| SEIDL/CE | Heinz Seidl collection, Salzburg. |

Early and middle Santonian heteromorph ammonites of the Gosau Group in the Northern Calcareous Alps

Brandenberg (Tyrol, Mühlbach)

Hyphantoceras plicatum (D'ORBIGNY, 1842)

Glyptoxoceras crispatum (MOBERG, 1885)

Neocrioceras (Neocrioceras) maderi IMMEL et al., 1982

Schlueterella compressa KLINGER, 1976

Baculites incurvatus DUJARDIN, 1837

Eiberg (Kufstein, Tyrol), early to middle Santonian

Neocrioceras (Schlueterella) pseudoarmatum (SCHLÜTER, 1872)

Hyphantoceras plicatum (D'ORBIGNY, 1842)

**Basin of Gosau (Rußbach, Salzburg),
early Santonian**

Randobach 3

Hyphantoceras plicatum (D'ORBIGNY, 1842)

Scaphites sp.

**Basin of Gosau (Rußbach, Salzburg),
middle Santonian**

Randobach 1

Polyptychoceras sp. juv.

Pseudoxybeloceras (Parasolenoceras) splendens COLLIGNON, 1969

Randobach 2

Eubostrychoceras (E.) salisburgense sp. nov.

Pseudoxybeloceras (P.) quadrinodosum (JIMBO, 1894)

Polyptychoceras sp. form 2

Pseudoxybeloceras (Parasolenoceras) splendens COLLIGNON, 1969

Baculites incurvatus DUJARDIN, 1837

Baculites fuchsi REDTENBACHER, 1873

Baculites brevicosta SCHLÜTER, 1876

Neffgraben

Didymoceras sp.

Glyptoxoceras retrorsum (SCHLÜTER, 1872)

Schlüterella compressa KLINGER, 1976

Baculites incurvatus DUJARDIN, 1837

Baculites brevicosta SCHLÜTER, 1876

Scaphites sp.

Gosau (Upper Austria), early Santonian

Edlbachgraben

Hyphantoceras plicatum (D'ORBIGNY, 1842)

Scalarites cingulatus (SCHLÜTER, 1872)

Neocrioceras (N.) sp. indet.

Pseudoxybeloceras (P.) quadrinodosum (JIMBO, 1894)

Baculites incurvatus DUJARDIN, 1837

Baculites brevicosta SCHLÜTER, 1876

**Pass Gschütt (forest road Wegscheidgraben),
middle Santonian**

Glyptoxoceras retrorsum (SCHLÜTER, 1872)

Schlüterella compressa KLINGER, 1976

Polyptychoceras sp., form 3

Baculites incurvatus DUJARDIN, 1837

**Grabenbach (p.p. Tiefengraben),
middle and early Santonian**

Muramotoceras costatum sp. nov.

Glyptoxoceras sp.

Neocrioceras (N.) gosaviense sp. nov.

Schlüterella compressa KLINGER, 1976

Polyptychoceras sp., form 1

Pseudoxybeloceras (Parasolenoceras) splendens COLLIGNON, 1969

Baculites incurvatus DUJARDIN, 1837

Baculites fuchsi REDTENBACHER, 1873

Baculites brevicosta SCHLÜTER, 1876

Baculites sp.

Scaphites leei REESIDE, 1927, form II (COBBAN, 1969)

Systematic Palaeontology

Order Ammonoidea ZITTEL, 1884

Suborder Ancyloceratina WIEDMANN, 1966

Superfamily Turrilitoidea GILL, 1871

Family Nostoceratidae HYATT, 1894

**Genus and Subgenus *Eubostrychoceras*
(*Eubostrychoceras*) MATSUMOTO, 1967: 332.**

Type species: *Eubostrychoceras indopacificum* MATSUMOTO, 1967 (Pl. 18, Fig. 1) by original designation.

***Eubostrychoceras (Eubostrychoceras) salisburgense*
sp. nov.**

(Pl. 1, Figs. 1–4)

Type: The holotype and only known specimen is SK/RA/2011/159.

Derivatio nominis: From Salzburg (Austrian federal state).

Diagnosis: Turrilicone, the whorls not in contact, with fine, regular ribs on the outer surface of the whorl and two rows of tubercles at the junction between the outer and lower whorl faces.

Description: The holotype is a 36.5 mm long fragment of a composite mould of a helicoid whorl with areas of whitish shell preserved. The whorl height ranges from 14 to 22 mm, the whorl width from 18 to 19 mm; the estimated diameter is about 40 mm. The dimension increases very slowly towards the adapertural end of the fragment. Coiling is sinistral. When complete, the overall shape must have been a tall and narrow whorled turrilcone with a low apical angle and a narrow umbilicus of about 8 mm in the accessible part of the fragment. There are no impressions of the previous whorl on the upper whorl face, indicating that the whorls were not in contact. The ornament consists of about 20 narrow and straight ribs per half whorl parallel to the axis of the helix, separated by narrow interspaces.

Ribs arise and end at the shoulders, some at the external row of tubercles. They never extend around the whole whorl. There are no constrictions, no flared and no looped ribs. Two rows of coarse tubercles are situated at the junction of the outer and lower whorl faces, the upper ones linked to the ribs. The initial coil and the aperture are missing. The sutures are not visible.

Discussion: *Eubostrychoceras salisburgense* sp. nov. differs from all other representatives of the genus in having tubercles at the junction of the outer and lower whorl faces, and ribs that do not extend around all of the whorl. *E. indopacificum* MATSUMOTO, 1967 (Pl. 18, Fig. 1; see also: KLINGER et al., 2007: 97, Figs. 10A–H) differs in having tight coiling and ribs encircling the shell, as does *E. muramotoi* MATSUMOTO, 1967 (Pl. 19, Figs. 1, 2); both also differ in having flared ribs. *E. japonicum* (YABE, 1904: Pl. 3, Fig. 8) has widely separated whorls with encircling and flared ribs (see MATSUMOTO, 1977: Pls. 48–52, Fig. 3). *E. elongatum* (WHITEAVES, 1903: Pl. 44, Fig. 2) has coarse and distant ribs. *E. densicostatum* MATSUMOTO, 1967 (Pl. 52, Fig. 2) differs in its rapidly increasing whorl section, dense and oblique ribbing, and periodic constrictions. *E. acuticostatum* (d'ORBIGNY, 1842: Pl. 147, Fig. 3) from the Santonian of France differs in its distant ribbing (KENNEDY in KENNEDY et al., 1995: 428, Pl. 28, Figs. 9, 31, 32). *E. saxonicum* (SCHLÜTER, 1875: Pl. 35, Fig. 10) from the Turonian and Coniacian of Germany and France differs in its contiguous whorls and wider apical angle (KAPLAN & SCHMID, 1988: 52). *E. matsumotoi* COBBAN, 1987 (Pl. 1, Figs. 1–26) from the Turonian and early Coniacian of the Western Interior of the United States differs in its larger apical angle and coarse ribbing with several constrictions. *E. otsukai* (YABE, 1904: Pl. 4, Fig. 1) from the Santonian and early Campanian of Japan and Madagascar differs in its coarse ribbing and occasional constrictions. The ribbing effaces around the dorsum (KLINGER & KENNEDY, 2003: 233). *E. woodsi* (KITCHIN, 1922: 49) from the English Chalk Rock differs in having the whorls in contact, a wider apical angle and constrictions. *E. protractum* COLLIGNON, 1969 from the early Campanian of Madagascar differs in having ribs that encircle the dorsum. *E. auriculatum* (COLLIGNON, 1965: Pl. 418, Fig. 1725) from the middle Coniacian of Madagascar has a larger apical angle and collar ribs on the last whorl. *E. nibelae* KLINGER & KENNEDY, 2003 from Campanian III of KwaZulu-Natal in South Africa differs in its tight coiling and large apical angle, whereas *E. zulu* KLINGER & KENNEDY, 2003 from the Coniacian part of the St. Lucia Formation of KwaZulu-Natal differs in its curved ribs, constrictions and its elongated loose helix. None of these species develop tubercles.

Occurrence: SK/RA/2011/159 from the Randobach 2 locality (Rußbach, Salzburg) is the only occurrence in the middle Santonian Gosau Group.

Genus and Subgenus *Didymoceras* HYATT, 1894

Type species: *Ancyloceras nebrascense* MEEK & HAYDEN, 1856 (71) by original designation of HYATT (1894: 573).

Didymoceras (*Didymoceras*) sp.

(Pl. 1, Fig. 14, Pl. 9, Fig. 1, Tab. 1)

Material: A single specimen, LE GO/2015/0003 from the middle Santonian of the Neffgraben (Rußbach, Salzburg).

Description: LE GO/2015/0003 is an internal mould of a fragment of a single coil of the median part of an individual, with extensive areas of the shell preserved, on a slab of hard calcareous sandstone together with five fragments of *Baculites incurvatus* DUJARDIN, 1837. The general shape appears to have been turrilicone, with a low apical angle and contiguous whorls. The whorl cross section is rounded. The juvenile part is missing, as is the body chamber, which may have been turned upwards (?) close to the adoral end of the fragment. The surface is covered by approximately 50 narrow ribs per whorl, separated by slightly wider interspaces. The rib index is 8. The ribs are coarser on the outer whorl face, weakening on the inner. The ribs are straight, becoming prorsiradiate towards the adapertural end of the fragment, and becoming irregular and developing pointed tubercles at the base of the outer whorl face. There are three irregularly spaced constrictions. Given the fragmentary nature of the specimen, it is left in open nomenclature.

Discussion: Comparison with previously described species is difficult as so many are also based on fragments. *Eodidymoceras enigma* KLINGER, KENNEDY & GRULKE, 2007 (102, Figs. 14A–K) from the upper Santonian/lower Campanian of KwaZulu-Natal and the lower Campanian of Madagascar differs from the present species in being larger, with a low helix, wide apical angle, and the whorls in contact. The helical growth stage has about 100 narrow ribs per whorl, every third to fifth one stronger and flared with two rows of pointed tubercles. *Didymoceras* (*Eodidymoceras*) *howarthi* KLINGER & KENNEDY, 2003 (295, Figs. 49, 50A, 51) possibly from the uppermost Santonian or lower Campanian part of the St. Lucia Formation of KwaZulu-Natal differs from *Didymoceras* (*D.*) sp. in its more loosely coiled helix with only 34 ribs per whorl. It has two rows of minute tubercles. *Didymoceras* (*Eodidymoceras* ?) sp. (KLINGER & KENNEDY, 2003: 300, Figs. 8E, 52A–D) from the Santonian or lower Campanian of KwaZulu-Natal has flared bituberculate major ribs separated by three to four minor ones. It also differs in the smaller diameter of the circular whorl section. *Didymoceras* (*Eodidymoceras*) *mitraikyense* (COLLIGNON, 1970: 20, Pl. 614, Fig. 2293) from the Lower Campanian of KwaZulu-Natal and the lower to middle Campanian of Madagascar differs in its extended corkscrew like he-

| Inventory No. | D (mm) | Wh (mm) | Wb ₁ (mm) | Wb ₂ (mm) | U (mm) | U (%) |
|-----------------|--------|---------|----------------------|----------------------|--------|-------|
| LE GO/2015/0003 | 62 | 26.4 | 21.8 | 15.2 | 22.4 | 36 |

Tab. 1.
Didymoceras (*D.*) sp. (LE GO/2015/0003). Wb₁ and Wb₂ in 180° distance. U % of D.

lix (KLINGER & KENNEDY, 2003: 294, Fig. 48) and the lower number of only 30 ribs per whorl. *Didymoceras subtuberculatum* HOWARTH, 1965 (374, Pl. 7, Figs. 2–6) from the Campanian of Egito (Angola) differs in its narrower section of the shell which is coiled in a loose helix, ornamented by numerous minor ribs and a few flared major ones often preceded by a constriction. *Didymoceras (D.) australis* KLINGER & KENNEDY, 2003 (282, Figs. 41–44, 50B–C) from Campanian III of KwaZulu-Natal differs in its regular coarse ribbing and coarse bituberculation. *Didymoceras binodosum* (KENNEDY & COBBAN, 1993: 92, Figs. 8.1, 8.2, 8.5, 8.6, 8.13–8.15, 8.22–8.24, 8.28, 8.29, 8.32, 8.33, 8.35–8.39, 9.1–9.5, 12.1) from the Campanian of the Western Interior of the United States (KENNEDY & COBBAN, 1999: 72, Figs. 3, 4) differs in its somewhat irregular ribbing with constrictions. *Didymoceras pueblense* COBBAN, KENNEDY & SCOTT, 1997 (Figs. 1–5) from the upper Campanian of the U.S. Western Interior differs in its weak ribbing with wide interspaces and some ribs bifurcating at the tubercles. The Campanian *Didymoceras cochleatum* (MEEK & HAYDEN, 1858) (see KENNEDY et al., 1999: Figs. 1–4) from the Pierre Shale of the U.S. Western Interior differs in its dense ribbing with small tubercles in two rows and occasional constrictions. The juvenile parts of *Didymoceras (D.)* sp. are not preserved but its adoral parts are very similar to those of *D. cochleatum*. The preserved evolution of *Didymoceras aff. hornbyense* (WHITEAVES, 1895) from the Campanian of Hornby Island (Vancouver Island, Canada) is similar (JONES, 1963: Pl. 23, Fig. 1) to our specimen. *Didymoceras (D.?) africanum* KLINGER & KENNEDY, 2003 (289, Figs. 46, 47A–C.) from the upper Campanian of KwaZulu-Natal differs in its low spire and very wide umbilicus. The upper Campanian *Didymoceras donezianum* (MIKHAILOV, 1951: Pl. 3, Fig. 23), described from the Donbass region (Ukraine), from the Vistula valley (Poland; BLASZKIEWICZ, 1980) and from Arkansas in the United States (KENNEDY & COBBAN, 1993) differs at the same growth stage as that of the present specimen in having fewer, strong ribs and wide interpaces. One fragment from the upper Campanian of the Gschließgraben (Austria) (KENNEDY & SUMMERSBERGER, 1984: Pl. 12, Figs. 8–10) is too small to be compared with the present specimen. The second one from the Gschließgraben *Didymoceras binodosum* (KENNEDY & COBBAN, 1993) differs in its regular bituberculation in the adapertural whorl and in the zigzag tuberculation (KENNEDY & SUMMERSBERGER, 1999: Pl. 2, Fig. 13) of the earlier whorl. The upper Campanian *Didymoceras aurarium* KENNEDY et al., 2000a (Pl. 1, Figs. 7–9, Text-Fig. 8) is much smaller and differs in its larger apical angle and its distant rursiradiate ribbing with occasional constrictions.

The late Campanian *Didymoceras draconis* STEPHENSON, 1941 (Pl. 82, Figs. 5–9) from the U.S. Western Interior, Delaware and also from Israel differs in its low helical coil and pairs of ribs arising at the tubercles. *Didymoceras nebrascense* (MEEK & HAYDEN, 1856: 71) from the Upper Campanian of the U.S. Western Interior (KENNEDY et al., 2000b: Figs. 3, 4, 6, 7, 8C, D, 9–13, 62) differs in having a densely ribbed and tuberculate middle growth stage, whereas the body chamber is coarsely ribbed with large tubercles. *Didymoceras stevensoni* (WHITFIELD, 1877: 39) (see KENNEDY et al., 2000b: 20, Figs. 8A, B, 14–17, 19D–I, 20–26) is coarsely ribbed in its middle growth stage, with bifurcations and strong tubercles. The loosely coiled spire of *Didymoceras cheyennense* (MEEK & HAYDEN, 1856) also from the late Campanian of the U.S. Western Interior (see KENNEDY et al., 2000b: 36,

Figs. 27–31, 33–38) differs in its distant ribbing with coarse tuberculation. *Didymoceras cf. D. draconis* (STEPHENSON, 1941: Pl. 82, Figs. 5–9) from the late Campanian Navesink Formation of New Jersey in the United States (KENNEDY et al., 2000a: 15, Figs. 5I, J) has a wide apical angle in its middle growth stage, and about 85 narrow ribs linking in pairs at relatively coarse tubercles at the junction of outer and lower whorlfaces. *Didymoceras (Didymoceras?) africanum* KLINGER & KENNEDY, 2003 (289, Figs. 46, 47A–C) from Campanian III of KwaZulu-Natal in South Africa differs in its coarse and irregular ribbing.

Occurrence: LE GO/2015/0003 is the first representative of the genus *Didymoceras* described from the Austrian Gosau Group. It co-occurs with *Baculites incurvatus* DUJARDIN, 1837 in the middle Santonian Hochmoos Formation of the Neßgraben (Rußbach, Salzburg). Previously described representatives of *Didymoceras (Didymoceras)* sp. are mostly of Campanian age. The specimen from the Gosau Group appears to be the earliest representative of the genus.

Genus *Hyphantoceras* HYATT, 1900

Type species: *Heteroceras roissyanum* SCHLÜTER, error for *reussianum* D'ORBIGNY, 1850 by the original designation of HYATT (1900: 587).

Hyphantoceras plicatum (D'ORBIGNY, 1842)

(Pl. 1, Figs. 6, 7)

- 1842 *Turrilites plicatus* D'ORBIGNY: 592, Pl. 143, Figs. 7, 8.
- 1876 *Turrilites plicatus* D'ORBIGNY; SCHLÜTER: 137, Pl. 36, Figs. 6, 7.
- 1955 *Turrilites plicatus* D'ORBIGNY; SORNAY (fiche 7, 3 Figs.).
- 1987 *Hyphantoceras (Hyphantoceras) orientaliforme* n. sp.; IMMEL: 133, Pl. 14, Fig. 11.
- 1994 *Hyphantoceras plicatum* (D'ORBIGNY, 1842); KAPLAN & KENNEDY: 54, Pl. 37, Figs. 7, 8.
- 1995 *Hyphantoceras plicatum* (D'ORBIGNY, 1842); KENNEDY in KENNEDY et al.: 427, Pl. 28, Figs. 20–23.
- 1995 *Hyphantoceras aff. plicatum* (D'ORBIGNY, 1842); KENNEDY in KENNEDY et al.: 427, Pl. 27, Fig. 22.
- 2010 *Hyphantoceras plicatum* (D'ORBIGNY, 1842); REMIN: 177, Fig. 17A.

Type: The holotype, by monotypy, is the original of *Turrilites plicatus* D'ORBIGNY, 1842 (Pl. 143, Figs. 7, 8) refigured and redescribed by KENNEDY in KENNEDY et al. (1995: 427, Pl. 28, Figs. 21, 22).

Material: BSP-1986 III 31, the holotype of *Hyphantoceras (Hyphantoceras) orientaliforme* IMMEL, 1987 from Brandenberg/Mühlbach (Tyrol) and an additional unregistered specimen, SK/RA/1982/67, 68; SEIDL/CE 2015/00004 (Seidl collection) and possibly a fragment NHMW 1982/0033/0001, from the Randobach 3 locality (Rußbach, Salzburg). SK/EB/2008/44, from the Edlbachgraben (Gosau, Upper Austria).

Description: Four whorls are preserved in SK/EB/2008/44, and eight whorls in SEIDL/CE.2015/00004. The general shape of the shell is a loose helix with regularly increasing whorl dimensions. The maximum height of the helix is 53 mm, Wb_{max} is 9.7 mm. The apical angle is 16°. There are about 26 delicate riblets that arise on the internal part of the helix, crossing the external side and returning to the internal part. Transversely elongated tubercles are arranged in three rows. In the earlier growth stage ribs are linked in pairs at tubercles, with a few nontuberculate ribs between. In SK/EB/2008/44, with a height of 44.4 mm, the juvenile part bears two rows of tubercles, the upper ones larger than the lower. 180° from the aperture the ornament changes, and there are three rows of tubercles. As size increases, ribs and tubercles become separated. The whorls are not in contact in any of the specimens.

Discussion: For a detailed description of the holotype see KENNEDY in KENNEDY et al., (1995: 427, Pl. 28, Figs. 21, 22). For the first time we are able to describe specimens of *Hyphantoceras plicatum* with four and eight whorls. *Hyphantoceras (Hyphantoceras) orientaliforme* IMMEL, 1987 (133, Pl. 14, Fig. 11) conforms closely to the general shape and ornament of *Hyphantoceras plicatum*, and is regarded as a synonym. *Hyphantoceras (Hyphantoceras) orientale* (YABE, 1904: 19, Pl. 3, Fig. 7) differs in having a very elongated helix and a lower rate of increase in whorl dimensions.

Occurrence: All of the Austrian specimens (Brandenberg/Mühlbach (Tyrol), Randobach 3 (Rußbach, Salzburg), Edlbachgraben (Gosau, Upper Austria) are of early Santonian age. The holotype (see KENNEDY in KENNEDY et al., 1995: 427) is from an unknown horizon at Soulatgé (France). The species also occurs also in the Coniacian of Westphalia (Dortmund-Mengede: KAPLAN & KENNEDY, 1994: 54, Pl. 37, Figs. 7, 8) and France (Soulatgé).

Genus *Muramotoceras* MATSUMOTO, 1977

Type species: *Muramotoceras yezoense* MATSUMOTO, 1977 (335, Pl. 53, Figs. 1–5, Pl. 54, Fig. 1, Text-Figs. 6, 7) by original designation.

Muramotoceras costatum sp. nov.

(Pl. 1, Figs. 5, 10)

Type: The holotype and only known specimen is NHMW 2017/0136/0001 (Pl. 1, Figs. 5, 10).

Derivatio nominis: *costatum* – ribbed.

Diagnosis: Nostoceratid with changing orientation of the helical coiling. An initial more or less vertical straight part is encircled by a wide coil leading to the upwards turned body chamber.

Description: The holotype is a large fragment of an internal mould with adherent white chalky shell. It consists of a more or less straight juvenile part, surrounded by the adult phragmocone. The embryonic part is missing, the surviving juvenile part is 19 mm long, its width (restored) is 9 mm. The diameter of the circular adult phragmocone is 85 mm, the umbilicus measures 45 mm (= 53 %). The

curved connection to the upwards-directed body chamber is missing. The remaining part of the body chamber (Pl. 1, Fig. 10) including the aperture is 70 mm long. Its section has been compressed by *post mortem* processes but must have been circular, with a (restored) diameter of about 23 mm. The initial juvenile part is closely ribbed, with about nine ribs and interspaces of equal width per 10 mm. Pairs of ribs link at four rows of tiny tubercles. This style of ribbing continues on the planispiral adult phragmocone. The paired ribs and linking tubercles are separated by three narrow, nontuberculate ribs. Looped ribs and tubercles increase in strength as size increases, reaching maximum strength on the body chamber. The aperture is flared, and marked by a slight expansion of the whorl. The sutures are not exposed.

Discussion: *Muramotoceras yezoense* MATSUMOTO, 1977 (335, Pl. 53, Figs. 1–5, Pl. 54, Fig. 1, Text-Figs. 6, 7) from the Turonian of Japan, has a comparable overall morphology. It differs from *Muramotoceras costatum* sp. nov. in its much simpler ribbing with coarse ribs separated by wide, smooth interspaces. *Muramotoceras laxum* MATSUMOTO, 1977 (337, Pl. 45, Figs. 1, 2, Pl. 52, Fig. 1, Text-Fig. 8) also from the Turonian of Japan, is smaller than *M. costatum* sp. nov., has similar ribbing to that of *M. yezoense*, and a long, slightly curved body chamber.

Occurrence: The holotype of *Muramotoceras costatum* sp. nov. is from the middle to early Santonian of the Grabenbach (Gosau, Upper Austria). The type species, *Muramotoceras yezoense* MATSUMOTO, 1977 was originally described from the Turonian of Japan and is also recorded from the Turonian of Alaska (PASCH & MAY, 1997, 2001).

Family Diplomoceratidae SPATH, 1926

Subfamily Diplomoceratinae SPATH, 1926

Genus *Scalarites* WRIGHT & MATSUMOTO, 1954

Type species: *Helicoceras scalare* YABE, 1904 (9, Pl. 3, Fig. 2) by original designation.

Scalarites cingulatus (SCHLÜTER, 1872)

(Pl. 1, Figs. 8, 9)

- 1872 *Crioceras (?) cingulatum* SCHLÜTER: 101, Pl. 30, Fig. 13.
- 1991 *Exiteloceras cingulatum* (SCHLÜTER, 1872), RIEGRAF & SCHEER: 390.
- 1995 *Scalarites cingulatum* (SCHLÜTER, 1872); KENNEDY & KAPLAN: 31, Pl. 20, Figs. 1–3 [with synonymy].
- 2006 *Scalarites cingulatum* (SCHLÜTER, 1872); KAPLAN, KENNEDY & SCHEER: 37, Pl. 8, Figs. 9–12.

Type: The holotype by monotypy is the original of SCHLÜTER (1872: Pl. 30, Fig. 13, 14) from the lower Campanian Dülmen Formation, refigured by KENNEDY & KAPLAN (1995: Pl. 20, Figs. 1–3).

Material: SK/EB/2009/47 from the early Santonian of the Edlbachgraben (Gosau, Upper Austria).

Description: SK/EB/2009/47 is an internal mould of a slightly curved fragment 53.4 mm long with a whorl height of 9.9 mm and a whorl breadth of 6.9–12.4 mm. Most of the original shell has been lost. The specimen is crushed laterally; the original whorl section may have been circular or slightly oval. The rursiradiate ribbing is well preserved, effacing on the dorsum, and strengthening across the flanks. Every third or fourth rib is much strengthened, flared, and bears ventrolateral tubercles close to the median line of the venter. The ribs are rounded in cross section and as wide as the interspaces. The sutures are not exposed.

Discussion: The general shape of the fragment suggests an open coil, best compared to that of specimens of *Scalarites sertata* (MÜLLER & WOLLEMANN, 1906: Pl. 10, Figs. 1–3). The rounded rib section and more or less regularly spaced flared and tuberculate ribs separate the fragment from the co-occurring *Schlüterella*. *Schlüterella* also differs also having a double row of ventrolateral tubercles, rather than the single ventrolateral row of *Scalarites cingulatus*. *Scalarites sertata* (MÜLLER & WOLLEMANN, 1906: 40, Pl. 9, Fig. 3, Pl. 10, Fig. 1–3) differing in having narrower, sharp ribs.

Occurrence: *Scalarites cingulatus* (SCHLÜTER, 1872) is recorded from the early Campanian of Germany and, for the first time, from the early Santonian of the Gosau Group.

Genus *Glyptoxoceras* SPATH, 1925

Type species: *Hamites rugatus* FORBES, 1846 (117, Pl. 11, Fig. 6) by original designation of SPATH (1925: 30).

Glyptoxoceras crispatum (MOBERG, 1885)

(Pl. 1, Figs. 11–13, Pl. 2, Fig. 5)

- | | |
|----------|--|
| 1885 | <i>Anisoceras (Hamites) crispatus</i> MOBERG: 32, Pl. 3, Figs. 12, 13. |
| 1979 ? | <i>Diplomoceras</i> (Subgenus?) <i>tenuisulcatum</i> (FORBES); SUMMESBERGER: 124, Pl. 3, Fig. 21. |
| 1982 | <i>Diplomoceras (Glyptoxoceras) indicum</i> (FORBES, 1846); IMMEL et al.: 26, Pl. 10, Figs. 5, 6. |
| 1982 | <i>Diplomoceras (Glyptoxoceras) subcompressum</i> (FORBES, 1846); IMMEL et al.: 26, Pl. 10, Fig. 7. |
| non 1982 | <i>Diplomoceras (Glyptoxoceras) subcompressum</i> (FORBES, 1846); IMMEL et al.: 26, Pl. 9, Figs. 4, 5, Pl. 11, Fig. 4 (= ? <i>Neocrioceras maderi</i> IMMEL et al., 1982). |
| 1987 | <i>Diplomoceras (Glyptoxoceras) subcompressum</i> (FORBES, 1846); IMMEL: 136, partim. |
| 1995 | <i>Glyptoxoceras crispatum</i> (MOBERG, 1885), KENNEDY in KENNEDY et al.: 430, Pl. 27, Figs. 16, 24, Pl. 29, Figs. 1, 8, 11, 19, 20 [with synonymy]. |
| 1997 | <i>Glyptoxoceras crispatum</i> (MOBERG, 1885); KENNEDY & CHRISTENSEN: 107, Text-Figs. 24a–b. |
| 2000 | <i>Glyptoxoceras cf. tenuisulcatum</i> (FORBES); SUMMESBERGER in EGGER et al.: 26. |
| 2000 | <i>Glyptoxoceras crispatum</i> (MOBERG, 1885); KENNEDY & KAPLAN: 96, Pl. 34, Fig. 2. |

- | | |
|-------|--|
| 2010 | <i>Glyptoxoceras crispatum</i> (MOBERG, 1885); WAGREICH et al.: 185, |
| 2017b | <i>Glyptoxoceras crispatum</i> (MOBERG, 1885); SUMMESBERGER et al.: 189, Pl. 12, Figs. 6–13. |

Types: The lectotype, by the subsequent designation of KENNEDY & CHRISTENSEN (1997: 107), is the original of MOBERG (1885: Pl. 3, Fig. 12), Swedish Geological Survey, type series no. 3877; paralectotype 3876 is in the same collection. Both are from the Santonian of Eriksdal, Sweden, and were refigured by KENNEDY & CHRISTENSEN (1997: Text-Figs. 24a–b).

Material: M14 (BSP); TLMF /SM/531, GPII P.8165 (BSP); SK/SG/2002/33, NHMW 2015/0530/0001, NHMW 2010/0081/0006, NHMW 1978/1963/0029, NHMW 2011/0054/0006, M 12, BSP 1963 XXX 30, SK/SG/1992/11, SK/SG/1996/18, SK/SG/2003/33, SK/SG/2006/41, SK/SG/1996/20, 22.

Description: The material from Brandenberg was described by IMMEL et al. (1982) as *Diplomoceras (Glyptoxoceras) indicum* (FORBES, 1846: 116, pars) and *Diplomoceras (Glyptoxoceras) subcompressum* (FORBES, 1846: 116, Pl. 11, Fig. 6). Detailed information about the shape is based upon SK/SG/2002/33 from the late Santonian of Schattau (SUMMESBERGER et al. (2017c). NHMW 2015/0530/0001 is a 49.5 mm long fragment of the straight shaft, comparable to NHMW 1978/1963/0029 (SUMMESBERGER, 1979: Pl. 3, Fig. 21). M 14 (IMMEL et al., 1982: Pl. 10, Fig. 7) is a fragment about 69 mm long with a whorl height of 16 to 18 mm whorl. TLMF/SM/531 (Pl. 1, Fig. 12) is a fragment 150 mm length. Both are characterized by very fine and dense (rib index 12) rectiradiate to slightly rursiradiate ribs. TLMF/SM/531 shows a few bifurcations. We interpret it as a part of the curved phragmocone, the near-straight shaft broken away.

Discussion: *Diplomoceras (Glyptoxoceras) subcompressum* (FORBES, 1846) is a Maastrichtian species and a synonym of *Glyptoxoceras rugatum* (FORBES, 1846: 116, Pl. 11, Fig. 6) (KENNEDY & HENDERSON (1992: 969). M 14, figured by IMMEL et al. (1982: Pl. 10, Fig. 7) differs from the other heteromorphs from Brandenberg in its much denser ribbing, without bifurcations. Fragments of finely ribbed specimens with rare bifurcations (IMMEL et al., 1982: Pl. 9, Figs. 4, 5, Pl. 11, Fig. 4) are thought to be fragments from juvenile *Neocrioceras maderi*. KENNEDY in KENNEDY et al., (1995: 430) united the Brandenberg specimens under *G. crispatum*. A further discussion of late Santonian *Glyptoxoceras* was given by SUMMESBERGER et al. (2017b) including the lower Santonian representatives. ?*Diplomoceras* (Subgenus?) *tenuisulcatum* (FORBES, 1846) figured by SUMMESBERGER (1979: Pl. 3, Fig. 21) is also referred to *Glyptoxoceras crispatum*.

Occurrence: In the Gosau Group *Glyptoxoceras crispatum* occurs in the early Santonian of Brandenberg (IMMEL et al., 1982), and in the late Santonian of the Schattau (Rußbach, Salzburg; SUMMESBERGER et al., 2017b). It is also present in the Middle Santonian *gallicus* Subzone of the Corbières (France; KENNEDY in KENNEDY et al. 1995), and was originally described from the Santonian of Sweden (MOBERG, 1885).

Glyptoxoceras retrorsum (SCHLÜTER, 1872)

(Pl. 2, Figs. 1, 7)

- 1872 *Ancyloceras retrorsum* SCHLÜTER: 97, Pl. 30, Figs. 5–10.
- 1984 *Neoglyptoxoceras cf. retrorsum* (SCHLÜTER, 1872); KENNEDY & SUMMESBERGER: 168, Pl. 6, Fig. 1.
- 1986 *Neoglyptoxoceras (?) retrorsum* (SCHLÜTER, 1872; KENNEDY: 106, Pl. 16, Figs. 1–4, 6, 7, Pl. 17, Figs. 1, 2, Text-Fig. 38. [with synonymy].
- 1997 *Glyptoxoceras retrorsum* (SCHLÜTER, 1872); KENNEDY & KAPLAN: 59, Pl. 5, Fig. 3.
- 2005 *Glyptoxoceras retrorsum* (SCHLÜTER, 1872); KAPLAN et al.: 108, Pl. 41, Fig. 1, Pl. 43, Figs. 5, 6, Pl. 45, Figs. 1, 3, 4, Pl. 46, Figs. 1–3, Pl. 48, Fig. 2, Pl. 49, Figs. 1, 2, Pl. 51, Fig. 3.

Type: The lectotype, by the subsequent designation of SPATH (1925: 31, footnote), is the original of SCHLÜTER (1872: Pl. 30, Figs. 5–7), refigured by KENNEDY (1986: Text-Figs. 38A–C).

Material: LE GO/2015/0002, SK/NE/1989/12.

Description: LE GO/2015/0002 is a composite mould with large parts of the brownish shell preserved. The specimen is more or less complete, although parts of the aperture and the earliest juvenile part are restored, and coiled in an ellipse. The whorl section is flattened by *post mortem* compaction, but was probably originally rounded. The total length along the venter is 180 mm; it measures 100 mm diagonally. The apertural part, curved like a hook, is the body chamber in our interpretation. The whorl height of the adapertural part is 5.6 mm, that of the final hook is 11.4 mm. The whorl breadth cannot be established, due to preservation on a slab of matrix. It is regularly ribbed, the ribs and interspaces are narrow and of equal width. The rib index of the juvenile part is 3, that of the final hook it is 7. The ribs are straight to slightly concave, from the curvature to the aperture they are rursiradiate. Next to the aperture the rib interspaces increase in width. SK/NE/1989/12 (Pl. 2, Fig. 2) is a 110.9 mm long curved fragment with comparable ribbing, and a single constriction just before the adapertural end.

Discussion: LE GO/2015/0002 and SK/NE/1989/12 are best to be compared with the early Campanian examples from the Münster Basin (KAPLAN et al., 2005: 108, Pl. 41, Fig. 1, Pl. 43, Figs. 5, 6, Pl. 45, Figs. 1, 3, 4, Pl. 46, Figs. 1–3, Pl. 48, Fig. 2, Pl. 49, Figs. 1, 2, Pl. 51, Fig. 3).

Occurrence: LE GO/2015/0002 and SK/NE/1989/12 are from the middle Santonian of the Neffgraben (Rußbach, Salzburg). The occurrences in the Münster Basin (KENNEDY & KAPLAN, 1997; KAPLAN et al., 2005) are early Campanian. The single individual from the Gschließgraben (Austria; KENNEDY & SUMMESBERGER, 1984: Pl. 6, Fig. 1) is of late Campanian age.

Glyptoxoceras sp.

(Pl. 3, Fig. 3)

Material: A single individual SK/GR/1993/40 from the middle Santonian of Grabenbach (Gosau, Upper Austria).

Description: SK/GR/1993/40 is a laterally compressed fragment of a body chamber with yellowish to brownish shell partially preserved. It measures about 120 mm around the terminal curvature. The whorl height, enhanced by deformation ranges from 14 to 24 mm. Ornament consists of narrow sharp ribs with somewhat wider interspaces. Close to and in the curvature the ribbing becomes narrower and widens towards the venter. None of the ribs bifurcate. They are rursiradiate on the straight part of the fragment, becoming rectiradiate on the curved sector. There are three collar ribs at the adapical end of the specimen, marking the adult aperture of the body chamber. There are neither tubercles nor spines.

Discussion: *Glyptoxoceras crispatum* (MOBERG, 1885) differs by its finer ribbing. *Glyptoxoceras retrorsum* (SCHLÜTER, 1872) differs by coarser ribbing towards the adapertural end. COLLIGNON (1969) described a similarly densely ribbed *Glyptoxoceras*, *G. subcompressum coarctatum*, from the early Campanian of Madagascar (COLLIGNON, 1969: Pl. 529, Figs. 2084, 2085). As the complete shape of the shell is unknown, we leave the identification open.

Occurrence: *Glyptoxoceras* sp. (SK/GR/1993/40) is from the middle Santonian of Grabenbach (Gosau, Upper Austria).

**Genus and subgenus *Neocrioceras* (*Neocrioceras*)
SPATH, 1921**

Type species: *Neocrioceras cf. spinigerum* JIMBO, 1894 (184 (38), Pl. 8, Figs. 1, 1a, b) by original designation of SPATH (1921a).

Remarks: We interpret the subgenus *Neocrioceras* (*Neocrioceras*) SPATH 1921 as criocone without parallel or subparallel shafts. In contrast *Schlüterella* WIEDMANN, 1962 comprises straight shafts linked by curved sectors. Following KLINGER et al. (2007: 109) *Neocrioceras* (*Neocrioceras*) SPATH 1921 is a distinct genus of the Diplomoceratinae. WRIGHT (1996) assigned both genera to two different subfamilies of the Diplomoceratidae SPATH, 1926.

***Neocrioceras* (*Neocrioceras*) *maderi* IMMEL, KLINGER &
WIEDMANN, 1982**

(Pl. 2, Figs. 4, 6, Pl. 4, Fig. 1, Tab. 2)

- 1982 *Neocrioceras* (*Neocrioceras*) *maderi* IMMEL, KLINGER & WIEDMANN: 24, Pl. 9, Fig. 2, Pl. 11, Figs. 1, 2.
- 1982 *Diplomoceras* (*Glyptoxoceras*) *subcompressum* (FORBES 1846); IMMEL, KLINGER & WIEDMANN: 26, Pl. 9, Figs. 4, 5, Pl. 11, Fig. 4 (only), not Pl. 10, Fig. 7 = *Glyptoxoceras crispatum* MOBERG, 1885.
- 1986 *Neocrioceras* (*Neocrioceras*) *maderi* IMMEL, KLINGER & WIEDMANN, 1982; MATSUMOTO et al.: 468.

- 1987 *Neocrioceras (Neocrioceras) maderi* IMMEL, KLINGER & WIEDMANN 1982; IMMEL: 134.
- 1991 *Neocrioceras (Schlueterella) cf. maderi* IMMEL, KLINGER & WIEDMANN, 1982; KENNEDY & CHRISTENSEN: 216, Pl. 3, Fig. 6, Pl. 6, Fig. 1, Pl. 7, Fig. 5.
- 1991 *Neocrioceras (Schlueterella) maderi* IMMEL, KLINGER & WIEDMANN, 1982; KENNEDY & COBBAN: 65.
- 1992 *Neocrioceras maderi*; KLOTZ: 237, Text-Fig. 1.

Type: The holotype, by original designation, is BSP 1981 I 107, the original of IMMEL et al. (1982: Pl. 11, Figs. 1a, b).

Material: Besides the holotype, IMMEL et al. (1982) mentioned seven specimens, all from the early Santonian of Brandenberg/Mühlbach (Tyrol). The almost complete one is from the Klotz collection (KL. 11501) at Rum (Tyrol; KLOTZ, 1992: Text-Fig. 1) also from Brandenberg/Mühlbach and refigured here (Pl. 4).

Description: Since the original description by IMMEL et al. (1982: 24, Pl. 9, Fig. 2, Pl. 11, Figs. 1, 2) additional material has been collected. The planispiral criocone shape of the species is demonstrated by the magnificent specimen in the Klotz collection from the early Santonian of Brandenberg (Pl. 4). It is preserved with brownish shell. The criocone spiral is slightly elongated by *post mortem* deformation into an ellipse. The body chamber is partially preserved. The last preserved portion of the body chamber can be removed. The internal whorls are crushed and somewhat restored. The whorls are separated by a distance equal to or wider than the whorl height or irregular as a result of *post mortem* deformation, the terminal part of the body chamber tending to uncoil. In all, five and a half whorls are present. The umbilicus is extremely wide (approximately 86 %). The whorl section is high oval, with feebly rounded umbilical and ventrolateral shoulders. The whorl expansion rate is low.

Ornament consists of narrow, sharp, prorsiradiate (Pl. 2, Figs. 4, 6), ribs and inner and outer ventrolateral spines. Some ribs bifurcate on the body chamber, next to the um-

bilical shoulder. All ribs cross the dorsum without interruption. The ribs flex forwards from the inner ventrolateral tubercles, and cross the venter in a feeble convexity. The rib index is 27 on the adult body chamber. The style of ribbing is more or less the same on the earlier whorls. The ribs do not appear to branch. The most striking feature is the inner and outer ventrolateral spines, which first appear at a diameter of 200 mm. Those in the inner ventrolateral row are closely spaced with 13 spines within 100 mm and about 8 spines in the outer ventral row. The ribs are linked in groups of two or three at the inner ventrolateral spines, with single ribs intercalating between successive groups. On a well-preserved 100 mm sector of the body chamber (Pl. 4) alternate inner and outer ventral spines are linked by groups of ribs. The intercalated ribs cross the venter and link in groups of two or three at the outer ventral spine on the opposite flank. This alternation of rib arrangement produces the difference in the number of inner and outer ventrolateral spines noted above. The body chamber appears to make up more than half of the outer whorl. The spines appear to have been about 20 mm long with more or less rounded bases. The sutures are not exposed.

Discussion: *Neocrioceras maderi* was referred to *Neocrioceras* with some doubt by MATSUMOTO et al. (1986: 468). The Brandenberg specimen (KLOTZ, 1992: Text-Fig. 1, Pl. 4) leaves no doubt as to the generic assignation of the species. The new material also demonstrates clearly that there are two successive ontogenetic stages, the inner whorls without spines, the body chamber with long spines. This indicates that fragments without spines described as *Diplomoceras (Glyptoxoceras) subcompressum* by IMMEL et al. (1982: Pl. 9, Figs. 4, 5, Pl. 11, Fig. 4 only, *non* Pl. 10, Fig. 7) are in fact fragments of the early whorls of *Neocrioceras maderi*. Specimen M 14 of IMMEL et al. (1982: Pl. 10, Fig. 7) was also referred to *Diplomoceras (Glyptoxoceras) subcompressum*. It has much denser and regular ribbing than the specimens referred to *maderi* above, together with narrow constrictions, and is a *Glyptoxoceras*.

The type species of *Neocrioceras*, *N. spinigerum* JIMBO, 1894 (184 (38), Pl. 8, Figs. 1, 1a, b) differs in its depressed, rapidly increasing whorl section, and much tighter coiling. The umbilicus comprises about 50 % of the diameter which is relatively narrow compared to that of *N. maderi*. The tuberculation is coarser even in much smaller individuals (MATSUMOTO et al., 1986: Text-Fig. 1B, Pl. 93).

Schlueterella compressa (KLINGER, 1976: 74, Pl. 33, Fig. 5, Text-Figs. 8j, 10g) is distinguished by its more regular style of ribbing with ribs arranged in pairs united by two rows of tubercles on either flank, the inner row situated on the inner third of the flank, the outer one on the ventrolateral shoulder; successive tuberculate rib groups are separated by two or three nontuberculate intercalated ribs.

Neocrioceras maximum KENNEDY & COBBAN (1991: 65, Pl. 10, Figs. 5, 8, 12, Pl. 11, Figs. 1, 5, Pl. 12, Figs. 13–16, Text-Fig. 22c) is a close ally which differs in its relatively weak ribbing, the tuberculate ribs wider than the interspaces, with two or three nontuberculate ribs between successive tuberculate groups. There are two rows of tubercles, one in a lateral position, the other on the ventrolateral shoulder, compared to the inner and outer ventrolateral arrangement in *N. maderi*. The holotype (KENNEDY & COBBAN, 1991: Pl. 12, Figs. 13–16) has in general much coarser ornament

| Inventory No. | Dia-meter | D _{max} (mm) | Wh _{max} (mm) | Wb _{max} (mm) | U (%) |
|---------------|-----------|-----------------------|------------------------|------------------------|-------|
| KL 11501 | D1 | 420 | 75 | 40 | 86 |
| KL 11501 | D2 | 250 | --,-- | --,-- | --,-- |
| KL 11501 | D3 | 280 | --,-- | --,-- | --,-- |
| KL 11501 | D4 | 180 | --,-- | --,-- | --,-- |
| KL 11501 | D5 | 136 | --,-- | --,-- | --,-- |
| KL 11501 | D6 | 95 | --,-- | --,-- | --,-- |
| KL 11501 | D7 | 67 | --,-- | --,-- | --,-- |
| KL 11501 | D8 | 50 | --,-- | --,-- | --,-- |
| KL 11501 | D9 | 30 | --,-- | --,-- | --,-- |
| KL 11501 | D10 | 15 | --,-- | --,-- | --,-- |

Tab. 2.
Neocrioceras (Neocrioceras) maderi IMMEL KLINGER & WIEDMANN, 1982 (KL 11501). U % of D. --,-- no measurements. D: diameter in several positions.

at comparable size. Tuberculation of the paratype (KENNEDY & COBBAN, 1991: Pl. 11, Fig. 5) is more irregular, the tubercles are smaller, and often situated upon single ribs, rather than linking groups of ribs.

Neocrioceras kossmati (SIMIONESCU, 1899: 257, Pl. 1, Figs. 6, 7) from the Coniacian of Romania (Szász, 1981: 100) is coiled in a very loose spire, apparently in a single plane, the umbilicus comprising 67 % of the diameter. Relatively narrow primary ribs are separated by two or three very narrow secondaries, with relatively wide interspaces (see PAULIUC, 1968: Pl. 30, Fig. 4). The primary ribs bear two rows of small tubercles, one at mid-flank, the other on the ventrolateral shoulder. The primary ribs are never linked in pairs, and bifurcations are very rare.

Neocrioceras gosaviense sp. nov. (see below) differs in having only a single row of tubercles on either side of the venter; the shape of the complete shell is unknown.

Occurrence: BSP 1981 I 107 (the holotype), GPII P.8166 and M10 (figured by IMMEL et al., 1982) are from the lower Santonian Mühlbach site at Brandenberg (Tyrol), as is the specimen figured by KLOTZ (1992: Fig. 1). *Neocrioceras maderi* co-occurs with *Cladoceramus undulatoplicatus* and is a basal Santonian species.

Neocrioceras (Neocrioceras) gosaviense sp. nov.

(Pl. 3, Figs. 4, 5)

Type: The holotype herewith designated is MA 1973/1, the original of Plate 3, Figures 4, 5, from the Santonian of the Tiefengraben (= Grabenbach of authors), Gosau, Upper Austria.

Derivatio nominis: After the community of Gosau, where it was collected.

Material: Besides MA 1973/1, the holotype, MA 1976/17 from the Late Santonian of the Schattau (SUMMERSBERGER et al., 2017b).

Diagnosis: Coiling is open, and in a single plane. Ornament is of regular, even ribs; there is a single row of ventrolateral tubercles on some of the ribs, with two to four nontuberculate ribs between successive tuberculate ones.

Description: The holotype is an internal mould, crushed to wafer thickness, retaining traces of original aragonitic shell. Total length measured along the venter is about 200 mm. The whorl height ranges from 19 to 27 mm. The original whorl section appears to have been high oval as is seen in MA 1976/17, which is less crushed than the holotype. Ornament consists of crowded, narrow, sharp, straight ribs, changing from prorsiradiate on the adapical shaft to rursiradiate around the curved sector and on the adapertural shaft. They are periodically linked to pairs by prominent ventrolateral spines and looped between the spines across the venter. The interspaces are somewhat wider than the ribs. Rib density at mid-flank is about 6 to 7 ribs per 10 mm. There are from two to four non-tuberculate ribs between the looped pairs. Ribbing strengthens markedly on the adapertural part the holotype, indicating the proximity of the adult aperture. Ribs coarsen, and interspaces widen, with three constrictions succeeded by collar ribs (Pl. 3, Figs. 4, 5). The specimen from the

Schattau (MA 1976/17) has two constrictions followed by stronger, sharp and narrow ribs. Both specimens seem to be body chamber fragments. The spines are about 4 mm long. We are not able to reconstruct the general shape of the shell, but it was probably a loosely coiled criocone.

Discussion: General style of ribbing and tuberculation together with the loose coiling of the body chamber leads us to place the species in *Neocrioceras*. It differs from all previously described species of both *Neocrioceras* and *Schlüterella* in having only a single row of ventrolateral tubercles. *Neocrioceras maderi* IMMEL, KLINGER & WIEDMANN, 1982, *N. compressum* (KLINGER, 1976), *N. maximum* KENNEDY & COBBAN, 1991 and the type species *N. spinigerum* (JIMBO, 1894) have two rows of ventrolateral tubercles; this is also the case in *Neocrioceras kossmati* (SIMIONESCU, 1899) which in all other characteristics is very similar.

Occurrence: *Neocrioceras gosaviense* sp. nov. occurs at Gosau (Upper Austria), in the middle to lower Santonian Grabenbach Formation of the Tiefengraben (= Grabenbach of authors) to the upper Santonian part of the Hochmoos Formation.

Neocrioceras (Neocrioceras) sp. indet.

(Pl. 3, Figs. 1, 2)

- 1894 *Crioceras spinigerum* JIMBO: 184, Pl. 24, Figs. 1, 1a, 1b, 1c.
1985 *Neocrioceras spinigerum* (Jimbo, 1894); MATSUMOTO: 56, Text-Figs. 1, 2.
1986 *Neocrioceras spinigerum* (JIMBO); MATSUMOTO et al.: 463–474, Pl. 93–94, with synonymy.

Material: SK/EB/2002/27a, b, c; three fragments of a single individual.

Description: SK/EB/2002/27a is half a whorl of an internal mould with adherent white, chalky shell, possibly part of the body chamber, and some fragments of the inner whorls. Details of morphology are best shown by SK/EB/2002/27b, an external mould with an estimated diameter of about 80 mm, and a maximum whorl height of about 30 mm. The umbilicus measures about 30 mm, about 37 % of the diameter. Ornament of the last whorl consists of about 100 slightly prorsiradiate narrow and sharp ribs separated by equal interspaces. Only a few bifurcate. There is a single row of very strong tubercles, linked to two or three ribs. These are separated by two or three non-tuberculate ribs. Groups of ribs link the tubercles over the venter.

Discussion: The poor preservation hinders specific identification of this interesting specimen; nevertheless, assignment to *Neocrioceras* seems to be justified. *Neocrioceras spinigerum* (JIMBO, 1894) differs in having coarser ribbing, and two rows of ventrolateral tubercles.

Occurrence: Early Santonian of Edlbachgraben (Gosau, Upper Austria).

Genus *Schlüterella* WIEDMANN, 1962

Type species: *Ancyloceras pseudoarmatum* SCHLÜTER, 1872 (99, Pl. 31, Figs. 1–3) by original designation by WIEDMANN (1962: 205). MATSUMOTO & MIYAUCHI (1984: 60) treated *Schlüterella* as a genus separate from *Neocrioceras* (see also the discussion of KLINGER & KENNEDY, 2003: 312).

Schlüterella compressa KLINGER, 1976

(Pl. 2, Figs. 2, 3, Pl. 5, Figs. 1, 3, 5, Pl. 6, Figs. 1–10, Tab. 3)

- 1921b *Neocrioceras* cf. *spinigerum*, JIMBO sp.; SPATH: 52, Pl. 7, Figs. 6a–c.
- 1961 *Bostrychoceras* sp.; GERTH: 123, Pl. 24, Figs. 8, 9.
- 1976 *Neocrioceras (Schlüterella) compressus* KLINGER: 74, Pl. 33, Fig. 5, Text-Figs. 8j, 10g.
- 1982 *Neocrioceras (Schlüterella) compressum* KLINGER 1976; IMMEL, KLINGER & WIEDMANN: 25, Pl. 9, Fig. 3, Pl. 10, Figs. 1–4, Pl. 11, Fig. 3.
- 1986 *Neocrioceras (Schlüterella) compressum* KLINGER (1976); MATSUMOTO in MATSUMOTO et al.: 468.
- 1987 *Neocrioceras (Schlüterella) compressum* KLINGER 1976; IMMEL: 134.
- 1991 *Neocrioceras (Schlüterella) compressum* KLINGER 1976; KENNEDY & COBBAN: 65, Pl. 10, Figs. 1, 2, Pl. 12, Figs. 4–7, Text-Fig. 25c.
- ? 1995 *Neocrioceras (Neocrioceras)* sp. juv. ? KENNEDY in KENNEDY et al.: 430, Pl. 28, Fig. 33.
- 1995 *Neocrioceras (Schlüterella) compressum* KLINGER 1976; KENNEDY in KENNEDY et al.: 430, Pl. 27, Figs. 13–15, 17, Pl. 29, Figs. 4–7.
- 2003 *Neocrioceras (Schlüterella) compressum* KLINGER, 1976; KLINGER & KENNEDY: 315, Text-Figs. 59, 60A–C, 61.
- 2005 *Neocrioceras (Schlüterella) compressum* KLINGER, 1976; KAPLAN et al.: 114, Pl. 52, Fig. 4.
- 2007 *Schlüterella compressum* KLINGER, 1976; KLINGER et al.: 109, Text-Figs. 9C, 18C–D.

Type: The holotype, by original designation, is the original of *Neocrioceras (Schlüterella) compressus* KLINGER (1976: 74, Pl. 33, Fig. 5, Text-Figs. 8j, 10g).

Material: The originals of IMMEL et al. (1982: M 2, Pl. 9, Fig. 3, M 60, Pl. 10, Figs. 1a, b, BSP 1959 VI 49, Pl. 10, Fig. 2, GP II P. 8167, Pl. 10, Fig. 3, GP II P. 8168, Pl. 11, Fig. 3, M 1, Pl. 10, Fig. 4), all from the early Santonian of Brandenberg/Mühlbach (Tyrol, Austria). SK/GR/1981/2, SK/GR/1981/9, SK/GR/1993/41, SK/GR/2015/51 are from the Santonian Gosau Group of Grabenbach; NHMW 2015/0402/0001 from the middle Santonian of Neffgraben, LE GO/2015/0001 from the Santonian of the Pass Gschütt area; one unregistered specimen from the parking place of the cable car (Schwaighofer collection, Rußbach, Salzburg); GPIB 31 255 and GPIB 31 339 described by GERTH (1961: Pl. 24, Figs. 8, 9) under *Bostrychoceras* sp. from the Santonian of the Gosau Group of Neffgraben (Rußbach, Salzburg) and Grabenbach (Gosau, Upper Austria).

Description: SK/GR/1981/2 (Pl. 6, Fig. 6) is an internal mould with partially preserved light brownish shell. It consists of a loosely coiled helix with a wide apical angle and a separate curved fragment. Due to compaction along the axis of coiling the apical angle cannot be determined. The smallest measurable diameter of the helix is 6 mm, the next measurable ones are 24 and 47.8 mm. At this size the umbilicus is 39.7 mm across ($U = 83\%$). The slightly curved fragment close by and apparently broken off during or after the fossilisation process might be the body chamber. It measures 78.8 mm in length and 18 mm in width. The whorl section appears to have been rounded. Ornament consists of straight fine ribs with narrow interspacers of more or less the same width around the whole shell; the rib index is about eight. On the helix, pairs of ribs are joined and loop between lateral and ventrolateral spines, with three nontuberculate ribs between successive tuberculate ones. Only two spines, 7.6 mm long, are preserved on the body chamber. Well preserved spines are present on SK/GR/1981/9 from the Grabenbach area (Pl. 6, Fig. 3) with completely preserved spines on LE GO/2015/0001 (Pl. 5, Fig. 1).

M 60 (IMMEL et al., 1982: Pl. 10, Fig. 1), refigured here (Pl. 5, Fig. 5), is a large fragment of a loosely coiled, elliptically deformed spire. Deformation vertical to the spire cannot be excluded. The whorl section is expanding slowly, and is high oval to almost circular. Wh_{max} is 26.8 mm at the adapertural end, Wb_{max} is 25 mm, and D_{max} is about 150 mm. Successive whorls are rather closely spaced, but this may be due, to a certain degree, to *post mortem* deformation. $U\%$ has an estimated value of 54–55 %. Due to deformation it is uncertain if the early whorls might have been helically coiled. The ornament of this specimen is characterised by regularly looped pairs of straight and closely spaced ribs in the adult stage with strong tubercles connecting the ribs on either side of the shell in two rows, the one ventrolateral, the other below mid-flank. In the adult stage the ribs and tubercles are arranged in zigzag pattern (Pl. 5, Fig. 3), as described by IMMEL et al. (1982: Pl. 10, Figs. 2, 3a). Ribs and interspaces increase in size towards the adult aperture. One or two intercalated ribs efface near the ventrolateral tubercles on one flank, and reappear on the other flank. Juvenile tuberculation seems to start with a single ventrolateral row, the lateral row appearing at a whorl height of approximately 15 mm.

SK/GR/1981/9 (Pl. 6, Figs. 3–5) and SK/GR/1993/41 (Pl. 6, Figs. 7, 8), from the Santonian of Grabenbach (Gosau, Upper Austria), may be body chamber fragments; they show the same arrangement of ribs and tubercles. In LE GO/2015/0001 the rib junctions at mid-flank are marked by a distinct tubercle, the ventrolateral ones by several millimeters long spines. None of the specimens show the sutures.

| Inventory No. | D (mm) | Wh (mm) | WB (mm) | U (mm) | U % |
|-----------------|--------|---------|---------|--------|------|
| LE GO/2015/0001 | 80 | 23.7 | 14.2 | 48.9 | 61.1 |

Tab. 3.

Measurements of *Schlüterella compressa* KLINGER, 1976 (LE GO/2015/0001). $U\%$ of D.

Discussion: MATSUMOTO et al. (1986: 469) treated *Schlüeterella* as a separate genus, rather than as a subgenus of *Neocrioceras*. WRIGHT (1996: 253) treated it as a subgenus of *Pseudoxybeloceras*. Despite differences, the Brandenberg specimens and those from the Gosau area are thought to be conspecific, or at least closely related. Fragmentary and deformed preservation in both areas of occurrence make absolute certainty impossible.

The Japanese *Schlüeterella kawadai* MATSUMOTO & MIYAUCHI, 1984 (61, Pl. 26, Fig. 1, Pl. 27, Figs. 3, 4, Pl. 28, Fig. 2, Pl. 29, Fig. 1, Pl. 30, Figs. 1–2, Pl. 31, Fig. 3, Text-Fig. 9) differs in its long and slightly arcuate shaft followed by a hook at the end, and in its coarser ornamentation. *Neocrioceras (Schlüeterella) pseudoarmatum* (SCHLÜTER, 1872: 99, Pl. 31, Figs. 1–3) from the Early Campanian of Westphalia (Germany) differs in having straight shafts (KENNEDY & KAPLAN, 1997: Pl. 64). *Neocrioceras maderi* IMMEL, KLINGER & WIEDMANN, 1982 (24, Pl. 9, Fig. 2, Pl. 11, Figs. 1, 2) differs in the distinct change of ornament with increasing diameter, the slightly more irregular ornament on the adult body chamber, and in having inner and outer ventrolateral, rather than the ventrolateral and lateral tubercles of the present species. *Neocrioceras spinigerum* (JIMBO, 1894) has a more depressed and more rapidly expanding whorl section, the whorls much tighter coiled, the relatively narrow umbilicus comprising about 50 % of the diameter. *Neocrioceras maximum* KENNEDY & COBBAN, 1991 is a close ally which differs in its narrow delicate ribs with generally two or three non-tuberculate ribs between successive tuberculated ones. Tuberculation of the paratype (KENNEDY & COBBAN, 1991: Pl. 11, Fig. 5) is more irregular, tubercles are smaller, and often positioned upon single, not looped ribs, whereas the holotype (KENNEDY & COBBAN, 1991: Pl. 12, Figs. 13–16) is similar with generally much coarser ornament at comparable size. *Neocrioceras kossmati* (SIMIONESCU, 1899), is coiled in a very loose spire ($U = 67\%$) apparently in a single plane. The style of ribbing is characterised by relatively narrow primaries, separated by two or three very narrow secondaries and relatively wide interspaces. The primary ribs bear two rows of small tubercles, one at mid-flank, the other in a ventrolateral position. The primaries are never linked in pairs, and bifurcation is very rare. *Neocrioceras gosavicense* sp. nov. (see above) differs in having only a single row of ventrolateral tubercles.

Occurrence: GPIB 255 is from the middle Santonian of the Neffgraben (Rußbach, Salzburg), GPIB 339 from the early to middle Santonian of the Grabenbach (Gosau, Upper Austria; GERTH, 1961). The Brandenberg (Tyrol, Austria) occurrence is early Santonian. The species also occurs in the middle Santonian *gallicus* Subzone of the Corbières, France, the early Santonian St. Lucia Formation in KwaZulu-Natal (South Africa), and the Middle Coniacian *Volviceramus involutus* Zone of Wyoming in the US Western Interior.

Subfamily Polyptychoceratinae MATSUMOTO, 1938

Genus and Subgenus *Pseudoxybeloceras* WRIGHT & MATSUMOTO, 1954

Type species: *Hamites quadrinodosus* JIMBO, 1894 (39, Pl. 7, Figs. 3, 4) by original designation.

Pseudoxybeloceras (Pseudoxybeloceras) quadrinodosum (JIMBO, 1894)

(Pl. 5, Figs. 2, 4, Pl. 6, Fig. 11, Pl. 7, Fig. 12)

- 1894 *Hamites quadrinodosus* JIMBO: 39, Pl. 7, Figs. 3, 4.
 1954 *Pseudoxybeloceras quadrinodosum* (JIMBO); WRIGHT & MATSUMOTO: 120, Pl. 7, Fig. 6, Text-Figs. 6, 9–12.
 1974 *Pseudoxybeloceras quadrinodosum* (JIMBO); SZÁSZ: 193, Pl. 1, Figs. 1–4, Pl. 2, Figs. 1–3, Pl. 3, Fig. 1, Text-Fig. 2.
 1977 *Pseudoxybeloceras quadrinodosum* (JIMBO); MATSUMOTO: 345, Pl. 57, Fig. 2, Pl. 61, Fig. 4.
 2003 *Pseudoxybeloceras (Pseudoxybeloceras) quadrinodosum* (JIMBO, 1894); KLINGER & KENNEDY: 319, Figs. 60D, 62 [with synonymy].

Type: The lectotype, by subsequent designation of WRIGHT & MATSUMOTO (1954: 120), is the specimen from the ?Santonian–Campanian of Hokkaido figured by JIMBO (1894: Pl. 7, Fig. 3) in the collections of the University Museum, Tokyo n° MM7524-1.

Material: Two fragments SK/RA/1981/32 from the middle Santonian of the Randograben 2 site (Rußbach, Salzburg) and SK/EB/2015/75 from the lower Santonian of the Edlbachgraben.

Description: SK/RA/1981/32 (Pl. 5, Figs. 2, 4, Pl. 7, Fig. 12) is a 59.6 mm long fragment of a straight shaft with part of a U-bend preserved at the adapertural end. It is an internal mould with extensive areas of the shell preserved, and has been deformed by *post mortem* crushing; the original whorl section was probably circular. The diameter increases rapidly towards the adapertural end of the fragment. The surface is covered with regular narrow and sharp ribs separated by somewhat wider interspaces. The rib index is about 7 to 8 at the apical end, and 11 at the adapertural end. The ribs are straight, do not branch, and extend over the dorsum (where they narrow slightly), flanks and venter. Tiny inner and outer ventrolateral tubercles, perched on slightly flared ribs are aligned parallel to the venter. Ribbing appears to be somewhat irregular in the area of tuberculation. Occasional non-tuberculated ribs are intercalated. SK/EB/2015/75 (Pl. 6, Fig. 11) is a curved fragment approximately 33 mm long, with an estimated original whorl height of about 7 mm. The ribs are feebly prossiradiate, concave and narrow, and separated by narrow interspaces; the rib index is about 7. There are worn lateral and ventrolateral tubercles on every fourth, slightly stronger rib.

Discussion: Co-occurring *Pseudoxybeloceras (Parasolenoceras) splendens* COLLIGNON, 1969, described below, appears to be more regular in its general shape, the whorl section ex-

panding more slowly. *Pseudoxybeloceras* (*Pseudoxybeloceras*) *matsumotoi* COLLIGNON, 1965 (12, Pl. 419, Fig. 1731) differs in its spatulate spines.

Occurrence: *Pseudoxybeloceras* (*Pseudoxybeloceras*) *quadrinodosum* (JIMBO, 1894) occurs from the Santonian to Campanian of Japan (MATSUMOTO, 1977). It is also recorded from the Campanian of Romania (SZÁSZ, 1974, 1982).

Subgenus *Parasolenoceras* COLLIGNON, 1969

Type species: *Parasolenoceras splendens* COLLIGNON, 1969 (44, Pl. 530, Figs. 2087, 2088) by original designation.

Pseudoxybeloceras (*Parasolenoceras*) *splendens* COLLIGNON, 1969

(Pl. 6, Figs. 12–15)

- 1969 *Parasolenoceras splendens* COLLIGNON, nov. gen., nov. sp.: 44, Pl. 530, Fig. 2087.
? 1995 *Pseudoxybeloceras* (*Parasolenoceras*) aff. *splendens* COLLIGNON, 1969; KENNEDY in KENNEDY et al.: 431, Pl. 29, Figs. 2, 3.
1996 *Pseudoxybeloceras* (*Parasolenoceras*) *splendens* COLLIGNON, 1969; WRIGHT: 253, Figs. 196/4a, b.
2005 *Pseudoxybeloceras* (*Parasolenoceras*) *splendens* COLLIGNON, 1969; KAPLAN et al.: 122, Pl. 52, Figs. 3, 5, Pl. 53, Figs. 1–3, Pl. 54, Figs. 1, 2 [with synonymy].
2014 *Parasolenoceras splendens* COLLIGNON, 1969; KENNEDY in WALASZCZYK et al.: 122, Figs. 32 D, E.

Type: The lectotype by the subsequent designation of KAPLAN et al. (2005: 122) is the original of COLLIGNON (1969: 44, Pl. 530, Fig. 2087), refigured by KAPLAN et al. (2005: Pl. 54, Figs. 1, 2).

Material: Three specimens: SK/GR/1983/31 from Grabenbach, SK/RA/1997/135, SK/RA/2005/153a from the site Randobraben 2 (Rußbach, Salzburg), and an additional one in the Seidl collection: SEIDL/CE 00014.01.

Description: SK/RA/2005/153a (Pl. 6, Figs. 12, 13) is a compressed fragment of a straight shaft, with white shell material preserved, 44.6 mm long, with an estimated whorl width of 5.15 mm. There are six to seven regular fine ribs per 10 mm length that extend across the dorsum, flanks and venter. Each rib bears a small ventrolateral tubercle.

SK/RA/1997/135 (Pl. 6, Fig. 14) is a fragment of a shaft of 42.5 mm length with a small curved part preserved. The phragmocone ends at the curvature; the body chamber is more or less straight. Ornament consists of about 4.8 sharp ribs/cm. Ribs are more or less straight and separated by somewhat wider interspaces. They coarsen towards the aperture and the interspaces increase in width. SK/GR/1983/31 (Pl. 6, Fig. 15) is the most complete specimen with two parallel shafts and the linking curved sector preserved. The fragment is about 60 mm long. The total length of both shafts including the curvature is about 120 mm. The estimated diameter of the smaller shaft must have been around 6 mm, the diameter at the restored end of the body chamber about 9 mm.

Discussion: Narrow straight fine ribs and a single row of tiny tubercles on each ventrolateral shoulder indicate that all three specimens belong to *Pseudoxybeloceras* (*Parasolenoceras*) *splendens*. COLLIGNON's original specimen (1969: 44, Pl. 530, Fig. 2087) is larger, but differs in no significant details from the Gosau specimens. *Pseudoxybeloceras* (*Parasolenoceras*) *wernickei* (WOLLEMANN, 1902: Pl. 4, Fig. 4, Pl. 5, Figs. 1, 2) is larger, with coarser, widely separated ribs. *Parasolenoceras periodicum* (MATSUMOTO & MIYAUCHI, 1984: 64, Pl. 28, Fig. 1, Pl. 31, Fig. 1) has major ribs with coarse tubercles that are linked across the venter by two or three ribs developed at irregular intervals, and separated by several ribs with weaker tubercles, linked across the venter by a single rib.

Occurrence: *Pseudoxybeloceras* (*Parasolenoceras*) *splendens* COLLIGNON, 1969 was first described from the early Campanian of Madagascar (COLLIGNON, 1969: 44, Pl. 530, Fig. 2087). It occurs also in the early Campanian of Westphalia (Germany; KAPLAN et al., 2005). A single specimen from the Corbières (KENNEDY in KENNEDY et al., 1995: Pl. 29, Figs. 2, 3) is from the Late Santonian *paraplanum* Zone. The Austrian specimens are from the middle Santonian.

Genus *Polyptychoceras* YABE, 1927

Type species: *Ptychoceras pseudo-gaultinum* YOKOYAMA, 1890 (181, Pl. 20, Figs. 1–3) by original designation. The species is based on three syntypes, the originals of YOKOYAMA (1890: 29, Pl. 46, Figs. 1–3). No lectotype has been designated according to MATSUMOTO (1984: 29), who pointed out that YOKOYAMA's Plate 20, Figures 1 and 2 are conspecific (and correspond to the prevailing interpretation of the species), while the original of YOKOYAMA's Plate 20, Figure 3 belongs to some other species.

Polyptychoceras sp., juv.

(Pl. 7, Fig. 5)

Material: A single specimen SK/RA/1988/117a, b from Randobach 1 site (Rußbach, Salzburg).

Description: SK/RA/1988/117 consists of external moulds of the left and right sides of the same specimen with only a small, 18.6 mm long fragment of the internal mould preserved. The specimen consists of three parallel shafts, linked by curved sectors, and a 6 mm long final shaft. The specimen is ornamented by single delicate feebly rursiradiate ribs. The index is nine approximately, decreasing to six on the final short shaft, which appears to be part of the body chamber. There are no constrictions or ribs, and the ribs neither branch nor loop.

Discussion: None of the previously described species of *Polyptychoceras* have such a high density of feebly rursiradiate ribs. The closest is the late Campanian *Polyptychoceras rectecostatum* (SCHLÜTER, 1872: 107, Pl. 29, Fig. 7; KAPLAN et al., 2005: 126, Pl. 48, Fig. 3) but here the rib index is 5, rather than up to 9, as in the present specimen.

Occurrence: Middle Santonian of Randobach.

***Polyptychoceras* sp., form 1**

(Pl. 7, Figs. 1, 2, 4)

Material: SK/GR/1981/7, SK/GR/1983/32 and NHMW 2015/0530/0002 are all from the Grabenbach area (Gosau).

Description: SK/GR/1981/7 is a relatively large crushed internal mould with at least three parallel shafts and large areas of the shell preserved. The juvenile parts and the aperture are missing. The internal shaft is broken and dislocated and its connection with the following median shaft is not preserved. The connection between the median and the third shaft is a well preserved U-curve. The internal shaft as far as observable is approximately 70 mm long, the median shaft about 105 mm, the last one is 120 mm long including the U-bend. The whorl height close to the adapertural end is 13.6 mm, at the internal shaft it measures 5.8 mm. The original whorl section was probably circular. The ribs are narrow, sharp and rursiradiate. The rib index is 6 from close to the aperture to the initial shaft. The interspaces are somewhat wider than the ribs. There are few irregularly spaced, inconspicuous constrictions. There are neither tubercles, nor flared ribs. NHMW 2015/0530/0002 and SK/RA/1983/32 are fragments with short parts of the shaft and the curved sector preserved.

Discussion: SK/GR/1981/7 differs from *Polyptychoceras pseudogaultinum* (YOKOYAMA, 1890: 29, Pl. 46, Figs. 1–3) in its slightly rursiradiate ribs. *Polyptychoceras obstrictum* (JIMBO, 1894: 184, Pl. 23, Fig. 2) differs in its straight and crowded ribs (rib index 10). The specimen figured by WHITEAVES, 1903 (Pl. 44, Fig. 3) has slightly rursiradiate ribs with occasional bifurcations. *Polyptychoceras haradanum* (YOKOYAMA, 1890: 182, Pl. 20, Fig. 5) from the Santonian of Hokkaido is similar but has coarser ribbing.

Occurrence: All three specimens of *Polyptychoceras* sp. form 1 occur in the lower and middle Santonian of the Gosau Group (Gosau, Upper Austria) only.

***Polyptychoceras* sp., form 2**

(Pl. 7, Fig. 3)

Material: SK/RA/1997/136 from the middle Santonian of Randobach 2.

Description: SK/RA/1997/136 is a curved fragment of an individual with at least two shafts, the longer one – in part possibly body chamber – measures 40 mm, the shorter one 34 mm. The curvature is more than 180°. The diameter of the terminal shaft is about 7 to 8 mm (reconstructed), that of the penultimate shaft is 6 to 7 mm (reconstructed). The straight ribs are narrow and sharp and separated by somewhat wider interspaces. Ribbing is regular, about 6 ribs per 10 mm on the terminal part and about 8 per 10 mm on the adapical part. Ribs are undivided. There are no tubercles. The sutures are not exposed.

Discussion: SK/RA/1997/136 differs from *Polyptychoceras* sp. form 1, above, by the almost circular course of the U-shaped part of the shell. This could, however, be the result of *post mortem* deformation. It is left in open nomenclature.

Occurrence: Middle Santonian of the Randobach 2 site (Rußbach, Salzburg)

***Polyptychoceras* sp., form 3**

(Pl. 7, Fig. 6)

Material: SK/GR/2014/49.

Description: SK/GR/2014/49 is a fragment of a crushed internal mould with the whitish shell completely preserved, consisting of a straight shaft and part of a curved sector, suggesting an individual with at least two parallel shafts. The length of the specimen is 26.4 mm. The whorl height is 6.2 mm, exaggerated by lateral compaction. The original whorl section was probably circular or oval. There are approximately six narrow, sharp, oblique prorsiradiate ribs per 10 mm that extend across the dorsum (where they are slightly effaced), flanks and venter. The interspaces are somewhat wider than the ribs. There are no tubercles. The suture is not exposed.

Discussion: *Polyptychoceras* sp. form 3 differs from *P. pseudogaultinum* in its oblique ribbing.

Occurrence: SK/GR/2014/49 is from the middle Santonian of Pass Gschütt (Gosau, Upper Austria).

Family Baculitidae GILL, 1871

Genus *Baculites* LAMARCK, 1799

Type species: *Baculites vertebralis* LAMARCK, 1801 (103), by the subsequent designation of MEEK (1876: 391).

***Baculites incurvatus* DUJARDIN, 1837**

(Pl. 8, Figs. 1–2, 4–13, Pl. 9, Figs. 1–10, Text-Figs. 3, 4, Tab. 4)

- 1837 *Baculites incurvatus* DUJARDIN: 232, Pl. 17, Figs. 13a–d.
- 1876 *Baculites incurvatus*, DUJ.; SCHLÜTER: 142, Pl. 39, Figs. 6, 7, Pl. 40, Fig. 3 [with synonymy].
- 1906 *Baculites incurvatus* DUJARDIN; MÜLLER & WOLLEMANN: 4, Pl. 2, Figs. 2–5.
- 1961 *Baculites incurvatus* DUJARD. 1837; GERTH: 121, Pl. 24, Fig. 6.
- 1982 *Baculites incurvatus* DUJARDIN 1837; IMMEL et al.: 27, Pl. 11, Figs. 5–7 [with synonymy].
- 1984 *Baculites incurvatus* DUJARDIN, 1837; KENNEDY: 143, Pl. 32, Figs. 12, 15–19, Pl. 33, Figs. 1–22, Text-Figs. 41, 42.
- 1987 *Baculites incurvatus* DUJARDIN 1837; IMMEL: 128.
- 1991 *Baculites cf. incurvatus* DUJARDIN, 1837; KENNEDY & CHRISTENSEN: 217, Pl. 1, Figs. 2a, b.
- 1996 *Baculites incurvatus* DUJARDIN, 1837; WRIGHT: 256, Figs. 199, 3 d, e.
- 1997 *Baculites incurvatus* DUJARDIN, 1837; KLINGER & KENNEDY: 92, Fig. 56.

- 2000 *Baculites incurvatus* DUJARDIN, 1837; KENNEDY & KAPLAN: 106, Pl. 35, Fig. 6, Pl. 38, Figs. 1–3.
- 2001 *Baculites incurvatus* DUJARDIN, 1837; KLINGER & KENNEDY: 169, Figs. 128 A–P [with synonymy].

Type: The lectotype, by the subsequent designation of IMMEL et al. (1982: 127) is the original of DUJARDIN (1837: Pl. 17, Fig. 13a), refigured by KENNEDY (1984: Pl. 33, Figs. 4–6) and KLINGER & KENNEDY (1997: Fig. 56).

Material:

a) Skoumal collection:

From Randobach (Rußbach, Salzburg) 14 specimens:

SK/RA/1981/37a; SK/RA/1982/70a, b, c, e; SK/RA/1982/71d, e; SK/RA/1983/92a, b; SK/RA/1983/93c; SK/RA/1984/105; SK/RA/2003/50c; SK/RA/2003/150a, c.

From Neffgraben (Rußbach, Salzburg) five specimens: SK/NE/1989/2, SK/NE/1989/11b, d, e; SK/NE/2013/21e.

From Edlbachgraben (Gosau, Upper Austria) one specimen: SK/EB/2003/30.

b) NHMW collection: about 50 specimens, and fragments.

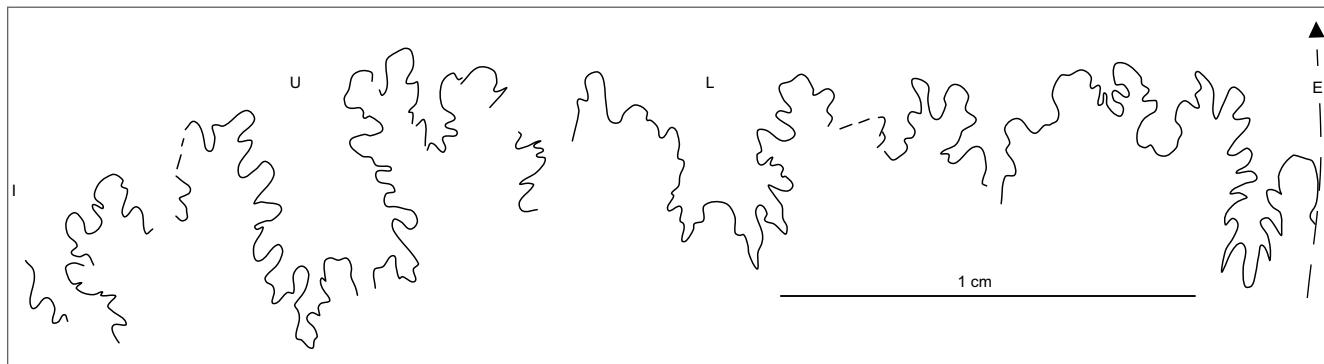
c) Mader collection (IMMEL et al., 1982): three specimens.

d) Gerth collection: GPIB 212 from Neffgraben (Rußbach, Salzburg); the original of GERTH (1961: Pl. 24, Fig. 6).

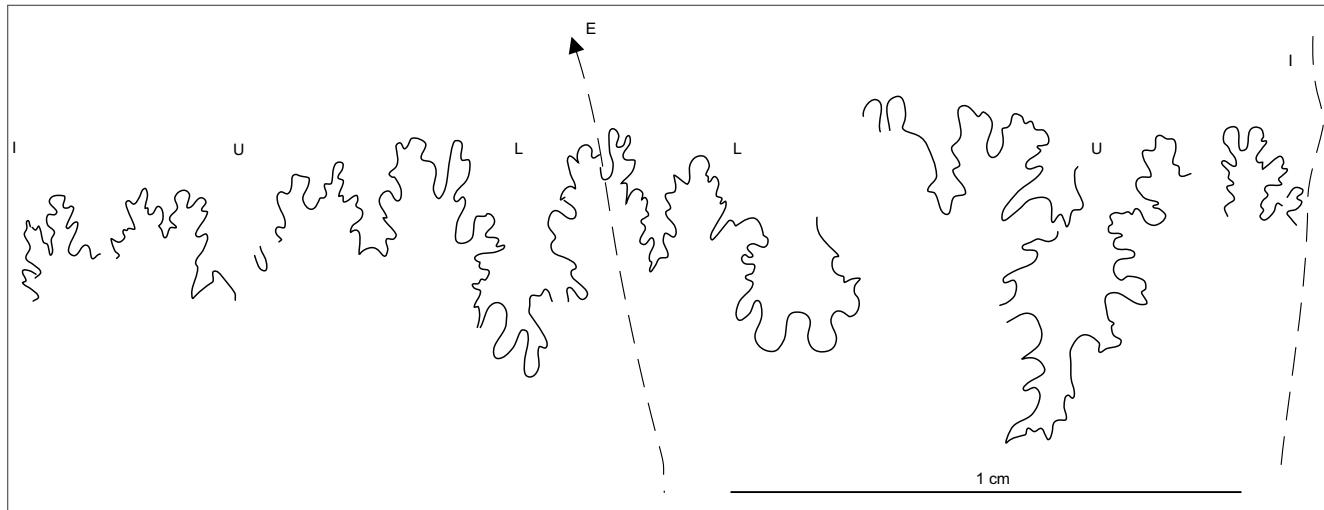
- e) Leiblfinger Prömer collection: LPG: five specimens on a slab (LE GO/2015/0003) from the Neffgraben (Rußbach, Salzburg).
- f) Seidl collection: SEIDL/CE 00003.

Description: *Baculites incurvatus* DUJARDIN, 1837, is a highly variable species, both in the form of the shell and the ornament. The material recently collected by Peter Skoumal demonstrates the occurrence of different types of shell form and sculpture at the same locality.

GERTH (1961: 121, Pl. 24, Fig. 6) was the first to figure a specimen of *B. incurvatus* from the Gosau Group (Neffgraben, Rußbach, Salzburg), a slightly curved fragment of the body chamber and a part of the phragmocone (length: 84 mm, Wb_{max}: 12 mm). It is preserved as an internal mould with adherent white shell, and is more or less flattened by compaction. The majority of the recently collected specimens from the Gosau area are also slightly curved, the venter convex in profile, the dorsum concave. Many of the specimens are also straight (e.g. Brandenberg: IMMEL et al., 1982: Pl. 11, Figs. 9–11). The venter is in many cases bordered by parallel shallow sulci. The adult apertural margin (which follows the course of the growth lines) is concave on the flanks, projecting forwards as a long ventral rostrum and a short dorsal rostrum (Pl. 8, Figs. 8, 12, 13, Pl. 9, Figs. 10, 11). The most prominent feature is the variable



Text-Fig. 3.
Suture of *Baculites incurvatus* DUJARDIN, 1837 (SK/EB/2003/30).



Text-Fig. 4.
Suture of *Baculites incurvatus* DUJARDIN, 1837 (SK/RA/1982/70a).

| Inventory No. | Length (mm) | Wh (mm) | Wb (mm) |
|-----------------|----------------------|---------------------|---------------------|
| SEIDL/CE 00003 | 250 _{rest.} | 23 _{rest.} | 15 _{rest.} |
| SK/NE/ 1989/2 | 250 _{rest.} | 15 _{rest.} | 15 _{rest.} |
| SK/RA/1982/70a | 160 _{rest.} | 12 _{rest.} | 10 _{rest.} |
| SK/RA/2003/150a | 160 _{rest.} | 13 _{rest.} | 12 _{rest.} |

Tab. 4.

Baculites incurvatus DUJARDIN, 1837 (all specimens are fragments with tentatively restored data; rest. = restored). Measurements from the apertural end of the fragment.

ornament. There are strong, distant, irregularly spaced prorsiradiate dorsolateral bullae. The growth lines project strongly forwards on the outer flanks and strengthen into well-developed ribs that cross the venter in a broad convexity. The suture was illustrated by GERTH (1961: Fig. 1).

Discussion: The closest relative of *Baculites incurvatus* appears to be the highly variable South African *Baculites capensis* Woods, 1906 (342, Pl. 44, Figs. 6, 7). KLINGER & KENNEDY (1997) distinguished 12 morphotypes on the basis of differences in sculpture. They also discussed the possibility of *B. capensis* being a subspecies or junior synonym of *B. incurvatus*. However, there are no curved individuals in the South African populations (KLINGER & KENNEDY, 1997: Figs. 27–33, 34A–L, ?34M–R, 35–54) and we keep the species separate here. *Baculites brevicosta* SCHLÜTER, 1876 (Pl. 11, Figs. 1–21), which co-occurs with *Baculites incurvatus* in the Gosau Group of Gosau and Rußbach differs in its distinctive crescentic and closely spaced dorsolateral bullae. Co-occurring *Baculites fuchsii* REDTENBACHER, 1873 (Pl. 10, Figs. 1–15) is smooth, apart from strengthened growth lines in some individuals. Species of *Boehmoceras* have a much more strongly curved shell (KENNEDY & KLINGER, 1997: 121).

Occurrence: The Austrian representatives of *Baculites incurvatus* DUJARDIN, 1837 appear in the early Santonian, with an acme in the middle Santonian. They disappear together with *Texanites quinque nodosus* and *Muniericeras gosauicum* below the Sandkalkbank Member in the late Santonian. In France (Touraine, Aquitaine) they appear in the middle Coniacian and extend into the late Coniacian in Germany. In Denmark they possibly occur in the Santonian.

Baculites brevicosta SCHLÜTER, 1876

(Pl. 8, Fig. 3, Pl. 11, Figs. 1–7, 9–20, Text-Fig. 5, Tab. 5)

- 1876 *Baculites brevicosta* SCHLÜTER: 141, Pl. 39, Figs. 9, 10.
non 1931 *Baculites cf. brevicosta* SCHLÜTER; COLLIGNON: 34, Pl. 5, Figs. 1, 1a, Pl. 9, Fig. 13 (= *B. capensis* Woods, 1906; teste KLINGER & KENNEDY, 1997: 53).
1959 *Baculites brevicosta* SCHLÜTER (1876); MATSUMOTO: 117, 121, 128.
1984 *Baculites cf. brevicosta* SCHLÜTER, 1876; KENNEDY: 146, Pl. 33, Figs. 23–25 [with synonymy].
1994 *Baculites brevicosta* SCHLÜTER, 1876; KAPLAN & KENNEDY: 59, Pl. 40, Figs. 15–19.
1997 *Baculites brevicosta* SCHLÜTER, 1876; KLINGER & KENNEDY: 106.

2001 *Baculites cf. brevicosta* SCHLÜTER, 1876; KLINGER & KENNEDY: 136, Figs. 128 Q, R, S, ?Figs. 103 R, S.

Type: The lectotype, by the subsequent designation of KENNEDY (1984: 146), is the original of SCHLÜTER (1876: 141, Pl. 39, Figs. 9, 10).

Material: Altogether we have about 25 specimens from the Gosau Group of the Gosau Basin (Austria). From Germany SCHLÜTER (1876: 141) mentioned only a few specimens of apparently Coniacian age (KENNEDY, 1984: 146; KLINGER & KENNEDY, 2001: 106).

Skoumal collection

SK/RA/1981/37b; SK/RA/1981/38a, b, c; SK/RA/1982/69a; SK/RA/1982/71a; SK/RA/1983/90; SK/RA/1983/92c, d, e; SK/RA/1983/93a, b; SK/RA/1983/100a; SK/RA/2003/150b, d; SK/NE/1989/11a, c; SK/NE/2001/19; SK/NE/2013/21a, b, c, d; SK/EB/2011/54a, b, c.

Seidl collection

SEIDL/CE 00009.

Description: *Baculites brevicosta* SCHLÜTER, 1876 is a rare species, described here for the first time from the Gosau Group. SCHLÜTER (1876: 141) described the lectotype as follows: "kleiner Bakulit [...], welcher auf den Flanken in der Nähe des Rückens gekrümmte, halbmondförmige kurze Rippen trägt." The crescentic (= halbmondförmig) ribs are also visible in SCHLÜTER's figure (1876: Pl. 39, Figs. 9, 10).

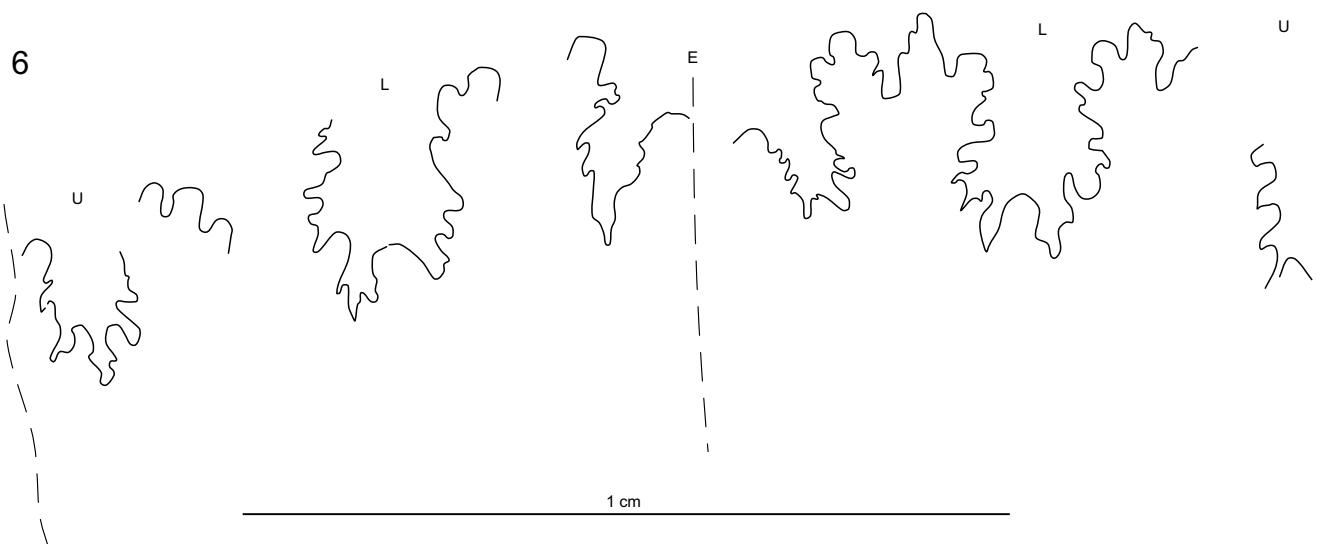
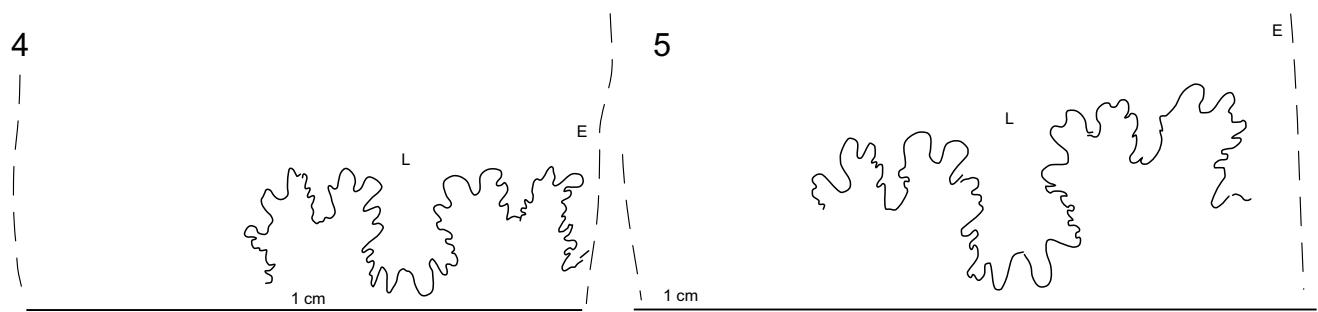
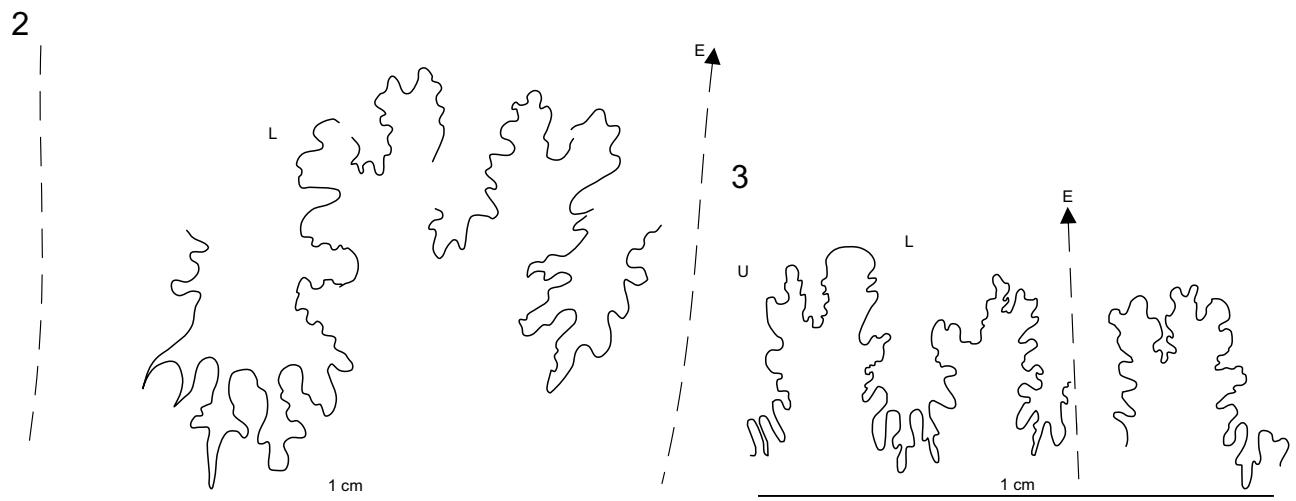
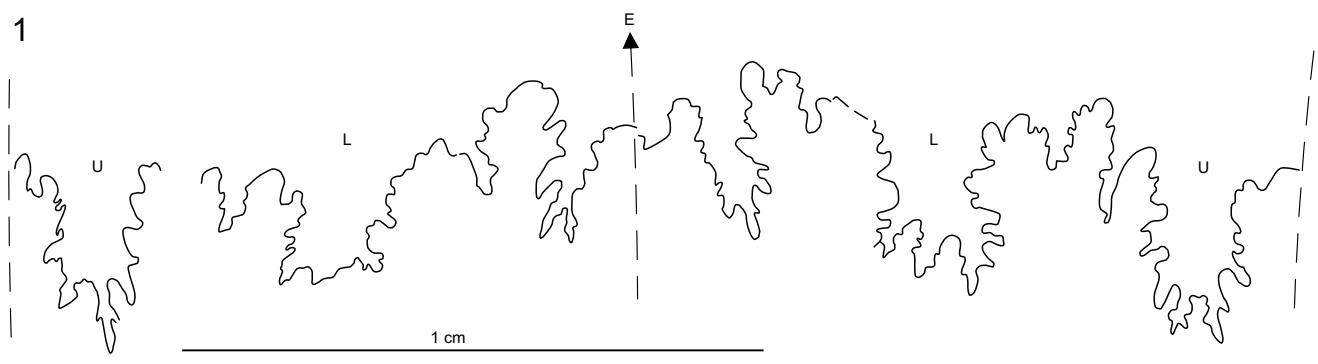
The general shape of the shell is slightly curved or straight. All Gosau specimens are preserved as internal moulds with adherent yellowish shell remains. All are crushed to a certain degree. Longitudinal measurements are still meaningful; the whorl section cannot be restored with accuracy.

SK/NE/2001/19 (Pl. 11, Fig. 4) is a body chamber fragment of 64 mm long, the venter gently rounded and bordered by ventrolateral sulci. It is elongated into a distinct rostrum with a rounded end forming part of the well preserved aperture with a short and broad dorsal protuberance, the rostra connected by a deep sinus on the flanks. The shell – in this case originally nacre – is decorated by closely spaced weak crescentic ribs, of which there are about six per centimeter. In SK/RA/1981/38a (Pl. 11, Fig. 3) the growth lines are strengthened into characteristic dorsolateral crescentic ribs, effaced on the mid-flank region, and reappearing on the outermost flank; close-spaced fine ribs extend across the venter. SEIDL/CE 00009 (Pl. 11, Fig. 1) is a 65 mm long fragment with closely spaced crescentic dorsolateral ribs of variable strength.

| Inventory No. | Length (mm) | Wh (mm) | Wb (mm) |
|-----------------|-------------|----------------------|----------------------|
| SK/NE/1989/11a | 87 | 15 _{rest.} | 13 _{rest.} |
| SK/RA/1981/38a | 81 | 11 _{rest.} | 9 _{rest.} |
| SK/RA/2003/150b | 80 | 6.5 _{rest.} | 5.5 _{rest.} |
| SEIDL/CE 00009 | 75 | 12 _{rest.} | 10 _{rest.} |

Tab. 5.

Measurements of *Baculites brevicosta* SCHLÜTER, 1876 (all specimens are fragments with tentatively restored data; rest. = restored). Measurements from the apertural end of the fragment.



◀ Text-Fig. 5.

Sutures of *Baculites brevicosta* SCHLÜTER, 1876.

1. SK/RA/1983/92d; 2. SK/NE/1989/11a; 3. SK/RA/2003/150b; 4. SK/RA/1983/93b juv.; 5. SK/RA/1983/93b juv.2; 6. SK/RA/1983/93b adult.

Discussion: The slight curvature of the shell and the shape of the aperture indicate a close relationship with *Baculites incurvatus*. The coarse dorsolateral tuberculation of the latter is, however, quite distinct. *Baculites fuchsi* is ornamented by delicate growth lines, and weak ventrolateral and ventral ribs in some individuals.

Occurrence: *B. brevicosta* SCHLÜTER, 1876 is a rare species in the Coniacian of Germany (see KAPLAN & KENNEDY, 1994: 59, Pl. 40, Figs. 15–19). It also occurs in the Upper Coniacian of the Corbières (KENNEDY, 1984: *B. cf. brevicosta* SCHLÜTER). The Austrian occurrences are the youngest, in the lower to middle Santonian.

Baculites fuchsi REDTENBACHER, 1873

(Pl. 10, Figs. 1–15, Text-Fig. 6, Tab. 6)

- 1873 *Baculites fuchsi* REDTENBACHER: 134, Pl. 30, Fig. 15.
 1979 *Baculites fuchsi* REDTENBACHER, 1873; SUMMESBERGER: 113, Pl. 1, Figs. 2, 3; Text-Figs. 2, 3 [with synonymy].
 1979 *Baculites* sp.; SUMMESBERGER: 116, Pl. 1, Figs. 8, 9, Text-Fig. 5.
 1982 *Baculites fuchsi* REDTENBACHER, 1873; IMMEL et al.: 28, Pl. 11, Fig. 8.
 1991 *Baculites* cf. *fuchsi* REDTENBACHER, 1873; KENNEDY & CHRISTENSEN: 217, Pl. 7, Figs. 1a, b.
 ? 1995 *Baculites* sp.; KENNEDY in KENNEDY et al.: 431, Pl. 27, Figs. 1–3.
 2017b *Baculites fuchsi* REDTENBACHER, 1873; SUMMESBERGER et al.: 193, Pl. 15, Fig. 4.
 2017c *Baculites fuchsi* REDTENBACHER, 1873; SUMMESBERGER et al.: 129, Fig. 7/2, 3.

Type: The holotype, by monotypy, is the original of REDTENBACHER (1873: 134, Pl. 30, Fig. 15).

Material: SK/1977/5, the original of SUMMESBERGER (1979: Pl. 1, Figs. 2–4), SK/1977/7, the original of SUMMESBERGER (1979: Pl. 1, Figs. 8, 9); GPII P. 8170, the original of

| Inventory No. | Length (mm) | Wh (mm) | Wb (mm) |
|---------------------|-------------------|-------------------|-------------------|
| NHMW 1865/0001/0138 | 72 _{est} | 15 _{est} | 12 _{est} |
| NHMW 2016/0047/0001 | 64 | 15 _{est} | 12 _{est} |
| OÖLM 2016/2 | -- | 16.8 | 13.9 |
| SK/RA/1983/99 | 129.2 | 15 _{est} | 14 _{est} |

Tab. 6.

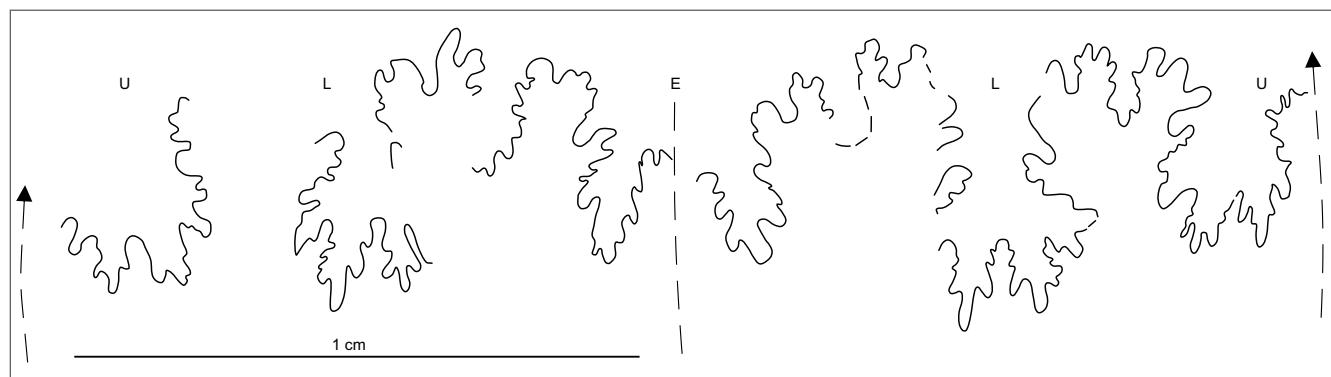
Measurements of *Baculites fuchsi* REDTENBACHER, 1873 (all fragments). _{est} = estimated. Measurements from the apertural end of the fragment.

IMMEL et al. (1982: Pl. 11, Fig. 8); NHMW 1865/0001/0138 (the holotype and original of REDTENBACHER, 1873: Pl. 30, Fig. 15), NHMW 1926/0002/2468 (ex coll. Heinrich); NHMW 2016/0047/0001; OÖLM/2016/1, OÖLM/2016/2; SK/RA/1982/69b, c; SK/RA/1982/70d, SK/RA/1982/71b, c; SK/RA/1983/92f, SK/RA/1983/99, SK/RA/1983/100b; SK/GR/1981/17b; HNS 6404.

Description: All specimens of *B. fuchsi* are straight fragments. Detailed descriptions were given by SUMMESBERGER (1979: 113, Pl. 1, Figs. 2, 3, Text-Figs. 2, 3) and by IMMEL et al. (1982: 28, Pl. 11, Fig. 8). The surface is smooth in most cases apart from weak undulations of the venter (SUMMESBERGER, 1979: 114) and faint growth lines parallel to the aperture.

Discussion: *Baculites fuchsi* REDTENBACHER, 1873 differs from co-occurring *B. incurvatus* and *B. brevicosta* in its very weakly ornamented to smooth surface. KLINGER & KENNEDY (1997: 46), stated that *B. bailyi* (WOODS, 1906) from South Africa, Madagascar, Antarctica, Hokkaido and British Columbia and *B. fuchsi* REDTENBACHER, 1873 are virtually indistinguishable, suggesting that *bailyi* might be a junior synonym. KLINGER & KENNEDY (1997: 46) also noted the parallelism of co-occurrence of the European near-smooth *B. fuchsi* and tuberculate *B. incurvatus* and the co-occurrence of tuberculate *B. bailyi* and near smooth *B. capensis* WOODS in the classic Mzamba section in northeastern Eastern Cape Province in South Africa.

Occurrence: The holotype is from the Tiefengraben (= Grabenbach, Gosau, Upper Austria). This and the majority of recently collected specimens are from the lower and middle Santonian. The Brandenberg specimen is from the



Text-Fig. 6.

Suture of *Baculites fuchsi* REDTENBACHER, 1873 (SK/RA/1982/69c).

Lower Santonian. The specimens described by SUMMERS-BERGER (1979) are from the Upper Santonian. *Baculites fuchsii* REDTENBACHER, 1873 is a typical Santonian species, occurring in the limited area of the Gosau Group. It is also described under *Baculites cf. fuchsii* REDTENBACHER, 1873 from the Coniacian/Santonian of Denmark (KENNEDY & CHRISTENSEN, 1991: 217) and Spain (SANTAMARIA, 1991; SANTAMARIA ZABALA, 1992).

Baculites sp.

(Pl. 11, Fig. 8)

Material: SK/GR/1981/17a is a single individual from the Grabenbach locality (Gosau, Upper Austria).

Description: SK/GR/1981/17a is an internal mould with large parts of the shell preserved. L is 88 mm, Wb is 17–21 mm. The single straight fragment is sculptured by four very coarse ribs crossing the flank in somewhat irregular distances.

Discussion: SK/GR/1981/17a is described in open nomenclature as it differs from the baculitids described above in its very coarse ornament. The sculpture recalls similarity to the Campanian *Baculites vanhoopeni* VENZO, 1936 (see KLINGER & KENNEDY, 1997).

Occurrence: SK/GR/1981/17a is single specimen from the middle Santonian of the Grabenbach locality (Gosau, Upper Austria).

Superfamily Scaphitoidea GILL, 1871

Family Scaphitidae GILL, 1871

Subfamily Scaphitinae GILL, 1871

Genus and subgenus *Scaphites* PARKINSON, 1811

Type species: *Scaphites equalis* J. SOWERBY, 1813, by subsequent designation by MEEK (1876).

Remarks: In general, Scaphitinae are quite common in the Coniacian and again in the Campanian of the Gosau Group but very rare in the Santonian. Doubtful *Scaphites* are mentioned from Brandenberg by KATSCHTHALER (1935) followed by BRINKMANN (1935) and FISCHER (1964). A single individual was described as “*Scaphites cf. meslei* GROSSOUIVRE” by GERTH (1956: 433, Text-Fig. 1), and was from the middle Santonian of the Neffgraben (Rußbach, Salzburg). Gerth believed to have it collected in the Coniacian (GERTH, 1961: 134/135, Text-Fig. 4). We have not seen the original specimen, and place it in the synonymy of *Scaphites leei* (see below).

Scaphites leei REESIDE, 1927, form II (COBBAN, 1969)

(Pl. 7, Figs. 7, 8)

Type: The holotype is USNM 73354 (REESIDE, 1927: Pl. 1, Figs. 17–22) by original designation. It was refigured by COBBAN (1969: Pl. 1, Figs. 8, 9).

- 1927 *Scaphites leei* REESIDE: 26, Pl. 20, Figs. 17–22.
- ? 1935 *Scaphites lamberti* var. *meslei* GROSSOUIVRE; BRINKMANN: 4.
- ? 1956 *Scaphites* cf. *meslei* GROSSOUIVRE; GERTH: 433, Text-Fig. 1.
- ? 1961 *Scaphites* cf. *meslei* GROSSOUIVRE; GERTH: 134, Text-Fig. 4.
- 1969 *Scaphites leei* REESIDE II; COBBAN: 15, Pl. 1, Figs. 8–18.
- 1987 *Scaphites (Scaphites) meslei* DE GROSSOUIVRE 1894; IM-MEL: 137, Pl. 14, Figs. 13, 14.
- 1995 *Scaphites leei* REESIDE, 1927, form II, COBBAN 1969; KENNEDY in KENNEDY et al.: 433, Pl. 30, Figs. 2–5, 6, 7–17, 20–21, 26–27.

Material: A single specimen, NHMW 1982/0034/0001 (Santonian, Grabenbach, Gosau, Upper Austria).

Description: NHMW 1982/0034/0001 is a fragment of an internal mould of a body chamber with adherent shell remaining, 23.7 mm long, 10.8 mm wide, the umbilicus 4.9 mm in diameter. Sharp and narrow strong ribs arise on the umbilical shoulder, some with an elongated bulla, some without. Some primary ribs terminate a bullate or triangular strong and acute ventrolateral tubercle. Narrow secondary ribs, some of them bifurcating, arise on the ventrolateral shoulder, cross the venter in a very feeble convexity, and are separated by wide interspaces.

Discussion: The closest relative of the present specimen seems to be the questionable *Scaphites* cf. *meslei* GROSSOUIVRE of GERTH (1956: Text-Fig. 1), which was already excluded from synonymy of the typically Coniacien *meslei* by KENNEDY (1984: 148).

Occurrence: *Scaphites leei* REESIDE, 1927, originally described from the U.S. Western Interior, occurs in the Middle and Upper Santonian of the Corbières (France). It is recorded from the Gosau for the first time.

Scaphites sp.

(Pl. 7, Figs. 9–11, Tab. 7)

Material: SK/RA/1996/130, SK/EB/1985/7.

Description: Both specimens are undeformed fragments of phragmocones with some original shell material preserved. They are thought to be conspecific. The whorl breadth and height increase rapidly in SK/RA/1996/130 (Pl. 7, Figs. 9, 10). There are seven primary ribs on a 120° whorl sector. They arise on the umbilical shoulder and are straight on the inner third of the flank, then slightly prosiradiate and falcold, sweeping back again in a shallow convexity, and passing straight across the venter. Most of the ribs bifurcate around the middle of the flank, and additional ribs intercalate, to give a total of about 21 ribs on the venter. The ornament of SK/EB/1985/7 (Pl. 7, Fig. 11) is comparable.

Discussion: These two phragmocones are specifically indeterminate.

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|----------------|-----------|------------|------------|-----------|----------|
| SK/RA/1996/130 | 16.8 | 10.2 | 7.3 | 1.9 | 8.8 |
| SK/EB/1985/7 | 20.1 | 13.8 | 5.6 | 2.3 | 8.7 |

Tab. 7.
Measurements of *Scaphites* sp. from the Santonian of the Gosau Group.

Occurrence: Both specimens occur in the early Santonian, in the Edlbachgraben (Gosau, Upper Austria) and Randbachgraben (Rußbach, Salzburg).

Biostratigraphical conclusions on the Santonian Gosau Group

In the Gosau Group the Zone of *Placenticeras polyopsis* can be divided by ammonites into three subzones which are defined by the appearance of the dominant ammonite.

List of the late Santonian Zone of *Placenticeras paraplanum*

- Gaudryceras mite* (HAUER, 1866)
- Pseudophyllites loryi* (KILIAN & REBOUL, 1909)
- Parapuzosia seppenradensis* (LANDOIS, 1895)
- Parapuzosia corbarica* (DE GROSSOUVRE, 1894)
- Kitchinites stenomphalus* SUMMESBERGER, 1979
- Hauericeras* (*Gardeniceras*) *welschi* DE GROSSOUVRE, 1894
- Hauericeras* (*Gardeniceras*) *lagarum* (REDTENBACHER, 1873)
- Eupachydiscus isculensis* (REDTENBACHER, 1873)
- Damesites sugata* (FORBES, 1846)
- Nowakites draschei* (REDTENBACHER, 1873)
- Nowakites savini* (DE GROSSOUVRE, 1894)
- Texasia dentatocarinata* (ROEMER, 1852)
- Placenticeras polyopsis* (DUJARDIN, 1837)
- Placenticeras paraplanum* WIEDMANN, 1978
- Placenticeras maherndli* SUMMESBERGER, 1979
- Diaziceras austriacum* (SUMMESBERGER, 1979)
- Eulophoceras jacobi* HOURCQ, 1949
- Reginaites gappi* WIEDMANN, 1978
- Amapondella amapondense* (VAN HOEPEN, 1921)
- Scalarites sertae* (MÜLLER & WOLLEMAN, 1906)
- Glyptoxoceras souqueti* COLLIGNON, 1969
- Glyptoxoceras crispatum* (MOBERG, 1885)
- Neocrioceras* (*Neocrioceras*) *gosaviense* sp. nov.
- Polyptychoceras* sp.
- Baculites fuchsii* REDTENBACHER, 1873
- Baculites sulcatus* BAILY, 1855
- Boehmoceras krekeleri* (WEGNER, 1905)
- Boehmoceras arculus* (MORTON, 1834)

List of the middle Santonian Zone of *Muniericeras gosauicum*

- Angulithes westphalicus* (SCHLÜTER, 1872)
- Cymatoceras* sp.
- Cymatoceras cf. huxleyanum* (BLANFORD, 1861)
- Gaudryceras mite* (HAUER, 1866)
- Saghalinites nuperus* (VAN HOEPEN, 1921)
- Parapuzosia corbarica* (DE GROSSOUVRE, 1894)
- Nowakites carezi* (DE GROSSOUVRE, 1894)
- Nowakites draschei* (REDTENBACHER, 1873)
- Eupachydiscus isculensis* (REDTENBACHER, 1873)
- Tragodesmoceras aff. clypeale* (SCHLÜTER, 1872)
- Muniericeras gosauicum* (HAUER, 1858)
- Pseudoschloenbachia inconstans* (DE GROSSOUVRE, 1894)
- Texanites quinquenodosus* (REDTENBACHER, 1873)
- Damesites sugata* (FORBES, 1846)
- Eubostrychoceras* (*E.*) *salisburgense* sp. nov.
- Didymoceras* (*Didymoceras*) sp.
- Muramotoceras costatum* sp. nov.
- Glyptoxoceras retrorsum* (SCHLÜTER, 1872)
- Glyptoxoceras* sp.
- Neocrioceras* (*Neocrioceras*) *gosaviense* sp. nov.
- Schlüterella* (*Schlüterella*) *compressa* KLINGER, 1976
- Pseudoxybeloceras* (*P.*) *quadrinodosum* (JIMBO, 1894)
- Pseudoxybeloceras* (*Parasolenoceras*) *splendens* COLLIGNON, 1969
- Polyptychoceras* sp., juv.
- Polyptychoceras* sp., form 1
- Polyptychoceras* sp., form 2
- Polyptychoceras* sp., form 3
- Baculites incurvatus* DUJARDIN, 1837
- Baculites fuchsii* REDTENBACHER, 1873
- Baculites brevicosta* SCHLÜTER, 1876
- Baculites* sp.

List of the early Santonian Zone of *Eulophoceras natalense* HYATT, 1903

- Cimomia* cf. *gosavica* (REDTENBACHER, 1873)
- Cymatoceras* sp.
- Angulithes westphalicus* (SCHLÜTER, 1872)
- Hyporbilites woodsi* (VAN HOEPEN, 1921)
- Anagaudryceras redtenbacheri* (IMMEL et al., 1982)
- ? *Anagaudryceras* cf. *subtililineatum* (KOSSMAT, 1895)
- Gaudryceras mite* (REDTENBACHER, 1873)
- Saghalinites nuperus* (VAN HOEPEN, 1921)
- Parapuzosia daubreei* (DE GROSSOUVRE, 1894)
- Parapuzosia corbarica* (DE GROSSOUVRE, 1894)
- Hauericeras* (*Gardeniceras*) aff. *gardeni* (BAILY, 1855)
- Nowakites carezi* (DE GROSSOUVRE, 1894)
- Nowakites savini* (DE GROSSOUVRE, 1894)

Eupachydiscus isculensis (REDTENBACHER, 1873), microconch
Texanites quinqueradiatus (REDTENBACHER, 1873)
Texasia cricki (SPATH, 1921)
Eulophoceras natalense HYATT, 1903
Hauericeras (Hauericeras) pseudogardneri (SCHLÜTER, 1872)
Kossmaticeras (Kossmaticeras) cf. sparsicostatum (KOSSMAT, 1897)
Patagiosites? sp.
? *Paratexanites serratomarginatus* (REDTENBACHER, 1873)
Hyphantoceras plicatum (D'ORBIGNY, 1842)
Scalarites cingulatus (SCHLÜTER, 1872)
Neocrioceras (N.) sp. indet.
Neocrioceras (Neocrioceras) maderi IMMEL et al., 1982
Schlüterella (Schlueterella) compressa KLINGER, 1976
Pseudoxybeloceras (P.) quadrinodosum (JIMBO, 1894)
Baculites incurvatus DUJARDIN, 1837
Baculites brevicosta SCHLÜTER, 1876
Scaphites leei REESIDE, 1927, form II, COBBAN, 1969
Scaphites sp.
Cladoceramus undulatoplicatus (F. ROEMER, 1852)

The early Santonian Zone of *Eulophoceras natalense* is present at the following localities: Brandenberg/Mühlbach, Edlbachgraben/Gosau, Randograben 3/Stöcklwaldgraben/Rußbach, lower part of the Grabenbach (= Tiefengraben), Gosau. *Texanites quinqueradiatus* appears together with *C. undulatoplicatus* and *E. natalense* in the lowest parts of the Gosau Group and co-occurs with *M. gosauicum* through the middle Santonian part of the section. Both disappear about 20 m below the base of the Sandkalkbank Member in the Neffgraben.

The basal middle Santonian is defined in the Gosau Group at the Randobach 2/Rußbach, Salzburg site with a mass occurrence of *Muniericeras gosauicum*. The middle Santonian is also indicated by the occurrence of *Muniericeras gosauicum* in the Neffgraben up to the confluence with the elliptica-Graben (GERTH, 1961), and in the middle and upper part of the Grabenbach (= Tiefengraben/Gosau).

Late Santonian biomarkers are limited to the Schattaugraben exposure (Rußbach, Salzburg) which is in lithostratigraphical contact with the Finstergrabenwandl (Gosau, Upper Austria; SUMMERSBERGER, 1979, 1980) and to the Hofergraben exposures (SUMMERSBERGER et al., 2017c). The characteristic ammonite fauna is listed above.

Revised list of heteromorph Ammonites described by IMMEL et al. (1982) and IMMEL (1987)

Neocrioceras (Neocrioceras) maderi IMMEL, KLINGER & WIEDMANN, 1982 → *Neocrioceras (Neocrioceras) maderi* IMMEL et al., 1982
Neocrioceras (Schlueterella) compressum KLINGER, 1976 → *Schlue-terella compressa* KLINGER, 1976
Diplomoceras (Glyptoxoceras) subcompressum (FORBES, 1846) → *Glyptoxoceras crispatum* (MOBERG, 1885)
Diplomoceras (Glyptoxoceras) indicum (FORBES, 1846) → *Glypto-xoceras crispatum* MOBERG, 1885
Baculites incurvatus DUJARDIN, 1837 → *Baculites incurvatus* DUJARDIN, 1837
Baculites fuchsii REDTENBACHER, 1873 → *Baculites fuchsii* REDTENBACHER, 1873
Hyphantoceras (Hyphantoceras) orientaliforme IMMEL, 1987 → *Hyphantoceras plicatum* (D'ORBIGNY, 1842)

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| <i>Eubostrychoceras (Eubostrychoceras) salisburgense</i> sp. nov. | 104 | Pl. 1, Figs. 1–4 |
| <i>Didymoceras (Didymoceras) sp.</i> | 105 | Pl. 1, Fig. 14, Pl. 9, Fig. 1, Tab. 1 |
| <i>Hyphantoceras plicatum</i> (d'ORBIGNY, 1842) | 106 | Pl. 1, Figs. 6, 7 |
| <i>Muramotoceras costatum</i> sp. nov. | 107 | Pl. 1, Figs. 5, 10 |
| <i>Scalarites cingulatus</i> (SCHLÜTER, 1872) | 107 | Pl. 1, Figs. 8, 9 |
| <i>Glyptoxoceras crispatum</i> (MOBERG, 1885) | 108 | Pl. 1, Figs. 11–13, Pl. 2, Fig. 5 |
| <i>Glyptoxoceras retrorsum</i> (SCHLÜTER, 1872) | 109 | Pl. 2, Figs. 1, 7 |
| <i>Glyptoxoceras</i> sp. | 109 | Pl. 3, Fig. 3 |
| <i>Neocrioceras (Neocrioceras) maderi</i> IMMEL, KLINGER & WIEDMANN, 1982 | 109 | Pl. 2, Figs. 4, 6, Pl. 4, Fig. 1, Tab. 2 |
| <i>Neocrioceras (Neocrioceras) gosaviense</i> sp. nov. | 111 | Pl. 3, Figs. 4, 5 |
| <i>Neocrioceras (Neocrioceras) sp.</i> indet. | 111 | Pl. 3, Figs. 1, 2 |
| <i>Schlüterella compressa</i> KLINGER, 1976 | 112 | Pl. 2, Figs. 2, 3, Pl. 5, Figs. 1, 3, 5, Pl. 6, Figs. 1–10, Tab. 3 |
| <i>Pseudoxybeloceras (Pseudoxybeloceras)</i> <i>quadrinodosum</i> (JIMBO, 1894) | 113 | Pl. 5, Figs. 2, 4, Pl. 6, Fig. 11, Pl. 7, Fig. 12 |
| <i>Pseudoxybeloceras (Parasolenoceras) splendens</i> COLLIGNON, 1969 | 114 | Pl. 6, Figs. 12–15 |
| <i>Polyptychoceras</i> sp., juv. | 114 | Pl. 7, Fig. 5 |
| <i>Polyptychoceras</i> sp., form 1 | 115 | Pl. 7, Figs. 1, 2, 4 |
| <i>Polyptychoceras</i> sp., form 2 | 115 | Pl. 7, Fig. 3 |
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| <i>Baculites incurvatus</i> DUJARDIN, 1837 | 115 | Pl. 8, Figs. 1, 2, 4–13, Pl. 9, Figs. 1–10, Text-Figs. 3, 4, Tab. 4 |
| <i>Baculites brevicosta</i> SCHLÜTER, 1876 | 117 | Pl. 8, Fig. 3, Pl. 11, Figs. 1–7, 9–20, Text-Fig. 5, Tab. 5 |
| <i>Baculites fuchsii</i> REDTENBACHER, 1873 | 119 | Pl. 10, Figs. 1–15, Text-Fig. 6, Tab. 6 |
| <i>Baculites</i> sp. | 120 | Pl. 11, Fig. 8 |
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| <i>Scaphites</i> sp. | 120 | Pl. 7, Figs. 9–11, Tab. 7 |

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Plate 1

Figs. 1–4: *Eubostrychoceras (Eubostrychoceras) salisburgense* sp. nov.; SK/RA/2011/159; holotype; Randobach, Rußbach, Salzburg.

Figs. 5, 10: *Muramotoceras costatum* sp. nov.; Fig. 5 is NHMW 2017/0136/0001; holotype; Fig. 10: dorsal view of the body chamber; Grabenbach, Gosau.

Figs. 6, 7: *Hyphantoceras plicatum* (d'ORBIGNY, 1842); SK/EB/2008/44; Edlbachgraben, Gosau.

Figs. 8, 9: *Scalarites cingulatus* (SCHLÜTER, 1872); SK/EB/2009/47; Edlbachgraben, Gosau.

Figs. 11–13: *Glyptoxoceras crispatum* (MOBERG, 1885); GP II P. 8165 (Fig. 11), TLMF/SM/531 (Fig. 12), M 14 (BSP; Fig. 13); Brandenberg.

Fig. 14: *Didymoceras (D.)* sp.; LE GO/2015/0003; Neffgraben, Rußbach.

Figs. 1–4, 14 are middle Santonian, Edlbachgraben and Brandenberg are lower Santonian. All but Fig. 14 are coated with ammonium chloride. Fig. 12 is a silicone cast; enlargements are indicated by 20 mm scale bars.



Plate 2

Figs. 1, 7: *Glyptoxoceras retrorsum* (SCHLÜTER, 1872); Fig. 1: LE GO/2015/0002, Fig 7: SK/NE/1989/12; Neffgraben, Rußbach.

Figs. 2, 3: *Schlueterella compressa* KLINGER, 1976; GPII P. 8167; Brandenberg.

Figs. 4, 6: *Neocrioceras (Neocrioceras) maderi* IMMEL et al., 1982; Fig. 4 is BSP 1981 I 107, the holotype; Fig. 6 is GPII, P. 8166; both from Brandenberg, Tyrol.

Fig. 5: *Glyptoxoceras crispatum* (MOBERG, 1885); NHMW 2015/0539/0001; Grabenbach, Gosau.

Figs. 1, 2, 5 are middle Santonian, Figs. 3, 4, 6, 7 are lower Santonian. All are coated with ammonium chloride. Fig. 1 is x 0.9, Figs. 2–7 are natural size.



Plate 3

Figs. 1, 2: *Neocrioceras (Neocrioceras)* sp. indet. 1; SK/EB/2002/27a, b; Edlbach, Gosau; lower Santonian.

Fig. 3: *Glyptoxoceras* sp.; SK/GR/1993/40; Grabenbach.

Figs. 4, 5: *Neocrioceras (Neocrioceras) gosaviense* sp. nov.; MA 1973/1; holotype; Grabenbach.

All are natural size. Figs. 1, 2 are lower Santonian, Figs. 3–5 are lower to middle Santonian. All are coated with ammonium chloride.

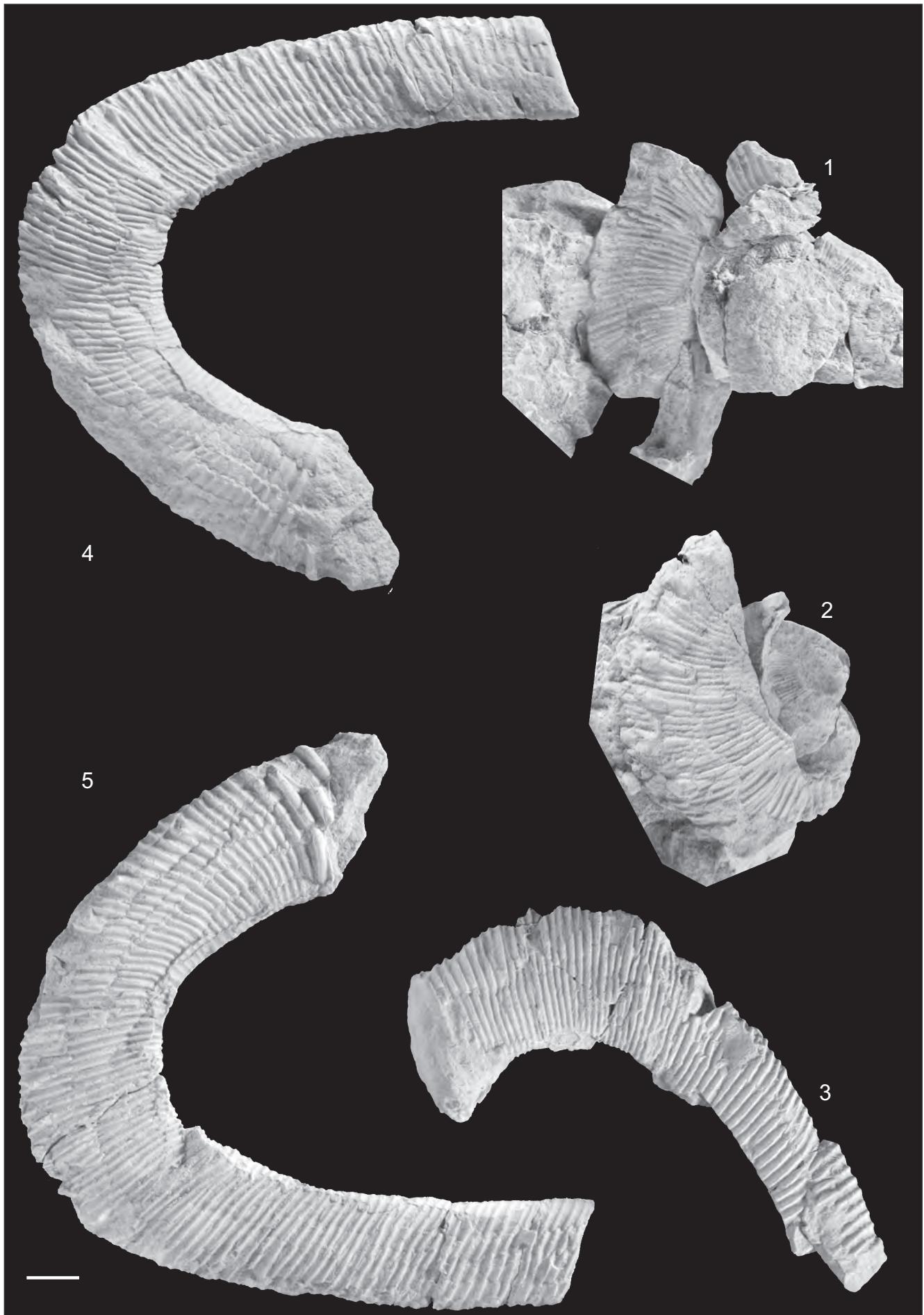


Plate 4

Fig. 1: *Neocrioceras (Neocrioceras) maderi* IMMEL et al., 1982; KL 11501; Brandenberg (Tyrol); lower Santonian.

Uncoated, 55 % of natural size.



Plate 5

Figs. 1, 3, 5: *Schlüterella compressa* KLINGER, 1976; Fig. 1 is LE GO/2015/0001, Pass Gschütt, Gosau, Fig. 3 is BSP 1959/VI/49, the original of IMMEL et al. (1982: Pl. 10, Fig. 2), Fig. 5 is a cast of M 60, the original of IMMEL et al. (1982: Pl. 10, Figs. 1a, b), Figs. 3 and 5 are from the lower Santonian of Brandenberg.

Figs. 2, 4: *Pseudoxybeloceras (Pseudoxybeloceras) quadrinodosum* (JIMBO, 1894); SK/RA/1981/32 from the middle Santonian of the Rando-bach 2 site.

Figs. 1, 3, 5 are natural size, Figs. 2, 4 are enlarged x 1,15. All but Fig. 1 are coated with ammonium chloride.



Plate 6

Figs. 1–10: *Schlueterella compressa* KLINGER, 1976; Fig. 1 is GPII P. 8168 (BSP) from Brandenberg, Fig. 2 is from the Santonian of the cable car parking place, Rußbach, Schwaighofer collection, unregistered. Figs. 3–5 are SK/GR/1981/9 from Grabenbach, Gosau, Figs. 6–8 are also from Grabenbach, Fig. 6 is SK/GR/1981/2, Figs. 7, 8 are SK/GR/1993/41, Fig. 9 is NHMW 2015/0402/0001 from Neffgraben, Rußbach, Fig. 10 is SK/GR/2015/51 from the Grabenbach, Gosau.

Fig. 11: *Pseudoxybeloceras (Pseudoxybeloceras) quadrinodosum* (JIMBO, 1894); SK/EB/2015/75 is from Edlbachgraben, Gosau.

Figs. 12–15: *Pseudoxybeloceras (Parasolenoceras) splendens* COLLIGNON, 1969; Figs. 12, 13 are SK/RA/2005/153a, Fig. 14 is SK/RA/1997/135 from Randobach, Rußbach, Fig. 15 is SK/GR/1983/31 from Grabenbach, Gosau.

All but Fig. 2 are coated with ammonium chloride, all but Figs. 12, 13 are natural size, enlargement is indicated by 20 mm scale bars.

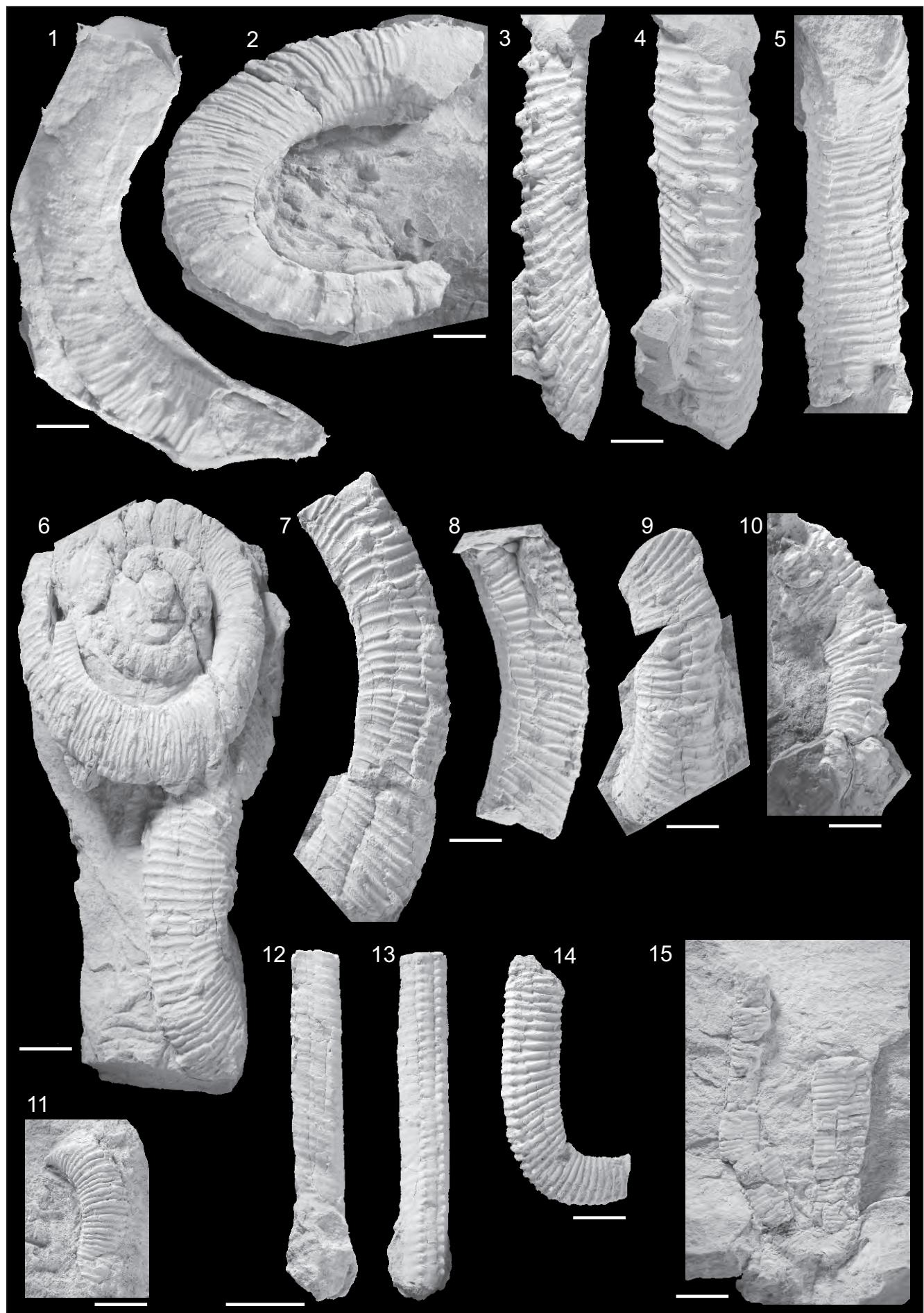


Plate 7

Figs. 1, 2, 4: *Polyptychoceras* sp., form 1; Fig. 1 is SK/GR/1981/7, Fig. 2 is NHMW 2013/0530/0002, Fig. 4 is SK/GR/1983/32; all are from Grabenbach, Gosau.

Fig. 3: *Polyptychoceras* sp., form 2; SK/RA/1997/136; Randobach, Rußbach 2 site.

Fig. 5: *Polyptychoceras* sp., juv.; SK/RA/1988/117a, b from the Randobach 1 site, Rußbach.

Fig. 6: *Polyptychoceras* sp., form 3; SK/GR/2014/49 from Grabenbach, Gosau.

Figs. 7, 8: *Scaphites leei* REESIDE, 1927, form II (COBBAN, 1969); NHMW 1982/0034/0001 from Grabenbach, Gosau.

Figs. 9–11: *Scaphites* sp.; Figs. 9, 10 are SK/RA/1996/130 (Randobach, Rußbach), Fig. 11 is SK/EB 1985/7 (Edlbach, Gosau).

Fig. 12: *Pseudoxybeloceras (Pseudoxybeloceras) quadrinodosum* (JIMBO, 1894); SK/RA/1981/32 from the middle Santonian of the Randobach 2 site.

Figs. 1, 3 are natural size, Fig. 2 is enlarged x 2, Fig. 4 is enlarged x 1,25, Fig. 5 is enlarged x 3, Figs. 6–11 are enlarged x 2, Fig. 12 is enlarged x 1,15. All are coated with ammonium chloride, Fig. 5 is enhanced by pencil. Scale bars are 10 mm.

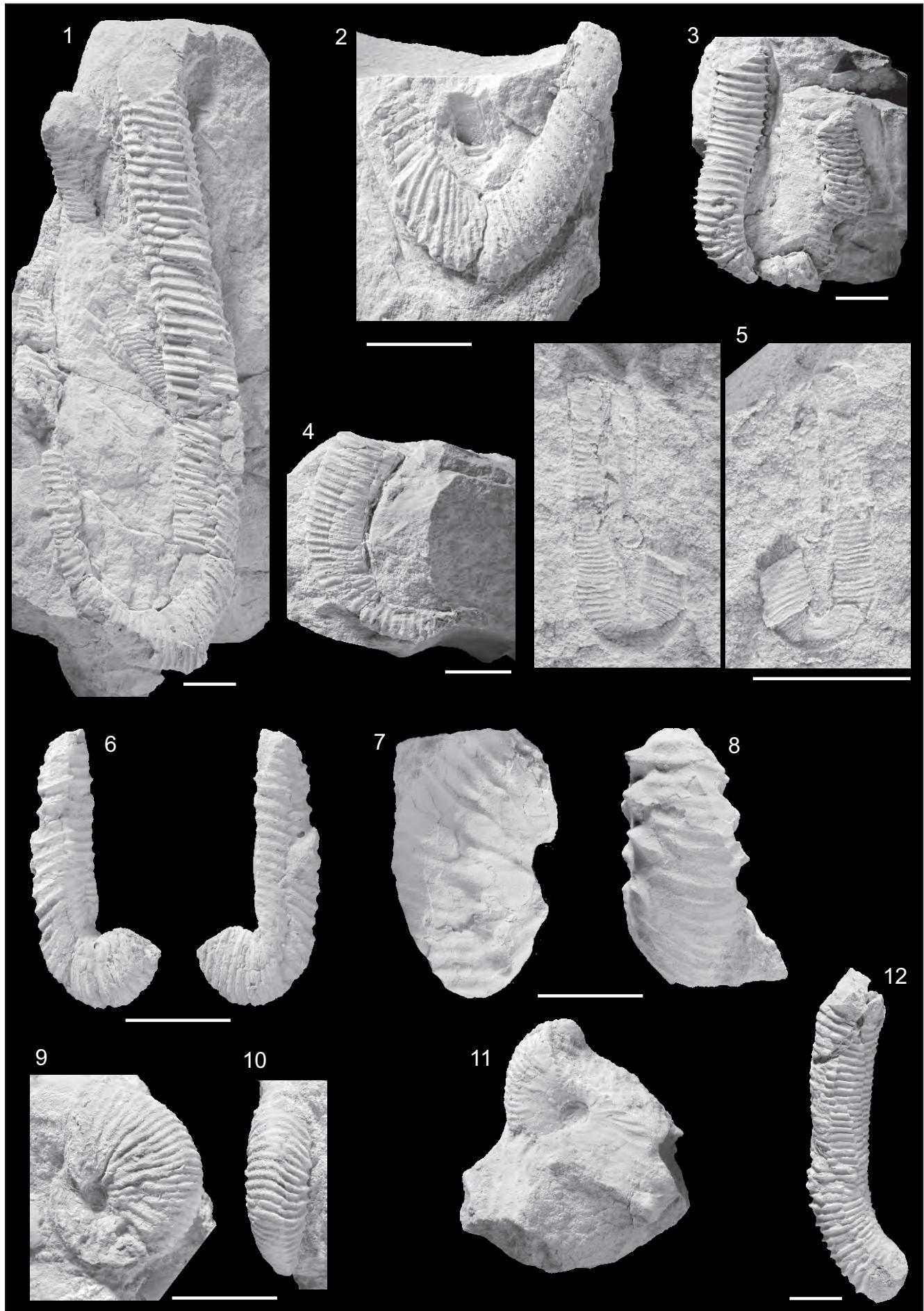


Plate 8

Fig. 1: SK/RA/1982/70a.

Fig. 2: SK/RA/1981/37a.

Fig. 3: SK/RA/1981/37b *B. brevicosta*.

Fig. 4: SK/RA/1982/70c.

Fig. 5: SK/RA/1983/92b.

Fig. 6: SK/RA/1982/70b.

Figs. 7, 8: SK/RA/1983/93c.

Fig. 9: SK/RA/2003/150c.

Figs. 10, 11: SK/EB/2003/30.

Fig. 12: SEIDL/CE 00003.

Fig. 13: SK/NE/1989/2.

Figs. 1, 2, 4–13: *Baculites incurvatus* DUJARDIN, 1837, Fig. 3 is *B. brevicosta* SCHLÜTER, 1876.

All are natural size, all are coated with ammonium chloride. Figs. 1–9 are from Randobach, Figs. 10, 11 are from Edlbachgraben, Figs. 12, 13 from Neffgraben, Rußbach. Figs. 1–9, 12, 13 are middle Santonian, Figs. 10, 11 are lower Santonian. Scale bar is 10 mm.



Plate 9

Baculites incurvatus DUJARDIN, 1837

- Fig. 1: LE GO/2015/0003; mass occurrence of *Baculites incurvatus* together with *Didymoceras* (*D*) sp.
- Figs. 2, 3: SK/RA/2003/150a.
- Fig. 4: SK/NE/2013/21e.
- Figs. 5, 6: SK/NE/1989/11b.
- Fig. 7: SK/RA/1982/70e.
- Figs. 8, 9: SK/RA/1982/71d.
- Fig. 10: SK/NE/1989/11d.

All but Figs. 8, 9 (= x 2) are natural size, all are coated with ammonium chloride. Figs. 2, 3, 7, 8, 9 are from Randobach, Rußbach, Figs. 1, 4, 5, 6, 10 are from Neffgraben, Rußbach; all are middle Santonian. Scale bars are 10 mm.



Plate 10

Baculites fuchsi REDTENBACHER, 1873

- Fig. 1: SK/RA/1983/99.
Fig. 2: SK/RA/1982/69c.
Figs. 3, 4: NHMW 2016/0047/0001.
Fig. 5: NHMW 1865/0001/0138 (holotype), Tiefengraben, Gosau.
Fig. 6: NHMW 1926/0002/2468 (ex coll. Heinrich).
Fig. 7: SK/RA/1982/71b.
Fig. 8: SK/RA/1982/70d.
Fig. 9: SK/GR/1981/17b.
Figs. 10, 11: OÖLM/2016/1.
Figs. 12, 13: OÖLM/2016/2.
Fig. 14: SK/RA/1983/100b.
Fig. 15: HNS 6404.

All but Figs. 7, 15 (= x 2) are natural size, all but Fig. 6 are coated with ammonium chloride. Figs. 1, 2, 7, 8, 14 are from Randobach, Figs. 5, 9 are from Tiefengraben (= Grabenbach), Gosau. Scale bars are 10 mm.

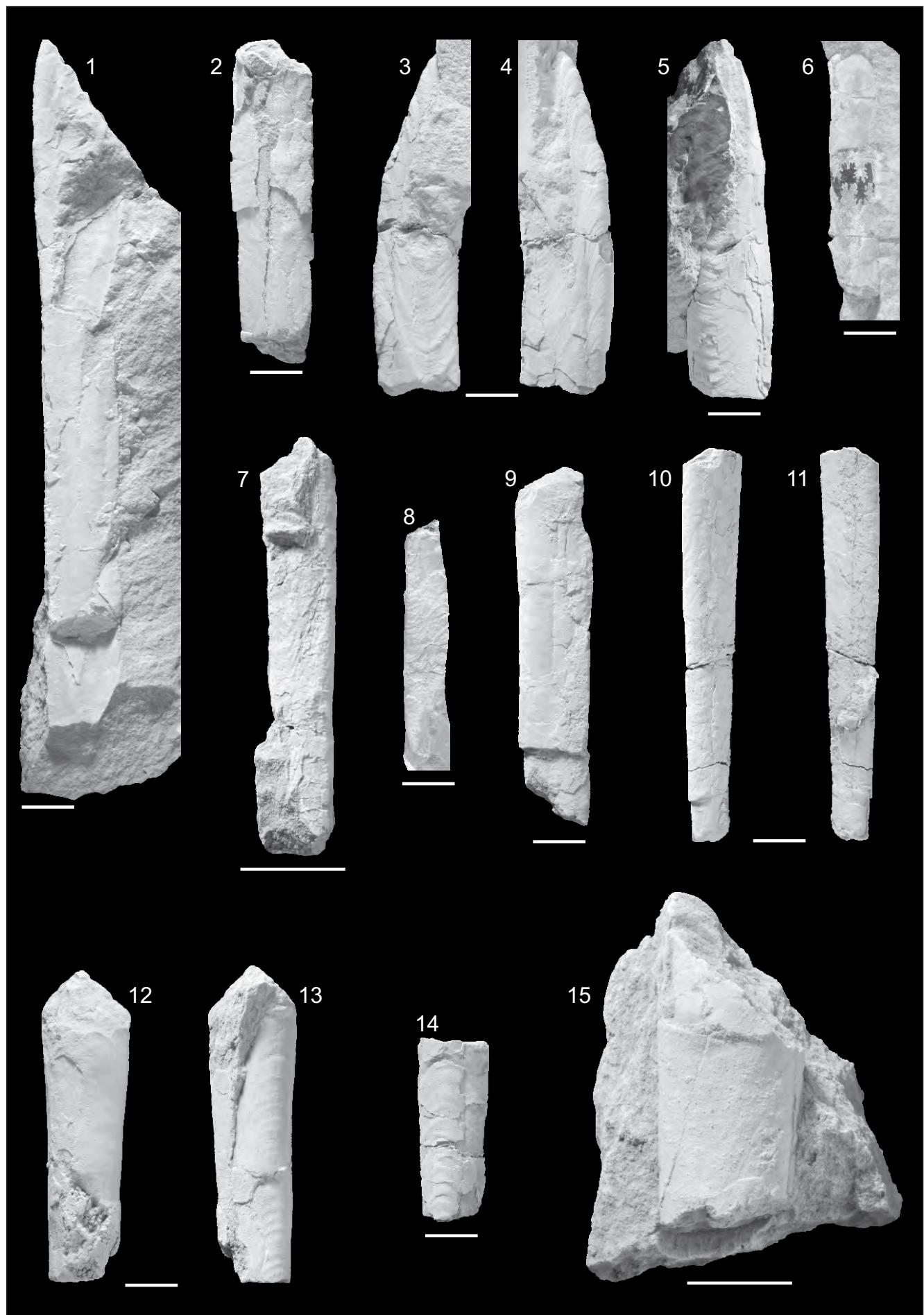
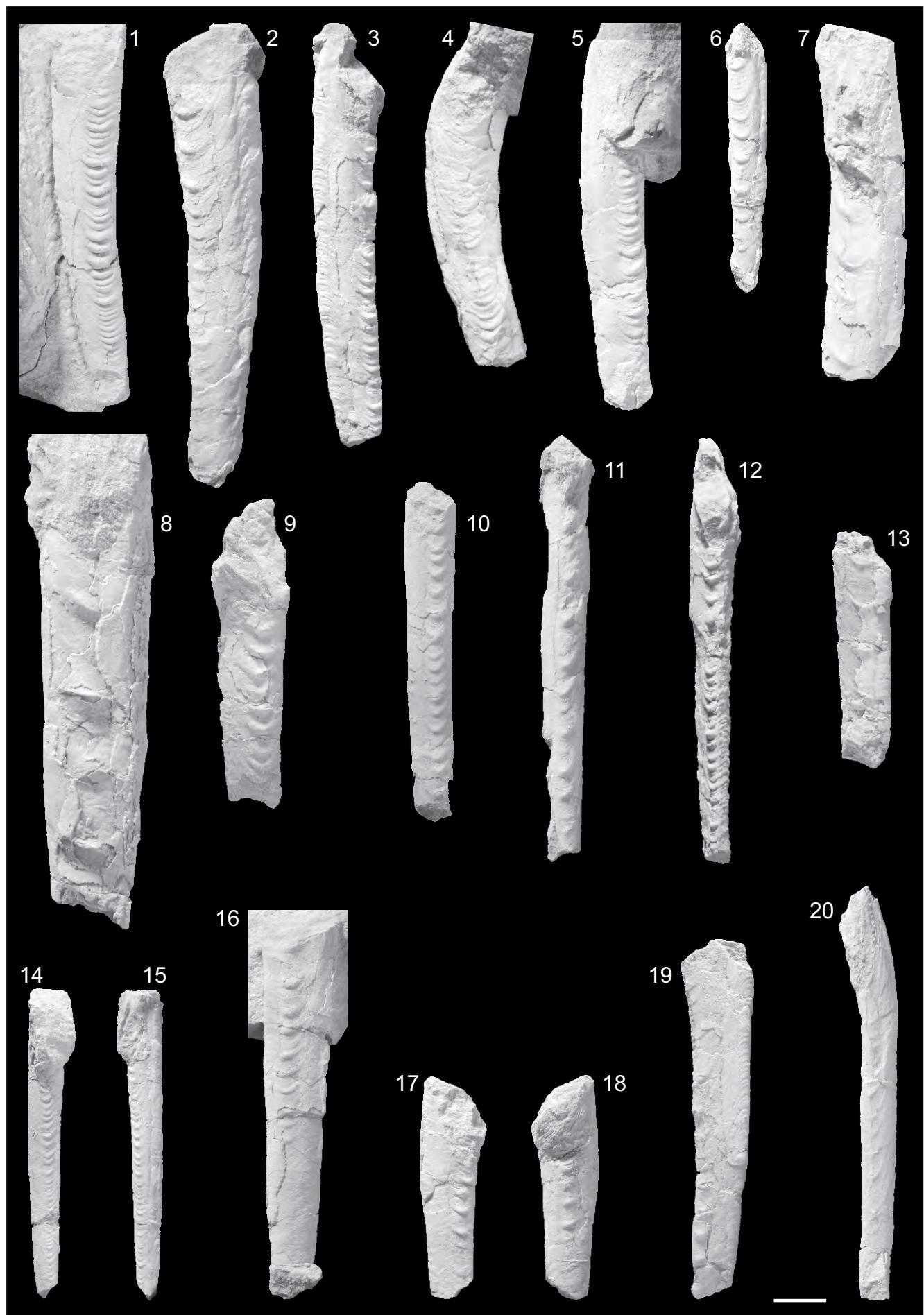


Plate 11

- Fig. 1: SEIDL/CE 00009.
Fig. 2: SK/NE/1989/11a.
Fig. 3: SK/RA/1981/38a.
Fig. 4: SK/NE/2001/19.
Fig. 5: SK/NE/2013/21c.
Fig. 6: SK/NE/2013/21b.
Fig. 7: SK/NE/1989/11c.
Fig. 8: SK/GR/1981/17a *Baculites* sp.
Fig. 9: SK/NE/2013/21d.
Fig. 10: SK/RA/1981/38c.
Fig. 11: SK/RA/2003/150b.
Fig. 12: SK/RA/1981/38a.
Fig. 13: SK/RA/1982/71a.
Figs. 14, 15: SK/RA/1983/90.
Fig. 16: SK/RA/1983/93b.
Figs. 17, 18: SK/RA/1983/92c.
Fig. 19: SK/RA/1983/93a.
Fig. 20: SK/RA/2003/150d.

Figs. 1–7, 9–20: *Baculites brevicosta* SCHLÜTER, 1876. Fig. 8 is *Baculites* sp.

All are natural size, all are coated with ammonium chloride, all are middle Santonian. Figs. 1–2, 4–6, 7, 9 are from Neffgraben, Rußbach, Figs. 3, 10–20 are from Randobach, Rußbach, Fig. 8 is from Grabenbach, Gosau.



Integrated stratigraphy of the upper Santonian (Upper Cretaceous) Hochmoos and Bibereck Formations of the Schattaugraben section (Gosau Group; Northern Calcareous Alps, Austria)

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17 Text-Figures, 14 Tables, 21 Plates

In memoriam

JOHN MICHAEL “JAKE” HANCOCK (1928–2004)
CHRISTOPHER J. WOOD (1939–2016)

Österreichische Karte 1:50.000

BMN / UTM

95 Sankt Wolfgang im Salzkammergut / NL 33-01-17 Hallstatt

Gosau Group

Santonian (Cretaceous)

Macro-, Micro-, Nannofossils

Stable Isotopes

Schattaugraben

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Abstract

The Schattaugraben section in the Salzburg (Rußbach) part of the Gosau basin was logged and sampled in detail. Its lower part is presented here as type section for the upper Santonian Hochmoos Formation (Hochmooschichten; WEIGEL, 1937) including the "Sandkalkbank Member". Its position on the northern slope of the Bibereck mountain and its fossiliferous higher part makes the Schattaugraben section equally suitable as a reference section for the lower part of the Bibereck Formation (Bibereck-Schichten; WEISS, 1975, 1977) according to the succeeding overlying part of the section including the *Micraster* Bed, comprising a 30 m interval of marls up to the top of the section.

Nautiloidea, ammonioidea, inoceramids, foraminifera and nannofossils are described. 40 taxa of cephalopods make the Schattaugraben assembles together with that from the Finstergrabenwandl to one of the most diverse late Santonian cephalopod faunas.

Some taxa are described for the first time from the Austrian Gosau Group, e.g. *Eutrephoceras montiscastoris* spec. nov., *Glyptoxoceras crispatum* (MOBERG, 1885) from the Hochmoos Formation and *Marsupites laevigatus* (FORBES in DIXON, 1850) from the Bibereck Formation, the latter co-occurring with *Boehmoceras arculus* (MORTON, 1834) and *Placenticeras paraplanum* WIEDMANN, 1978, indicating for the *Paraplanum* Subzone of the late Santonian, and with *Nowakites savini* (DE GROSSOURE, 1894), *Scalarites sertiformis* (MÜLLER & WOLLEMAN, 1906) in the *Micraster* Bed of the Bibereck Formation. *Texasia dentatocarinata* (F. ROEMER, 1852) recorded for the first time from the Gosau Group occurs 16 m above the *Micraster* Bed and is the highest ammonite from the Bibereck Formation and equally the youngest one in the type area of the Gosau Group. *Cordiceramus muelleri muelleri* (PETRASCHECK, 1906) and *Sphenocerasmus ex gr. pachti/cardissoides* occur in a remarkable cluster of articulated specimens in the Sandkalkbank Member of the topmost Hochmoos Formation. Within the *Micraster* Bed the planktic foraminifera *Globotruncanita elevata* (BROTZEN) and *Globotruncanita stuartiformis* (DALBIEZ) have their first (local) appearance. *Dicarinella asymetrica* (SIGAL) is still present up to the top of the section, indicating the *asymetrica* total range zone or the *asymetrica-elevata* concurrent range zone according to planktic foraminiferal zonations. Nannofossils give evidence for nannofossil standard zones CC17 and UC12–13.

The Schattaugraben was chosen as type section of the Hochmoos Formation as it is closest to the Hochmoosgraben mentioned by FELIX (1908) and used by WEIGEL (1937) as type area of the "Hochmoos Schichten". The Sandkalkbank Member (WEIGEL, 1937) is included in the topmost interval of the Hochmoos Formation. Ammonites (WIEDMANN, 1978; SUMMESBERGER, 1979, 1980, 1992; revised herein), bivalves (DHONDRT, 1987) and gastropods (KOLLMANN, 1980) described from the Sandkalkbank Member are part of the Hochmoos Formation at the Schattaugraben section.

The higher part of the Schattaugraben section was chosen as a reference section for the Bibereck Formation as it is best exposed at the northern slope of the type area, the Bibereck mountain. The *Micraster* Bed is included in the lower part of the Bibereck Formation.

Integrierte Stratigrafie des oberen Santoniums (Oberkreide) der Hochmoos- und Bibereck-Formation im Bereich des Schattaugrabens (Gosau-Gruppe; Nördliche Kalkalpen, Österreich)

Zusammenfassung

Das Profil des Schattaugrabens im Salzburger Teil des Beckens von Gosau (Rußbach) wurde vermessen und detailliert beprobt. Der Liegendteil einschließlich des Sandkalkbank Members bis zur Unterkante der *Micraster* Bank wird zum Typusprofil der obersantonalen Hochmoos-Formation (= Hochmooschichten; WEIGEL, 1937) vorgeschlagen. Der namengebende Hochmoosgraben verläuft parallel zum Schattaugraben in geringer Distanz. Der konkordant über der Hochmoos-Formation folgende und durch seine Lage am Nordabhang des Biberecks prädestinierte Hangendteil des Schattaugrabens wird als Referenzprofil für den tieferen Teil der Bibereck-Formation (= Bibereck Schichten; WEISS, 1975, 1977) vorgeschlagen. Dazu zählt von der Unterkante der *Micraster* Bank aufwärts die 30 Meter mächtige Mergelfolge bis zum Profilende.

Cephalopoden, Inoceramen, Foraminiferen und Nannofossilien werden beschrieben. 40 Taxa machen die Cephalopodenfauna des Schattaugrabens mit der benachbarten Fundstelle des „Finstergrabenwandls“ zu einer der reichsten des oberen Santoniums.

Einige Taxa werden zum ersten Mal aus der österreichischen Gosau-Gruppe bekannt gemacht: *Glyptoxoceras crispatum* (MOBERG, 1885) aus der Hochmoos-Formation, *Nowakites savini* (DE GROSSOURE, 1894) gemeinsam mit *Marsupites laevigatus* aus der *Micraster* Bank der Bibereck-Formation. *Boehmoceras arculus* (MORTON, 1834) und *Placenticeras paraplanum* WIEDMANN, 1978, kennzeichnend für die *Paraplanum* Subzone des oberen Santoniums, treten von der „Sandkalkbank“ bis einschließlich der *Micraster* Bank auf. *Texasia dentatocarinata* (F. ROEMER, 1852) tritt 16 m über der *Micraster* Bank auf und ist der jüngste bisher aus der Typusregion der Gosau Gruppe bekannt gewordene Ammonit. *Cordiceramus muelleri muelleri* (PETRASCHECK, 1906) und *Sphenocerasmus ex gr. pachti/cardissoides* bilden einen bemerkenswerten Cluster doppelklappiger Individuen in der Sandkalkbank der Hochmoos-Formation.

In der *Micraster* Bank treten die planktonischen Foraminiferen *Globotruncanita elevata* (BROTZEN) und *Globotruncanita stuartiformis* (DALBIEZ) (lokal) erstmals auf. *Dicarinella asymetrica* (SIGAL) weist die *asymetrica* Reichweitenzone und die *asymetrica-elevata* Überlappungszone der Planktonforaminiferen-Zonierungen bis an das obere Profilende nach. Nannofossilien belegen die Nannofossil-Standard Zonen CC17 und UC12–13.

Der Schattaugraben wird als Typusprofil der Hochmoos-Formation vorgeschlagen, da er nahe dem Hochmoosgraben liegt, der von FELIX (1908) erwähnt und von WEIGEL (1937) als Typusgebiet der „Hochmoos Schichten“ festgelegt wurde. Die Sandkalkbank-Subformation (WEIGEL, 1937) ist damit Teil des höchsten Abschnitts der Hochmoos-Formation. Ammoniten (WIEDMANN, 1978; SUMMESBERGER, 1979, 1980, 1992; revidiert in dieser Arbeit), Bivalven (DHONDRT, 1987) und Gastropoden (KOLLMANN, 1980) aus der Sandkalkbank-Subformation sind damit der Hochmoos-Formation des Schattaugraben-Profilen gegenüberzustellen.

Der höhere Teil des Schattaugraben-Profilen bildet ein Referenzprofil für die Bibereck-Formation als gut aufgeschlossener Teil im Typusgebiet dieser Formation, dem Bibereck. Die *Micraster* Bank ist damit ein Teil des unteren Abschnittes der Bibereck-Formation.

Introduction

MICHAEL WAGREICH & HERBERT SUMMESBERGER

Late Cretaceous chronostratigraphy still lacks formally defined and agreed Global Boundary Stratotype Sections and Points (GSSP), e.g. for the base of the Campanian (see GALE et al., 2008; WAGREICH et al., 2010; OGG & HINNOV, 2012). At the Second International Symposium on Cretaceous Stage Boundaries in Brussels in 1995 a decision was made to use the extinction level (LO – last oc-

currence) of the crinoid *Marsupites testudinarius* (SCHLOTHEIM, 1820) as the boundary-marker (HANCOCK & GALE, 1996). GALE et al. (2008) proposed the Waxahachie dam-spillway (WDS) in the Austin chalk in north-central Texas, USA, as a GSSP for the base of the Campanian stage. However, the succession of biostratigraphic events and their correlations to chemostratigraphic and magnetostratigraphic scales still remains partly unresolved, especially in correlating low- ("tethyan") and high-latitude ("boreal") zones in the late Santonian (e.g. SAGEMAN et al., 2014; COCCIONI & PREMOLI SILVA, 2015; THIBAULT et al., 2016). More recent-

ly, the base of the Campanian was proposed to be rather defined by magnetostratigraphy, using the base of Chron C33r, i.e. the first reversal after the Long Cretaceous Normal magnetochron C34n (OGG & HINNOV, 2012; WAGREICH et al., 2015) which is in close proximity to the major bioevents around the boundary, i.e. the LO *Marsupites testudinarius*, the LO of the planktic foraminifer *Dicarinella asymmetrica*, and the first occurrence (FO) of the nannofossil *Brionsonia (Aspidolithus) parca parca*.

WAGREICH et al. (2010) reported briefly on the results of an integrated stratigraphic investigation of an upper Santonian section in the type area of the Gosau Group in the Northern Calcareous Alps of Austria with respect to its implications for boundary markers and events. Correlation to the proposed GSSP at the WDS was possible, focusing especially on calcareous nannofossil and planktic foraminifera zonations. The present paper gives detailed results on the palaeontology of cephalopods, inoceramid bivalves as well as some details on nannofossils and foraminifera. A correlation to the proposed GSSP at the WDS and other sections is given, and stratigraphic events are summarised and discussed.

Geological setting and geographical position

MICHAEL WAGREICH & HERBERT SUMMESBERGER

The Gosau Group (Turonian–Eocene) of the Northern Calcareous Alps (Text-Fig. 1A) was deposited in the north-western Tethys at a palaeolatitude of about 30° N in a subtropical climatic belt (WAGREICH & FAUPL, 1994; FAUPL & WAGREICH, 2000). The Gosau Group records transtensional strike-slip and pull-apart basin subsidence after a major deformational event (WAGREICH & DECKER, 2001), followed by a deepening event (WAGREICH, 1993). The Gosau basin succession of the type area around Gosau (Upper Austria) comprises about 1,000 m of upper Turonian to lowermost Campanian terrestrial and shallow-water marine sediments of the Lower Gosau Subgroup, which are unconformably overlain by deep-water deposits of the Upper Gosau Subgroup (WAGREICH & FAUPL, 1994) (Text-Fig. 2).

A transgressive and deepening succession of late Turonian to Santonian age is overlain by a shallowing succession of upper Santonian age, including the Hochmoos Formation. The overlying marls of the Bibereck Formation record a sudden deepening of the Gosau basin, leading to the deposition of bathyal pelagic marls and marly limestones and turbidites (WAGREICH & KRENMAYR, 2005). The Schattaugraben section described by WAGREICH et al. (2010) and in this paper records a transitional interval from the upper part of the Hochmoos Formation continuously to the lower part of the Bibereck Formation in the upper Santonian. It is situated within the basin centre, thus recording an extended stratigraphic interval compared to coeval condensed basin margin sections to the south (WAGREICH & DECKER, 2001; WAGREICH & NEUHUBER, 2005). The Schattaugraben (“Schattau” of local collectors; geographic coordinates of crossing point of Schattaugraben with the Schattau forest road: WGS 84 N 47°35'10,1" E 013°30'01,1") is located on the Salzburg side of the Gosau basin in the area of the village of Rußbach.

The Hochmoos Formation with the Sandkalkbank Member representing the top of the formation, overlain by the Bibereck Formation is exposed. The Schattaugraben locality is mentioned several times in the literature (e.g. REUSS, 1854; PETRASCHECK, 1906; FELIX, 1908: Tab. 1, “Hochmoosgraben und Schattauwald”, 330–335; KÜHN, 1925). The highly fossiliferous Sandkalkbank Member (Finstergrabenwandl locality; WGS 84 N 47°35'00", E 013°30'49") which was extensively studied by previous workers (WIEDMANN, 1978; SUMMESBERGER, 1979, 1980, 1992; KOLLMANN, 1980; DHONDRT, 1987) crosses also the Schattaugraben, interrupted by a minor local fault (Text-Fig. 3). Clusters of articulated *Cordiceramus muelleri muelleri* (PETRASCHECK, 1906) together with *Sphenoceras ex gr. pachti/cardissoides* occurring within the Sandkalkbank Member indicate a late Santonian age. This is in accordance with the ammonite fauna of the Zone of *Placenticeras paraplanum* and *Boehmoceras arculus* (WAGREICH et al., 2010). The Micraster Bed (KÜHN, 1925) lies about 10 metres above the top of the Sandkalkbank Member at the base of the Bibereck Formation [N 47°35'02,3", E 013°30'04,4" (= UTM33 0387286 / 5271168)]. The stratigraphic age was also proven by foraminifera (*D. asymmetrica*; WEISS, 1975; WAGREICH et al., 2010) and the presence of *Marsupites laevigatus* (FORBES in DIXON, 1850) (WAGREICH et al., 2010).

The Schattaugraben section comprises a total of ca. 94 metres of marly siltstone to sandstone with abundant macrofossil content (gastropods, solitary corals, inoceramids and other bivalves, ammonites, echinoderms). The sequence was deposited under generally shallow marine environmental conditions. Unfortunately, planktic microfauna and nannoflora are rather poor in the lower part of the section (parts of the Hochmoos Formation) and first and last occurrences of marker taxa may be influenced by facies changes. Three occurrences of fossils in the Schattaugraben sequence deserve to be named “mass occurrences”: The occurrence of echinoids in the Micraster Bed, the cluster of inoceramids within the Sandkalkbank Member and the repeated occurrence of *Gervillia solenoides* DEFRANCE in the whole section especially in the Micraster Bed (Text-Fig. 3).

Locality

The Cretaceous-Paleogene Gosau basin extends across the border of two Austrian federal states: Upper Austria around the village of Gosau; Salzburg around the village of Rußbach (Text-Fig. 1B). The Schattaugraben section is on the Salzburg side. The locality Finstergrabenwandl belongs to the village Gosau on the Upper Austrian side of the basin. The two villages are connected by road No. B 166 across the Pass Gschütt (996 m).

Locality details

Junction of the Schattaugraben with the forest road Schattau: (= N 47°35'10,1" E 013°30'01,1").

Position outcrop Micraster Bed: N 47°35'02,3" E 013°30'04,4" (= UTM33 0387286 / 5271168).

Position Finstergrabenwandl locality: N 47°35'00", E 013°30'49" (WGS 84).

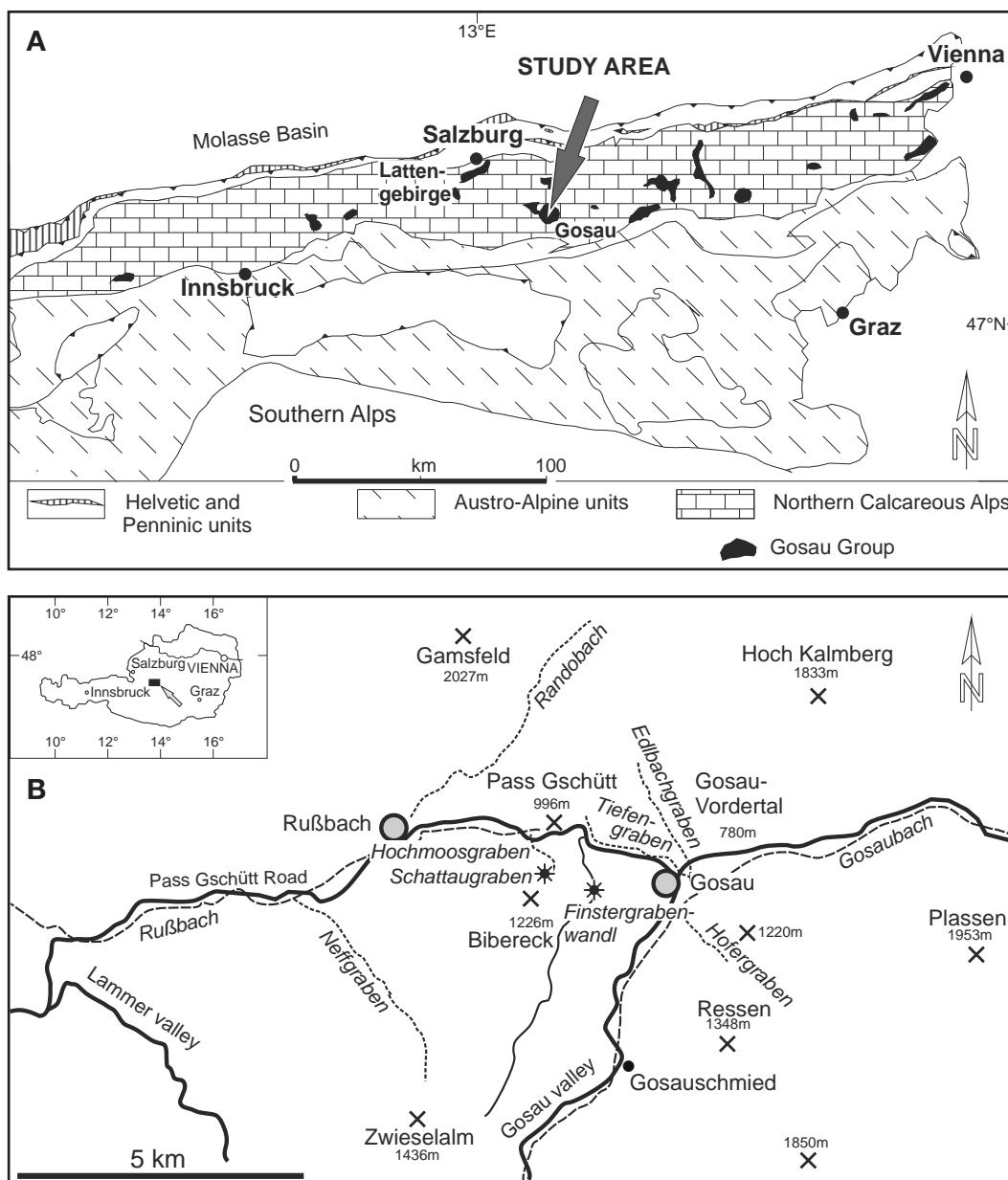
Geological Map of the Republic of Austria 1:50.000, Sheet 95 St. Wolfgang im Salzkammergut.

Gosauschmied: The locality "Gosauschmied" is close to a restaurant of the same name, the former house of a blacksmith and 4 km SSE from the Schattaugraben. The Neffgraben (also: Nefgraben) is a large gorge situated south of Rußbach more or less parallel to the Schattaugraben and towards the west to the nearby situated chairlift.

Methods

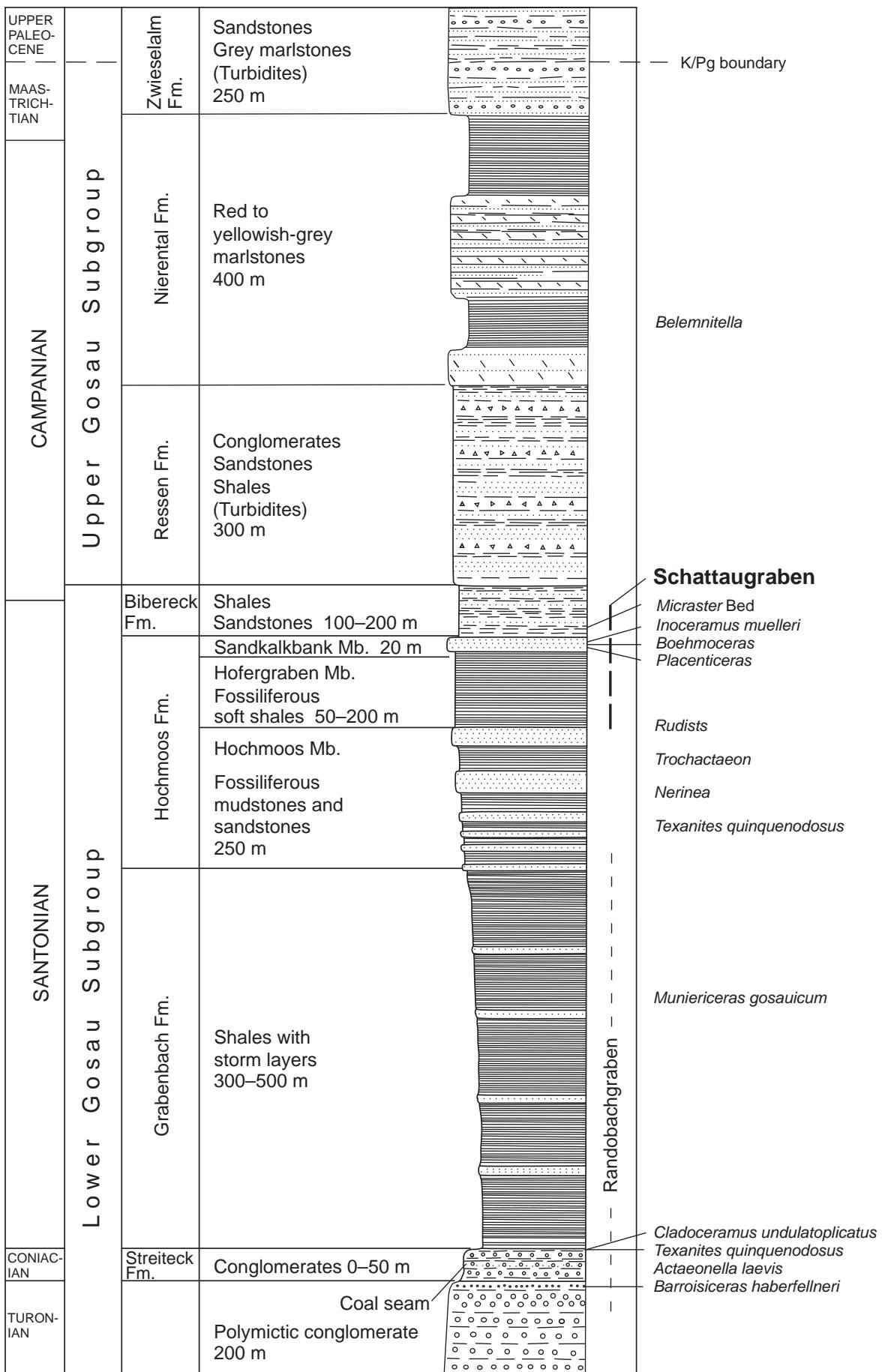
The integrated multi-disciplinary stratigraphic investigation of the Schattaugraben section included macrofossil sampling and identification, especially of ammonites, ino-

ceramids (H. Summesberger, W.J. Kennedy, P. Skoumal, K.-A. Tröger), foraminifera (M. Trenkwalder, E. Wolfgring, M. Wagreich), calcareous nannofossils (M. Wagreich), palaeomagnetic sampling (R. Scholger, H. Haubold), stable isotope data (C. Spötl, M. Wagreich) and strontium isotope data (M. Horschinegg, M. Wagreich). Sampling was done essentially in two phases, starting in 1997/1998 (macrofossils, foraminifera, nannofossils, palaeomagnetics) and continuing in 2005/2006 after the finding of *Marsupites laevigatus* (foraminifera, nannofossils, isotope samples). For methods used on foraminifera, nannofossils, stable isotopes and strontium isotopes see WAGREICH et al. (2010). Macrofossil samples are housed in the collection of the Department of Geology and Palaeontology of the Museum of Natural History Vienna (NHMW), microfossil samples are stored in the collection of the Department of Geodynamics and Sedimentology, University of Vienna.



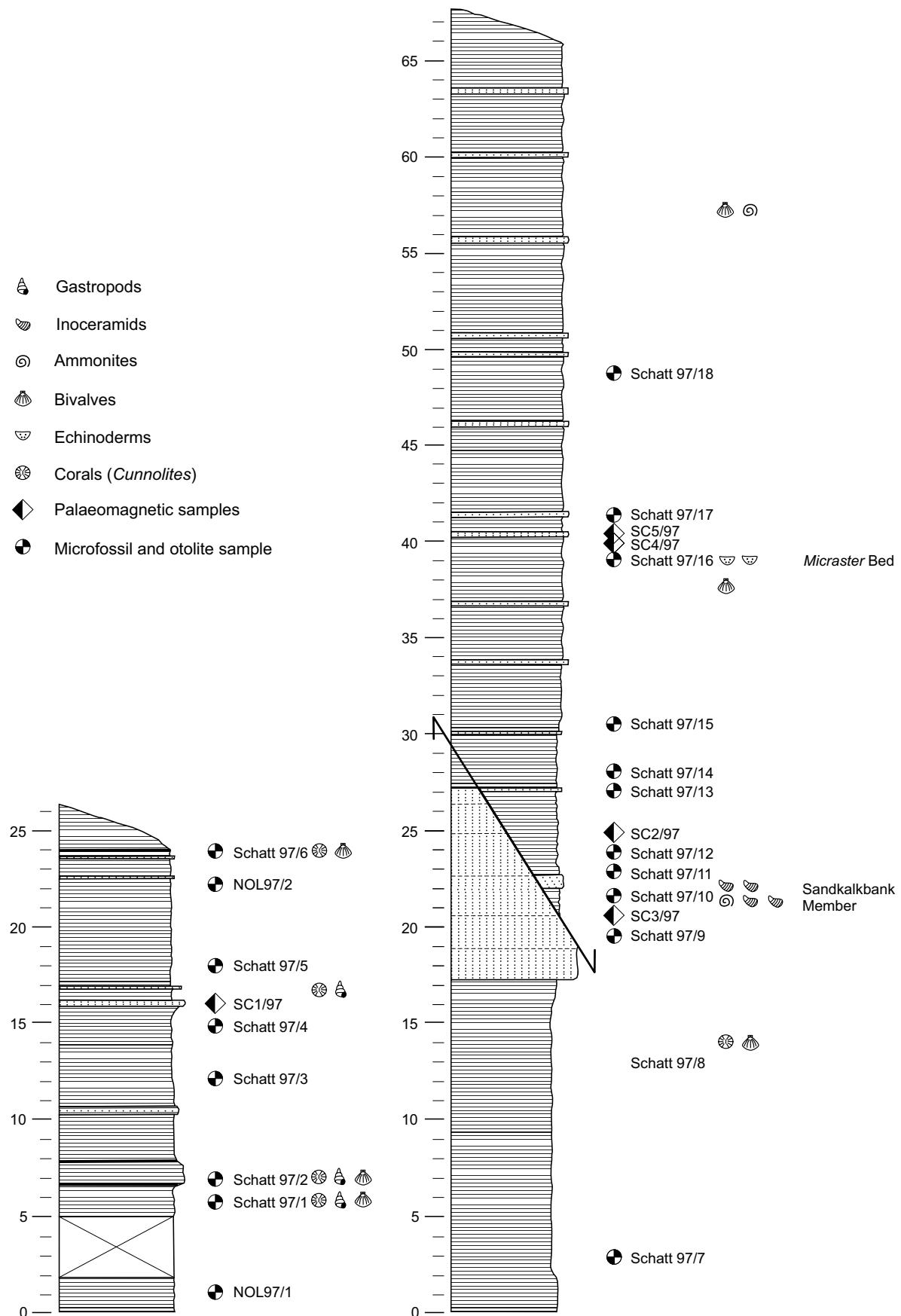
Text-Fig. 1.

A. Schematic geological map of the Eastern Alps. Occurrences of Gosau sediments (black). B. Overview road map of the position of the Schattaugraben section indicating the localities mentioned in the text. With alterations after WAGREICH et al. (2010); * localities of Schattaugraben and Finstergrabenwandl.

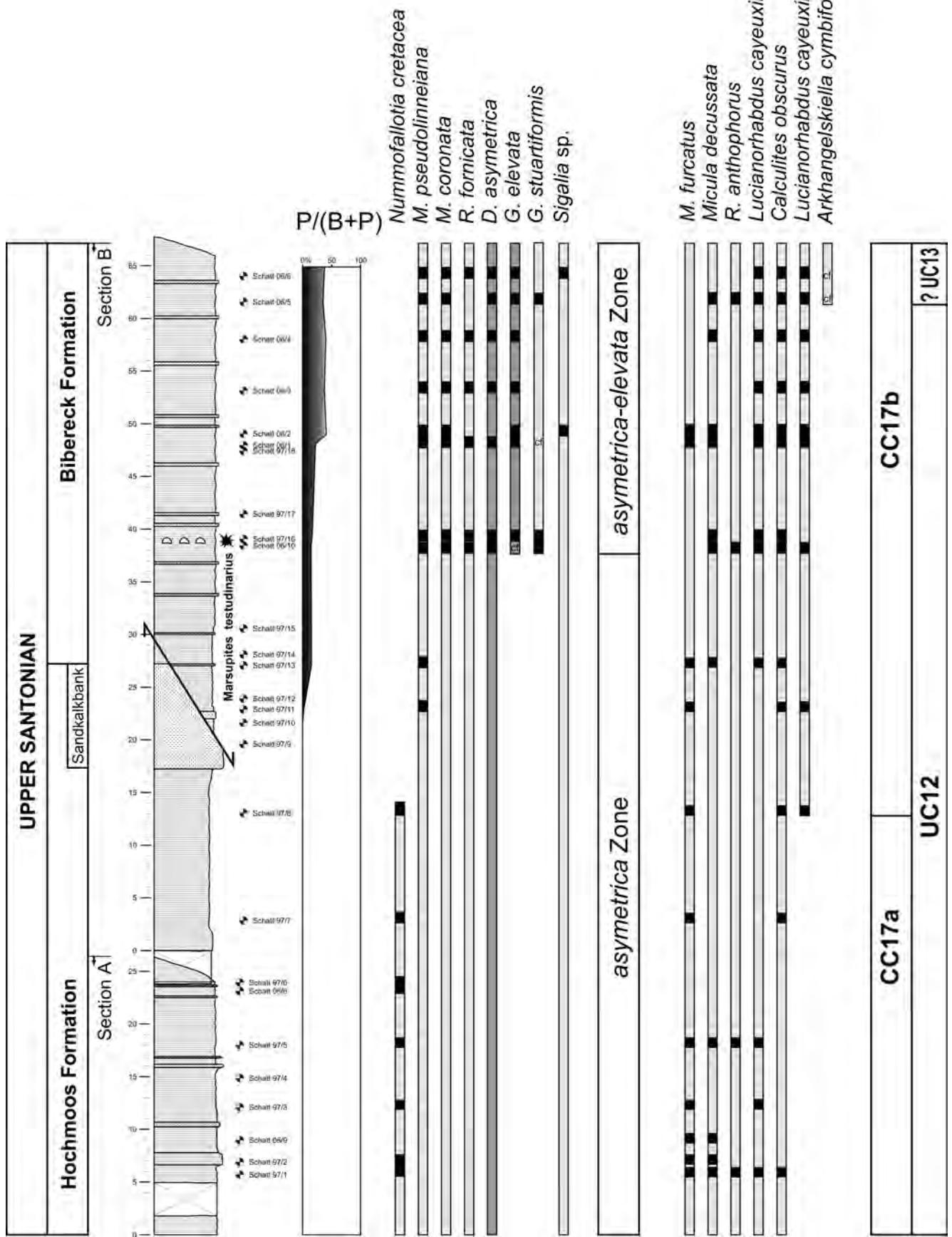


Text-Fig. 2.

Compiled section of the Gosau area indicating the Schattaugraben section (with alterations after SUMMERSBERGER et al., 2017a, b).



Text-Fig. 3.
Section of the Schattau graben measured in 1997 by SUMMESBERGER, WAGREICH, SCHNEIDER & TRENKWALDER.



Text-Fig. 4.

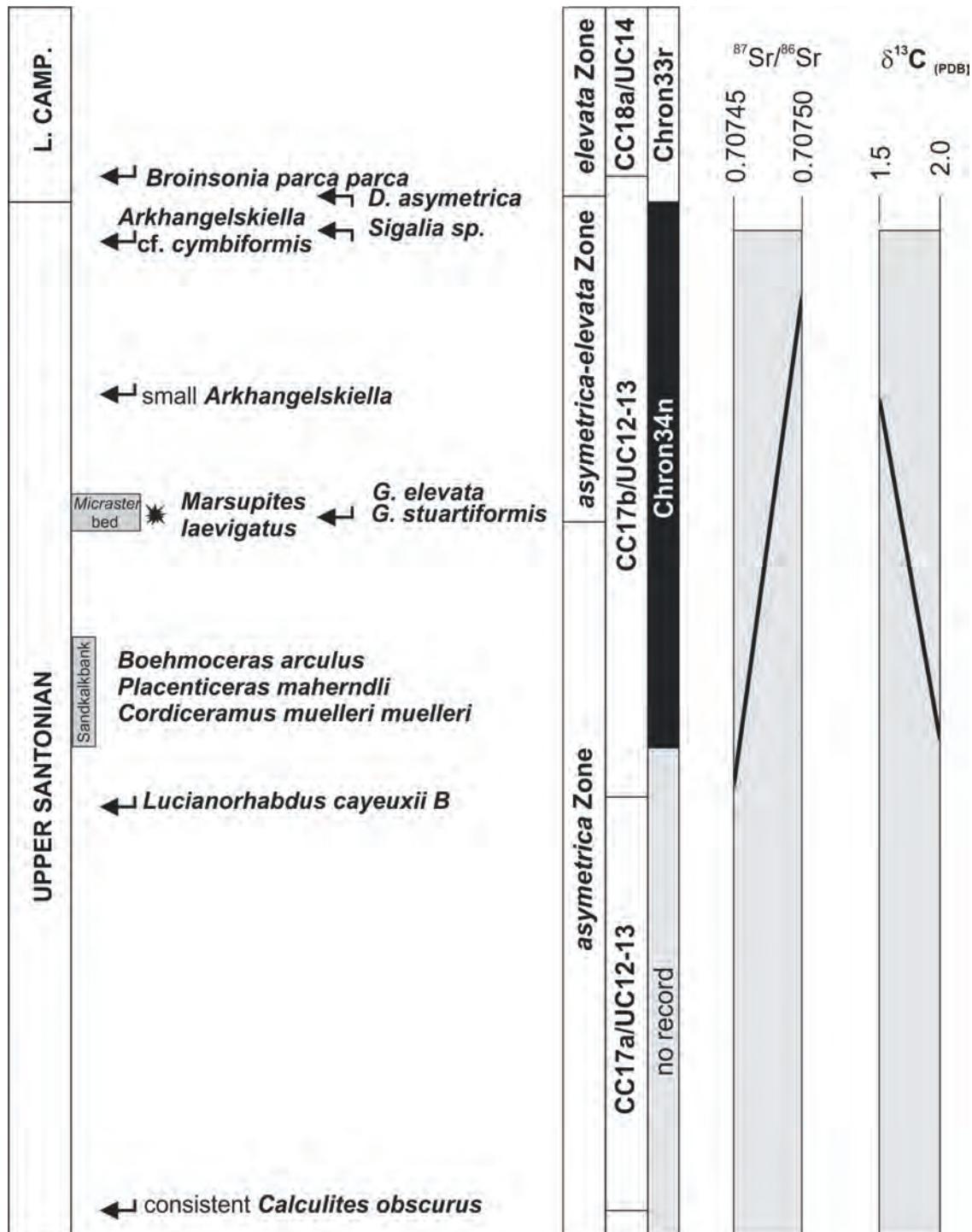
Overview of the lithological log of the Schattau graben section (parts A and B), zonations and ranges of key planktic foraminifera and nannofossils. Asterix marks occurrence of the crinoid *Marsupites laevigatus* in the section. P/(B+P) – percentage of planktonic foraminifera out of total foraminiferal assemblage (size fraction > 0.25 mm). With alterations after WAGREICH et al. (2010).

Results

Lithostratigraphy

The sedimentological and stratigraphic data from the Schattaugraben section allow a more precise insight into the lithostratigraphy of the Gosau Group of Gosau-Abtau in the centre of the Gosau basin (compare PLÖCHINGER, 1982; WAGREICH, 1988). The lower part of the section includes fossiliferous marls and sandstones of the Hochmoos Formation. The succeeding Sandkalkbank Member,

an up to 30 m thick sandstone interval, marks the top of the Hochmoos Formation (KOLLMANN, 1982). The overlying marls with few sandstone beds are still fossiliferous and include the *Micraster* Bed about 10 m above the top of the Sandkalkbank Member. By definition, this part of the section has to be included into the Bibereck Formation (WEISS, 1975, 1977; WAGREICH, 1988), and forms a transitional interval into the typically macrofossil-poor, increasingly pelagic grey marls of the Bibereck Formation described from other sections (WAGREICH, 1988; WAGREICH & NEUHUBER, 2005).



Text-Fig. 5.

Integrated stratigraphy around the Santonian/Campanian boundary in the Gosau area (after WAGREICH et al., 2010, 2015).

The Schattaugraben is parallel and close to the Hochmoosgraben (FELIX, 1908: Pl. 26) and is thus situated in the type area of the Hochmoos Formation (WEIGEL, 1937: Text-Fig. 2). The sedimentary contact of the Hochmoos Formation with the underlying Grabenbach Formation (WEIGEL, 1937; WEISS, 1975; KOLLMANN, 1982) is not exposed in the Schattaugraben section. As outcrops in the Hochmoosgraben are unsatisfactory, we propose to use the Schattaugraben section as type section for the Hochmoos Formation, because it exposes the upper part of this formation including the Sandkalkbank Member, and the boundary with the overlying Bibereck Formation. This boundary is thus situated at the lithological change from fine-grained indurated calcareous sandstones of the top-most Sandkalkbank Member to softer grey marls and marlstones of the Bibereck Formation.

The *Micraster* Bed outcrops near the base of the Bibereck Formation and rests conformably on the Hochmoos Formation (Text-Fig. 6). The upper part of the Bibereck Formation in the Schattaugraben is covered by Quaternary moraine, but continuity is given by another parallel ditch west of the Schattaugraben where an increasingly fine-grained argillaceous succession is exposed. The depositional environment changed continuously to deeper water/bathyal due to accelerating subsidence (WAGREICH, 1988, 1993). The Bibereck Formation is also exposed at the nearby Zieselberg forest road (type section of WEISS, 1975, 1977 and WAGREICH, 1988) and at the Hofergraben (Text-Fig. 1B) a few kilometres towards southeast. The continuous exposure of the Schattaugraben section makes it an important reference section for the lower part of the Bibereck Formation.

Foraminifera

(MICHAEL WAGREICH & ERIK WOLFGRING)

In the lower part of the Schattaugraben section the shallow-water depositional depths hindered the application of planktic foraminiferal zonations due to the lack of planktic foraminifera in the foraminiferal assemblages below and immediately above the Sandkalkbank Member (TRENK-WALDER, 1999). *Nummofallotia cretacea* is a typical benthic

shallow-water foraminifera present in most of the samples from these shallow-water marls (WEISS, 1977). This species may be restricted to the Coniacian–Santonian (GENDROT, 1968).

The presence of the planktic foraminifer *Dicarinella asymmetrica* within the underlying Grabenbach Formation outside the Schattau section (WAGREICH, 1992) indicates a possible correlation of the lower part of the Schattaugraben section to the Santonian *asymmetrica* Zone of the standard planktic foraminiferal zonations (e.g. CARON, 1985; ROBASZYNSKI & CARON, 1995) up to 38 m (Text-Fig. 4). The first local occurrence of the planktic foraminifera *Globotruncanita cf. elevata* and *G. stuartiformis*, still associated with *Dicarinella asymmetrica*, are recognised in grey marls of the *Micraster* Bed about 18 m above the fault that displaces the Sandkalkbank Member against the marls (Text-Figs. 3–5). This indicates the *asymmetrica–elevata* Concurrent Range Zone (WAGREICH, 1992) from 38 to 64 m of the Schattau section (Text-Fig. 4). *Sigalia decorticata* and *Sigalia* sp. are rarely present within this part of the section, pointing to the lower part of the *asymmetrica–elevata* Zone (WAGREICH, 1992), probably still below the Santonian/Campanian boundary (GALE et al., 2008).

According to GALE et al. (1995), the Santonian/Campanian boundary, as defined by the LO of *Marsupites testudinarius*, is situated within the *asymmetrica* Total Range Zone or the *asymmetrica–elevata* Concurrent Range Zone. Based on the WDS section, GALE et al. (2008) indicated that the LO of *Marsupites testudinarius* occurs above the FO of both *Globotruncanita stuartiformis* and the LO of the *Sigalia*-group, and below the LO of *D. asymmetrica*. Thus it lies within the *asymmetrica–elevata* Zone sensu WAGREICH (1992), as the FO of *G. stuartiformis* approximates to the FO of *G. elevata* (e.g. PREMOLI SILVA & SLITER, 1994; COCCIONI & PREMOLI SILVA, 2015).

The Schattaugraben section records a rich benthic foraminifera-fauna. The foraminiferal communities from the lower part of the section (below the Sandkalkbank) indicate a shallow water environment; the Hochmoos Formation yields abundant larger benthic foraminifera (*Nummofallotia cretacea*), miliolid foraminifera (*Quinqueloculina* spp., *Spiroloculina fassistomata*) as well as rotaliid foraminifera (*Hoglobulina* spp., *Gavelinella* spp.). Following the distinct deepening recorded upwards the Sandkalkbank Member, fully marine outer neritic conditions prevail and consequently

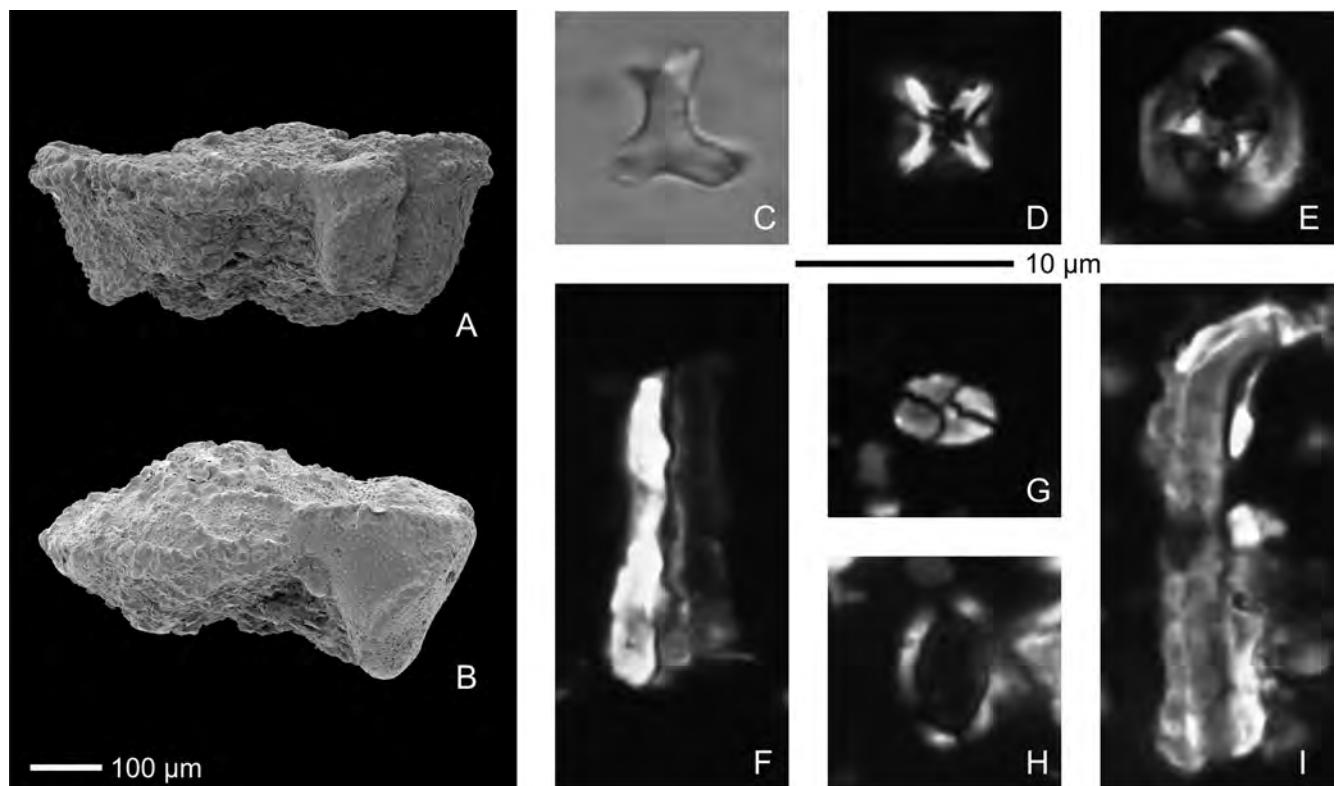


Text-Fig. 6.
Schattaugraben, Rußbach, Salzburg; *Micraster* Bed.
Outcrop situation 2010.

some elements of the benthic foraminiferal fauna change: tubular and bi- and triserial agglutinated foraminifera (e.g. *Ammobaculites* spp., *Dorothia* spp., *Gaudryina* spp., *Tritaxia* spp.) as well as spiral calcareous benthic foraminifera (*Gavelinella* spp., *Lenticulina* spp.) are recorded in the younger deposits at the Schattau section (in the Bibereck Formation). A list of taxa identified from the Schattaugraben can be found below in the following list. Plates 17–21 depict stratigraphically indicative planktic and benthic foraminifera from the Schattaugraben section.

Alphabetic list of foraminiferal taxa present in the Schattau section.

- Ammobaculites agglutinans* (D'ORBIGNY)
- Bolivinopsis praelonga* (SCHWAGER)
- Bulbocaculites* sp.
- Conorboides squamiformis* REUSS
- Contusotruncana fornicata* (PLUMMER)
- Contusotruncana morozovae* (VASILENKO)
- Dentalina cf. solvata* (CUSHMAN)
- Dentalina communis* D'ORBIGNY
- Dentalina gracilis* D'ORBIGNY
- Dicarinella asymetrica* (SIGAL)
- Dicarinella concavata* (BROTZEN)
- Dorothia biformis* FINLAY
- Dorothia bulletta* (CARSEY)
- Dorothia oxycona* (REUSS)
- Dorothia pupa* (REUSS)
- Dorothia trochus* (D'ORBIGNY)
- Eouvigerina* sp.
- Epistomina cf. colomi* DUBORDIEU & SIGAL
- Epistomina* sp.
- Fondicularia angusta*
- Fondicularia* sp.
- Gaudryina laevigata* FRANKE
- Gaudryina pyramidata* CUSHMAN
- Gaudryina reicheli* (?) BARTENSTEIN, BETTENSTAEDT & BOLLI
- Gaudryina rugosa* D'ORBIGNY
- Gavelinella ammonoides* (REUSS)
- Gavelinella lorneiana* (D'ORBIGNY)
- Gavelinella stelligera* (MARIE)
- Gavelinella tumida* BROTZEN
- Globorotalites michelinianus* (D'ORBIGNY)
- Globotruncana bulloides* (VOGLER)



Text-Fig. 7.

Key planktic foraminifera and nannofossil marker species recognised in the Schattau section.
Planktic foraminifera (SEM photographs): A. *Dicarinella asymetrica* (SIGAL, 1952), side view, sample Schatt 06-4; B. *Globotruncanita stuartiformis* (DALBIEZ, 1955), side view, sample Schatt 06-10.
Calcareous nannofossils (Zeiss light microscope, all crossed-polarised light except C; for taxonomy see p. 162–163; C. *Marthasterites furcatus*, sample Schatt 97-1; D. *Micula decussata*, sample Schatt 97-1; E. *Reinhardtites anthophorus*, sample Schatt 97-1; F. *Lucianorhabdus cayeuxii*, Schatt 06-3; G. *Calculites obscurus*, sample Schatt 97-1; H. *Arkhangelskiella cf. cymbiformis*, sample Schatt 06-5; I. *Lucianorhabdus cayeuxii* (curved morphotype), sample Schatt 97-13.

| | |
|---|---------------------------------------|
| <i>Globotruncana cf. arca</i> CUSHMAN | <i>Stensioeina exsculpta</i> (REUSS) |
| <i>Globotruncana linneiana</i> (D'ORBIGNY) | <i>Subreophax scalaris</i> |
| <i>Globotruncana neotricarinata</i> PETRIZZO | <i>Triplasia murchisoni</i> REUSS |
| <i>Globotruncanita elevata</i> (BROTZEN) | <i>Tritaxia jarvisii</i> CUSHMAN |
| <i>Globotruncanita stuartiformis</i> (DALBIEZ) | <i>Tritaxia tricarinata</i> (REUSS) |
| <i>Gyroidinoides beisselli</i> (WHITE) | <i>Tritaxia trilatera</i> (CUSHMAN) |
| <i>Gyroidinoides nitidus</i> (REUSS) | <i>Vaginulina trilobata</i> D'ORBIGNY |
| <i>Haplophragmium aequale</i> (ROEMER) | <i>Valvulinaria lenticula</i> (REUSS) |
| <i>Haplophragmoides</i> sp. | <i>Ventilabrella eggeri</i> (CUSHMAN) |
| <i>Planoheterohelix globulosa</i> (EHRENBERG) | <i>Verneuilina muensteri</i> REUSS |
| <i>Hoeglundina cf. supracretacea</i> | |
| <i>Lagena</i> sp. | |
| <i>Lagenula sulciformis</i> POZARYSKA & URBANEK | |
| <i>Lenticulina marcki</i> (REUSS) | |
| <i>Lenticulina secans</i> (REUSS) | |
| <i>Lenticulina</i> spp. | |
| <i>Lenticulina subalata</i> (REUSS) | |
| <i>Lenticulina subangulata</i> (REUSS) | |
| <i>Marginotruncana angusticarinata</i> (GANDOLFI) | |
| <i>Marginotruncana coronata</i> BOLLI | |
| <i>Marginotruncana marginata</i> REUSS | |
| <i>Marginotruncana pseudolinneiana</i> PESSAGNO | |
| <i>Marginotruncana sinuosa</i> PORTHAULT | |
| <i>Marginotruncana undulata</i> (LEHMANN) | |
| <i>Neoflabellina laterecompressa</i> TOLLMANN | |
| <i>Nodosaria affinis</i> (?) D'ORBIGNY | |
| <i>Nodosaria cf. vertebralis</i> D'ORBIGNY | |
| <i>Nodosaria</i> sp. | |
| <i>Nodosaria</i> sp. 1 | |
| <i>Nodosaria zippei</i> REUSS | |
| <i>Nummofallotia cretacea</i> (SCHLUMBERGER) | |
| <i>Oridosalis umbonatus</i> (REUSS) | |
| <i>Osangularia</i> sp. | |
| <i>Praebulimina braebra</i> (STEMPROKOVA-JIROVA) | |
| <i>Praebulimina reussi</i> (MORROW) | |
| <i>Quadrimerophina</i> sp. | |
| <i>Quinqueloculina aspera</i> D'ORBIGNY | |
| <i>Ramulina</i> sp. 1 | |
| <i>Saracenaria triangularis</i> (D'ORBIGNY) | |
| <i>Sigalia decoratissima</i> (DE KLASZ) | |
| <i>Sigalia</i> sp. | |
| <i>Spiroloculina fassistomata</i> GRZYBOWSKI | |
| <i>Spirolectammina baudouiniana</i> (D'ORBIGNY) | |
| <i>Spirolectammina praelonga</i> (REUSS) | |

Nannoplankton

(MICHAEL WAGREICH)

Nannoplankton samples from the Schattaugraben section display a good to moderate preservation with a higher degree of overgrowth in the upper part of the section. Nannofossil abundances are moderate at around 10–20 specimens per field of view, with varying amounts of calcareous silt. In total, 71 nannofossil species could be distinguished. Nannofossil assemblages are dominated by the genera *Wattnaueria*, *Zeugrhabdotus*, *Prediscosphaera*, *Cribrosphaerella*, *Chias-tozygus* and *Eiffellithus*. Holococcoliths like *Lucianorhabdus* ssp. and *Calculites* ssp. are consistently present in moderate to high abundances.

The Schattaugraben section shows the following succession of nannofossils marker species from base to top (Text-Figs. 5, 7): (1) co-occurrence of *Lucianorhabdus cayeuxii* and *Calculites obscurus* together with *Marthasterites furcatus* (Text-Fig. 8) and *Micula decussata* from the base of the section onwards, (2) curved *Lucianorhabdus cayeuxii* (L. cayeuxii B of WAGREICH, 1992) are consistently present from below the Sandkalkbank upwards, (3) small *Arkhangelskiella* sp. (< 10 µm) resembling *Arkhangelskiella cymbiformis* occur above the *Micraster* Bed, in the topmost part of the section. The first occurrence of *Broinsonia parca parca* is not recorded in the section. *Broinsonia parca expansa*, the possible ancestor of *B. parca parca*, is extremely rare and was found only in two samples. In neighbouring sections and elsewhere in the Gosau Basin, *B. parca parca* appears in the uppermost part of the Bibereck Formation (WAGREICH, 1992; WAGREICH & NEUHUBER, 2005), apparently not exposed in the Schattaugraben section.

Calcareous nannoplankton zonations at the Santonian–Campanian boundary interval either use the classical standard zonation scheme of SISSINGH (1977) and PERCH-NIELSEN (1985) with CC zones (see also OGG & HINNOV, 2012) or the newer BURNETT (1998) UC zones. In the late Santonian/early Campanian interval, PERCH-NIELSEN (1985) recognised the standard zones CC16 (defined by the FO of *Lucianorhabdus cayeuxii*), CC17 (defined by the FO [“first regular occurrence” after SISSINGH (1977)] of *Calculites obscurus*), and CC18 (defined by the FO of *Broinsonia parca parca*). Most nannofossil workers placed the base of the Campanian within CC17 or at the base of CC18 (e.g. PERCH-NIELSEN, 1985; WAGREICH, 1992; CUNHA et al., 1997). WAGREICH (1992) recognised the FO of curved morphotypes of

Lucianorhabdus cayeuxii as a regional marker in northwestern Tethyan sections from Spain to Hungary within CC17, below the Santonian/Campanian boundary (WAGREICH, 1992; LANTOS et al., 1997; KÜCHLER & WAGREICH, 2002) and thus divided this zone into two subzones, CC17a and CC17b, base defined by the FO of curved *Lucianorhabdus cayeuxii*.

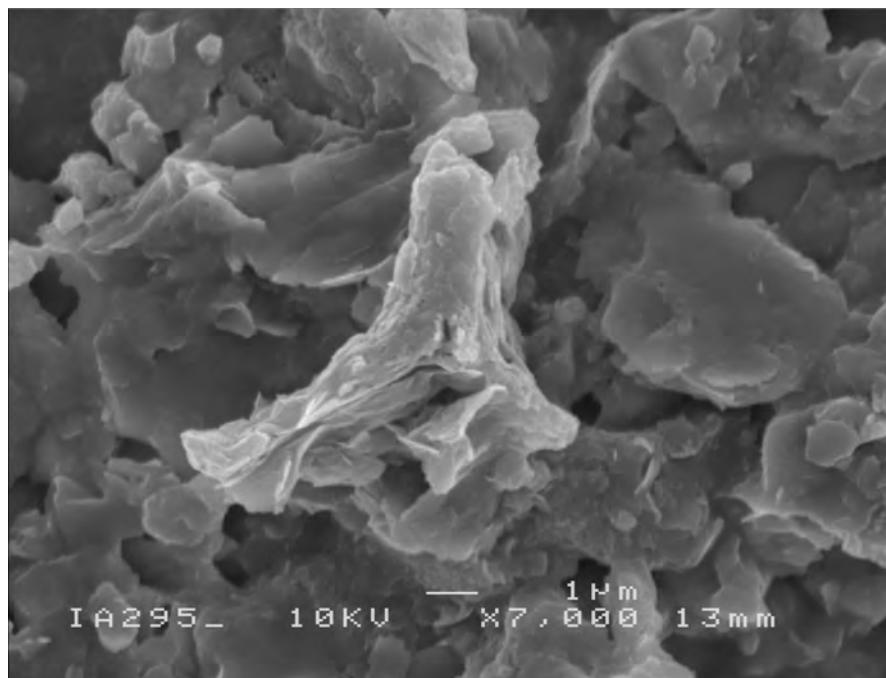
BURNETT (1998) defined new UC zones and subzones for the Santonian to basal Campanian: zone UC12, base defined by the LO of *Lithastrinus septenarius* (middle to late Santonian), UC13, base defined by the FO of *Arkhangelskiella cymbiformis*, and UC14a, base defined by the FO of *Broinsonia parca parca*, top defined by the FO of *Broinsonia parca constricta*. Originally, BURNETT (1998) placed the Santonian/Campanian boundary as defined by the LO of *Marsupites testudinarius*, in the uppermost part of UC12, just below the FO of *Arkhangelskiella cymbiformis*. LATERON, HAMPTON et al. (2007) found the FO of *Arkhangelskiella cymbiformis* considerably lower in the late Santonian, close to the base of the *Uintacrinus socialis* crinoid Zone which indicates that *A. cymbiformis* is not a reliable marker for the Santonian/Campanian boundary.

Within the Schattaugraben section, nannofossil standard zone CC17 of PERCH-NIELSEN (1985) was identified in the lower part of the section based on the co-occurrence of *Lucianorhabdus cayeuxii* and *Calculites obscurus*. This corresponds to zone UC12 of BURNETT (1998) as *Lithastrinus septenarius* is absent in the section except one questionable occurrence in one sample probably due to reworking. Curved *Lucianorhabdus cayeuxii* are present from below the Sandkalkbank Member upwards, which indicates the regional nannofossil zone CC17b of WAGREICH (1992). No abundance increase of *Calculites obscurus* has been recognised in contrast to chalk sections where an acme of this species was recognised around the Santonian/Campanian boundary (HAMPTON et al., 2007). The topmost part of the Schattaugraben section can be assigned to UC13 as small morphotypes of *Arkhangelskiella cf. cymbiformis* are present. However, *Arkhangelskiella cymbiformis* is not regarded as a reliable marker here due to the very low abundances encountered. Ac-

cording to HAMPTON et al. (2007) the Santonian/Campanian boundary has to be placed above that nannofossils event, and is not represented in the Schattaugraben section but occurs in neighbouring sections to the west where *Broinsonia parca parca* was found (WAGREICH, 1988). A full list of all nannofossil taxa encountered in the Schattaugraben section is given below.

List of nannofossil taxa encountered in the Schattaugraben section. Nannofossil taxonomy follows mainly BURNETT (1998) and the Nannotax web site (www.mikrotax.org/Nannotax3/index.html); bibliographic references can be found in PERCH-NIELSEN, 1985, and BURNETT, 1998. *Marthasterites cf. inconspicuus/furcatus*: see Text-Figure 8.

- Ahmuellerella octoradiata* (GÓRKA, 1957) REINHARDT, 1966
Amphizygus brooksi BUKRY, 1969
Arkhangelskiella cf. A. cymbiformis VEKSHINA, 1959 (< 10 µm)
Biscutum constans (GÓRKA, 1957) BLACK in BLACK & BARNES, 1959
Biscutum cf. B. ellipticum (GÓRKA, 1957) BLACK in BLACK & BARNES, 1959
Braarudosphaera bigelowii (GRAN & BRAARUD, 1935) DEFLANDRE, 1947
Broinsonia enormis (SHUMENKO, 1968) MANIVIT, 1971
Broinsonia cf. B. matalosa (STOVER, 1966) BURNETT in GALE et al., 1995
Broinsonia parca expansa (STRADNER, 1963) WISE & WATKINS in WISE, 1983
Calculites obscurus (DEFLANDRE, 1959) PRINS & SISSINGH in SISSINGH, 1977
Calculites ovalis (STRADNER, 1963) PRINS & SISSINGH in SISSINGH, 1977
Chiastozygus litterarius (GÓRKA, 1957) MANIVIT, 1971
Corollithion exiguum STRADNER, 1961
Corollithion signum STRADNER, 1963



Text-Fig. 8.
Marthasterites cf. inconspicuus/furcatus, sample Schatt 97-1 (SEM photograph). Note: bad preservation.

- Cretarhabdus conicus* BRAMLETTE & MARTINI, 1964
- Cribrosphaerella ehrenbergii* (ARKHANGELSKY, 1912) DEFLANDRE in PIVETEAU, 1952
- Cyclagelosphaera* sp.
- Cylindralithus* sp.
- Cylindralithus biarcus* BUKRY, 1969
- Cylindralithus cf. C. sculptus* BUKRY, 1969
- Cylindralithus serratus* BRAMLETTE & MARTINI, 1964
- Eiffellithus eximius* (STOVER, 1966) PERCH-NIELSEN, 1968
- Eiffellithus turriseiffelii* (DEFLANDRE in DEFLANDRE & FERT, 1954) REINHARDT, 1965
- Gartnerago obliquum* (STRADNER, 1963) NOEL, 1970
- Gartnerago* cf. *G. segmentatum* (STOVER, 1966) THIERSTEIN, 1974
- Haqius* sp.
- Helicolithus trabeculatus* (GÓRKA, 1957) VERBEEK, 1977
- Lithastrinus grillii* STRADNER, 1962
- Lithastrinus cf. L. septenarius* FORCHHEIMER, 1972
- Lithraphidites carniolensis* DEFLANDRE, 1963
- Lucianorhabdus arcuatus* FORCHHEIMER, 1972
- Lucianorhabdus* sp.
- Lucianorhabdus cayeuxii* DEFLANDRE, 1959
- Lucianorhabdus cayeuxii* ssp. B DEFLANDRE, 1959 (curved morphotype)
- Lucianorhabdus maleformis* REINHARDT, 1966
- Lucianorhabdus cf. L. maleformis* REINHARDT, 1966 (small morphotype)
- Manivitella pemmatoidea* (DEFLANDRE in MANIVIT, 1965) THIERSTEIN, 1971
- Marthasterites furcatus* (DEFLANDRE in DEFLANDRE & FERT, 1954) DEFLANDRE, 1959
- Microrhabdulus belgicus* HAYE & TOWE, 1963
- Microrhabdulus decoratus* DEFLANDRE, 1959
- Micula decussata* VEKSHINA 1959
- Nannoconus* sp.
- Nannoconus* cf. *N. multicadus* DEFLANDRE & DEFLANDRE-RIGAUD, 1959
- Nannoconus* cf. *N. trutti trutti* BRÖNNIMANN, 1955
- Octolithus multiplus* (PERCH-NIELSEN, 1973) ROMEIN, 1979
- Ottavianus giannus* RISATTI, 1973
- Pharus simulacrum* WIND & WISE in WISE & WIND, 1977
- Prediscosphaera cretacea* (ARKHANGELSKY, 1912) GARTNER, 1968
- Prediscosphaera spinosa* (BRAMLETTE & MARTINI, 1964) GARTNER, 1968
- Quadrum* cf. *Q. gartneri* PRINS & PERCH-NIELSEN in MANIVIT et al., 1977 (small morphotype)
- Reinhardtites anthophorus* (DEFLANDRE, 1959) PERCH-NIELSEN, 1968
- Retecapsa crenulata* (BRAMLETTE & MARTINI, 1964) GRÜN in GRÜN & ALLEMANN, 1975
- Retecapsa* cf. *R. surirella* (DEFLANDRE & FERT, 1954) GRÜN in GRÜN & ALLEMANN, 1975
- Rhagodiscus angustus* (STRADNER, 1963) REINHARDT, 1971
- Rhagodiscus asper* (STRADNER, 1963) REINHARDT, 1967
- Rhagodiscus reniformis* PERCH-NIELSEN, 1973
- Rhagodiscus splendens* (DEFLANDRE, 1953) VERBEEK, 1977
- Rotelapillus* sp.
- Russellia* sp.
- Semihololithus?* sp.
- Staurolithites* cf. *crux* (DEFLANDRE & FERT, 1954) CARATINI, 1963
- Stephanolithion?* sp.
- Tranolithus minimus* (BUKRY, 1969) PERCH-NIELSEN, 1984
- Tranolithus orionatus* (REINHARDT, 1966a) REINHARDT, 1966b
- Watznaueria barnesiae* (BLACK, 1959) PERCH-NIELSEN, 1968
- Zeugrhabdotus biperforatus* (GARTNER, 1968) BURNETT, 1998
- Zeugrhabdotus diplogrammus* (DEFLANDRE in DEFLANDRE & FERT, 1954) BURNETT in GALE et al., 1996
- Zeugrhabdotus embergeri* (NOËL, 1958) PERCH-NIELSEN, 1984
- Zeugrhabdotus erectus* (DEFLANDRE in DEFLANDRE & FERT, 1954) REINHARDT, 1965
- Zeugrhabdotus* cf. *Z. sigmoides* (BRAMLETTE & SULLIVAN, 1961) BOWN & YOUNG, 1997
- Zeugrhabdotus spiralis* (BRAMLETTE & MARTINI, 1964) BURNETT, 1998

Biostratigraphy

(HERBERT SUMMESBERGER & MICHAEL WAGREICH)

KENNEDY et al. (1995: 385, Fig. 7) established the *Paraplanum* Subzone as top Santonian subzone of the *Polyopsis* Zone, demonstrable in the Corbières, in Aquitaine, in the Münster basin (Raben near Recklinghausen) and originally in the Austrian “Sandkalkbank” of the Gosau Group, the index ammonite *Placenticeras polyopsis* (DUJARDIN, 1837) co-occurs in the lower part of the zone in Northwest Europe and the Corbières, but co-occurring with typical late Santonian taxa like *Marsupites*, *Boehmoceras* and *P. paraplanum* in the Münster basin, Aquitaine. This assemblage of the *Paraplanum* Subzone is described and completed in the Schattau-Graben section of the Gosau Group (Austria). *Texlesia dentocarinata* occurring above the *Micraster* Bed near the top of the section together with *Inoceramus germanicus* is the youngest ammonite in the Gosau area. After HANCOCK & GALE (1996) it occurs below the Santonian/Campanian boundary. All indications by inoceramids point to a top Santonian age (HANCOCK & GALE: 167), corroborated by the findings of *Marsupites laevigatus*, a precursor of *M. testudinarius*, in the upper part of the section (WAGREICH et al., 2010). Based on ammonites and inoceramids it was not possible to find a marker horizon for the base of the Campanian in the Schattau-Graben section.

Chronostratigraphy

(MICHAEL WAGREICH)

Biostratigraphic data from the Schattau-Graben section are corroborated by stable isotope data and strontium isotopes (WAGREICH et al., 2010) to fix the chronostratigraphic position of the section within the Santonian–Campanian boundary interval. Carbon isotope data from the section indicate a trend from higher values around the Sandkalkbank Member to lower values at the top of the section. Correlation with the standard curve of JARVIS et al. (2006) may

thus indicate that the profile from the Sandkalkbank Member to the top of the section may represent the decreasing part of the late Santonian Hawks Brow event (WAGREICH et al., 2010). The Hawks Brow event has its peak around the base of the *Marsupites* Zone with a succeeding decrease in the lower part of this zone. However, our data did not allow the position of the peak to be identified.

$^{87}\text{Sr}/^{86}\text{Sr}$ ratios were also reported by WAGREICH et al. (2010). The corrected isotope value (for methods see WAGREICH et al., 2010) from the Sandkalkbank Member (0.707466) is markedly lower than the value for the *Micraster* Bed (around 0.707500) (Text-Fig. 5). This ratio is already above the range of reported values for the Santonian/Campanian boundary (GALE et al., 1995; SCHÖNFELD et al., 1996; MCARTHUR et al., 2001) although still within the error range for the strontium isotope curve of MCARTHUR et al. (2001). WAGREICH et al. (2010) concluded that high diagenetic influence may have slightly altered strontium isotopes from the Schattaugraben section.

Putting all evidence together the chronostratigraphic position of the Schattaugraben section can be constrained to the late Santonian, below the lower boundary of the Campanian, both as defined by the LO of *Marsupites testudinarius* and by the base of the magnetochron C33r. A late Santonian age is based on evidence from carbon isotopes, i.e. the decreasing part of the late Santonian Hawks Brow event of JARVIS et al. (2006) below the Santonian/Campanian boundary event (WENDLER, 2013), planktic foraminifera, i.e. the *asymetrica-elevata* Concurrent Range Zone or the *asymetrica* Zone, nannofossils, i.e. standard zones CC17 and UC12/UC13, echinoids, ammonites and inoceramids.

According to the carbon isotope curve of JARVIS et al. (2006) and their absolute age models the upper part of the Schattaugraben section (65 m) may most probably cover an interval from ca. 84.2 Ma (Hawks Brow peak) to ca. 83.8 Ma (onset of carbon isotope increase to Santonian/Campanian boundary event), i.e. around 400 ka. Although the base is only loosely constrained this gives a mean sediment accumulation rate of ca. 16 cm/ka. According to newer age models of SAGEMAN et al. (2014) and cyclostratigraphy applied by THIBAULT et al. (2016) the total stratigraphic range of *Marsupites* covers only one single 405 ka orbital cycle, thus the upper part of the Schattaugraben section may include an even shorter time interval of considerably less than 405 ka, slightly older than the Santonian/Campanian boundary at 84.19 Ma (SAGEMAN et al., 2014).

Abbreviations

| | | | |
|------|--|-------|--|
| NHMW | Museum of Natural History Vienna, Austria. | GBA | Geologische Bundesanstalt (Geological Survey of Austria, former k. k. Geologische Reichsanstalt), Vienna, Austria. |
| SK | Dr. Peter Skoumal collection, Vienna, Austria. | OÖLM | Oberösterreichisches Landesmuseum, Linz, Austria. |
| MA | Wolf-Peter Maherndl collection, Bad Ischl, Austria. | BMNH | British Museum of Natural History, London, UK. |
| CG | Gustav Gapp collection, Gosau, Austria. | BSP | Bayerische Staatssammlung für Paläontologie und historische Geologie, Munich, Germany. |
| PIUW | Institute of Palaeontology, University of Vienna, Austria. | GIUL | Geological Institute University of Leipzig, Germany. |
| HNS | Haus der Natur, Salzburg, Austria. | TUBF | Inoceramid Collection, Geological Institute, Mining Academy Freiberg, Germany. |
| | | r | right valve |
| | | l | left valve |
| | | d | double valved |
| | | def. | deformed |
| | | rest. | restored |
| | | est. | estimated |

Systematic Palaeontology

Inoceramids

(KARL-ARMIN TRÖGER & HERBERT SUMMERSBERGER)

Phylum Mollusca LINNAEUS, 1758

Class Bivalvia LINNAEUS, 1758

Subclass Pteriomorpha BEURLEN, 1944

Order Pteroida NEWELL, 1965

Superfamily Pteriacea GRAY, 1847

Family Inoceramidae GIEBEL, 1852

Five species of Inoceramidae occur in the Late Santonian *Paraplanum* Subzone of the Schattaugraben section: *Cordiceramus muelleri muelleri* (PETRASCHECK, 1906), *Cordiceramus germanicus* (HEINZ, 1928), *Cordiceramus bueltenensis* (SEITZ, 1961), *Platyceramus ahsenensis* (SEITZ, 1961) and *Sphenoceramus ex gr. pachti/cardissoides*.

Genus *Cordiceramus* HEINZ, 1932

Type species: *Inoceramus cordiformis* J. DE C. SOWERBY (1823), designated by HEINZ (1932).

Cordiceramus muelleri muelleri (PETRASCHECK, 1906)

Pl. 1, Fig. 2

- 1866 *Inoceramus cripsi* var. *regularis* D'ORBIGNY; ZITTEL: Pl. 14, Fig. 3, Pl. 15, Fig. 5.
 1906 *Inoceramus Mülleri* nov. spec. PETRASCHECK: 160, Text-Fig. 1, Pl. 6, Figs. 1, 2.

- 1961 *Inoceramus (Cordiceramus) mülleri mülleri* PETRASCHECK; SEITZ: 127, Pl. 7, Figs. 2, 5, 8, Text-Figs. 27, 28.
- 1961 *Inoceramus (Cordiceramus) mülleri gosauensis* n. subsp.; SEITZ: 135, Pl. 8, Fig. 3, Text-Figs. 29, 30.
- 1967 *Inoceramus (Cordiceramus) mülleri* PETRASCHECK; SEITZ: 45, 126, Pl. 1, Fig. 4.
- 1987 *Inoceramus (Cordiceramus) muelleri* PETRASCHECK, 1906; DHONDRT: 65, Pl. 3, Figs. 4, 5.
- 1994 *Cordiceramus muelleri muelleri* (PETRASCHECK); TRÖGER & SUMMESBERGER: 185, Pl. 3, Fig. 5.
- 2000 *Cordiceramus muelleri* (PETRASCHECK); SUMMESBERGER in EGGER et al.: 27.
- 2007 *Cordiceramus muelleri* (PETRASCHECK); WALASZCZYK & COBBAN: 137, 139, Fig. 6A.
- 2010 *Cordiceramus muelleri muelleri* (PETRASCHECK, 1906); WAGREICH et al.: 186.
- 2017c *Cordiceramus muelleri muelleri* (PETRASCHECK, 1906); SUMMESBERGER et al.: 123.
- 1928** *Inoceramus germanicus* HEINZ: 82, footnote 1.
- 1931** *Endocostea typica* WHITFIELD; RIEDEL: 664, Pl. 75, Figs. 3, 4 [only].
- 1932** *Inoceramus nigrita* HEINZ: 12.
- 1933** *Germanoceramus germanicus* (HEINZ); HEINZ: 250, Pl. 21, Fig. 2 [only].
- 1961** *Inoceramus (Cordiceramus) mülleri germanicus* HEINZ, 1928; SEITZ: 131–135, Pl. 7, Fig. 6, Pl. 8, Figs. 1, 6, 7, Pl. 15, Fig. 1, Text-Figs. 29, 30 [with synonymy].
- 1967** *Inoceramus (Cordiceramus) mülleri germanicus* HEINZ; SEITZ: 129–131, Pl. 23, Fig. 3, Pl. 26, Figs. 4, 5, Pl. 27, Figs. 1, 4, 6.
- 1994** *Cordiceramus muelleri germanicus* (HEINZ, 1928); TRÖGER & SUMMESBERGER: 176, 185, Pl. 3, Fig. 5.
- 2006** *Cordiceramus germanicus* (HEINZ, 1933); WALASZCZYK & COBBAN: 314, Figs. 43.1, 43.2 [with complete synonymy].
- 2008** *Cordiceramus germanicus* (HEINZ, 1933); WALASZCZYK in GALE et al.: 150, Text-Figs. 15A–C, E.

Type: Lectotype is GBA/1906/006/0001, the original of *Inoceramus Mülleri* PETRASCHECK, 1906 (Pl. 6, Figs. 1, 2), designated by SEITZ (1961: 127). A cast was refigured by SEITZ (1961: Pl. 7, Fig. 2a).

Type locality: Hofergraben, Gosau (Upper Austria), close to the localities Finstergrabenwandl and Gosauschmied, late Santonian Sandkalkbank Member of the Hochmoos Formation.

Material: Besides the lectotype (GBA/1906/006/0001) eight partially bivalved specimens from the Schattaugraben section: SK/B/SG/1996/1, SK/B/SG/1996/2/1 r and l, SK/B/SG/1996/2/2 r and l, SK/B/SG/1996/2a, SK/B/SG/1996/3 r and l; NHMW 2006z0165/0001 r and l, NHMW 2000/0004 r and l, NHMW 2000/0006 r and l; one specimen from Finstergraben (Gosau; Collection Felix, GIUL); three specimens from Heudeber-Danstedt near Halberstadt (Subhercynian Cretaceous Basin; TUBF).

Description: For description see SEITZ (1961: 127–130), for new interpretation of the *Endocostea* ‘scar’ see LÓPEZ (2006).

Discussion: DHONDRT (1987: 66) suggested “that the differences stated to exist by Seitz between the ‘subspecies’, of *I. muelleri* are probably simply due to normal biological variability, ... combined with a deformation factor.” In this context it is interesting to note, that the type specimen of SEITZ (1961: Pl. 8, Fig. 3) new subspecies “*Inoceramus (Cordiceramus) mülleri gosauensis*” is a specimen from the Schattaugraben section. Already SEITZ (1967) concluded, that “*Inoceramus (Cordiceramus) mülleri gosauensis*” was a deformed specimen of “*Cordiceramus muelleri muelleri* (PETRASCHECK)”. This was confirmed by DHONDRT (1987).

Occurrence: In the type area (Gosau basin, Austria) *Cordiceramus muelleri muelleri* occurs abundantly in the late Santonian *Paraplanum* Subzone. There is a remarkable mass occurrence in the Sandkalkbank Member of the Santonian Schattaugraben section. Elsewhere (e.g. Germany) it occurs in the late Santonian and possibly in the lowermost Campanian (DHONDRT, 1987: 66).

Cordiceramus germanicus (HEINZ, 1928)

Pl. 2, Fig. 1

- 1928** *Inoceramus germanicus* HEINZ: 82, footnote 1.
- 1931** *Endocostea typica* WHITFIELD; RIEDEL: 664, Pl. 75, Figs. 3, 4 [only].
- 1932** *Inoceramus nigrita* HEINZ: 12.
- 1933** *Germanoceramus germanicus* (HEINZ); HEINZ: 250, Pl. 21, Fig. 2 [only].
- 1961** *Inoceramus (Cordiceramus) mülleri germanicus* HEINZ, 1928; SEITZ: 131–135, Pl. 7, Fig. 6, Pl. 8, Figs. 1, 6, 7, Pl. 15, Fig. 1, Text-Figs. 29, 30 [with synonymy].
- 1967** *Inoceramus (Cordiceramus) mülleri germanicus* HEINZ; SEITZ: 129–131, Pl. 23, Fig. 3, Pl. 26, Figs. 4, 5, Pl. 27, Figs. 1, 4, 6.
- 1994** *Cordiceramus muelleri germanicus* (HEINZ, 1928); TRÖGER & SUMMESBERGER: 176, 185, Pl. 3, Fig. 5.
- 2006** *Cordiceramus germanicus* (HEINZ, 1933); WALASZCZYK & COBBAN: 314, Figs. 43.1, 43.2 [with complete synonymy].
- 2008** *Cordiceramus germanicus* (HEINZ, 1933); WALASZCZYK in GALE et al.: 150, Text-Figs. 15A–C, E.

Holotype is the original of *Inoceramus germanicus* (HEINZ, 1933: Pl. 21, Fig. 2) from Groß Bütten next Braunschweig (Germany) designated by SEITZ (1961: 131).

Material: NHMW 2010/0081/0010 from the Bibereck Formation on top of the Schattaugraben section, NHMW 2000z0003d, NHMW 2010/0003 r from the Schattaugraben section, NHMW 1997z0144/0001 l, NHMW 1997z0144/0006 l, NHMW 1990/0029/0201, NHMW 1990/0029/0195 from the Sandkalkbank Member of the Hochmoos Formation, furthermore ZITTEL’s original (1866: Pl. 15, Fig. 5; NHMW 1864/0040/1187) from the nearby situated Hofergraben (Gosau, Upper Austria).

Description and Discussion: For description see SEITZ (1961: 131–135), for discussion see WALASZCZYK & COBBAN (2006: 315).

Occurrence: Following SEITZ (1961: 131) *Cordiceramus germanicus* (HEINZ, 1928) occurs in the Santonian and is possibly limited to the late Santonian. In the Gosau Group it occurs in the late Santonian *Paraplanum* Subzone of the Schattaugraben section from the Sandkalkbank Member of the Hochmoos Formation through the basal Bibereck Formation, co-occurring at the top of the section with *Texasia dentatocarinata* (F. ROEMER, 1852). After WALASZCZYK & COBBAN (2006: 316) it occurs in the late Santonian and early Campanian of Europe, West Asia, Africa and North America. After WALASZCZYK in GALE et al. (2008: 150) *C. germanicus* marks the lowest of three inoceramid Zones in the Austin Chalk of the Waxahachie section of Texas.

Cordiceramus bueltenensis (SEITZ, 1961)

Pl. 2, Fig. 2

- 1961 *I. (Cordiceramus) bueltenensis bueltenensis* n. sp., n. ssp.; SEITZ: 142, Pl. 9, Figs. 2, 4–6, Text-Figs. 33, 34.
- 2006 *Cordiceramus bueltenensis* SEITZ, 1961; WALASZCZYK & COBBAN: 318, Text-Figs. 45.1–45.3, 45.6, 46.1 [with synonymy].
- 2008 *Cordiceramus bueltenensis*; COBBAN et al.: Fig. 2.

Type: Holotype by original designation is the original of SEITZ (1961: Pl. 9, Fig. 1).

Material: A single specimen, NHMW 2010/0081/0011, from the *Micraster* Bed (sample n°: Schattau 16).

Description: NHMW 2010/0081/0011 is an internal mould of the right valve with preserved remnants of shell.

Discussion: After WALASZCZYK & COBBAN (2006: 318) the differences between the two subspecies *I. (Cordiceramus) bueltenensis bueltenensis* (SEITZ, 1961) and *I. (Cordiceramus) bueltenensis wolanskya* (SEITZ, 1961) reflects size differences and are not of taxonomic importance.

Occurrence: *Cordiceramus bueltenensis* (SEITZ, 1961) occurs in the Santonian of Germany (Groß Bütlen), Spain, France, Romania, Crimea, Caucasus, Turkmenian Republic, Madagascar, North- and Central America. In the Schattaugraben section it occurs in the *Micraster* Bed of the Bibereck Formation (*Paraplanum* Subzone) and is described here for the first time from the Gosau Group of Austria.

Genus *Platyceramus* HEINZ, 1932

Type species: *Inoceramus mantelli* (DE MERCEY) BARROIS, 1879 (Pl. 4, Fig. 1) by original designation of HEINZ (1932).

Platyceramus ahsenensis (SEITZ, 1961)

Pl. 1, Fig. 1

- 1931 *Inoceramus cycloides* WEGNER var. *quadrata* n. var. RIEDEL: 662, Pl. 74, Fig. 4.
- 1961 *Inoceramus (Platyceramus) cycloides ahsenensis* SEITZ: 63, Pl. 1, Figs. 7, 9, 10, Text-Figs. 12, 13 [with synonymy].
- 1967 *Inoceramus (Platyceramus) cycloides ahsenensis* SEITZ, 1961; SEITZ: 45, 81, Pl. 1, Fig. 2, Pl. 11, Figs. 1, 2, Pl. 13, Fig. 3, Text-Figs. 12, 13.
- 1987 *Inoceramus (Platyceramus) spec. cf. Inoceramus (Platyceramus) cycloides ahsenensis* SEITZ, 1961; DHONDTE: 66.
- 1994 *Platyceramus cycloides ahsenensis* (SEITZ, 1961); TRÖGER & SUMMESBERGER: 173, Text-Fig. 3.
- 2004 *Platyceramus ahsenensis* (SEITZ, 1961); REMIN: 593.
- 2006 *Platyceramus ahsenensis* (SEITZ, 1961); WALASZCZYK & COBBAN: 295, Text-Figs. 32.2–32.5.
- 2008 *Platyceramus ahsenensis* (SEITZ, 1961); WALASZCZYK in GALE et al.: 153–154, Text-Figs. 16A–D.

Type: Holotype by the subsequent designation of SEITZ (1961: 64) is *Inoceramus cycloides* WEGNER var. *quadrata* n. var. RIEDEL, 1931 (662, Pl. 74, Fig. 4).

Material: A single specimen NHMW 2010/0081/0012 is from the *Micraster* Bed in the Bibereck Formation.

Description: NHMW 2010/0081/0012 is an almost complete internal mold of a left valve with adherent shell remains. The specimen is slightly flattened, the hinge line is preserved. The surface is covered by a thin rusty layer.

Discussion of the species: See WALASZCZYK & COBBAN (2006: 295).

Occurrence: The occurrence in the Schattaugraben section is late Santonian. *P. ahsenensis* occurs in the *Micraster* Bed together with *Boehmoceras arculus* and *B. krekelei* in the *Paraplanum* Subzone. Elsewhere it occurs from Santonian to early Campanian (see WALASZCZYK & COBBAN, 2006: 295). In the Waxahachie section (Texas; WALASZCZYK in GALE et al., 2008: 151, Text-Fig. 14) it occurs in the *Platyceramus ahsenensis* Acme Zone, this is above the *Cordiceramus germanicus* Zone and 3–5 metres below the base of the Campanian.

Genus *Sphenoceramus* J. BOEHM, 1915

Type species: *Inoceramus cardisoides* GOLDFUSS (1835) by subsequent designation of SEITZ (1965: 29).

Sphenoceramus ex gr. cardisoides (GOLDFUSS, 1835) / *pachti* (ARKHANGELSKY, 1916)

Pl. 2, Figs. 3a–b

cf. 1994 *Sphenoceramus cardisoides* (GOLDFUSS, 1835) subsp. indet. (transition to *Sphenoceramus pachti* ARKHANGELSKY, 1916); TRÖGER & SUMMESBERGER: 177, Pl. 3, Figs. 3, 3a, 3b.

Types: The holotype of *Sphenoceramus cardisoides* (GOLDFUSS, 1835) is the original of *Inoceramus cardisoides* GOLDFUSS, 1835 (Pl. 110, Fig. 2) from Germany. The lectotype of *Sphenoceramus pachti pachti* is the original of *Inoceramus cardisoides* var. *pachti* (ARKHANGELSKY, 1916 (Pl. 3, Fig. 2).

Material: A single specimen NHMW 2010/0081/0013 from the *Micraster* Bed of the Bibereck Formation.

Description: NHMW 2010/0081/0013 is a distorted fragment with shell remains.

Discussion: TRÖGER in TRÖGER & SUMMESBERGER (1994) noted the close relation between the figured specimen of *Sphenoceramus cardisoides* (GOLDFUSS, 1835) and *Sphenoceramus pachti* (ARKHANGELSKY, 1916). Again WALASZCZYK (in WALASZCZYK & COBBAN, 2006) understood both taxa as representatives of a group. SEITZ (1961) used the *Sphenoceramus cardisoides/pachti* group as a biostratigraphical marker for the base of the Santonian.

Occurrence: Following TRÖGER (2009: 128) *Sphenoceramus pachti pachti* occurs in the early and middle Santonian and rarely in the late Santonian, more or less contemporane-

ously with *Sphenoceramus cardisoides cardisoides*, which occurs in the middle and rarely in the late Santonian and early Campanian, also in the latest Coniacian. The Austrian occurrence is late Santonian *Paraplanum* Subzone.

Age indication by inoceramids

(HERBERT SUMMESBERGER & KARL-ARMIN TRÖGER)

Following WALASZCZYK (in GALE et al., 2008) *Cordiceramus germanicus* occurs in the *C. germanicus* Acme Zone which is dominated by the *C. muelleri* fauna. The *C. germanicus* Acme Zone is followed by the *Platyceramus ahsenensis* Acme Zone. This biostratigraphic succession in the top Santonian/Campanian Waxahachie section can be correlated tentatively with the Schattaugraben section: the mass occurrence of *Cordiceramus muelleri* in the Sandkalkbank Member corresponding to the *Cordiceramus germanicus* Acme Zone and the rare occurrence of *Platyceramus ahsenensis* in the *Micraster* Bed with the occurrence of the *P. ahsenensis* fauna in the Waxahachie section. Elsewhere (e.g. Germany) *Cordiceramus muelleri* occurs in the late Santonian too and possibly in the earliest Campanian (DHONDT, 1987: 66). All age indications by inoceramids point to a top Santonian age (Zone of *Placenticeras paraplanum* and *Boehmoceras arculus*) of the lithostratigraphical part of the Hochmoos and Bibereck Formations.

Cephalopods

Abbreviations

| | |
|-----|----------------------------------|
| Wh | whorl height in mm |
| Wb | whorl breadth in mm |
| D | whorl diameter in mm |
| U | umbilicus in mm |
| U % | percentage of U in relation to D |

Nautiloids

(HERBERT SUMMESBERGER)

Class Cephalopoda CUVIER, 1797
Subclass Nautiloidea AGASSIZ, 1847
Order Nautilida AGASSIZ, 1847
Suborder Nautilina AGASSIZ, 1847
Superfamily Nautilacea DE BLAINVILLE, 1825
Family Nautilidae DE BLAINVILLE, 1825
Genus *Eutrephoceras* HYATT, 1894

Type species: *Nautilus Dekayi* MORTON (1834) by designation of WHITFIELD (1892).

Eutrephoceras cf. indicum (D'ORBIGNY, 1850)

Pl. 3, Figs. 1–5, Pl. 4, Figs. 1–3, Text-Figs. 9, 10, Tab. 1

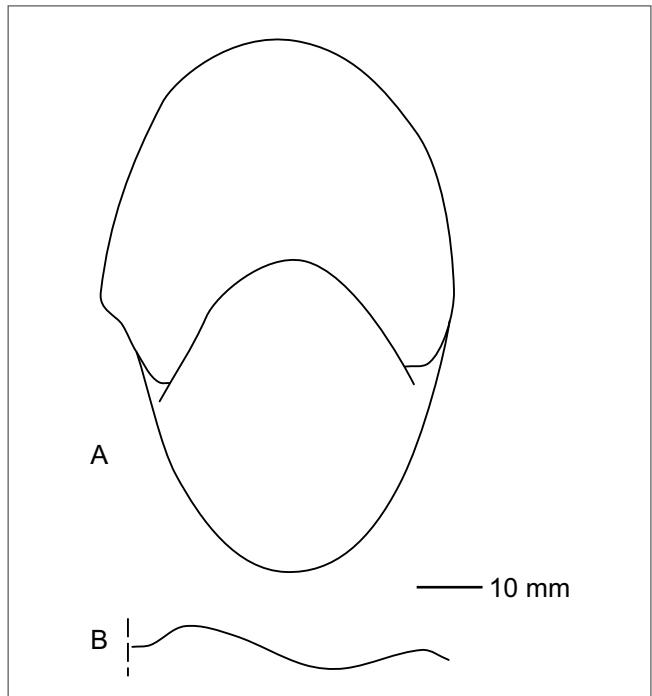
Compare

- cf. 1850 *Nautilus indicus* D'ORBIGNY, Prodrome II: 211.
- cf. 1960a *Eutrephoceras indicum* (D'ORBIGNY, 1850); WIEDMANN: 159, Text-Figs. 3–5, Pl. 21, Fig. G, Pl. 25, Figs. 1–4). With additional synonymy.
- cf. ? 1960b *Eutrephoceras sublaevigatum* (D'ORBIGNY); WIEDMANN: 715.
- cf. 2000 *Eutrephoceras cf. indicum* (D'ORBIGNY, 1850); WILMSEN: 39, Pl. 4, Figs. 3a–c, Pl. 5, Figs. 10, 23.

Type: See WIEDMANN (1960a: 159).

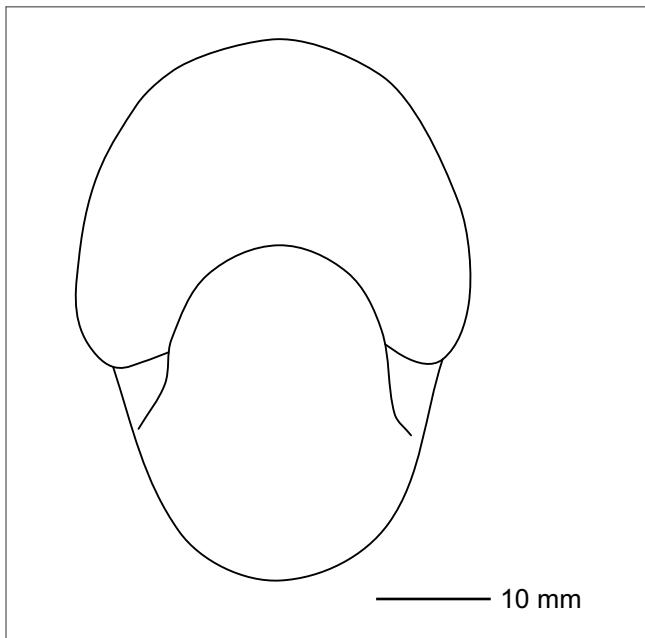
Material: A single adult specimen from the Schattaugraben section NHMW 2009z0045/0001, a second adult one from the Gosau Group without locality details: NHMW 2009z0046/0001, a single subadult specimen (NHMW 1990/0029/0517a) and nine juveniles (NHMW 1990/0029/0515b, NHMW 1990/0029/0518a, NHMW 2009z0047/0002, SK/1983/10, SK/1983/14/1–5) from the Late Santonian Sandkalkbank Member (Hochmoos Formation, Gosau Group) of the locality Finstergrabenwandl (Gosau, Upper Austria). Two very small juveniles of *Eutrephoceras cf. indicum* (D'ORBIGNY, 1850) (D about 26 mm; SK/SG/2010/52a, b) are the only representatives of the Nautiliida in the *Micraster* Bed of the Bibereck Formation.

Description: NHMW 2009z0045/0001 (Pl. 3, Figs. 1a, b, Text-Fig. 9) is the internal mould of a body chamber with two chambers of the phragmocone preserved. Although lacking the greater part of the phragmocone it is undeformed. The apertural margin is more or less complete



Text-Fig. 9.

A. *Eutrephoceras cf. indicum* (D'ORBIGNY, 1850) from the Austrian Gosau Group, NHMW 2009z0045/0001; upper Santonian, Schattaugraben section, Salzburg; diagrammatic cross section, restored. B. suture.



Text-Fig. 10.
Eutrephoceras cf. indicum (d'ORBIGNY, 1850), NHMW 1990/0029/0515/2 from the Late Santonian Hochmoos Formation/Sandkalkbank Member of the locality Finstergrabenwandler, Gosau, Upper Austria; apertural diagrammatic cross section, restored.

(Text-Fig. 9). The shell is missing but a few areas retaining a white powdery substance. The matrix is a fine grained hard calcareous sand- to siltstone. The section is slightly high oval. The greatest whorl breadth is close to the umbilicus. The flanks are gently inflated and continuously passing into the rounded umbilical wall as well as into the evenly rounded venter without ventrolateral shoulders. The umbilicus is tiny. There is no sculpture visible on the internal mould. Close to the apertural margin there is a moderate protuberance only on the left side possibly recording a minor pathological deformation or damage in life. The septa are slightly sinuous with concavities mid-flank and on the venter. The position of the siphuncle is unknown.

NHMW 2009z0046/0001 from the Austrian Gosau Group but without locality details is of comparable shape and size with shell preserved. Distinct growth lines are visible (Pl. 3, Fig. 2b). They arise projecting forward, bending backward at midflank forming a large concave sinus over the venter. NHMW 1990/0029/0515b (Pl. 3, Figs. 3a, b, Text-Fig. 10) is an undeformed and wholly septate juvenile.

Discussion: It should be kept in mind that NHMW 2009z0046/0001 lacks locality details. Its horizon within

the Austrian Gosau Group remains doubtful. Nevertheless, its close to identical shape leads to the assumption that both specimens might be conspecific. Therefore, the preserved growth lines of NHMW 2009z0046/0001 might be used additionally to the description. Open nomenclature is used as the identification is based only on a small collection from the middle Turonian of Spain (WIEDMANN, 1960a: 159, Text-Figs. 3–5, Pl. 21, Fig. G, Pl. 24, Figs. 1–4).

Eutrephoceras indicum (d'ORBIGNY, 1850) from the middle Turonian of Spain differs by its slightly triangular whorl section (WIEDMANN, 1960a: Text-Figs. 3, 4). *Eutrephoceras cf. indicum* (d'ORBIGNY, 1850) from the middle Turonian *Romaniceras ornatissimum* Zone in Spain (WILMSEN, 2000: 39, Pl. 4, Figs. 3a–c, Pl. 5, Figs. 10, 23) is very similar and differs by slightly wider whorl breadth ($Wb/Wh = 1.02$ after WILMSEN, 2000: 39). *Eutrephoceras montiscastoris* spec. nov. described below is globular with a laterally widened aperture. *Eutrephoceras sublaevigatum* (d'ORBIGNY, 1850) (see WIEDMANN, 1960a: 165) from the Maastrichtian Gosau Group of Grünbach (Lower Austria) differs in its greater whorl breadth. *Eutrephoceras bouchardianum* (d'ORBIGNY, 1840) from the Albian of France (TINTANT & GAUTHIER, 2006) has a much wider aperture. *Eutrephoceras darupense* (SCHLÜTER, 1876) has much more widely spaced septa and has a more compressed whorl section. *Cimomia gosavica* (REDTENBACHER, 1873), co-occurring and re-described below differs in its high oval whorl section. *Angulithes* sp. from the early Maastrichtian of Gams (SUMMESBERGER et al., 2009) differs in its much narrower whorl section. *Angulithes (Angulithes) neubergicus* (REDTENBACHER, 1873) from the early Maastrichtian of Neuberg (Styria, Austria) differs from *Eutrephoceras indicum* in its triangular narrow whorl section, and fastigiate venter.

Occurrence: NHMW 2009z0045/0001 is from the upper Santonian of the Schattaugraben section without detailed information about its position within the section. NHMW 2009z0046/0001 is an unlabelled specimen from the Austrian Gosau Group. The remaining ones are from the Sandkalkbank Member of the Hochmoos Formation (late Santonian, Zone of *Boehmoceras arculus* and *Placenticeras paraplanum*, Gosau Group, Austria). Elsewhere *Eutrephoceras indicum* (d'ORBIGNY, 1850) is reported from the late middle Turonian of Spain and from the "Senonian" of India and Chile (WIEDMANN, 1960a; WILMSEN, 2000).

| Inventory No. | D _{rest} (mm) | Wb (mm) | Wh (mm) | Wb/Wh | U (%) |
|---------------------|------------------------|---------|---------|-------|-------|
| NHMW 2009z0045/0001 | 84 | 52 | 50 | 1.04 | -- |
| NHMW 2009z0046/0001 | 83 | 48.6 | 57.5 | 0.84 | -- |
| NHMW 1990z0029/515b | 51.4 | 35 | 26 | 1.34 | 2.5 |
| NHMW 1990z0029/517a | 72 | 45 | 40 | 1.15 | -- |
| NHMW 1990z0029/518a | 48.5 | 34 | 30 | 1.13 | -- |

Tab. 1.
Measurements of *Eutrephoceras cf. indicum* (d'ORBIGNY, 1850) from the Austrian Gosau Group. U % of D.

Eutrephoceras montiscastoris SUMMESBERGER,
spec. nov.

Pl. 4, Figs. 4–6, Pl. 5, Figs. 1–3, Text-Fig. 11, Tab. 2

- ? 1876 *Nautilus* cf. *Neubergicus* SCHLÜTER: 174; non REDTENBACHER, 1873.
- ? 1876 *Nautilus Neubergicus* SCHLÜTER: Pl. 48, Figs. 3–5; non REDTENBACHER, 1873.
- ? 1960a *Eutrephoceras darupense* (SCHLÜTER, 1876); WIEDMANN: 157 (partim).
- ? 1960b *Eutrephoceras* cf. *neubergicum* (REDTENBACHER); WIEDMANN: 715.
- ? 1960b *Eutrephoceras* sp.; WIEDMANN: 717.
- ? 1991 *Eutrephoceras darupense* (SCHLÜTER, 1876); RIEGRAF & SCHEER: 428.
- ? 2000 *Eutrephoceras darupense* (SCHLÜTER, 1876); WILMSEN: 39, Pl. 4, Figs. 4, 5.

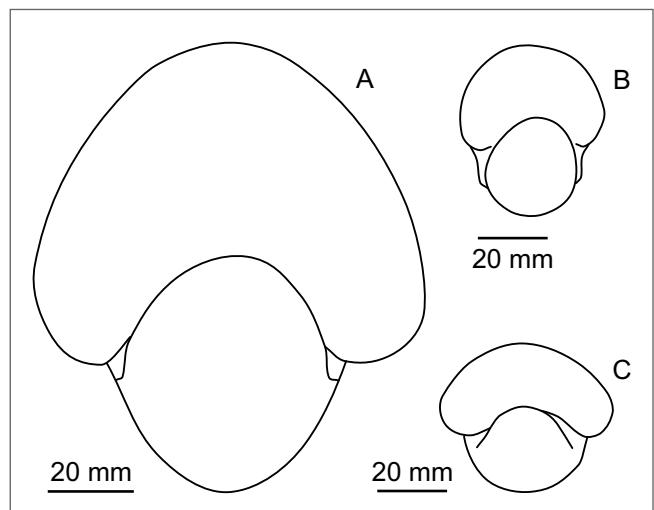
Type: Holotype designated herein is NHMW 1990/0029/0515a (Pl. 5, Figs. 1a–c) from the Sandkalkbank Member of the Hochmoos Formation of the locality Finstergrabenwandl at the Upper Austrian side of the basin of Gosau.

Etymology: After the Bibereck mountain (lat.: mons castoris) where the localities Schattaugraben and Finstergrabenwandl are situated.

Material: Besides the holotype (NHMW 1990/0029/0515a) a single individual (SK/SG/2007/49) is from the Schattaugraben section, five are from the Sandkalkbank Member of the locality Finstergrabenwandl (NHMW 1990/0029/0515/3, NHMW 1990/0029/0519/1, NHMW 2009z0047/0001, 2009z0047/0002, SK/1978/23) and a single specimen from the Sandkalkbank Member of the Schattau forest road (NHMW 2009z0048/0001).

Diagnosis: Globular shape in all growth stages, umbilicus deep and narrow, in adult stages closed, hornlike widened aperture in adults.

Description: One adult specimen (NHMW 1990/0029/0515a) and four juveniles from the Sandkalkbank Member of the locality Finstergrabenwandl are preserved as internal moulds with adherent remnants of white chalky shell. The general outline is globular. The whorl section is depressed and reniform. The width increases rapidly, widening finally to a hornlike aperture (Pl. 4, Figs. 4–6, Pl. 5, Figs. 1–3) with a maximum width close to the umbilicus. The umbilicus is very narrow and deep, in adult specimens closed. The um-



Text-Fig. 11.

Diagrammatic cross sections of *Eutrephoceras montiscastoris* spec. nov.: A. NHMW 1990/0029/0515/1; B. NHMW 1990/0029/0519/1; C. SK/SG/2007/49.

bilical wall is almost vertical, the umbilical shoulder is narrowly rounded. The flanks are constantly curved passing continuously into the venter. There is no ornament visible on the moulds from the Finstergrabenwandl. The regularly spaced sutures are prorsiradiate next to the umbilicus, sweeping back at the umbilical shoulder forming a shallow concavity midflanks and bending forward again in the ventrolateral region, crossing the venter with a slight concavity. The position of the siphuncle cannot be observed.

SK/SG/2007/49 from the Schattaugraben section is a distorted individual mainly consisting of the body chamber. It is, extraordinarily for the Schattaugraben section, preserved with light brownish shell. This preservation records fine somewhat irregular and occasionally thickened growth lines. They cross the flanks slightly curved and the venter with a marked concavity. The umbilicus of this specimen seems to have been almost closed. The apertural margin is damaged. All data measured on the deformed specimen are still meaningful. NHMW 2009z0048/0001 from the Schattaugraben forest road is a fragment of an internal mould of the phragmocone with adherent shell.

Discussion: *Eutrephoceras montiscastoris* spec. nov. differs from all described taxa from the Gosau Group by its globular shape and its laterally extremely widened aperture. *Eutrephoceras sublaevigatum* (D'ORBIGNY) (see WIEDMANN (1960a: 165) from the Maastrichtian Gosau Group of Grünbach (Lower

| Inventory No. | D (mm) | Wb (mm) | Wh (mm) | Wb/Wh | U (%) |
|-----------------------|--------|---------|---------|-------|-------|
| NHMW 1990/0029/0515a | 98.5 | 66 | 51 | 1.29 | -- |
| NHMW 1990/0029/0515/3 | 38 | 24 | 20 | 1.2 | -- |
| NHMW 1990/0029/0519/1 | 32 | 24 | 16 | 1.5 | -- |
| NHMW 2009z0047/0001 | 46.7 | 32.5 | 30 | 1.08 | -- |
| NHMW 2009z0047/0002 | 47.4 | 32 | 27 | 1.18 | -- |
| SK/SG/2007/49 | 65 | 42 | 36 | 1.16 | -- |

Tab. 2.

Measurements of *Eutrephoceras montiscastoris* spec. nov. from the Late Santonian Sandkalkbank Member of the Gosau Group. U % of D.

Austria) differs in its narrower whorl section. The apertures cannot be compared as the only adult specimen, the original of REDTENBACHER (1873: 95, 96, Pl. 22, Fig. 2) lacks the body chamber. *Cimomia gosavica* (REDTENBACHER, 1873), co-occurring with *Eutrephoceras montiscastoris* spec. nov. and re-described below differs by its high oval section without any widening of the adult aperture. *Nautilus sowerbianus* HAUER, 1858 (non D'ORBIGNY, 1840) from the early Maastrichtian of Neuberg (Styria, Austria) was re-described under *Nautilus neubergicus* by REDTENBACHER (1873: 97, Pl. 22, Fig. 4; see below) and put under synonymy of *A. (Angulithes) fleuriausianus* (D'ORBIGNY, 1840) by WIEDMANN (1960a: 183). SCHLÜTER (1876: Pl. 48, Figs. 2, 4, 5) described two specimens from the Westphalian late Coniacian Zone of *Ammoneites Margae* and compared them in the text with some caution with *Nautilus cf. neubergicus* REDTENBACHER (SCHLÜTER, 1876: 174, 175). He figured them under *Nautilus neubergicus* REDTENBACHER (SCHLÜTER, 1876: Pl. 48, Figs. 2, 4, 5). In our opinion Schlüter's specimens belong to a distinct taxon which possibly is identical or at least a close ally of *E. montiscastoris* spec. nov. described above. WIEDMANN (1960a: 157) put *N. cf. neubergicus* SCHLÜTER (non REDTENBACHER) under synonymy with *Eutrephoceras darupense* (SCHLÜTER, 1876). He was followed by RIEGRAF & SCHEER (1991: Pl. 48), WITTLER et al. (1999: 37) and WILMSEN (2000: 39). We believe that *N. darupensis* SCHLÜTER, 1876 (Pl. 49, Figs. 3, 4) is also a distinct taxon differing from *N. cf. neubergicus* SCHLÜTER (non REDTENBACHER) by its much wider spaced chamber walls and narrower whorl section (see also KENNEDY, 2002: Pl. 43, Figs. 1, 2). We follow WIEDMANN's opinion (1960a: 183, 184) that *Nautilus neubergicus* REDTENBACHER from the Maastrichtian Gosau Group of Neuberg (Styria) is an *Angulithes*. But we do not believe that it is synonymous with *A. (Angulithes) fleuriausianum* (D'ORBIGNY, 1840) as WIEDMANN (1960a: 183) suggested (a typical Cenomanian species after COBBAN & KENNEDY, 1993: E2). We are certain that SCHLÜTER's specimens of *Nautilus neubergicus* SCHLÜTER (non REDTENBACHER) do not belong to *E. darupense* (SCHLÜTER, 1876), nor to *Angulithes neubergicus* (REDTENBACHER, 1873). Anyway, this Maastrichtian taxon differs also from *E. montiscastoris* spec. nov. by its narrower whorl section and fastigiate venter. *Angulithes* sp. from the early Maastrichtian of Gams (SUMMESBERGER et al., 2009) differs in its much narrower discoidal shape and its fastigiate venter.

Eutrephoceras cf. indicum (D'ORBIGNY, 1850) from the Schattaugraben section (see above) and also co-occurring with *E. montiscastoris* spec. nov. differs in its narrower whorl breadth and its slightly high oval whorl section. Also *Eutrephoceras indicum* (D'ORBIGNY, 1850) differs in its narrower aperture. *Eutrephoceras darupense* (SCHLÜTER, 1876) from the Westphalian and British Campanian differs by wider spaced chamber walls and also, compared with SCHLÜTER's measurement (1876: 175) by a somewhat narrower whorl section (see also: KENNEDY, 2002: Pl. 43, Figs. 1, 2). *Eutrephoceras bouchardianum* (D'ORBIGNY, 1840) from the Albian of France (TINTANT & GAUTHIER, 2006) is similar, its whorl section even more depressed. The general shape is globular but without hornlike widening of the aperture.

Occurrence: Upper Santonian Hochmoos Formation in the Schattaugraben section (Rußbach, Salzburg, Austria) and Sandkalkbank Member of the Hochmoos Formation of the Finstergrabenwandler, situated next to the Schattaugraben (Gosau, Upper Austria).

Family Hercoglossinae SPATH, 1927

Genus *Cimomia* CONRAD, 1866

Type species: *Nautilus Burtini* GALEOTTI 1837 from the Eocene of Belgium by original designation of CONRAD (1866). We follow KUMMEL (1956: 441) and place *Cimomia* as a distinct genus into the subfamily Hercoglossinae (SPATH, 1927).

Cimomia gosavica (REDTENBACHER, 1873)

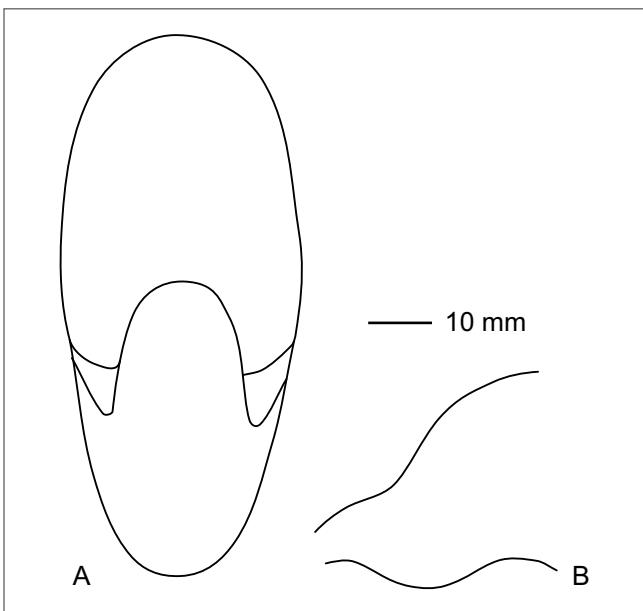
Pl. 6, Figs. 1–3, Pl. 7, Fig. 1, Text-Figs. 12, 13, Tab. 3

- 1873 *Nautilus gosavicus* REDTENBACHER: 96, Pl. 22, Figs. 2a, b.
 1956 *Eutrephoceras gosavicus* (REDTENBACHER) 1873; KUMMEL: 382.
 1960b *Angulithes (Cimomia) gosavicus* (REDTENBACHER) 1873; WIEDMANN: 178, Pl. 20, Fig. M.
 1975 *Cimomia ?gosavicus* (REDTENBACHER, 1873); SHIMANSKY: 134, Tab. 41.
 2009 *Angulithes (Cimomia) gosavicus* (REDTENBACHER, 1873); SUMMESBERGER et al.: 166.
 2009 *Angulithes (Cimomia) gosavicus* (REDTENBACHER, 1873); SUMMESBERGER et al.: 167.
 2012 *Cimomia gosavica* (REDTENBACHER, 1873); SUMMESBERGER & ZORN: 104, Pl. 6, Figs. 3 a–d.

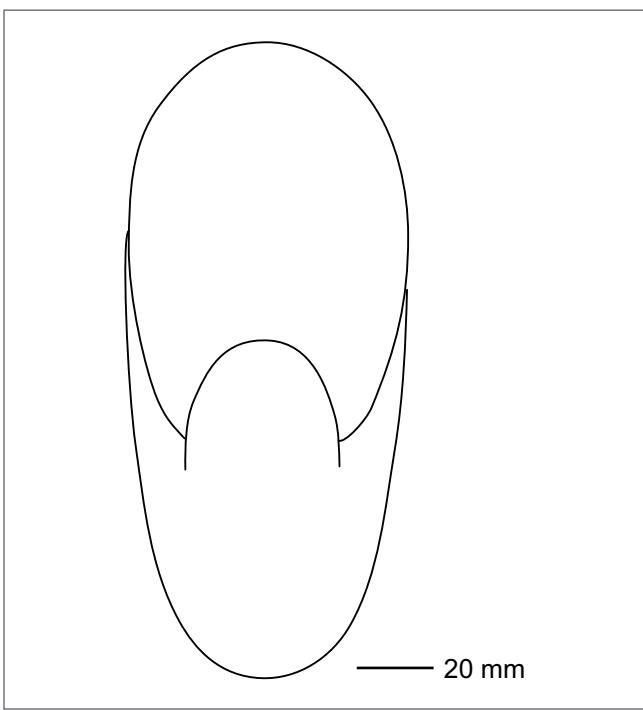
Type: Holotype by monotypy is the original of *Nautilus gosavicus* REDTENBACHER, 1873 (Pl. 22, Figs. 2a, b) preserved in the collections of the Geological Survey of Austria (GBA 1873/0001/0003) designated and refigured herewith (Pl. 6, Figs. 2a–d).

Material: Five specimens: NHMW 2009z0045/0002, an internal mould from the late Santonian of the Schattaugraben section, NHMW 1990/0029/0514, NHMW 1990/0029/0520 (on display in the NHMW exhibition hall 8), SK/1983/13 all from the late Santonian of the Finstergrabenwandler and the type specimen, the original of REDTENBACHER (1873: Pl. 22, Fig. 2; GBA 1873/0001/0003) from the nearby Neffgraben at the Salzburg side (Rußbach) of the Gosau Basin.

Description: NHMW 2009z0045/0002 (Pl. 6, Figs. 1a–c) from the Schattaugraben is a distorted internal mould of a phragmocone with adherent massive remains of shell within and around the umbilicus. The body chamber is broken away. D_{\max} : 81.3 mm, Wh_{est} : 50 mm, Wb_{est} : 33.4 mm, Wb/Wh : 0.67 (Tab. 3). Wh increases rapidly, greatest breadth is at the internal third of the flank, the flanks are moderately inflated and slightly convergent towards the venter. The venter is evenly rounded without distinct ventrolateral shoulders. The flanks pass smoothly into the rounded umbilical wall. The umbilicus is occluded by massive shell remains. There are about 23 chambers present on the preserved whorl of the phragmocone. The sutures are strongly sinuous with a backward flexure mid-flank. The position of the siphuncle cannot be observed. There is no ornamentation. NHMW 2009z0045/0002 is interpreted here as the phragmocone of an adult individual. GBA 1873/0001/0003, REDTENBACHER's original (1873: Pl. 22, Figs. 2a, b) from the Neffgraben section is interpreted as the phragmocone of a juvenile individual. It is a partially crushed chambered



Text-Fig. 12.
Cimomia gosavica (REDTENBACHER, 1873) from the Austrian Gosau Group, NHMW 2009z0045/0002; Late Santonian, Schattaugraben section, Salzburg; diagrammatic cross section, restored. A. apertural view, B. suture.



Text-Fig. 13.
Cimomia gosavica (REDTENBACHER, 1873) from the Austrian Gosau Group, NHMW 1990/0029/0514; Late Santonian, Finstergrabenwandl, Gosau, Upper Austria; diagrammatic cross section, restored; apertural view.

phragmocone with parts of the shell preserved. The suture is slightly sinuous. The flanks pass evenly into the rounded umbilical wall and equally into the rounded venter. The siphuncle is in central position. Indistinct growth lines are visible in the umbilical region, where shell is preserved. NHMW 1990/0029/0514 (Pl. 7, Figs. 1a, b) is the internal mould of a large adult specimen with preserved extensive remnants of light brownish shell. The shell was bored by sponges. The individual is very involute with a tiny but not occluded umbilicus. The whorl section is high oval. The flanks are gently curved, passing without developing a ventrolateral shoulder into the rounded venter, and without umbilical edge into the more or less vertical umbilical wall. Whorl height and width increase proportionally. About three quarters of the last whorl are body chamber, the apertural margin is gently curved. The suture as far as it can be observed crosses the flank with a slight concavity flexed backwards on the outer third of the flank, possibly crossing the venter in a broad convexity. SK/1983/13 is of similar size to NHMW 1990/0029/0514 but preserved with white chalky shell remains. The umbilicus is closed due to post mortem distortion.

Discussion: There is a little difference between REDTENBACHER's original from the Neffgraben (Pl. 6, Figs. 2a-d), apparently a juvenile, and the specimen from the Schattaugraben section (Pl. 6, Figs. 1a-c). Both have a tiny to occluded umbilicus, and both are laterally compressed with a high oval whorl section. *Angulithes* (A.) *neubergicus* (REDTENBACHER, 1873) from the early Maastrichtian of Krampen near Neuberg and suggested by WIEDMANN (1960a: 183–185) to be synonymous with the Cenomanian *Angulithes* (A.) *fleuriausianus* (D'ORBIGNY, 1840) differs in its more slender shape and fastigiate venter (WIEDMANN, 1960a: Pl. 20, Fig. O). *Angulithes* (A.) *fleuriausianus* (D'ORBIGNY, 1840) from Cenomanian through Coniacian of western Europe and Spain (WIEDMANN, 1960a: 185) has a more accentuated venter and distinctly convergent flanks leading to its characteristic "triangular" shape (see WIEDMANN, 1960a: Pl. 21, Fig. L). *Angulithes* (A.) sp. indet. from the early Maastrichtian of the Gams Basin (Styria, Austria) (SUMMESBERGER et al., 2009: Figs. 1, 5) differs in its angular venter and small but open umbilicus. *Eutrephoceras sublaevigatum* (D'ORBIGNY, 1840) (REDTENBACHER, 1873: 95, Pl. 22, Figs. 1a, b) and "Nautilus resupinatus" (REDTENBACHER, 1873 (97, Pl. 22, Figs. 3a, b), conspecific after WIEDMANN (1960a: 165) with the former, both from the Maastrichtian of Grünbach (Lower Austria) differ in their much greater whorl breadth. *Eutrephoceras monticasteris* spec. nov. described above from the neighbouring Finstergrabenwandl, from the Schattaugraben section and from the Schattaugraben forest road differs in its globular shape and hornlike widening of the aperture. *Eutrephoceras indicum* (D'ORBIGNY, 1850) differs in its stouter whorl section.

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | Wb/Wh | U (mm) | U (%) |
|------------------------|--------|---------|---------|-------|--------|-------|
| GBA 1873/0001/0003 | 66 | 35.5 | 27.4 | 0.77 | -- | -- |
| NHMW 1990/0029/0514190 | 110.7 | 77 | 69 | 0.9 | 5 | 2.6 |
| NHMW 2009z0045/0002 | 81.3 | 50 | 33.4 | 0.67 | -- | -- |

Tab. 3.
Measurements of *Cimomia gosavica* (REDTENBACHER, 1873) from the Gosau Group. U % of D.

Occurrence: NHMW 2009z0045/0002 occurs within the Schattaugraben sequence. Its stratigraphic range within the *Paraplanum* Subzone of the late Santonian is without any doubt. This is also the case in NHMW 1990/0029/0514, NHMW 1990/0029/0520 and SK/1983/13 from the upper Santonian Sandkalkbank Member of the Hochmoos Formation of the Finstergrabenwandl (Gosau, Upper Austria). Redtenbacher's original from the nearby Neffgraben is of (possibly middle) Santonian age.

Ammonites

(HERBERT SUMMESBERGER & WILLIAM J. KENNEDY)

Subclass Ammonoidea ZITTEL, 1884

Introduction

As the "Sandkalkbank" Member of the Hochmoos Formation is included in the Schattaugraben section, we include a revision of the nearby and stratigraphically synchronous ammonite fauna of the Finstergrabenwandl (WIEDMANN, 1978; SUMMESBERGER, 1979, 1980, 1992) below.

Suborder Lytoceratina HYATT, 1889

Superfamily Tetragonitoidea HYATT, 1900

Family Gaudryceratidae SPATH, 1927

Genus and Subgenus *Gaudryceras* GROSSEVOIRE, 1894

Type species: *Ammonites mitis* HAUER, 1866 by subsequent designation of BOULE et al. (1906).

Gaudryceras mite (HAUER, 1866)

not figured

- 1866 *Ammonites mitis* HAUER: 6, Pl. 2, Figs. 3, 4.
- 1873 *Ammonites glaneggense* REDTENBACHER: 119, Pl. 27, Fig. 3.
- 1979 *Gaudryceras mite* (HAUER); SUMMESBERGER: 113, Pl. 1, Fig. 1.
- 1979 *Gaudryceras mite* (HAUER); KENNEDY & SUMMESBERGER: 74, Pl. 1, Figs. 1a-d, Pl. 2, Figs. 1a-c, 2a, b, Text-Fig. 1 [with synonymy].
- 1979 *Gaudryceras glaneggense* (REDTENBACHER); KENNEDY & SUMMESBERGER: 76, Pl. 3, Figs. 1a-b, Pl. 4, Figs. 1a-b [with synonymy].
- 1980 *Gaudryceras mite* (HAUER); SUMMESBERGER: 276, Pl. 1, Fig. 1, Text-Fig. 2.
- 1995 *Gaudryceras mite* (HAUER, 1866); KENNEDY et al.: 390, Pl. 1, Figs. 20, 21.
- 1996 *Gaudryceras mite* (HAUER, 1866); SUMMESBERGER & KENNEDY: 112, Pl. 1, Figs. 1-4 [with synonymy].
- 2000 *Gaudryceras mite* (HAUER, 1866); WIESE: 128, Pl. 1, Fig. 1 [with synonymy].

2017a *Gaudryceras mite* (HAUER, 1866); SUMMESBERGER et al.: 15.

Type: Holotype by monotypy: GBA 1866/0001000/3 in the collection of the Geological Survey of Austria, the original of HAUER (1866: Pl. 2, Figs. 3, 4) refigured by SUMMESBERGER & ZORN (2012: Pl. 5, Figs. 1a-d).

Material: SK/1979/4 from the locality Finstergrabenwandl (Gosau, Upper Austria).

Discussion: *Gaudryceras glaneggense* (REDTENBACHER, 1873) was put under synonymy of *Gaudryceras mite* (HAUER, 1866) by SUMMESBERGER & KENNEDY (1996).

Occurrence: *Gaudryceras mite* (HAUER, 1866) has a worldwide distribution and a range from Turonian to Maastrichtian. In Austria it occurs in the Turonian (Strobl/Weissenbach, Salzburg), in the Coniacian (Glanegg, Strobl/Weissenbach) and in the middle Santonian of Randobach (Rußbach, Salzburg) and in the late Santonian of the locality Finstergrabenwandl (Gosau, Upper Austria).

Genus *Anagaudryceras* SHIMIZU, 1934

Type species: *Ammonites sacya* FORBES (1846: 113, Pl. 14, Fig. 10) by the original designation of SHIMIZU (1934: 67).

Anagaudryceras redtenbacheri (IMMEL, KLINGER & WIEDMANN, 1982)

Pl. 8, Fig. 1, Tab. 4

- 1873 *Ammonites* sp. indet. cfr. *sacya* FORBES; REDTENBACHER: 125, Pl. 30, Figs. 4a, b.
- 1982 *Gaudryceras* sp.; IMMEL et al.: 10, Pl. 1, Fig. 6.
- 1982 *Patagiosites redtenbacheri* n. sp.; IMMEL et al.: 19, Pl. 5, Fig. 7, Pl. 6, Figs. 5-7, Pl. 7, Figs. 1a, b.
- 1987 *Patagiosites redtenbacheri* IMMEL, KLINGER & WIEDMANN 1982; IMMEL: 94.
- 2017a *Anagaudryceras redtenbacheri* (IMMEL, KLINGER & WIEDMANN, 1982); SUMMESBERGER et al.: 14.

Type: Holotype by original designation is the original of *Patagiosites redtenbacheri* IMMEL et al., 1982 (Pl. 7, Fig. 1; BSP 1982 I 9) from the lower Santonian Gosau Group of Mühlbach/Brandenberg (Tyrol, Austria).

Material: A single specimen SK/SG/2003/38 from the Schattaugraben section (Rußbach, Salzburg).

Description: SK/SG/2003/38 is a 57.6 mm long fragment of an internal mould of the body chamber with adherent yellowish to brownish shell. The preserved part is not much deformed. General shape is a polygyral coil with relatively slowly increasing whorl height and a shallow and wide umbilicus. The section is compressed oval with slightly inflated flanks and greatest breadth at midflank. The ventrolateral shoulder is gently curved, the venter is smooth, *post mortem* compaction has produced a spurious "keel", the umbilical shoulder is narrowly rounded, the umbilical wall is (sub)vertical. The surface of the shell is covered by

| Inventory No. | D _{est} (mm) | Wh (mm) | Wb (mm) | Wb/Wh | U (mm) | U (%) |
|---------------|-----------------------|---------|---------|-------|--------|-------|
| SK/SG/2003/38 | 58 | 19.7 | 12.3 | 0.62 | 25.9 | 4.6 |

Tab. 4.

Measurements in mm of *Anagaudryceras redtenbacheri* (IMMEL, KLINGER & WIEDMANN, 1982). U % of D.

fine and dense slightly falcoid lirae. Three strong collar ribs succeeded by a shallow constriction and a fourth weaker one are crowded on the adapertural portion (30 mm) of the body chamber.

Discussion: The species, new for the Hochmoos Formation, is undoubtedly identical with that from the early Santonian of Brandenberg described by IMMEL et al. (1982: 19, Pl. 5, Fig. 7, Pl. 6, Figs. 5–7, Pl. 7, Fig. 1). Polygyral coiling, relatively wide umbilicus and the crowding of collar ribs on the adapertural portion of the body chamber excludes an assignment to the genus *Patagiosites*. Crowding of collar ribs suggests an adult representative of the Gaudryceratidae. *Ammonites* sp. indet. cfr. *Ammonites sacya* FORBES from the Utatur Group of South India discussed by IMMEL et al. (1982: 19), has a different style of ornamentation on the apertural end of the body chamber (STOLICZKA, 1965: Pl. 75, Fig. 7), and its whorl height increases more rapidly. *Ammonites* sp. indet. cfr. *Ammonites sacya* FORBES (REDTENBACHER, 1873: 125, Pl. 30, Fig. 4) from the late Coniacian of Glanegg (Salzburg, Austria) seems to be identical with the present species rather than closer to the Cenomanian *Gaudryceras sacya* (FORBES, 1846) which is synonymous with *Anagaudryceras buddha* (FORBES, 1846; fide KENNEDY & KLINGER, 1979: 146). REDTENBACHER (1873: 125) in contrast to the interpretation of IMMEL et al. (1982: 19) excluded the identity of *Ammonites* sp. indet. cfr. *sacya* (FORBES, 1846) with *Ammonites patagiosus* SCHLÜTER. *G. denseplicatum* JIMBO, 1894 has a higher whorl section and a smaller umbilicus (KENNEDY et al., 1995: Pl. 4, Figs. 12, 13); *G. varicostatum* VAN HOEPEN, 1921, described at length by KENNEDY & KLINGER (1979: 133, Fig. 1, Pl. 3, Figs. 1–3, Pl. 4, Figs. 1a, b, Pl. 7, Figs. 2a–c, Pl. 14, Figs. 11a–c) has a coarser liration and more rapidly increasing whorl height on the body chamber. *Gaudryceras mite* (HAUER, 1866), co-occurring in the Gosau Group and originally described from the late Turonian of Strobl/Weissenbach (Salzburg, Austria) extends stratigraphically up to the late Santonian Sandkalkbank Member (SUMMESBERGER, 1979, 1980) of the Hochmoos Formation. Its adult stage is much larger (SUMMESBERGER & KENNEDY, 1996: Pl. 1, Fig. 4), the liration of subadult individuals is much coarser than that of the present one (e.g. the holotype; SUMMESBERGER & KENNEDY, 1996: Pl. 1, Fig. 1; SUMMESBERGER, 1979: Pl. 1, Fig. 1).

Occurrence: *Anagaudryceras redtenbacheri* (IMMEL, KLINGER & WIEDMANN, 1982) occurs in the Austrian Gosau Group at three localities of different age: Glanegg/late Coniacian, *Serratomarginatum* Zone; Brandenberg/early Santonian, *Undulatoplicatus* Zone; Schattaugraben section, Hochmoos Formation/late Santonian *Paraplanum* Subzone.

Family Tetragonitidae HYATT, 1900

Subfamily Tetragonitinae HYATT, 1900

Genus *Pseudophyllites* KOSSMAT, 1895

Type species: *Ammonites indra* FORBES, 1846 by original designation.

Pseudophyllites loryi (KILIAN & REBOUL, 1909)

not figured

- 1909 *Desmoceras (Latidorsella) Loryi* KILIAN & REBOUL: 18, Pl. 1, Figs. 4, 5.
 1926 *Tetragonites latus* MARSHALL: 149, Pl. 20, Figs. 6, 6a, Pl. 32, Figs. 1, 2.
 ? 1926 *Pseudophyllites whangaroensis* MARSHALL: 153, Pl. 20, Fig. 2, Pl. 21, Fig. 11, Pl. 32, Figs. 5, 6.
 1953 *Pseudophyllites peregrinus* SPATH: 4, Pl. 1, Figs. 6–9.
 1965 *Pseudophyllites skoui* BIRKELUND: 37, Pl. 3, Figs. 2–6, Text-Figs. 26–33.
 1977 *Pseudophyllites latus* (MARSHALL, 1926); KENNEDY & KLINGER: 190, Figs. 25, 26 [with synonymy].
 1982 *Pseudophyllites latus* (MARSHALL 1926); IMMEL et al.: 10, Pl. 2, Figs. 3, 4.
 1986 *Pseudophyllites loryi* (KILIAN & REBOUL, 1909); MACELLARI: 18, Figs. 11.1–11.10, 13.
 1987 *Pseudophyllites latus* (MARSHALL 1926); IMMEL: 67.
 1992 *Pseudophyllites latus* (MARSHALL 1926); SUMMESBERGER: 98, Pl. 1, Fig. 1, Text-Fig. 1.
 1993 *Pseudophyllites loryi* (KILIAN & REBOUL, 1909); WARD & KENNEDY: 22 [with additional synonymy].
 2000 *Pseudophyllites latus* (MARSHALL); SUMMESBERGER in EGGER et al.: 26.

Type: Lectotype subsequently designated by MACELLARI (1986: 16): the original of *Desmoceras (Latidorsella) Loryi* KILIAN & REBOUL, 1909 (Pl. 1, Figs. 4, 5).

Discussion: MACELLARI (1986: 18) pointed out that *Pseudophyllites latus* (MARSHALL, 1926) and *P. peregrinus* (SPATH, 1953) are junior synonyms of *P. loryi* (KILIAN & REBOUL, 1909). WARD & KENNEDY (1993: 54) also put *P. skoui* BIRKELUND, 1965 and *P. whangaroensis* MARSHALL, 1926 under synonymy of *P. loryi* (KILIAN & REBOUL, 1909). The latter one is attributed in the synonymy with a question mark, as it shows a distinct sculpture in the only figured fragment (MARSHALL, 1926: Pl. 32, Fig. 5).

Occurrence: *Pseudophyllites loryi* (KILIAN & REBOUL, 1909) has a worldwide distribution occurring in the southern hemisphere as well as in Greenland. From the Gosau Group of Austria, it was first described from the late Santonian Sandkalkbank Member of the Hochmoos Formation (SUM-

MESBERGER, 1992: 97, Pl. 1, Text-Fig. 1). Stratigraphically it ranges from Santonian to Maastrichtian (see WARD & KENNEDY (1993: 22).

Suborder Ammonitina HYATT, 1889

Superfamily Desmoceratoidea ZITTEL, 1895

Family Desmoceratidae ZITTEL, 1895

Puzosiinae SPATH, 1922

Genus and Subgenus *Parapuzosia* NOWAK, 1913

Type species: *Sonneratia daubreei* DE GROSSOUIRE (1894: 154, Pl. 28) by original designation.

***Parapuzosia (Parapuzosia) corbarica*
(DE GROSSOUIRE, 1894)**

Pl. 8, Fig. 4, Text-Fig. 14, Tab. 5

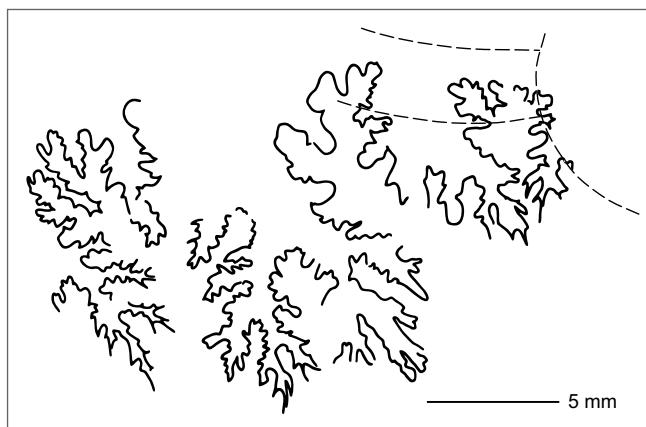
- 1894 *Puzosia corbarica* DE GROSSOUIRE: 174, Pl. 27, Fig. 1.
 1982 *Parapuzosia corbarica* (DE GROSSOUIRE 1894); IMMEL et al.: 12, Pl. 3, Fig. 3, Pl. 4, Fig. 1.
 1987 *Parapuzosia corbarica* (DE GROSSOUIRE 1894); IMMEL: 89.
 1995 *Parapuzosia (Parapuzosia) corbarica* (DE GROSSOUIRE, 1894); KENNEDY & KAPLAN: 27, Pl. 34.
 1995 *Parapuzosia (Parapuzosia) corbarica* (DE GROSSOUIRE, 1894); KENNEDY et al.: 391, Pl. 2, Fig. 9, Pl. 5, Figs. 1–3, Text-Figs. 12, 13 [with synonymy].
 2017a *Parapuzosia corbarica* (DE GROSSOUIRE, 1894); SUMMESBERGER et al.: 18.

Type: Holotype by original designation is the original of DE GROSSOUIRE (1894: 174, Pl. 27, Figs. 1a, b), refigured by KENNEDY & KAPLAN (1995: Pl. 34).

Material: A single juvenile specimen NHMW 1978/1955/0003 ex Schaefer collection from the Schattau section.

Description: NHMW 1978/1955/0003 is an internal mould of a juvenile individual of about 85 mm in diameter with adherent whitish shell remains. It is slightly elongated into an ellipse, measurements nevertheless still being meaningful.

The general outline is identical with that of the holotype: the section high oval with gently rounded flanks, a gently rounded ventrolateral shoulder and an abruptly rounded umbilical edge. The umbilical wall is vertical. The umbili-



Text-Fig. 14.
External suture of *Parapuzosia (Parapuzosia) corbarica* (DE GROSSOUIRE, 1894), NHMW/1978/1955/0003. Scale bar: 5 mm.

cus is rather deep and relatively narrow, the outer whorl covering more than two thirds of the preceding one. Wh expanding rapidly, Wb expanding slowly. The body chamber comprises about 200° of the last whorl. The terminal part of the phragmocone is marked by the well preserved last suture (Text-Fig. 14). There are about seven collar ribs per whorl arising from weak bullae at the umbilical edge in regular distances, each followed by a distinct constriction. The primaries are separated by approximately eleven prorsiradiate riblets, about 70 per whorl covering the external third of the flanks, all concave at the flank and strongly projected over the venter. The inner two thirds of the flanks are more or less smooth with the exception of the constrictions and collar ribs. The suture (Text-Fig. 14) is deeply incised with a large irregularly bifid E/L.

Discussion: The species was discussed at length by KENNEDY et al. (1995: 391–393). The Schattau specimen differs in some details from the Corbières specimen: The umbilicus is deeper and the number of intercalaries lower. The holotype from Sougraïnes aux Croutets has more primaries.

Occurrence: The Schattau specimen is from the late Santonian Zone of *Boehmoceras arculus*, *Placenticeras paraplanum* and *Marsupites testudinarius*. Its position within the measured section is unknown. The species also occurs in the early Santonian of the Gosau Group of Brandenberg/Mühlbach (Tyrol; IMMEL et al., 1982) and the middle Santonian of the Randograden (Rußbach, Salzburg; SUMMESBERGER et al., 2017a). In the Corbières (France; KENNEDY, 1995) it ranges from the late Coniacian *Serratomarginatus* Zone through the late Santonian *Paraplanum* Subzone.

| Inventory No. | D _{max/rest} (mm) | Wh _{max} (mm) | Wb _{max} (mm) | Wb/Wh | U _{max/rest} (mm) | U (%) |
|---------------------|----------------------------|--------------------------|--------------------------|-------|----------------------------|-------|
| NHMW 1978/1955/0003 | 90 | 39.5 | 23.3 | | 23 | 25 |
| | D _{-90°} | Wh _{-90°} (mm) | Wb _{-90°} (mm) | Wb/Wh | U _{-90°} (mm) | U (%) |
| NHMW 1978/1955/0003 | 61.7 | 26.3 | 20.2 | | 15.1 | 24.5 |
| | | Wh _{-270°} (mm) | Wb _{-270°} (mm) | | | |
| NHMW 1978/1955/0003 | | 18.8 | 12.4 | | -- | -- |

Tab. 5.
Parapuzosia (Parapuzosia) corbarica (DE GROSSOUIRE, 1894). rest = restored. U % of D.

? *Parapuzosia* (*Parapuzosia*) cf. *seppenradensis*
(**LANDOIS**, 1895)
not figured

Compare

- cf. 1895 *Pachydiscus seppenradensis* LANDOIS: 1–10, Pls. 1, 2.
- ? cf. 1979 *Parapuzosia* cf. *seppenradensis* (LANDOIS); SUMMESBERGER: 126, Pl. 4, Fig. 24, Pl. 5, Fig. 25, Text-Figs. 14, 15.
- cf. 1995 *Parapuzosia* (*Parapuzosia*) *seppenradensis* (LANDOIS, 1895); KENNEDY & KAPLAN: 21, Pls. 35–41, Text-Figs. 4–7 [with synonymy].
- 2016 *Parapuzosia* (*Parapuzosia*) *seppenradensis* (LANDOIS, 1895); KAPLAN: 49–61, 8 Figs.

Type: Lectotype designated by KENNEDY & KAPLAN (1995: 21): the larger of the specimens figured by LANDOIS (1895: Pl. 2) from the Early Campanian of Lüdinghausen-Seppenrade, Dülmen Schichten, Germany.

Discussion: There is no additional information on the large Austrian specimen since the description of SUMMESBERGER (1979). Additional discussion by KENNEDY & KAPLAN (1995: 21) leads finally to the same conclusion, that the Gosau specimen cannot be identified with certainty with *Parapuzosia* (*P.*) *seppenradensis* (LANDOIS, 1895). *Parapuzosia* (*Parapuzosia*) *daubréei* (DE GROSSOUIRE, 1894: Pl. 28) from the early Santonian of the Corbières differs in its smaller umbilicus and slightly curved very strong primary ribs and numerous intercalatories projecting forward over the venter. *Parapuzosia* (*Parapuzosia*) *corbarica* (DE GROSSOUIRE, 1894: Pl. 27), described above from the Schattaugraben section has even more intercalatories between somewhat weaker primaries followed by constrictions.

Occurrence: A single specimen of ? *Parapuzosia* (*Parapuzosia*) cf. *seppenradensis* (LANDOIS, 1895) was collected from the late Santonian Zone of *Boehmoceras arculus* and *Placenticeras paraplanum* of the Sandkalkbank Member of the Hochmoos Formation at the Upper Austrian side of the basin of Gosau.

Genus *Kitchinites* SPATH, 1922
(= *Neopuzosia* MATSUMOTO, 1954)

Type species: *Holcodiscus pondycherryanus* KOSSMAT (1897) by the original designation of SPATH (1922). Splitting into the subgenera *Kitchinites* SPATH (1922) and *Neopuzosia* (MATSUMOTO, 1954) was discussed by HENDERSON (1970: 33, 34) and SUMMESBERGER (1979: 133). We follow WRIGHT (1996: 78) who regarded *Neopuzosia* as junior synonym of *Kitchinites*.

Kitchinites stenomphalus SUMMESBERGER, 1979
not figured

- 1979 *Kitchinites stenomphalus* SUMMESBERGER: 131, Pl. 7, Figs. 28, 29, Text-Fig. 18.
- Non 1982 *Kitchinites stenomphalus* SUMMESBERGER, 1979; IMMEL et al.: 14, Pl. 2, Fig. 5. (= *Nowakites carezi* (DE GROSSOUIRE, 1894, juv.)).

Non 1987 *Kitchinites stenomphalus* SUMMESBERGER 1979; IMMEL: 90. (= *Nowakites carezi* (DE GROSSOUIRE, 1894, juv.)).

Type: Holotype by original designation: SK/1978/12, the original of *Kitchinites stenomphalus* SUMMESBERGER, 1979 (131, Pl. 7, Figs. 27–29, Text-Fig. 18).

Material: A single specimen: SK/1978/12 from the Finstergrabenwandl, figured and described by SUMMESBERGER (1979).

Discussion: The specimen from the lower Santonian Gosau Group of Brandenberg (Tyrol, Austria) figured and described by IMMEL et al. (1982: 14, Pl. 2, Fig. 5) and IMMEL (1987) differs from the holotype from the Finstergrabenwandl in its much lower whorl height. It is better assigned to juveniles of *Nowakites carezi* (DE GROSSOUIRE, 1894).

Occurrence: *K. stenomphalus* SUMMESBERGER (1979) occurs only in the upper Santonian of the Finstergrabenwandl in the Austrian Gosau Group.

Genus *Hauericeras* DE GROSSOUIRE, 1894

Type species: *Ammonites pseudogardeni* SCHLÜTER (1872) by the original designation of DE GROSSOUIRE (1894).

Subgenus *Gardeniceras* MATSUMOTO & OBATA, 1955

Type species: *Ammonites gardeni* BAILY (1855) by the original designation of MATSUMOTO & OBATA (1955).

Hauericeras (*Gardeniceras*) *welschi*
DE GROSSOUIRE, 1894

not figured, Tab. 6

- 1894 *Hauericeras Welschi* DE GROSSOUIRE: 222, Pl. 35, Fig. 9.
- 1925 *Hauericeras Welschi* GROSSOUIRE; DIENER: 96.
- 1939 *Hauericeras Welschi* DE GROSSOUIRE, 1894; BASSE: 46, Pl. 3, Fig. 9.
- 1979 *Hauericeras* (*Gardeniceras*) *gardeni* (BAILY); SUMMESBERGER: 133, Pl. 6, Fig. 27, Text-Fig. 19.
- 1995 *Hauericeras* (*Gardeniceras*) *welschi* DE GROSSOUIRE, 1894; KENNEDY: 396, Pl. 3, Fig. 12, Pl. 4, Figs. 3–5, Text-Fig. 14.
- 2000 *Hauericeras* (*G.*) *gardeni* (BAILY); SUMMESBERGER in EGGER et al.: 26.

Type: *Hauericeras welschi* DE GROSSOUIRE, 1894 (222, Pl. 35, Fig. 9) is based on two syntypes, which could not be traced by KENNEDY et al. (1995: 396).

Material: A single specimen (NHMW 1980/0064) from the Böhm collection (Salzburg) from the Finstergrabenwandl site (Gosau Group, Hochmoos Formation, "Sandkalkbank" Member; Gosau, Upper Austria).

| Inventory No. | D _{est} (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|----------------|--------------------------|------------|------------|-----------|----------|
| NHMW 1980/0064 | 69.6 | 27.8 | -- | 25.0 | 35.7 |

Tab. 6.

Measurements of *Hauericeras (Gardeniceras) welschi* DE GROSSOURE, 1894 (NHMW 1980/0064). U % of D.

Description: NHMW 1980/0064 is the internal mould of a phragmocone, possibly a subadult specimen, without adherent remnants of shell. The surface is of brown “rusty” colour. Coiling is evolute, the umbilicus comprising 35.7 % of the diameter, the subsequent chambers covering the earlier ones by one third. The whorl height increases regularly, the whorl breadth is not measurable. The flanks are gently rounded, the maximum width being close to the umbilicus. *Post mortem* the specimen is laterally compacted. The umbilical wall is low (1.6 mm), subvertical and gently convex. The umbilical edge is sharp. Towards the outer third the flanks are convex, converging to the fastigiate venter. The siphonal keel is visible where the adherent matrix is preserved. Five distinctly feeble sinuous biconcave constrictions per whorl are present on the internal mould. They arise at the umbilical edge with a shallow concavity, changing below midflanks into a distinct convexity and bending forward again into a distinct concavity ending at the keel. There is no sculpture visible on the mould. For the well preserved suture see SUMMESBERGER (1979: Fig. 19).

Discussion: The single specimen (SUMMESBERGER, 1979: 133, Pl. 6, Fig. 27, Text-Fig. 19) from the late Santonian Gosau Group of Finstergrabenwandl (Gosau, Upper Austria) was originally described as *Hauericeras (Gardeniceras) gardeni* (BAILY, 1855). It is described here as *Hauericeras (Gardeniceras) welschi* DE GROSSOURE, 1894, differing from *H. (G.) gardeni* (BAILY, 1855), see KENNEDY & KLINGER (2011: Figs. 1A–C, 2, 3A–D, 4A–F, 5A–H, 6, 7, 10M–O) in its more rapidly expanding whorl height and smaller umbilicus. The most distinctive difference is the shape of the constrictions: NHMW 1980/64 has five biconcave constrictions per volution whereas *H. (G.) gardeni* (BAILY, 1855) shows concave constrictions, projecting distinctly forward on the ventro-lateral shoulder. Biconcave constrictions are common in *Hauericeras pseudogardeni* (SCHLÜTER, 1872), e.g. KENNEDY & KAPLAN (1995: Pls. 1, 2, Pl. 3, Figs. 1, 2, Pl. 4, Pl. 5, Figs. 1, 2, 6, Pl. 6, Figs. 1, 7, Pl. 7, Figs. 1–4, Pl. 8) and MATSUMOTO in MATSUMOTO et al. (1990: Fig. 1).

Hauericeras gardeni (IMMEL et al., 1982: Pl. 5, Fig. 1–4, Pl. 6, Fig. 1; non BAILY, 1855) from the early Santonian Gosau Group of Brandenberg (Tyrol, Austria) differs in its concave constrictions (IMMEL et al., 1982: Pl. 5, Fig. 1), and has a wider umbilicus and slower expanding whorl height. This is also the case in a specimen from the early Santonian Gosau Group of Rußbach (Salzburg, Austria), which is conspecific in our opinion with the specimens from Tyrol. They are described under *Hauericeras (Gardeniceras) aff. gardeni* BAILY 1855 by SUMMESBERGER et al. (2017a).

Hauericeras (Gardeniceras) lagarum (REDTENBACHER, 1873), a close ally of *Hauericeras (Gardeniceras) gardeni* (BAILY, 1855) and *Hauericeras angustum* (YABE, 1904) from India and Japan but both have a wider umbilicus. In *H. angustum* it is 37–44 % after MATSUMOTO in MATSUMOTO et al. (1990: 445).

In *Hauericeras (Gardeniceras) pseudoangustum* COLLIGNON, 1961 the umbilicus is somewhat wider, the height of the whorls increasing more slowly than in *H. (G.) welschi* (DE GROSSOURE, 1894) and its constrictions (fide KENNEDY & KLINGER, 2011: 53) are concave.

Hauericeras (Gardeniceras) madagascariense COLLIGNON, 1961 differs in its larger size, larger umbilicus, lower whorl height and concave constrictions (KENNEDY & KLINGER, 2011: Fig. 8).

Hauericeras schlüteri (REDTENBACHER, 1873: 114, Pl. 26, Fig. 2) from the middle Coniacian of the Schmolnauer Alpe (Strobl/Weissenbach, Salzburg, Austria) has a distinctly narrower umbilicus.

Hauericeras (Hauericeras) pseudogardeni (SCHLÜTER, 1872) differs in its much smaller umbilicus (e.g. KENNEDY & KAPLAN, 1995: Pls. 1–4, Pl. 5, Figs. 1, 2, 6, Pl. 6, Figs. 1, 7, Pls. 7, 8.) and in case of adult individuals much larger size.

The lectotype of *Hauericeras rembda* (FORBES, 1846) from the Maastrichtian of India is a small individual with relatively narrow umbilicus (KENNEDY & HENDERSON, 1992: Pl. 6, Figs. 10–12; KENNEDY & KLINGER, 2011: Figs. 10G, H). The paralectotype (KENNEDY & HENDERSON, 1992: Pl. 6, Fig. 16; KENNEDY & KLINGER, 2011: Fig. 10A) shows a fragmentary constriction which seems to be concave.

Hauericeras fayoli DE GROSSOURE, 1894 from the late Campanian/Maastrichtian of Tercis (France; teste KENNEDY & SUMMERSBERGER, 1984: 157, Pl. 1, Figs. 8, 12, Pl. 2, Figs. 13–15) differs by its flexuous constrictions, greater whorl breadth and smaller whorl height. The Maastrichtian *Hauericeras sulcatum* (KNER, 1849) is more involute, with 6–7 rather concave constrictions per whorl.

Occurrence: *Hauericeras (Gardeniceras) welschi* DE GROSSOURE, 1894 was described originally from the Santonian of the chemin de Sougraïnes in the Corbières, southern France, which corresponds after KENNEDY et al. (1995: 384) with the late Santonian *Paraplanum* Subzone. The same age is given for the individual from the Austrian Gosau Group.

Hauericeras (Gardeniceras) lagarum (REDTENBACHER, 1873)

Pl. 8, Figs. 2, 3, Pl. 9, Fig. 7, Text-Fig. 15, Tab. 7

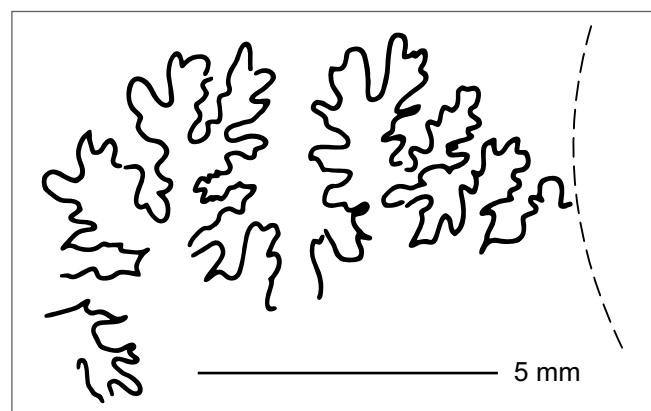
- 1873 *Ammonites lagarus* REDTENBACHER: 112, Pl. 25, Figs. 3a, b.
- 1901 *Hauericeras lagarum*; DE GROSSOURE: 638.
- 1925 *Hauericeras lagarum* (REDTENBACHER, 1873); DIENER: 95.
- 1935 *Hauericeras lagarum* REDT.; BRINKMANN: 3.
- 1961 *Hauericeras lagarum* REDTENBACHER; COLLIGNON: 95.
- 1985 *Hauericeras lagarum* (REDTENBACHER); SUMMERSBERGER: 152.
- 1995 *Hauericeras (Gardeniceras) lagarum* (REDTENBACHER, 1873); KENNEDY et al.: 397, Pl. 4, Fig. 17 [with synonymy].
- 2012 *Hauericeras (Gardeniceras) lagarum* (REDTENBACHER, 1873); SUMMERSBERGER & ZORN: 106, Pl. 13, Fig. 2.
- 2017a *Hauericeras (Gardeniceras) lagarum* (REDTENBACHER, 1873); SUMMERSBERGER et al.: 21, Text-Fig. 5.

Types: *Ammonites lagarus* REDTENBACHER, 1873 (112, Pl. 25, Figs. 3a, b) from the Austrian Coniacian is based upon two syntypes combined by REDTENBACHER in his original figure (1873: Pl. 25, Fig. 3), one of them is lost (KENNEDY et al., 1995: 397). The surviving one, HNS 6391 (Pl. 9, Figs. 7a, b) from the late Coniacian Gosau Group of Glanegg (Salzburg) is here designated lectotype. The second and lost syntype was a gypsum cast of an external mould from the middle Coniacian Gosau Group of the Schmolnauer Alpe (Strobl/Weissenbach, Salzburg; SUMMERSBERGER, 1985: 150) and after REDTENBACHER (1873: 113: "..., so dass sich beide Stücke aufs schönste ergänzen." [fitting in excellently to the first specimen]). The gypsum cast is lost but the external mould used for its production has been located in the collection of the Geological Survey of Austria in Vienna (SUMMERSBERGER & ZORN, 2012: 106) and is a paralectotype.

Material: Two specimens from the late Santonian *Paraplanum* Subzone of the Hochmoos Formation of the Schattaugraben section (Rußbach, Salzburg): NHMW 1978/1955/0001 ex Schuberger collection without locality details and SK/SG/1984/3 from the *Micraster* Bed. The preservation of NHMW 1978/1955/0001 suggests that it might be from the same level. A juvenile specimen, NHMW 2006z0203/0001, from the *Micraster* Bed is referred with some doubt to the same species. HNS 6391 the original of REDTENBACHER (1873: 112, Pl. 25, Figs. 3a, b.) from the late Coniacian Glanegg Marls (Gosau Group) of Glanegg (Salzburg).

Description: The whorl section, somewhat deformed by compaction, appears to have been strongly compressed with flattened inner flanks, convergent outer flanks and a sharp and entire siphonal keel. The umbilical wall is low and distinctly convex, the umbilical edge is gently rounded. Both specimens from the Schattaugraben section are flattened and elongated by *post mortem* deformation; both are internal moulds with preserved yellowish shell. Coiling is evolute, with a very small overlap over the preceding volution, a slowly expanding whorl height and a wide and shallow umbilicus. The phragmocones are badly crushed. Both Schattaugraben individuals are of equal size, the better preserved one SK/SG/1984/3 measures D: 59 mm, Wh: 11.8 mm and Wb: 7.2 mm. Wh is relatively low. The flanks are smooth except for approximately 4–5 slightly flexuous constrictions per whorl (Pl. 8, Figs. 2a–c) which are only visible on the internal mould and strongly projected forwards at the ventrolateral shoulder. The suture is partially visible in NHMW 1978/1955/0001 (Text-Fig. 15).

HNS 6391 preserved in hard brownish sandstone fits well with the Schattau specimens differing only in its more rapidly increasing whorl height.



Text-Fig. 15.
External suture (fragment) of *Hauericeras (G.) lagarum* (REDTENBACHER, 1873); NHMW/1978/1955/0001 from the Schattaugraben section. Scale bar: 5 mm.

Discussion: *Hauericeras (Gardeniceras) lagarum* (REDTENBACHER, 1873) is a close ally of *Hauericeras (Gardeniceras) aff. gardeni* (BAILY, 1855) differing in the minor overlapping of the preceding whorl. *Hauericeras (Gardeniceras) welschi* (GROSSOURE, 1894) from the French and Austrian Santonian and its ally *H. angustum* (YABE, 1904) from India and Japan differ in their greater whorl height and sharp umbilical edge. *Hauericeras schlueteri* (REDTENBACHER, 1873: 114, Pl. 26, Fig. 2) from the middle Coniacian of the Schmolnauer Alpe (Strobl/Weissenbach, Salzburg, Austria) is based on a juvenile with a distinctly narrower umbilicus.

Occurrence: *Hauericeras (Gardeniceras) lagarum* (REDTENBACHER, 1873) occurs in the middle Coniacian of the Corbières (France; KENNEDY et al., 1995) and Austria (the paralectotype), in the late Coniacian (Glanegg; the lectotype) and in the late Santonian *Paraplanum* Subzone of the Hochmoos Formation (Schattaugraben section; this paper).

Subfamily Desmoceratinae ZITTEL, 1895

Genus *Damesites* MATSUMOTO, 1942

Type species: *Desmoceras damesi* JIMBO (1894) by original designation.

Damesites sugata (FORBES, 1846)

not figured

- | | |
|------|---|
| 1846 | <i>Ammonites Sugata</i> FORBES: 113, Pl. 10, Figs. 2a–c. |
| 1864 | <i>Ammonites Sugata</i> FORBES; STOLICZKA: 60, Pl. 32, Figs. 4–6, Pl. 33, Figs. 1, 2. |
| 1921 | <i>Desmoceras compactum</i> VAN HOEPEN: 21, Pl. 4, Figs. 5–7, Text-Fig. 11. |

| Inventory No. | D _{est} (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|---------------------|-----------------------|-------------|---------|--------|-------|
| SK/SG/1984/3 | 47.3 | 15.6 (32 %) | 7.4 | 21 | 44.4 |
| NHMW 1978/1955/0001 | 47 | 17.9 (38 %) | 8.3 | 22.6 | 48.1 |
| HNS 6391 | 67 | 23 (34 %) | -- | 27 | 40.2 |

Tab. 7.

Measurements of representatives of *Hauericeras (Gardeniceras) lagarum* (REDTENBACHER, 1873): 1 and 2 from the Schattaugraben section (this paper); 3 from Glanegg (Late Coniacian). U % of D.

- 1961 *Damesites compactus* (VAN HOEPEN, 1921); COLLIGNON: 70, Pl. 26, Figs. 4a, b, Text-Fig. 8.
- 1980 *Damesites compactus* (VAN HOEPEN); SUMMESBERGER: 278, Pl. 1, Figs. 3–4, Text-Fig. 4.
- 1982 *Damesites cf. compactus* (VAN HOEPEN, 1921); IMMEL et al.: 14, Pl. 2, Fig. 6.
- 1982 *Damesites* sp.; IMMEL et al.: 15, Pl. 2, Fig. 7.
- 1987 *Damesites compactus* (VAN HOEPEN 1921); IMMEL: 90, Pl. 8, Fig. 5.
- 2013 *Damesites sugata* (FORBES, 1846); KENNEDY & KLINGER: 44, Text-Figs. 7A–J.
- 2017a *Damesites sugata* (FORBES, 1846); SUMMESBERGER et al.: 22, Pl. 8, Figs. 1, 2, 4, 5, Text-Fig. 6 (with complete synonymy).

Types: The lectotype is BMNH C22647, the original of FORBES (1846: Pl. 10, Figs. 2a–c). It was figured by KENNEDY & HENDERSON (1991: Text-Figs. 1A, B) and KENNEDY & KLINGER (2013: Text-Figs. 7D, E). There are three paralectotypes, BMNH C22675, of which BMNH C3561a is a further fragment, and BMNH 24196a, b, while BMNH C3561b may be a further paralectotype. The type material is from South India.

Material: SK/1979/7, a single specimen from the Sandkalkbank Member of the Finstergrabenwandl locality (Hochmoos Formation, Gosau Group), described by SUMMESBERGER (1980: 278, Pl. 1, Figs. 3, 4, Text-Fig. 4) and SK/NE/1991/15.

Description and discussion: The specimen from the Sandkalkbank Member was described by SUMMESBERGER (1980) under *Damesites compactus* (VAN HOEPEN, 1921) as a juvenile. In 2013 KENNEDY & KLINGER put *Damesites compactus* under synonymy of *Damesites sugata* (FORBES, 1846). We follow this opinion.

Occurrence: *Damesites sugata* (FORBES, 1846) ranges from the late Coniacian through the Santonian of the Corbières and in the Circumpacific Realm (KENNEDY et al., 1995). It occurs in the Coniacian to Santonian of India, Madagascar and South Africa, in Japan and Saghalin it occurs „approximately“ (MATSUMOTO & OBATAN, 1955: 133, Pl. 26, Figs. 4a, b, 5a, b, Pl. 27, Figs. 3a, b, 4a–d) in the Santonian. SK/1979/7 is from the late Santonian Sandkalkbank Member (Hochmoos Formation; Finstergrabenwandl; Gosau, Upper Austria); SK/NE/1991/15 from the middle Santonian Hochmoos Formation of the Neffgraben.

Damesites cf. sugata (FORBES, 1846)

Pl. 8, Fig. 6

Compare

- 1846 *Ammonites Sugata* FORBES: 113, Pl. 10, Figs. 2a–c.
- 1864 *Ammonites Sugata* FORBES; STOLICZKA: 60, Pl. 32, Figs. 4–6, Pl. 33, Figs. 1, 2.
- 1921 *Desmoceras compactus* VAN HOEPEN: 21, Pl. 4, Figs. 5–7, Text-Fig. 12.
- 1961 *Damesites compactus* VAN HOEPEN; COLLIGNON: 70, Pl. 26, Figs. 4a, b, Text-Fig. 8.
- 1980 *Damesites compactus* (VAN HOEPEN); SUMMESBERGER: 278, Pl. 1, Figs. 3, 4, Text-Fig. 4.

- 1982 *Damesites* cf. *compactus* (VAN HOEPEN 1921); IMMEL et al.: 14, Pl. 2, Figs. 6a, b.
- 1982 *Damesites* sp.; IMMEL et al.: 14, Pl. 2, Fig. 7.
- ? 1982 *Damesites obscurus* (SCHLÜTER, 1872); IMMEL et al.: 15.
- 1987 *Damesites compactus* (VAN HOEPEN 1921); IMMEL: 90, Pl. 8, Fig. 5.

Material: A single specimen SK/SG/1992/15 from the Schattaugraben section.

Description: The specimen before us is a small (D 21 mm), crushed internal mould with much of the partly nacreous shell adherent. The feeble but distinct keel is well preserved.

Discussion: The above specimen from the Hochmoos Formation is not well enough preserved to separate it clearly from other taxa.

Occurrence: Late Santonian Gosau Group of the Schattaugraben section.

Family Pachydiscidae SPATH, 1922

Genus *Nowakites* SPATH, 1922

Nowakites draschei (REDTENBACHER, 1873)

Pl. 8, Fig. 8

- 1873 *Ammonites Draschei* nov. sp.; REDTENBACHER: 123, Pl. 30, Fig. 1.
- 1979 *Nowakites draschei* (REDTENBACHER); SUMMESBERGER: 138, Pl. 8, Figs. 33–36, Text-Figs. 23–25 (with synonymy).
- 1995 *N. draschei* (REDTENBACHER, 1873); KENNEDY in KENNEDY et al.: 400.

Type: Holotype by monotypy and refigured here (Pl. 8, Figs. 8a, b), *Ammonites Draschei* REDTENBACHER, 1873 (Pl. 30, Fig. 1; OÖLM 1938/30).

Material: Four individuals: OÖLM 1938/30, the holotype from the Santonian of the Neffgraben at Rußbach (Salzburg side of the Gosau basin), NHMW 2013/0467/0001 and SK/1977/8, 11.

Discussion: *N. draschei* (REDTENBACHER, 1873) from the Santonian of the nearby Neffgraben (Rußbach, Salzburg, Gosau Group) is very close to or even conspecific with *N. talavignesi* (d'ORBIGNY, 1850); see KENNEDY et al. (1995: 401, Pl. 6, Figs. 15–19, Pl. 8, Figs. 1–5, 8–12). The species was discussed by SUMMESBERGER (1979: 138) and KENNEDY et al. (1995: 400).

Occurrence: In the Austrian Gosau Group *Nowakites draschei* was erroneously interpreted to be of Coniacian age by previous authors (FELIX, 1908; DIENER, 1925; BRINKMANN, 1935). Its true Santonian age was pointed out by COLLIGNON (1955).

***Nowakites savini* (DE GROSSOUIRE, 1894)**

Pl. 8, Fig. 9, Tab. 8

- 1894 *Sonneratia savini* DE GROSSOUIRE: 152, Pl. 25, Fig. 4 [only].
- Non 1894 *Sonneratia savini* DE GROSSOUIRE: 152, Pl. 37, Fig. 4 (= microconch of *N. talavignesii* (D'ORBIGNY, 1850) fide KENNEDY et al., 1995: 401).
- 1922 *Nowakites savini* GROSSOUIRE; SPATH: 124.
- 1983 *Nowakites savini* (DE GROSSOUIRE); COLLIGNON in BILOTTE & COLLIGNON: 186, Pl. 2, Fig. 6.
- 1995 *Nowakites savini* (DE GROSSOUIRE, 1894); KENNEDY et al.: 402, Pl. 8, Figs. 16–23, Pl. 9, Figs. 1, 6, 7, Pl. 19, Fig. 7, Pl. 22, Figs. 1, 2, 4, Text-Fig. 20C [with synonymy].
- ? 2004 *Nowakites savini*; REMIN: 590, Fig. 4 (Tab.).
- 2017a *Nowakites savini* (DE GROSSOUIRE, 1894); SUMMESBERGER et al.: 25, Pl. 9. Figs. 1, 2, Pl., 10, Fig. 1.

Type: The holotype by original designation is the original of DE GROSSOUIRE (1894: Pl. 25, Fig. 4). It could not be traced by KENNEDY et al. (1995: 402) and seems to be lost.

Material: Three specimens: NHMW 2010/0081/0001 from the *Micraster* Bed of the late Santonian Bibereck Formation of the Schattaugraben section, MA 1982/19 also from the Schattaugraben section, NHMW 2010/0082/0001 from the early Santonian Grabenbach Formation of the Edlbachgraben of Gosau (Upper Austria) and SK/RA/2014/164 from the early Santonian of the Randobach (Rußbach, Salzburg).

Description: NHMW 2010/0081/0001 (Pl. 8, Fig. 9) is a crushed and corroded fragment of the body chamber of a relatively large individual partially preserved with whitish shell. Umbilical dimensions cannot be measured due to preservation. NHMW 2010/0082/0001 from the early Santonian Grabenbach Formation is the best preserved specimen and apparently conspecific with the above mentioned one. *Nowakites savini* (DE GROSSOUIRE, 1894) is a medium sized species with involute coiling. The umbilicus is moderately deep, the umbilical wall slightly convex. The whorl section is high oval. The distinctive feature is the very coarse sculpture: about nine umbilical tubercles give rise to coarse and sharp single, slightly prorsiradiate and concave ribs or pairs of ribs, two or three intercalatories are situated between, all coarsening towards the aperture, about 40 on the last whorl. Ribs are projecting forwards on the ventrolateral shoulder. Few indistinct constrictions per whorl are accompanied by strong "collar" ribs.

Discussion: The specimens NHMW 2010/0081/0001 and NHMW 2010/0082/0001 are very close to GROSSOUIRE's type specimen of *N. savini* (DE GROSSOUIRE, 1894: Pl. 25, Fig. 4) from Sougraiges aux Croutets (Aude, France) which is now apparently lost (KENNEDY, 1995: 402). We have not seen the unfigured specimen quoted by REMIN (2004) from Poland. *Nowakites carezi* (DE GROSSOUIRE, 1894) differs in its finer ribbing in juvenile stages, with distinct coarsening during late ontogeny. *Nowakites tallavignesi* (D'ORBIGNY, 1850) from the Coniacian (?) of the Corbières (KENNEDY, 1995: Pl. 8, Figs. 1–5, 8–12) and from Romania and Armenia differs in its lower whorl height and less prominent ribbing, with about 20 ribs per half whorl. *Nowakites pailletteanus* (D'ORBIGNY, 1841) from the *Tridorsatum* and *Margae* Zones of the French Coniacian is more delicately ribbed with narrower ribs and wider rib interspaces.

Occurrence: *Nowakites savini* (DE GROSSOUIRE, 1894) is a long ranging species. In the Corbières it occurs in the early and middle Santonian, in Bulgaria in the Coniacian. In the Gosau Group it occurs together with *Cladoceramus undulatoplicatus* (ROEMER) from basal Santonian to the top Santonian *Micraster* Bed within the Zone of *Boehmoceras arculus*, *Placenticeras paraplanum* and *Marsupites laevigatus* several meters above the Sandkalkbank Member with the main occurrence of *Cordiceramus muelleri muelleri* (PETRASCHECK, 1906).

Genus *Eupachydiscus* SPATH, 1922

Type species: *Ammonites isculensis* REDTENBACHER, 1873 (122, Pl. 29, Fig. 1) by the original designation of SPATH (1922).

***Eupachydiscus isculensis* (REDTENBACHER, 1873)**

Pl. 8, Fig. 7

- 1873 *Ammonites isculensis* REDTENBACHER, 1873 (122, Pl. 29, Fig. 1).
- 1979 *Eupachydiscus isculensis* (REDTENBACHER, 1873); HERM et al.: 49, Pl. 8, Fig. A.
- 1979 *Eupachydiscus isculensis* (REDTENBACHER, 1873); SUMMESBERGER: 136, Pl. 7, Figs. 30, 31, Pl. 8, Fig. 32, Text-Figs. 20–22.
- 1982 *Eupachydiscus isculensis* (REDTENBACHER, 1873); IMMEL et al.: 22, Pl. 7, Figs. 8–11, Pl. 8, Figs. 1–4.
- 1982 *Pseudomenuites katschthaleri* IMMEL, KLINGER & WIEDMANN: 20, Pl. 7, Figs. 2–5.
- 1986 *Eupachydiscus isculensis* (REDTENBACHER, 1873); KENNEDY: 52, Pl. 2, Figs. 5, 6, Pl. 10, Figs. 13, 14, Text-Fig. 19 [with synonymy].

| Inventory No. | D (mm) | Wh _{maxrest} (mm) | Wb _{maxrest} (mm) | | |
|---------------------|-----------------------|----------------------------|----------------------------|--------|-------|
| NHMW 2010/0081/0001 | 108 | 48.3 | 31.8 | | |
| Inventory No. | D _{est} (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
| NHMW 2010/0082/0001 | 99.3 | 51.6 | 31.3 | 21.9 | 22 |

Tab. 8.

Measurements of *Nowakites savini* (DE GROSSOUIRE, 1894) from the Santonian of the Gosau Group. U % of D.

- 1987 *Eupachydiscus isculensis* (REDTENBACHER, 1873); IMMEL: 94.
- 1987 *Pseudomenites katschthaleri* IMMEL et al.; IMMEL: 96.
- ? 1992 *Eupachydiscus cf. isculensis* (REDTENBACHER, 1873); KENNEDY et al.: 270, Pl. 1, Figs. 9, 10.
- 1995 *Eupachydiscus isculensis* (REDTENBACHER, 1873); KENNEDY: 404, Pl. 9, Figs. 9, 10, Pl. 10, Fig. 12, Pl. 11, Figs. 1–3, 5–8, Text-Figs. 18, 19 [with additional synonymy].
- 2000 *Eupachydiscus isculensis* (REDTENBACHER, 1873); SUMMERSBERGER in EGGER et al.: 26, Fig. 17.
- 2000 *Eupachydiscus isculensis* (REDTENBACHER, 1873); KENNEDY & KAPLAN: 60, Pls. 5–7.
- 2006 *Eupachydiscus isculensis* (REDTENBACHER, 1873); KENNEDY & KLINGER: 34, Figs. 15, 16 [with additional synonymy].
- 2010 *Eupachydiscus isculensis* (REDTENBACHER, 1873); REMIN: 175, Figs. 14F, 17I.
- 2017a *Eupachydiscus isculensis* (REDTENBACHER, 1873); SUMMERSBERGER et al.: 27, Pl. 9, Figs. 6–8, Pl. 10, Fig. 3.

Type: The holotype by monotypy is the original of *Ammonites isculensis* REDTENBACHER (1873: Pl. 29, Fig. 1) from the Gosau Group of Kohlbüchl near Bad Ischl (Upper Austria), refigured by KENNEDY (1986: Text-Fig. 19), KENNEDY (1995: 404, Text-Fig. 18) and KENNEDY & KAPLAN (2000: Pl. 6), ÖÖLM 2/2007 in the collection of the Oberösterreichisches Landesmuseum, Linz, Austria.

Material: A complete and well preserved juvenile NHMW 1935/0003/0037 and two small fragments of juveniles from the Schattaugraben section SK/SG/1990/4, SK/SG/1990/6 in addition to the specimens from the Sandkalkbank Member described by SUMMERSBERGER (1979).

Description: In spite of their preservation both specimens show the specific characteristics of *E. isculensis*. Additional descriptions of the species are provided by KENNEDY (1986), KENNEDY (1995) and KENNEDY & KLINGER (2006).

Discussion: KENNEDY (1986: 54) believed *Pseudomenites katschthaleri* IMMEL et al. (1982) from the early Santonian of Mühlbach (Brandenberg, Tyrol) to be the microconch of *Eupachydiscus isculensis* (REDTENBACHER, 1873). This was recently endorsed by KENNEDY & KLINGER (2006: 34).

Occurrence: *E. isculensis* is common at all Santonian localities of the Gosau Group. It occurs together with *Cladoceramus undulatoplicatus* in the early Santonian of Mühlbach (Brandenberg, Austria; IMMEL et al., 1982), in the late Santonian Sandkalkbank Member together with *Boehmoceras arculus* and *Placenticeras paraplanum*. REDTENBACHER's type specimen (1873: 29) from the Gosau Group of Bad Ischl (Austria) is not precisely horizoned. *E. isculensis* occurs in the Corbières, in Romania and Zululand. In Madagascar it ranges from Santonian to early Campanian. Its occurrence in the Coniacian mentioned by HERM et al. (1979: 49) needs revision (see IMMEL, 1987: 94).

Genus *Pachydiscus* ZITTEL, 1884

Type species: *Ammonites neubergicus* HAUER (1858) subsequently designated by DE GROSSOUIRE, 1894.

Pachydiscus sp. indet. juv.

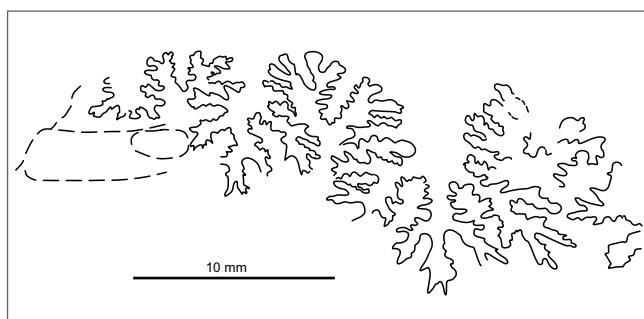
Pl. 8, Fig. 5, Text-Fig. 16, Tab. 9

Material: A single small specimen from the Schattaugraben section: NHMW 2010/0081/0002.

Description: The specimen is a laterally slightly crushed and elliptically elongated internal mould without adherent shell. The surface is covered by excellently preserved sutures, enhanced by brownish colouring of the saddles and lobes possibly due to iron oxide. The sculpture consists of about eleven single primary ribs on the last whorl, arising at the umbilical edge with a distinct bulla and a few irregularly intercalated ones arising near the umbilical edge or midflanks without a bulla. All ribs weaken towards the ventrolateral edge, and are effaced on the venter.

Discussion: Juvenile individuals of *Eupachydiscus isculensis* of comparable size differ in general in their greater Wb, and denser ribs that cross the venter in a distinct convexity. Juvenile pachydiscids from the Corbières, figured by KENNEDY (1995: Pl. 10, Figs. 1–6, 9–11) differ in having smooth shells with occasional constrictions. *Pseudomenites katschthaleri* (IMMEL et al., 1982: 20, Pl. 7, Figs. 2–5) interpreted as the microconch of *E. isculensis* (fide KENNEDY, 1995) differs in having looped ribs and ventrolateral tubercles (IMMEL et al., 1982: Pl. 7, Figs. 2–5). Similar but also differing in having ventrolateral tubercles is the juvenile *E. isculensis* from the Mzamba Formation of Pondoland, South Africa figured by KENNEDY & KLINGER (2006: Fig. 15).

Occurrence: Upper Santonian *Micraster* Bed of the Bibereck Formation of the Schattaugraben section.



Text-Fig. 16.
External suture of *Pachydiscus* sp. indet. juv.; NHMW 2010/0081/0002 from the *Micraster* Bed, Schattaugraben, Rußbach, Salzburg.

| Inventory No. | D _{rest} (mm) | W _h _{max} (mm) | W _b _{max} (mm) | U (mm) | U (%) |
|---------------------|------------------------|------------------------------------|------------------------------------|--------|-------|
| NHMW 2010/0081/0002 | 22 | 10 | 8.1 | 4 | 18 |

Tab. 9.
Measurements of *Pachydiscus* sp. indet. juv.; NHMW 2010/0081/0002 from the *Micraster* Bed, Schattaugraben section, Salzburg. Rest = restored, max = maximum. U % of D.

Family Muniericeratidae WRIGHT, 1952

Genus *Texasia* J.B. REESIDE JR., 1932

(= *Lehmaniceras* COLLIGNON, 1966)

Type species: *Ammonites dentato-carinatus* F. ROEMER (1852) by subsequent designation of WRIGHT (1957: 432).

***Texasia dentatocarinata* (F. ROEMER, 1852)**

Pl. 9, Fig. 1, Tab. 10

- 1849 *Ammonites dentato-carinatus* F. ROEMER: 417 [nom. nud.].
- 1852 *Ammonites dentato-carinatus* F. ROEMER: 33, Pl. 1, Figs. 2a, b.
- 1904 *Schloenbachia dentato-carinata* F. ROEMER, 1852; LASSWITZ: 29.
- 1928 *Barroisiceras dentatocarinatum* (ROEMER); ADKINS: 252.
- 1932 *Barroisiceras dentatocarinatum* (ROEMER); ADKINS: 453.
- 1932 *Barroisiceras (Texasia) dentatocarinatum* (ROEMER) LASSWITZ; REESIDE: 15, Pl. 3, Figs. 1–10, Pl. 4, Figs. 1–3, Pl. 5, Fig. 1.
- 1963 *Texasia dentatocarinata* (ROEMER, 1852); YOUNG: 119, Pl. 72, Figs. 1–3, 6, 7, Pl. 73, Figs. 1–3, 5, 6, 10, Text-Figs. 10h, p, q, 11b.
- 1969 *Texasia dentatocarinata* (RÖMER); MATSUMOTO: 300–301, Text-Figs. 1, 2.
- ? 1982 *Barroisiceras (Texasia) dentatocarinatum* (ROEMER); RENZ: 113, Pl. 38, Fig. 3.
- 1996 *Texasia dentatocarinata* (ROEMER); WRIGHT: 107, Text-Figs. 82a–c.
- 2004 *Texasia dentatocarinata* (ROEMER, 1852); KENNEDY et al.: 437, Pl. 2, Figs. 1–2, 6–7.
- 2008 *Texasia dentatocarinata* (RÖMER); COBBAN et al.: 85.
- 2010 *Texasia dentatocarinata* (F. ROEMER, 1852); WAGREICH et al.: 186.
- 2013 *Texasia dentatocarinata* (ROEMER, 1852); KENNEDY & KLINGER: 39, Fig. 4.

Type: The lectotype is the original of F. ROEMER (1852: Pl. 1, Figs. 2a, b), by the subsequent designation of MATSUMOTO (1969: 300), housed in the Geological Institute of the University of Bonn (Inv. Nr. 48a).

Material: NHMW 1998z0013/0001, a single specimen from above the *Micraster* Bed in the Bibereck Formation of the Schattaugraben section, Rußbach, Salzburg.

Description: The crushed fragment of an internal mould is preserved with adherent chalky shell. Most of the specimen is the adapertural part of the body chamber. The phragmocone is damaged. The suture is not visible. The

specimen is high whorled, slender, with flat flanks, the whorls rapidly increasing in height. The umbilicus is rather narrow and deep, the umbilical wall is vertical. The venter seems to have been fastigiate. Coarse umbilical tubercles are widely spaced. With increasing diameter, they elongate into a strong bulla, giving rise to single, sometimes bifurcating straight and prorsiradiate primary ribs, with terminal ventrolateral clavi. Nine umbilical tubercles on the last whorl correspond to about 14 or 15 ventrolateral clavi. The style of ribbing is somewhat irregular. Some of the ribs fade out on the flanks, leaving large smooth intervals between the ribs. The most striking feature is the siphonal keel bearing strong clavi.

Discussion: General shape and ornament agree well with those of the figured specimens from Texas (e.g. ROEMER, 1852: Pl. 1, Fig. 2; REESIDE, 1932: Pl. 3, Fig. 6; YOUNG, 1963: Pl. 72, Figs. 3, 6, 7, Pl. 73, Fig. 1; KENNEDY et al., 2004: Pl. 2, Figs. 1–3, 6–7; KENNEDY & KLINGER, 2013: Fig. 4). The widely variable *Texasia cricki* (SPATH, 1921) is similar in some of its synonyms, e.g. *Lehmaniceras sornayi* (COLLIGNON, 1966) (see the refigured holotype in the revision of KENNEDY & KLINGER, 2013: Fig. 2A), has about eight umbilical bullae becoming coarse and rounded tubercles during ontogeny. The ribs are broader than those of *T. dentatocarinata*. *Texasia riviereae* (COLLIGNON, 1983), following KENNEDY & KLINGER (2013: 34) also synonymous with *Texasia cricki* (SPATH) from the early Santonian of southern France differs in its slightly flexuous ribs (KENNEDY, 1995: Pl. 13, Figs. 1, 5, 6, 9, 13, 14, Pl. 18, Figs. 13, 14). *Texasia gracile* (COLLIGNON, 1966), another synonym of *T. cricki* (SPATH) following KENNEDY & KLINGER (2013) differs in its narrower and feebly convex ribbing with about 30 ventrolateral clavi per whorl. The specimen from Venezuela figured by RENZ (1982: Pl. 38, Fig. 3) is much larger, with slightly flexuous ribs and seems rather to belong to the Coniacian *T. dartoni* REESIDE (1932) which is also present in the early Coniacian of Spain (SANTAMARIA ZABALA, 1991: 206, Pl. 14, Fig. 3).

Occurrence: *Texasia dentatocarinata* (F. ROEMER, 1852) occurs in the Dessau Formation (YOUNG, 1963: 14) of the Austin Group (YOUNG, 1963: 11) (= Austin Chalk) in Texas and ranges from the *Texanites shiloensis* Zone upwards into the *Submortoniceras tequesquitense* Zone (YOUNG, 1963: 22, 23, 120): late Santonian to early Campanian after YOUNG (1963). HANCOCK & GALE (1996) place its occurrence below the Santonian/Campanian boundary making it to a useful index fossil of the late Santonian. It is described herein for the first time from Europe and the Gosau Group.

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|---------------------|--------|-----------------------------|---------|--------|-------|
| NHMW 1998z0013/0001 | 64.4 | 30 _{between clavi} | -- | 14.8 | 22.9 |

Tab. 10.
Texasia dentatocarinata (F. ROEMER, 1852), measurements of NHMW 1998z0013/0001. U % of D.

Superfamily Hoplitoidea H. DOUVILLE, 1890**Family Placenticeratidae HYATT, 1900****Genus *Placenticeras* MEEK, 1876**

Type species: *Ammonites placenta* DEKAY (1828) by original designation.

***Placenticeras polyopsis* (DUJARDIN, 1837)**

Pl. 9, Figs. 3, 4, 6, Pl. 10, Figs. 1, 6

- 1837 *Ammonites polyopsis* DUJARDIN: 232, Pl. 17, Fig. 12a.
- 1872 *Ammonites syrtalis* MORTON; SCHLÜTER: 46, Pl. 14, Figs. 1–10, Pl. 15, Fig. 5.
- 1903 *Placenticeras depressum* HYATT: 237.
- 1925 *Placenticeras depressum* HYATT; DIENER: 185.
- 1935 *Placenticeras depressum* HYATT; BRINKMANN: 5.
- 1935 *Placenticeras ex aff. syrtale* (MORTON, 1872); BRINKMANN: 5.
- 1935 *Barroisiceras haberfellneri* HAUER; BRINKMANN: 5.
- 1978 *Stantonoceras depressum* (HYATT); WIEDMANN: 667, Pl. 1, Figs. 1, 2, Text-Figs. 2B, 3A.
- 1979 *Stantonoceras depressum* (HYATT); SUMMESBERGER: 145, Pl. 10, Figs. 42–43, Pl. 11, Figs. 44–47, Pl. 12, Figs. 48–52, Text-Figs. 31–37.
- 1980 *Diplacmoceras*; SUMMESBERGER in MATURA & SUMMESBERGER: 146, Fig. 33.
- 1982 *Diplacmoceras*; KOLLMANN & SUMMESBERGER: 37, 49.
- 1982 *Stantonoceras depressum* (HYATT); KOLLMANN & SUMMESBERGER: 49.
- 1983 *Placenticeras polyopsis* (DUJARDIN, 1837); KENNEDY & WRIGHT: 856, Pls. 85–86, Text-Figs. 1–4 [with synonymy].
- 1985 *Placenticeras polyopsis* (DUJARDIN); SUMMESBERGER: 158, Tab. 3.
- 1985 *Placenticeras cf. bidorsatum* (ROEMER); SUMMESBERGER: 159.
- ? 1985 *Placenticeras aff. paraplanum* WIEDMANN; AMEDRO & HANCOCK: 24, Figs. 11a–c, f, g.
- 1987 *Placenticeras polyopsis* (DUJARDIN 1837); IMMEL: 98.
- 1991 *Placenticeras polyopsis* (DUJARDIN, 1837); KENNEDY & COBBAN: 176.
- 1991 *Placenticeras polyopsis* (DUJARDIN 1837); SANTAMARIA ZABALA: 83, Pl. 3, Fig. 3, Pl. 4, Fig. 3.
- 1992 *Placenticeras polyopsis* (DUJARDIN, 1837); SANTAMARIA ZABALA: 229, Pl. 1, Figs. 6, 7.
- 1994 *Placenticeras cf. bidorsatum*; TRÖGER & SUMMESBERGER: 186, Tab. 15.
- 1994 *Placenticeras polyopsis* (DUJARDIN); TRÖGER & SUMMESBERGER: 185.
- 1995 *Placenticeras polyopsis* (DUJARDIN, 1837); KENNEDY in KENNEDY et al.: 410, Pl. 17, Figs. 2–7, 9, 10, Pl. 18, Figs. 7–12, Text-Fig. 21 [with additional synonymy].

Non 1995 *Placenticeras polyopsis* (DUJARDIN 1837); LOMMERZHEIM: 61, Pl. 5, Figs. 3–5.

2000 *Placenticeras polyopsis* (DUJARDIN); SUMMESBERGER in EGGER et al.: 26.

2007 *Placenticeras polyopsis* (DUJARDIN, 1837); SUMMESBERGER: 408, Figs. 6, 7.

2007 *Placenticeras polyopsis*; GALLEMI et al.: 12, Fig. 8.

2017c *Placenticeras polyopsis* (DUJARDIN, 1837), juv.; SUMMESBERGER et al.: 124.

Type: The lectotype is the original of DUJARDIN (1837: Pl. 17, Fig. 12a) by the subsequent designation of KENNEDY & WRIGHT (1983: 856).

Material: There are five large fragments from the Schattaugraben section at our disposal, one from the Maherndl collection: MA 1976/19 (Pl. 10, Fig. 6), four from the Skoumal collection: SK/SG/1998/29 (Pl. 10, Fig. 1), SK/SG/1998/29a, SK/SG/1998/30 (Pl. 9, Fig. 4) and SK/SG/2002/35 (Pl. 9, Fig. 3). All are from the Sandkalkbank Member of the Schattaugraben (Text-Fig. 3). SUMMESBERGER (1979: 145) mentioned 33 specimens from the Sandkalkbank Member of the Finstergrabenwandl (Gosau, Upper Austria). One from the Finstergrabenwandl is CG, 1978/02 (Pl. 9, Fig. 6). Many more are housed in private collections. Further specimens from the late Santonian of the Scharrergraben (Lower Austria) and from the late Santonian of Maiersdorf (Lower Austria) will be described elsewhere.

Discussion: SUMMESBERGER (1979: 145ff.) described macroconchs (form A) and microconchs (form B) of *P. polyopsis* from the late Santonian of the Finstergrabenwandl. They are distinguished by the larger adult size of the former and the more prominent ornamentation of the latter. *Placenticeras paraplanum* WIEDMANN, 1978 is closely related to *P. polyopsis*, from which it differs in its narrower venter and less prominent sculpture. *P. maherndl* SUMMESBERGER, 1979 differs in its distinct falcoid ribbing. Co-occurring *P. polyopsis*, *P. paraplanum* and *P. maherndl* show distinct dimorphism (see also the comprehensive discussion of KENNEDY & WRIGHT, 1983: 858–866).

Misidentification of *P. polyopsis* from the Schattaugraben section (Pl. 10, Figs. 6a, b) as *Diplacmoceras* (SUMMESBERGER in MATURA & SUMMESBERGER, 1980: 146, Fig. 33; KOLLMANN & SUMMESBERGER, 1982: 37) respectively *Placenticeras cf. bidorsatum* (ROEMER, 1841) (KOLLMANN & SUMMESBERGER, 1982: 37; SUMMESBERGER, 1985: 158) led to the erroneous interpretation of the Schattaugraben locality as early Campanian.

Occurrence: *P. polyopsis* ranges through the Santonian in France (KENNEDY & WRIGHT, 1983: 866; KENNEDY, 1995: 411). The Austrian occurrences of *P. polyopsis* are limited to the late Santonian *Paraplanum* Subzone, co-occurring with *Boehmoceras arculus*, *P. paraplanum* and *Cordiceramus muelleri* ssp., all indicative for a late Santonian age (Schattaugraben section, Gosau Basin, Salzburg, Finstergrabenwandl; Gosau Basin, Upper Austria; Maiersdorf, “Neue Welt Basin”, Lower Austria; Scharrergraben/Piesting, Lower Austria). Recent investigation (WAGREICH et al., 2010) leaves no doubt, that the boundary between Santonian and Campanian cannot be placed exactly in the Schattau section. The evidence for the presence of Campanian

sediments is still missing. Therefore the “Ammonite Fauna Gosau V” of “Early Campanian” age of SUMMESBERGER (1985) is abandoned.

Local evolutionary trends: Smooth individuals of the genus *Placenticeras* occur in the early Santonian parts of the sections (Grabenbach, Gosau; KOLLMANN & SUMMESBERGER, 1982: 58) of the Gosau Group, generally badly preserved, but identifiable as representatives of the genus *Placenticeras* even in small fragments by their characteristic sutures. Coarsely sculptured individuals appear for the first time some metres below the Sandkalkbank Member in the Hochmoos Formation of the Neffgraben (Rußbach, Salzburg). In the *Paraplanum* Subzone of the Sandkalkbank Member the genus *Placenticeras* is represented by three taxa: *P. polyopsis* (DUJARDIN), *P. paraplanum* WIEDMANN, 1978 and *P. maherndli* SUMMESBERGER, each of them by a dimorphic pair. The occurrence of *Placenticeras polyopsis* (DUJARDIN, 1837) might be due to immigration from West. Out of this pool in the Gosau Group, possibly deriving from the *P. paraplanum* stock, the Early Campanian *Milleri-Bidorsatum* group (SUMMESBERGER et al., 1996; SUMMESBERGER, 2007) developed. *Placenticeras milleri* (HAUER, 1866: 4, Pl. 2, Figs. 1, 2) occurs in the early Campanian Gosau Group of the Gosau Basin of Kainach (Austria, Styria) whereas *Placenticeras bidorsatum* (F.A. ROEMER, 1841) appears contemporaneously in Germany (e.g. Münster Basin).

Placenticeras paraplanum WIEDMANN, 1978

Pl. 9, Fig. 5

- 1978 *Placenticeras paraplanum* WIEDMANN: 666, Pl. 1, Figs. 3, 4, Text-Fig. 2a.
- 1979 *Placenticeras paraplanum* WIEDMANN; SUMMESBERGER: 152, Pl. 13, Figs. 53–57, Text-Figs. 38, 39.
- 1980 *Placenticeras paraplanum* WIEDMANN; SUMMESBERGER: 281.
- 1985 *Placenticeras aff. paraplanum* WIEDMANN; AMEDRO & HANCOCK: 24, Text-Figs. 11a–c, f, g.
- 1987 *Placenticeras paraplanum* WIEDMANN, 1978; KENNEDY: 769, Pl. 80, Figs. 1–3, 8–10.
- 1991 *Placenticeras paraplanum* WIEDMANN, 1978; KENNEDY & COBBAN: 176.
- 1995 *Placenticeras paraplanum* WIEDMANN, 1978; KENNEDY in KENNEDY et al.: 411, Pl. 17, Figs. 11, 12, Pl. 18, Figs. 1–4.
- 2000 *Placenticeras paraplanum* (WIEDMANN); SUMMESBERGER in EGGER et al.: 26.
- 2007 *Placenticeras paraplanum* WIEDMANN, 1978; SUMMESBERGER: 409, Figs. 8, 9.
- 2017a *Placenticeras paraplanum* WIEDMANN, 1978; SUMMESBERGER et al.: 35., Pl. 10, Fig. 4, Tab. 12.

Type: Holotype by original designation is the original of WIEDMANN (1978: Pl. 1, Figs. 3, 4, Text-Fig. 2a) from the late Santonian *Paraplanum* Subzone (Sandkalkbank Member, Hochmoos Formation, Gosau Group) of Gosau (Upper Austria), refigured here (Pl. 9, Figs. 5a–c).

Description, Discussion, Occurrence: Besides the holotype in the Gapp collection (Gosau) four specimens of *P. paraplanum* WIEDMANN, 1978 are described by SUMMES-

BERGER (1979: 152, Pl. 1, Figs. 3, 4) from the Skoumal collection (Vienna). All are from the late Santonian Sandkalkbank Member (Hochmoos Formation, Gosau Group) of the Finstergrabenwandler site (Gosau, Upper Austria). A fine specimen from the Neffgraben (Rußbach, Salzburg) was described by SUMMESBERGER et al. (2017a, this volume). Elsewhere it occurs in the Corbières and in the Aquitaine basin in France.

Placenticeras maherndli SUMMESBERGER, 1979

Pl. 9, Fig. 2, Tab. 11

- 1979 *Placenticeras maherndli* SUMMESBERGER: 155, Pl. 14, Figs. 58–61, Pl. 15, Figs. 62–66, Text-Figs. 40–47.
- 1982 *Placenticeras maherndli* SUMMESBERGER; KOLLMANN & SUMMESBERGER: 49.
- 1983 *Placenticeras maherndli* SUMMESBERGER, 1979; KENNEDY & WRIGHT: 866.
- 1987 *Placenticeras maherndli* SUMMESBERGER 1979; IMMEL: 98.
- 1991 *Placenticeras maherndli* SUMMESBERGER, 1979; KENNEDY & COBBAN: 176.
- 1994 *Placenticeras maherndli* SUMMESBERGER; TRÖGER & SUMMESBERGER: 185.
- 1995 *Placenticeras maherndli* SUMMESBERGER, 1979; KENNEDY in KENNEDY et al.: 411, Pl. 22, Fig. 7.
- ? 1995 *Placenticeras maherndli* SUMMESBERGER 1979; LOMMERZHEIM: 63, Pl. 6, Figs. 1–3.
- 2000 *Placenticeras maherndli* SUMMESBERGER; SUMMESBERGER in EGGER et al.: 26, Fig. 16/2.
- ? 2000 *Placenticeras maherndli* SUMMESBERGER, 1979; KENNEDY & KAPLAN: 74, Pl. 2, Fig. 6.
- 2007 *Placenticeras maherndli* SUMMESBERGER, 1979; SUMMESBERGER: 410, Figs. 10, 11.
- cf. 2017c *Placenticeras aff. maherndli* SUMMESBERGER, 1979; SUMMESBERGER et al.: 124, Fig. 7/4, Tab. 2.

Type: The holotype by original designation is MA 1977/2, the original of SUMMESBERGER (1979: Pl. 14, Figs. 58, 59).

Material: SK/SG/1981/1, a single specimen collected loose in the bed of the Schattaugraben, preservation suggests it came from the Sandkalkbank Member.

Description: SK/SG/1981/1 is a fragment mainly consisting of the body chamber but with the septal face of the inner whorl exposed. The surface is heavily corroded, leaving traces of whitish shell between the falcoïd ribs only. The main characteristic of the specimen is its inflated body chamber section especially towards the apparently preserved aperture. The moderately narrow umbilicus is about 10 mm deep, the umbilical wall is vertical to slightly convex. The umbilical shoulder is moderately rounded. About six umbilical bullae per half whorl give rise to pairs of falcoïd ribs, in between three or four intercalated ones, all in slightly irregular distances more or less equal to the width of the ribs. Ribs are corroded towards the aperture but preserved umbilical bullae indicate by crowding that the aperture is very close.

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | U (mm) | U (%) |
|---------------|------------------------------|------------|------------|-----------|----------|
| SK/SG 1981/1 | 85.0 (D _{max/est}) | 35.8 | 38.3 | 10.8 | 12.7 |
| SK/SG 1981/1 | 65.3 (D _{-180°}) | 35.6 | 25.7 | 8.9 | 13.6 |
| SK/SG 1981/1 | 45.0 (D _{-360°}) | 19.3 | 12.7 | 7.9 | 17.5 |

Tab. 11.

Measurements of *Placenticeras maherndli* SUMMESBERGER, 1979 (SK/SG 1981/1). The data are slightly altered by deformation but still meaningful. U % of D.

Discussion: The characteristic falcoid ribbing leaves no doubt about this specimen belonging to *Placenticeras maherndli* SUMMESBERGER, 1979. The specimen differs in its inflated body chamber from previous described material from the Gosau Group (SUMMESBERGER, 1979) and from specimens from the Corbières (KENNEDY, 1995: 411, Pl. 22, Fig. 7). *Placenticeras maherndli* SUMMESBERGER, 1979 described by LOMMERZHEIM (1995: 63, Pl. 6, Figs. 1–3) from boreholes in the Münster Basin (NW Germany) are doubtful in our view as the preservation of the figured specimens is rather poor (unidentifiable after KENNEDY & KAPLAN, 2000: 74, Pl. 2, Fig. 6).

Occurrence: The species was originally described in 1979 from the Sandkalkbank Member of the Hochmoos Formation of the Austrian Gosau Group. Outside the Gosau Group the species was found in the Paraplanum Zone of the Corbières (KENNEDY, 1995). The report from the Münster Basin (Germany) is doubtful (see above).

Superfamily Acanthoceratoidea DE GROSSOUIRE, 1894

Family Sphenodiscidae HYATT, 1900

Subfamily Lenticeratinae HYATT, 1900

Genus *Diaziceras* SPATH, 1921

Type species: *Diaziceras tissotiaeforme* SPATH (1921) by original designation.

Diaziceras austriacum (SUMMESBERGER, 1979)

not figured

- 1979 *Skoumalia austriaca* gen. nov., sp. nov., Form A; SUMMESBERGER: 141, Pl. 9, Figs. 37–38, Text-Figs. 26–28.
- Non 1979 *Skoumalia austriaca* gen. nov., sp. nov., Form B; SUMMESBERGER: 143, Pl. 9, Figs. 39–41, Text-Figs. 29, 30 (= *Eulophoceras jacobi* HOURCQ, 1949).
- Non 1980 *Skoumalia austriaca* gen. nov., sp. nov., Form B; SUMMESBERGER: 280, Pl. 2, Figs. 5, 6, Pl. 3, Figs. 7, 8, Text-Figs. 5, 6 (= *Eulophoceras jacobi* HOURCQ, 1949).
- 1995 *Eulophoceras austriacum* (SUMMESBERGER, 1979); KENNEDY: 426, Pl. 25, Figs. 3–5, Pl. 26, Fig. 8.
- 1996 *Eulophoceras austriacum* SUMMESBERGER, 1979; WRIGHT: 205, Figs. 157c, d.

2012b *Diaziceras austriacum* (SUMMESBERGER, 1979); KENNEDY & KLINGER: 12.

Type: The holotype by original designation is SK/1977/14, the original of *Skoumalia austriaca*, form A, SUMMESBERGER (1979: 141, Pl. 9, Figs. 37–38 (only), Text-Figs. 26–28 (only)).

Material: SK/1977/14, the holotype, is the only known specimen.

Description: SK/1977/14 is a laterally compressed internal mould of a throughout chambered phragmocone, the body chamber is missing. There is no shell preserved. General outline is oxycone with fastigiate venter and sharp keel. Wh increases rapidly, the last whorl covering most of the preceding one. The umbilicus comprises about 13 % of the diameter. The umbilical shoulder is rounded, the umbilical wall as far as visible is slightly convex. Measurements of *Skoumalia austriaca*, form A are given by SUMMESBERGER (1979: 141). Four strong irregular umbilical bullae give rise to straight prorsiradiate, shallow ribs terminating with irregular interspaces in about eight weak ventral bullae. For the characteristic suture see SUMMESBERGER (1979: Text-Figs. 27, 28) and KENNEDY & KLINGER (2012b: Figs. 4A, C). E/A is deeply incised with irregular folioles, deep narrow A and bifid A/U₂.

Discussion: *Diaziceras austriacum* (SUMMESBERGER, 1979) was originally described as the form A of a pair of dimorphs (*Skoumalia austriaca* SUMMESBERGER, 1979), whose partner *Skoumalia austriaca* SUMMESBERGER 1979, form B (143, Text-Figs. 29, 30; 1980: 280, Pl. 2, Figs. 5–6, Pl. 3, Figs. 7–8, Text-Figs. 5, 6) is now separated as *Eulophoceras jacobi* HOURCQ, 1949, described below.

Diaziceras tissotiaeforme SPATH, 1921 is much more inflated and differs strongly in sculpture: Seven very strong umbilical tubercles give rise to prorsiradiate strong bifurcating and trifurcating primary ribs. Together with some intercalatory ones they terminate in about 20 conical ventrolateral tubercles. The asymmetrical E/A of the holotype (see KENNEDY & KLINGER, 2012b: Fig. 4F) is deeply incised with intricate suture elements.

Diaziceras guillantoni HOURCQ, 1949 is similar but somewhat more inflated than *D. austriacum*. Its umbilicus is also somewhat wider – 17 % in the holotype and 18–21 % in the specimens figured by COLLIGNON (1969), compared to 13 % in case of *D. austriacum*. The main difference is in the ornament: about 6–7 relatively weak umbilical tubercles connected by low broad ribs to about 20 ventrolateral tubercles. The sutures are less deeply incised than those of *D. austriacum*. *Eulophoceras jacobi* HOURCQ, 1949, formerly interpreted as the partner of a dimorphic pair with *D. austriacum* was discussed in 2012 (KENNEDY & KLINGER, 2012a: 35, Pl. 12A–C). *E. jacobi* (see below) differs strongly in its near-smooth surface and smaller umbilicus.

Eulophoceras natalense HYATT, 1903 differs in its tiny umbilicus and its dimorphism described by SUMMESBERGER et al. (2017a).

Occurrence: *Diaziceras austriacum* (SUMMESBERGER, 1979) was described under *Skoumalia austriaca* SUMMESBERGER, 1979 from the late Santonian of the Gosau Basin and under *Eulophoceras austriacum* (SUMMESBERGER, 1979) from the Paraplanum Subzone of the La Jouane section in the French Corbières (KENNEDY, 1995: 426, Pl. 25, Figs. 3–5).

Genus *Eulophoceras* HYATT, 1903

Type species: *Eulophoceras natalense* HYATT, 1903 by original designation.

Eulophoceras jacobi HOURCQ, 1949

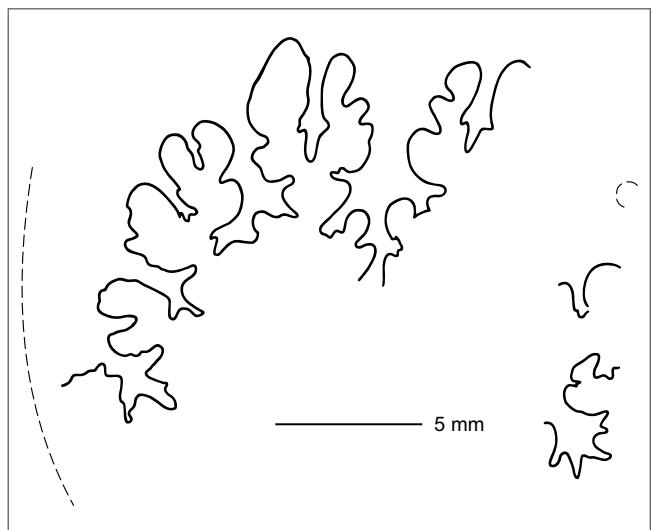
Pl. 10, Figs. 2–5, Text-Fig. 17

- 1949 *Eulophoceras Jacobi* HOURCQ: 95, Pl. 1, Fig. 2.
- 1969 *Eulophoceras Jacobi* HOURCQ; COLLIGNON: 204, Pl. 600, Fig. 2253.
- 1979 *Skoumalia austriaca* gen. nov., sp. nov., Form B; SUMMESBERGER: 143, Pl. 9, Figs. 39–41, Text-Figs. 29, 30.
- Non 1979 *Skoumalia austriaca* gen. nov., sp. nov., Form A; SUMMESBERGER: 141, Pl. 9, Figs. 37–38, Text-Figs. 26–28 (= *Diaziceras austriacum* (SUMMESBERGER, 1979)).
- 1980 *Skoumalia austriaca* SUMMESBERGER; Form B; SUMMESBERGER: 280, Pl. 2, Figs. 5–6, Pl. 3, Figs. 7–8, Text-Figs. 5, 6.
- 1982 *Skoumalia austriaca* SUMMESBERGER; KOLLMANN & SUMMESBERGER: 49, partim.
- 1985 *Eulophoceras austriacum* (SUMMESBERGER) "forme B"; AMÉDRO & HANCOCK: 23–24, Figs. 11d, e.
- 1987 ? *Eulophoceras austriacum* (SUMMESBERGER 1979); IMMEL: 113, partim.
- 1987 *Eulophoceras austriacum* (SUMMESBERGER, 1979); KENNEDY: 776, Pl. 82, Figs. 1–3.
- 1995 *Eulophoceras austriacum* (SUMMESBERGER, 1979); KENNEDY in KENNEDY et al.: 426, Pl. 26, Fig. 8, Text-Fig. 33.
- Non 1995 *Eulophoceras austriacum* (SUMMESBERGER, 1979); KENNEDY in KENNEDY et al.: 426, Pl. 25, Figs. 3–5, Text-Fig. 34 (= *Diaziceras austriacum* (SUMMESBERGER, 1979)).
- Non 1995 *Eulophoceras austriacum* (SUMMESBERGER 1979); LOMMERZHEIM: 61, Pl. 5, Fig. 2.
- 2000 *Eulophoceras austriacum* (SUMMESBERGER); SUMMESBERGER in EGGER et al.: 26, partim.
- 2012a *Eulophoceras jacobi* HOURCQ, 1949; KENNEDY & KLINGER: 32, 35, Figs. 4, 12A–C.
- 2017c *Eulophoceras jacobi* HOURCQ, 1949; SUMMESBERGER et al.: 125, Fig. 4/1–8, Tab. 3.

Type: The lectotype is the original of HOURCQ (1949: Pl. 11, Fig. 2, Text-Fig. 7) subsequently designated by KENNEDY & KLINGER (2012a: 35).

Material: SK/SG/1998/31 and SK/SG/2002/32 from the Sandkalkbank Member of the Schattaugraben, SK/SG 2007/44, 45 from the *Micraster* Bed of the Schattaugraben section, SK/1978/21 and SK/1979/3, all from the Sandkalkbank Member of the locality Finstergrabenwandl.

Description: SK/SG/1998/31 is discoidal with an entire keel, which is distinctly separated from the flank by a ventrolateral facet. Towards the aperture the entire sharp keel becomes rounded.



Text-Fig. 17.

External suture of *Eulophoceras jacobi* HOURCQ, 1949. SK/SG/1998/31 from the Sandkalkbank Member (Hochmoos Formation, Schattaugraben section); fragment of the external suture. Scale bar: 5 mm.

Coiling is involute with a tiny umbilicus ($U = 6.6\%$). Umbilical bullae are indicated by tiny swellings. About 10 feeble ventrolateral and slightly prorsiradiate bullae are present.

SK/SG/1998/31 is very close to SK/1979/3 described by SUMMESBERGER (1980: 280, Pl. 2, Figs. 5, 6, Pl. 3, Figs. 7, 8, Text-Figs. 5, 6). Ribs are very low and barely detectable (SUMMESBERGER, 1980: Pl. 2, Fig. 7) as are the spiral ridges (SUMMESBERGER, 1980: Pl. 3, Fig. 7). SK/SG/2002/32 is a juvenile with partially preserved shell. It is impregnated by iron oxide indicated by the brownish colour. It shows distinct umbilical bullae, giving rise to indistinct falcoid ribs with tiny bullae at the ventrolateral shoulder. For the characteristic suture see SUMMESBERGER (1980: Text-Fig. 6) and KENNEDY & KLINGER (2012a: Fig. 11D). E/A is deeply incised with irregular folioles, deep wide A and bifid A/U₂.

Discussion: *Diaziceras austriacum* (SUMMESBERGER, 1979) differs in its larger umbilicus (13 %) and in the strong umbilical tubercles (SUMMESBERGER, 1979: 142, Pl. 9, Fig. 37, Text-Fig. 26).

Eulophoceras natalense HYATT, 1903 differs in its distinctly rounded venter towards the aperture in adult specimens and in its dimorphism described by SUMMESBERGER et al. (2017a).

E. bererense HOURCQ, 1949; differs in its prorsiradiate and falcoid ribbing (KENNEDY & KLINGER, 2012a: Text-Fig. 12D, Figs. 13A–D, Fig. 14); for further discussion see the revision of KENNEDY & KLINGER (2012a). We have not seen the specimen figured by LOMMERZHEIM (1995: Pl. 5, Fig. 2). In our opinion it seems to be a different taxon.

Occurrence: The Austrian specimens of *E. jacobi* HOURCQ, 1949; are from the top Santonian Sandkalkbank Member of the Hochmoos Formation of the Gosau Group. Further specimens are from the late Santonian of the Hofergraben site (Gosau, Upper Austria; SUMMESBERGER et al., 2017c). It is also described from the late Santonian of France (from the Charentes: AMÉDRO & HANCOCK, 1985; from the Aquitaine Basin: KENNEDY, 1987; from the Corbières: KENNEDY, 1995). Co-occurrence with *Placenticeras*

paraplanum, *Boehmoceras arculus* and *Marsupites laevigatus* endorses the stratigraphical position of *E. jacobi* in the top Santonian. On the other hand, the specimens from Madagascar are said to be lowest Campanian (COLLIGNON, 1969). Juvenile SK/SG/2002/32 (Pl. 10, Fig. 5) recalls the juvenile ornamentation of *E. natalense* described by SUMMESBERGER et al. (2017a).

Family Collignoniceratidae WRIGHT & WRIGHT, 1951

Subfamily Texanitinae COLLIGNON, 1948

Genus *Reginaites* REYMENT, 1957

Type species: *Peroniceras (Reginaites) quadrituberculatum* REYMENT (1957) by original designation.

Remarks: *Reginaites* REYMENT (1957) was introduced as a subgenus of the Coniacian genus *Peroniceras*. YOUNG (1963: 76) ranked it within the subfamily Texanitinae. This was followed and discussed at length by KLINGER & KENNEDY (1980: 107–111) and WRIGHT (1996: 197).

Reginaites gappi WIEDMANN, 1978

Pl. 10, Figs. 7–8

- 1978 *Reginaites gappi* WIEDMANN: 668–669, Pl. 2, Figs. 1–3, Text-Figs. 2C, 3B.
- 1979 *Reginaites gappi* WIEDMANN 1978; SUMMESBERGER: 159.
- 1980 *Reginaites gappi* WIEDMANN; SUMMESBERGER: 281.
- 1980 *Reginaites gappi* WIEDMANN (1978); KLINGER & KENNEDY: 110.
- 1987 *Reginaites gappi* WIEDMANN 1978; IMMEL: 112.
- 1991 *R. gappi* WIEDMANN, 1978; KENNEDY & COBBAN: 177.

Type: The holotype by original designation is the specimen figured by WIEDMANN (1978: Pl. 2, Figs. 1–3) registered under CG 03 in the Gapp collection (Gosau, Upper Austria) and refigured here (Pl. 10, Figs. 8a, b).

Material: Three specimens: CG 03 (Gapp collection), the original of WIEDMANN (1978), NHMW 1990/0029/0526 and an unregistered specimen in the Maherndl collection (Bad Ischl).

Description: The sculpture of *R. gappi* consists of about 24 prorsiradiate bituberculate strong ribs. The interspaces are somewhat wider than the ribs. The tubercles are very strong, even in the juvenile stage. For details see the description of WIEDMANN (1978: 668–669).

Discussion: *R. quadrituberculatum* (sic) REYMENT, 1957 differs in its generally weaker ornament, especially the umbilical tubercles of the adult specimen and in a lateral row of very feeble tubercles (KLINGER & KENNEDY, 1980: Fig. 89). *R. durhami* YOUNG (1963: 92, Pl. 39, Fig. 2, Pl. 49, Figs. 1, 2, 4, Text-Fig. 22b) also has weaker ornament and a lateral row of weak tubercles.

R. hataii MATSUMOTO (1965: 240) was thought by the author to merit assignment to another genus (*Reymentites* (= *Regi-*

naites) REYMENT following KENNEDY & KLINGER, 1980 and WRIGHT, 1996).

It differs from *R. gappi* in its narrower ribs and a lateral row of tubercles that efface on the outer whorls.

R. leei (REESIDE, 1927) from the Early Campanian of New Mexico (KLINGER & KENNEDY, 1980: 110) has weaker ornament, and tiny umbilical tubercles. The main difference from *R. reymenti* KLINGER & KENNEDY, 1980 (111, Figs. 86–88) is the splitting of the ventrolateral node into two at a diameter larger than 60 mm. Furthermore, the umbilical tubercles are much smaller than in *R. gappi*. In *R. zulu* KLINGER & KENNEDY, 1980 (116, Figs. 90–92, 93A, B, 94) distant ribs (19 per whorl) are strongly prorsiradiate, becoming somewhat indistinct in the later growth stage.

The existence of a median row of tubercles at least in some representatives convinced YOUNG (1963: 38) as well as KLINGER & KENNEDY (1980) to include the genus *Reginaites* in the subfamily Texanitinae. They were followed by WRIGHT (1996) and by the present authors.

Reginaites exilis KENNEDY & COBBAN, 1991 ("subtilis" in plate explanation) from the Late Santonian *Shiloensis* Zone of Texas and Mississippi (USA) differs in its feeble tuberculation

Occurrence: *Reginaites gappi* WIEDMANN, 1978 is known only from the Sandkalkbank Member of the Hochmoos Formation (Gosau Group, locality Finstergrabenwandl) which belongs to the Subzone of *Placenticeras paraplanum* and *Boehmoceras arculus*.

Suborder Ancyloceratina WIEDMANN, 1966

Superfamily Turrilitoidea GILL, 1871

Family Nostoceratidae HYATT, 1894

Nostoceratidae gen. et sp. indet.

Pl. 12, Fig. 3

Material: A single specimen (NHMW 1978/1963/0027), already described by SUMMESBERGER (1979: 124, Pl. 3, Fig. 20) and refigured here, from the nearby Finstergrabenwandl.

Description and Discussion: NHMW 1978/1963/0027 shows four slowly expanding whorls of an apparently helicoidal spire. It has been flattened by *post mortem* compaction of the helix making measuring of the apical angle impossible. It differs in more irregular ribbing and ventrolateral spines of 1.7 mm length from the initial helix SK/SG/1998/27, which is tentatively assigned to *Glyptoceras* group 2 (see below) and from the initial coils SK/SG/1996/23, 24 which are tentatively assigned to *Ampondella amapondense* (VAN HOEPEN, 1921). They differ also in their more rapid increasing whorl height and whorl breadth. Assignment to a co-occurring taxon seems unlikely at this time.

Occurrence: *Paraplanum* Subzone (late Santonian Sandkalkbank Member, Hochmoos Formation, Gosau Group; Austria), co-occurring with *Placenticeras paraplanum* and *Boehmoceras arculus*.

Genus *Amapondella* KLINGER & KENNEDY, 1997b

Type species: *Heteroceras amapondense* VAN HOEPEN (1921) by original designation of KLINGER & KENNEDY (1997b: 246).

Amapondella amapondensis (VAN HOEPEN, 1921)

Pl. 11, Figs. 1–11

- 1921 *Heteroceras amapondense* VAN HOEPEN: 17, Pl. 4, Figs. 1–2.
- 1976 *Hyphantoceras (Madagascarites ?) amapondense* (VAN HOEPEN, 1921); KLINGER: 71, Pl. 32, Figs. 5a, b, Pl. 33, Figs. 2, 3, Text-Figs. 10d, e.
- 1979 *Hyphantoceras (Madagascarites ?) amapondense* (VAN HOEPEN); SUMMESBERGER: 123, Pl. 3, Fig. 19, Text-Fig. 13.
- 1979 ?*Diplomoceras* (Subgenus ?) *largesulcatum* (FORBES); SUMMESBERGER: 125, Pl. 3, Figs. 22, 23.
- 1980 *Hyphantoceras (Madagascarites ?) amapondense* (VAN HOEPEN); SUMMESBERGER: 277, Pl. 1, Fig. 2, Text-Fig. 3.
- 1982 *Hyphantoceras (?) amapondense* (VAN HOEPEN, 1921); LEWY: 24, Figs. 1–6.
- 1985 *Hyphantoceras (?Madagascarites) amapondense* (VAN HOEPEN, 1921); KLINGER: 6, Figs. 4J–K.
- 1987 *Hyphantoceras (?Madagascarites) amapondense* (VAN HOEPEN 1921); IMMEL: 134.
- 1991 *Hyphantoceras (?) amapondense* (VAN HOEPEN, 1921); KENNEDY & COBBAN: 181, Figs. 9, 10.
- 1995 *Hyphantoceras ? amapondense* (VAN HOEPEN, 1921); KENNEDY in KENNEDY et al.: 428, Pl. 28, Figs. 24–30.
- ? 1995 *Scalarites serra* (MÜLLER & WOLLEMAN, 1906); KENNEDY & KAPLAN: 31, Pl. 20, Figs. 6, 7, [only; Figs. 4, 5 = *Scalarites serra* (MÜLLER & WOLLEMAN, 1906)].
- 1997 *Eubostrychoceras (Amapondella) amapondense* (VAN HOEPEN, 1921); KLINGER & KENNEDY: 239, Figs. 12A–C, Figs. 13A–C, Fig. 14A, Figs. 15A–E, Figs. 17A–C.
- ? 2000 *Hyphantoceras* sp.; KENNEDY & KAPLAN: 92, Pl. 38, Fig. 8.
- 2003 *Eubostrychoceras (Amapondella) amapondense* (VAN HOEPEN, 1921); KLINGER & KENNEDY: 235, Figs. 5, 6, 7A, 8A–D, 9A–C [with synonymy].
- 2007 *Amapondella amapondense* (VAN HOEPEN, 1921); KLINGER et al.: 104, Text-Figs. 11A–C, Figs. 12B–I.

Type: Holotype by original designation is the specimen figured by VAN HOEPEN (1921: Pl. 4, Figs. 1–2).

Material: A series of fragments of body chambers and middle growth stages was available for study: MA1976/12, 13; SK/SG/1992/14, SK/SG/2003/36, 37; SK/SG/2005/39; NHMW 2010/0081/0003 from the Schattaugraben section. SK/2000/1 from the Sandkalkbank Member from the exposures of a forest road close to the Finstergrabenwand locality (Zwieselalm forest road); NHMW 1978/1963/0020 (SUMMESBERGER, 1979: Pl. 3, Fig. 19, Text-Fig. 13); NHMW 1978/1963/0028 (SUMMESBERGER, 1979: Pl. 3, Figs. 22, 23), SK 1979/2 (SUMMESBERGER, 1980: Pl. 1, Fig. 2, Text-Fig. 3). Furthermore, we assign some helically coiled initial stages from the *Micraster* Bed of the Schattaugraben section to

the species: SK/SG/1996/23, 24 and fragments of subadult phragmocones: NHMW 2010/0081/0003, NHMW 2010/0081/0004 and a very small fragment NHMW 2010/0081/0005 all from the Schattaugraben section.

Description: Initial stage: SK/SG/1996/23, 24 (Pl. 11, Figs. 10–11) are two slightly crushed fragments of a loosely helically coiled low spire, the whorls originally apparently not touching but barely separated. Both are slightly elongated into a somewhat elliptical outline of 14–17 mm in diameter. Wh as far as measurable is from 2 to 5 mm, U is approximately 8 mm, U % is > 50 %. Wh and Wb are increasing rapidly. The style of ribbing recalls the “standard” ribbing of the adult individuals. The ribs are sharp, distant, undivided, occasionally accentuated and sometimes with wider interspaces anticipating the irregular ribbing of the adult shells with wider interspaces and flares.

Adult stage: MA/1976/12 (Pl. 11, Fig. 2) is a 51 mm long fragment of an internal mould of an irregularly coiled helical whorl with adherent powdery shell remnants. The general outline of the fragment suggests it to be the aperture of an adult individual. The width close to the apertural end is 13.6 mm. Four prominent flared, very strong and sharp ribs are spaced at irregular distances from 11 to 13 mm. In between 3 to 6 much weaker ribs of different width are intercalated at irregular intervals. The intercalated ribs are weakened on the dorsum or even efface. The primary ribs cross the whorl without interruption. MA 1976/13 (Pl. 11, Fig. 4) is of comparable proportions, shape and style of ribbing but badly corroded. SK/SG/1992/14 (Pl. 11, Fig. 6) is a badly crushed body chamber fragment too, which shows the ventrally arranged flares. The best specimen is SK/2000/1 representing two parts of the volution of an adult specimen, interrupted by a missing piece (Pl. 11, Figs. 1a, b). No sutures are visible as all specimens are body chamber fragments. The type of ribbing unites these fragments of different portions of the shell: single undivided sharp ribs with ribs narrower than the interspaces, in juvenile stages accentuated ones, in adult stages flared ones accompanied by wider interspaces. Between the dominating primaries are three to eight secondaries arranged in distances wider than the ribs.

Discussion: The identification is based on the combined characteristics of fragments which are tentatively interpreted to belong together. Initial coils are never found preserved together with the adult phragmocone and body chamber of a single individual. Combined with the already described specimens from the upper Santonian Sandkalkbank Member (SUMMESBERGER, 1979, 1980) the restored shell was an initial low helix followed by an irregular loose helix with wider distances between whorls (SUMMESBERGER, 1980: Pl. 1, Fig. 2) and finally an upward turned aperture (KLINGER & KENNEDY, 1997b: Figs. 12F, 13A–C; 2003: Fig. 5F, the holotype). In 1997 KLINGER & KENNEDY (1997b) state the early ornament consisted of uniform ribbing, but in some cases the later ornament might appear also in the very early stages of the helix. This seems to be the case in two individuals from the *Micraster* Bed of the Schattaugraben section. Affinities and differences are discussed at length by KLINGER & KENNEDY (2003). *Eodidymoceras enigma* (KLINGER et al., 2007: 102, Figs. 14A–K, 15A–N) is very similar but has bituberculate ribbing.

The flattened initial coil of a specimen of Nostoceratinae gen. et sp. indet. from the Sandkalkbank of the Finstergrabenwandl (SUMMESBERGER, 1979: 124, Pl. 3, Fig. 20; see above) differs in its low expansion rate of the section together with a different style of ribbing. Ribs are less sharp, even blunt in section, more irregularly and tightly spaced. Combined with distinct spines of almost 2 mm length the restored helix belongs to a different taxon.

The initial coil (SK/SG/1998/27) of what we believe to belong to *Glyptoxoceras* group 2 (Pl. 13, Fig. 9; see below) differs by lower expanding rate and sharp narrow ribs with wider interspaces.

Occurrence: *Amapondella amapondensis* (VAN HOEPEN, 1921) occurs in the *Paraplanum* Subzone of the Sandkalkbank Member of the Hochmoos Formation of the Gosau Group of the Schattaugraben section and of the Finstergrabenwandl, Austria. After KLINGER & KENNEDY (1997b) the occurrences in Zululand, Pondoland and Madagascar are late Santonian or earliest Campanian in age which agrees well with the Austrian range at the top of the upper Santonian Sandkalkbank member.

Family Diplomoceratidae SPATH, 1926

Subfamily Diplomoceratinae SPATH, 1926

Genus *Scalarites* WRIGHT & MATSUMOTO, 1954

Type species: *Helicoceras scalare* YABE, 1904 (Pl. 9, Fig. 2 only) by original designation.

Scalarites sertae (MÜLLER & WOLLEMAN, 1906)

Pl. 12, Fig. 2.

- 1906 *Crioceras sertae* MÜLLER & WOLLEMAN: 20, Pl. 9, Fig. 3, Pl. 10, Figs. 1, 2 [only; Fig. 3 = ? *Glyptoxoceras* (fide KENNEDY & KAPLAN, 1995: 31)].
- 1995 *Scalarites sertae* MÜLLER & WOLLEMAN, 1906; KENNEDY & KAPLAN: 31, Pl. 20, Figs. 4, 5 [only; non: Figs. 6, 7 = ? *Amapondella amapondensis* (VAN HOEPEN, 1921)].
- 2000 *Scalarites sertae* (MÜLLER & WOLLEMAN, 1906); KENNEDY & KAPLAN: 102.
- 2000 *Scalarites sertae*; KAPLAN & KENNEDY: 111.

Type: Lectotype herewith designated is the original of *Crioceras sertae* MÜLLER & WOLLEMAN, 1906 (Pl. 10, Fig. 1) from the early lower Campanian (after KAPLAN in KENNEDY & KAPLAN, 1995: 11) of the brick pit "Aktienziegelei" (formerly: Actien-Ziegelei) near Braunschweig (Germany).

Material: A single specimen SK/SG/1981/2 from the *Micraster* Bed of the Hochmoos Formation (Schattaugraben section, Rußbach, Salzburg).

Description: SK/SG/1981/2 is an internal mould of a curved fragment of the phragmocone with yellowish shell preserved. Length is 63.7 mm, Wh 7.8–9.1 mm (deformed), length measured ventrally is 94 mm. The specimen is flattened by *post mortem* deformation, its original whorl section might have been circular or slightly elliptical. As far as

visible the coiling was criocone in an even plane. The surface is covered by straight and rectiradiate undivided riblets with a moderately sharp section. In irregular distances of 3 to 8 "normal" ones delicately flared collar riblets occur followed by indistinct constrictions. Riblets and interspacers are of equal width. The rib index is about eight per cm.

Discussion: We follow KENNEDY & KAPLAN (1995: 102) keeping *Scalarites sertae* (MÜLLER & WOLLEMAN, 1906) specifically separated from *Scalarites cingulatum* (SCHLÜTER, 1872) from the Early Campanian of Westphalia, the latter differing by sharper rib section and less intercalated "normal" riblets between flared ones. Future work might lead to referring both rare forms to a single species. See also KENNEDY & KAPLAN (1995: 31, Pl. 20, Figs. 1–3; 2000: 100, Pl. 34, Fig. 1). The above described specimen resembles closely the earlier part of the loosely coiled specimen figured by MÜLLER & WOLLEMAN (1906: Pl. 10, Fig. 1).

Scalarites scalaris (YABE, 1904) from the Japanese Turonian differs in its more even 10–12 sharp and narrowly spaced riblets between the flared ones (WRIGHT & MATSUMOTO, 1954: Text-Fig. 1). *Scalarites mihoensis* WRIGHT & MATSUMOTO, 1954 (Pl. 7, Figs. 1, 2, Text-Fig. 2) from the Japanese Turonian to Coniacian is similar to *S. scalaris* with only a few flared ribs and occasional constrictions. *Scalarites* sp. from the French Coniacian (KENNEDY, 1984: 140, Pl. 32, Figs. 7–10) is a badly preserved fragment with much coarser ribbing.

Occurrence: *Scalarites sertae* occurs in the late Santonian Zone of *Boehmoceras arculus* (sensu KAPLAN in KENNEDY & KAPLAN, 2000), *Placenticeras paraplanum* and *Marsupites testudinarius* of the Schattaugraben section, in the upper *B. arculus* Zone in the Münster Basin (Germany; KAPLAN & KENNEDY, 2000: 111) and in the early Campanian *Bidorsatum* Zone of Braunschweig (Germany; KAPLAN in KENNEDY & KAPLAN, 1995: 11).

Genus *Glyptoxoceras* SPATH, 1925

Type species: *Hamites rugatus* (FORBES, 1846) by the original designation of SPATH (1925).

Remarks: As described below, the co-occurrence of six taxa of the genus *Glyptoxoceras* in the *Micraster* Bed of about 1 m thickness is questionable and further studies of additional material are needed to clarify intraspecific variation.

Glyptoxoceras souqueti COLLIGNON, 1983

Pl. 12, Fig. 1

- 1983 *Glyptoxoceras souqueti* COLLIGNON: 186, Pl. 1, Fig. 4.
- 1995 *Glyptoxoceras souqueti* COLLIGNON, 1983; KENNEDY in KENNEDY et al.: 429, Pl. 29, Figs. 14, 15, 18.
- ? 1995 *Glyptoxoceras souqueti* COLLIGNON, 1983; KENNEDY in KENNEDY et al.: 429, Pl. 29, Figs. 12, 13, 16, 17.

Type: The holotype by original designation is the original of COLLIGNON (1983: Pl. 1, Fig. 4), refigured by KENNEDY (1995: Pl. 29, Figs. 14, 15, 18).

Material: A single fragment SK/SG/2007/47 from the *Micraster* Bed of the Bibereck Formation.

Description: SK/SG/2007/47 is a fragment of an internal mould with most of the shell preserved. It is laterally compacted by *post mortem* deformation in a single plane. Length is about 47 mm. The original shape of the whole individual cannot be restored from such a small fragment. It might have been loosely coiled. Coiling radius changes close to the adapertural end of the specimen. The section, distinctly increasing with age, might have been round or oval from 5 to 8 mm. Ribbing in regular distances is recti- to slightly prorsiradiate. Rib index might have been from 3 to 5. Ribs are single and relatively strong and cross the dorsum and venter without interruption. Rib interspacers are about the double width of the ribs. Rib section is squarish, the rib vertex is flat. The suture is not visible.

Discussion: SK/SG/2007/47 differs from other representatives of *Glyptoxoceras* from the Schattaugraben locality (see below) in having squarish rib sections, wider and regular rib distances and by the conspicuously increasing diameter of the restored whorl section. Its changing radius of involution is comparable to that of the holotype (KENNEDY, 1995: Pl. 29, Figs. 14, 15). The absence of straight portions, in both the Corbières material, and the Gosau specimen supports specific separation from *Glyptoxoceras crispatum* described below (see KENNEDY, 1995: 429).

Occurrence: *Glyptoxoceras souqueti* COLLIGNON occurs in the *Paraplanum* Subzone of the Gosau Group and in the *Gallicus* and *Paraplanum* Zones of the Corbières (KENNEDY, 1995).

Glyptoxoceras crispatum (MOBERG, 1885)

Pl. 12, Figs. 6–13

- | | |
|----------|---|
| 1885 | <i>Anisoceras (Hamites) crispatus</i> MOBERG: 32, Pl. 3, Figs. 12, 13. |
| 1979 | ? <i>Diplomoceras</i> (Subgenus ?) <i>tenuisulcatum</i> (FORBES); SUMMESBERGER: 124, Pl. 3, Fig. 21. |
| 1982 | <i>Diplomoceras (Glyptoxoceras) indicum</i> (FORBES 1846); IMMEL et al.: 26, Pl. 10, Figs. 5, 6. |
| 1982 | <i>Diplomoceras (Glyptoxoceras) subcompressum</i> (FORBES 1846); IMMEL et al.: 26, Pl. 10, Fig. 7. |
| Non 1982 | <i>Diplomoceras (Glyptoxoceras) subcompressum</i> (FORBES 1846); IMMEL et al.: 26, Pl. 9, Figs. 4, 5, Pl. 11, Fig. 4. |
| 1995 | <i>Glyptoxoceras crispatum</i> (MOBERG, 1885); KENNEDY & JAGT: 275–295. |
| 1995 | <i>Glyptoxoceras crispatum</i> (MOBERG, 1885), KENNEDY et al.: 430, Pl. 27, Figs. 16, 24, Pl. 29, Figs. 1, 8, 11, 19, 20 [with synonymy]. |
| 2000 | <i>Glyptoxoceras cf. tenuisulcatum</i> (FORBES); SUMMESBERGER in EGGER et al.: 26. |
| 2000 | <i>Glyptoxoceras crispatum</i> (MOBERG, 1885); KENNEDY & KAPLAN: 96, Pl. 34, Fig. 2. |
| 2017b | <i>Glyptoxoceras crispatum</i> (MOBERG, 1885); SUMMESBERGER et al.: 108, Pl. 1, Figs. 11–13, Pl. 2, Fig. 5. |

Types: A series of fragments is preserved in the type collection of the Geological Survey of Sweden (KENNEDY et al., 1995: 430). The types were figured and a lectotype designated in KENNEDY & CHRISTENSEN (1997: 107, Text-Fig. 24 A).

Material: SK/SG/1992/11, SK/SG/1996/18, SK/SG/2002/33, SK/SG/2006/41, all from the late Santonian Sandkalkbank Member of the Hochmoos Formation, SK/SG/1996/20, 22 and NHMW 2010/0081/0006 from the late Santonian *Micraster* Bed of the Bibereck Formation, all from the Schattaugraben section, furthermore NHMW 1978/1963/0029, the original of SUMMESBERGER (1979: Pl. 3, Fig. 21) from the late Santonian Sandkalkbank Member of the nearby Finstergrabenwandl locality (Gosau, Upper Austria). A further fragment at our disposal is NHMW 2010/0083/0002 (2011/0054/0006) from the neighbouring late Santonian locality Gosauschmied (Gosau, Upper Austria). Three specimens from the early Santonian Brandenberg/Mühlbach site (Tyrol) figured by IMMEL et al. (1982: M 12, the original of Pl. 10, Fig. 5, BSP, 1963 XXX 30), the original of IMMEL et al. (1982: Pl. 10, Fig. 6), and with some doubt M 14, the original of IMMEL et al. (1982: 10, Fig. 7).

Description: SK/SG/2002/33 from the Schattaugraben section provides a fairly complete view of an adult individual (Pl. 12, Fig. 13). The open criocone coil ($Wd_{est} = 36$ mm) of the phragmocone is followed by a straight shaft of about 75 mm length. The preserved part of the shaft is slightly curved at the adapertural end suggesting a terminal hook. A body chamber fragment possibly belonging to the specimen mentioned, is preserved on the same slab. The embryonic part is missing. The preserved parts of the individual are bilaterally symmetrical. NHMW 1978/1963/0029, the original of SUMMESBERGER (1979: Pl. 3, Fig. 21) from the late Santonian Sandkalkbank Member of the Finstergrabenwandl at the adapical part of the figured plaster cast also shows the beginning of a curvature leading to the initial criocone coil. All individuals are deformed by lateral compaction suggesting an originally round or high oval cross section. The surface is covered by regular narrow sharp delicate, slightly rursi- to rectiradiate ribs increasing regularly in strength through ontogenesis. The ribs cross the dorsum and the venter without interruption. There are no bifurcations nor intercalatories. Rib index at a tentatively restored section is, reduced with age, approximately 9 in the final stage but about 14 in the curved parts in the initial coil. A straight fragment of the shaft of 61 mm length from the *Micraster* Bed of the Schattaugraben section sequence (SK/SG/1996/18) suggests its prorsiradiate ribbing being possibly caused by distortion. There are no sutures visible.

Discussion: A redescription of MOBERG's (1885) original was given by KENNEDY (1995: 430). None of the specimens from the Corbières provides the complete view of the shell. The specimen from the Schattau and the individual from Westphalia figured by KENNEDY in KENNEDY & KAPLAN (2000: Pl. 34, Fig. 2) confirm the opinion (KENNEDY, 1995), that fragments of the criocone part and fragments of the straight shaft belong together. The Westphalian specimen supports our view, that the adult individual had a final hook after the straight shaft. The juvenile portion is visible on neither specimen. We agree with KENNEDY (1995: 430), that the late Maastrichtian taxa *Diplomoceras (Glyptoxoceras) subcompressum* (FORBES, 1846) and *Diplomoceras*

(*Glyptoxoceras*) *indicum* (FORBES, 1846) from India are not present in the early Santonian of Brandenberg (Tyrol) (IMMEL et al., 1982: 26, Pl. 9, Figs. 4, 5, Pl. 10, Figs. 5–7, Pl. 11, Fig. 4). As none of the specimens figured, none of the Austrian specimens nor Moberg's types (MOBERG, 1885: Pl. 3, Fig. 12) show rib bifurcations, we doubt also the assignment of the Brandenberg specimens (IMMEL et al., 1982: 26, Pl. 9, Figs. 4, 5, Pl. 11, Fig. 4) to *Glyptoxoceras crispatum* (MOBERG, 1885) as suggested by KENNEDY (1995: 430).

Glyptoxoceras aquisgranense (SCHLÜTER, 1872) from the lower Campanian Vaals Formation (Germany, Belgium) and from Ariège (France; KENNEDY et al., 1992) differs by its open planispiral adult stage and by the absence of straight portions apart from the initial shaft.

Glyptoxoceras rubeyi (REESIDE, 1927) from the Pierre Shale of Wyoming has an open elliptical coiling in a single plane. Specimens figured are preserved with ammonitella. Ribbing is initially closely spaced, becoming more distant towards the aperture. Ribs are rectiradiate. Rib index changes from 4 to 5. The specimens are very small, the most complete one measures 22 mm in length.

Glyptoxoceras roemerii (GEINITZ, 1849) from the Vaals Formation of the Aachener Kreide (HOLZAPFEL, 1887: Pl. 5, Figs. 4, 5) has an elliptical open coil with initially tight ribbing and increasing rib distances towards the aperture (KENNEDY in KENNEDY & KAPLAN, 2000: Pl. 35, Fig. 5).

Glyptoxoceras vaalsiensis (HOLZAPFEL, 1887: Pl. 5, Figs. 6, 7) from the Vaals Formation of the Aachener Kreide is known from fragments only, indicating an open criocone or elliptical coil with strong narrow spaced rectiradiate ribs.

Glyptoxoceras novimexicanum (REESIDE, 1927) from the upper part of the Mancos Shales in New Mexico is a large taxon, with criocone or elliptical coiling, straight and distant ribs which appear to be prorsiradiate (REESIDE, 1927: Pl. 4, Figs. 1–3). If REESIDE's other specimens (Pl. 4, Figs. 5, 6) also belong to this species, it also has straight shafts and at least one hook.

Glyptoxoceras sp. (*Hamites* sp.) REESIDE (1927: Pl. 4, Figs. 7, 8 only) from the same locality as his Figs. 1–4 on the same plate is a short straight fragment with more distant ribbing.

Glyptoxoceras sp. (*Hamites* sp.) REESIDE (1927: Pl. 4, Figs. 9, 10 only) is a curved fragment with narrow spaced prorsiradiate ribbing.

Fragments of *Glyptoxoceras ellisoni* YOUNG 1963 from the lower Campanian Dessau limestone of Texas (Austin Chalk) are larger and have blunt rectiradiate ribs (rib index 4) weakening on the dorsum. The shape of the complete individual is unknown, fragments are straight or slightly curved suggesting a complex shape of the whole shell.

Glyptoxoceras octostriatum (COLLIGNON, 1969) is larger with sharp regularly spaced annular ribs. Individuals figured by KLINGER & KENNEDY (2003: Figs. 56A, B, D, E, F) are slightly curved. A single one (Fig. 56D) has a curved adapical portion suggesting two parallel shafts. Nevertheless, the shape of the complete shell is unknown.

Glyptoxoceras souqueti COLLIGNON, 1983 from the middle and upper Santonian of the Corbières differs in the absence of straight portions. It has an irregular elliptical coiling and coarser ribbing (KENNEDY, 1995: 430).

Glyptoxoceras texanum KENNEDY, LANDMAN & COBBAN, 2001 from the late Santonian Blossom Sand (Austin Chalk) of Texas is based on a relatively large body chamber fragment with rursiradiate ribbing and constrictions. The rib index is 6–10, the ribs are crowding towards the aperture.

Neoglyptoxoceras retrorsum (SCHLÜTER, 1872) from the Campanian of Germany and France is much larger and possibly criocone (KENNEDY, 1986: 106, Pl. 16, Figs. 1–4, 6, 7, Pl. 17, Figs. 1, 2).

As already stated by KENNEDY (1995: 430) *Diplomoceras* (*Glyptoxoceras*) *indicum* (non FORBES, 1846), (IMMEL et al., 1982: 26, Pl. 10, Figs. 5–7) would be better assigned to *Glyptoxoceras crispatum* than to the late Maastrichtian species.

Diplomoceras (*Glyptoxoceras*) *subcompressum* (FORBES, 1846), (IMMEL et al., 1982: 26, Pl. 9, Figs. 4, 5, Pl. 11, Fig. 4) was put in synonymy with *Glyptoxoceras crispatum* (MOBERG, 1885) by KENNEDY (1995: 430). We doubt this, as the ribs of these specimens figured partially bifurcate.

Occurrence: Early Santonian of Eriksdal (Sweden) and Brandenberg (Austria); from early Santonian *carezi* Subzone to the middle Santonian *gallicus* Subzone of the Corbières, France. Late Santonian Zone of *Boehmoceras arculus* (sensu KAPLAN in KENNEDY & KAPLAN, 2000) in Westphalia and late Santonian Zone of *Boehmoceras arculus*, *Placenticeras paraplanum* and *Marsupites testudinarius* in the Schattaugraben section (Austria).

Fragmentary *Glyptoxoceras*

Individuals of *Glyptoxoceras* from the Schattaugraben that are too fragmentary to identify specifically are shown in Plate 13 from Figure 1 to 15, and in Plate 14 from Figure 1 to 6.

The sequence includes numerous fragments of *Glyptoxoceras* that differ in coiling mode, rib style and density. The nature of the material is such that we cannot establish the extent of intraspecific variation, or how many species are present. The material falls into four groups:

Glyptoxoceras group 1 differs by coarser ribbing, rib index being about 6. *Glyptoxoceras* group 2 differs by wider spaced ribbing and generally smaller dimensions. *Glyptoxoceras* group 3 differs by its smaller dimensions and by development of hooks in a stage of growth, where *G. crispatum* is criocone. *Glyptoxoceras* group 4 differs by narrowing of rib distances towards the aperture (all are described below).

Group 1

Pl. 13, Fig. 1

Material: A single specimen, MA 1976/16 from the *Paraplanum* Subzone of the Schattaugraben section (Hochmoos Formation, Gosau Group; Rußbach, Salzburg, Austria).

Description and discussion: MA 1976/16 is a fragment of a straight shaft (L 40 mm) with indication of curvature at one end. It is an internal mould with subcircular whorl section and adherent white powdery shell. It has regularly arranged rectiradiate annular sharp ribs, somewhat narrower than the interspaces. The rib index is 6. The suture is not visible. This poor fragment does not allow specific identification but it is clearly belonging to the present genus.

It differs from *Glyptoxoceras crispatum* (MOBERG, 1885) in its wider rib interspaces. It differs from group 2, 3 and 4 described below in its larger size.

Similar fragments occur in the early Campanian Vaals Formation of Belgium (JAGT, 1989).

Group 2

Pl. 13, Figs. 3–9

Material: Seven specimens: SK/SG1998/27, SK/SG/2006/40, SK/SG/2007/48; NHMW 2006z0203/0004-0005; NHMW 2011/0054/0004 (ex collection Skoumal), all from the Schattaugraben section (Rußbach, Salzburg). NHMW 2011/0054/0005 from the locality "Gosauschmied" (Gosau, Upper Austria) close to the Schattaugraben. One unregistered specimen from the Skoumal collection.

Description: All specimens are slightly curved fragments of internal moulds indicating a criocone shape of the shell. All are preserved with adherent white or yellowish remnants of chalky shell. The length of the fragments is from 18 to 42 mm. NHMW 2006z0203/0004 consists of two fragments, 42 and 28 mm long suggesting a circular whorl of about 50 mm diameter. SK/SG/1998/27 (Pl. 13, Fig. 9) is a fragment of a tightly coiled initial helix of about 25 mm diameter with a wide apical angle. It consists of three visible whorls. All specimens are deformed to different degrees. The whorl section appears to have been circular with a restored Wh of 4–9 mm. The rectiradiate to prorsiradiate ribs are narrow and widely spaced; the rib index is between 4 and 5. The ribs and interspaces are equal or subequal. A few individuals have one or two accentuated ribs or irregularly wider interspaces.

Discussion: The identic style of ribbing leads to the conclusion that the initial helix (SK/SG/1998/27) and the gently curved body fragments are parts of a criocone heteromorph ammonite. The connection between helix and adult part of the shell remains unknown, as is the shape of body chamber and aperture.

Group 3

Pl. 13, Figs. 10–15, Pl. 14, Figs. 1–6, Tab. 12

Material: 11 specimens from the *Micraster* Bed of the Bibereck Formation of the Schattaugraben section: NHMW 2006z0203/0001–0003, NHMW 2006z0203/0007, NHMW

2011/0054/0002, SK/SG/1992/13, 16, SK/SG/1994/17, SK/SG/2002/34, SK/SG/2006/42, 43, SK/SG2009/50 and one from the Gosauschmied site: NHMW 2011/0153/0001.

Description: All specimens are fragments of small individuals from 26 to 33 mm length, all have a straight or slightly curved shaft. All but a single one have a hook at the adapertural end. NHMW 2006z0203/0002 has a hook at its adapical end. All are internal moulds with adherent remnants of shell. There is no embryonic part preserved, and no sutures are visible. All are laterally crushed. Whorl height is from 3 to 5 mm. The Wh data (Tab. 12) are slightly restored. The ribs are sharp and narrow, the interspaces somewhat wider than the ribs. Where the shell is preserved (SK/SG/1994/17, SK/SG/2006/43) rib section is more rounded and ribs and interspaces are of equal width. Rib density is about 10 per cm, rib index is from 3 to 6 (Tab. 12). Ribs are prorsiradiate on the shaft and recti- to rursiradiate (NHMW 2011/0054/0002) on the hook. All ribs are equally shaped, none are collared, flared, or bifurcating. They cross venter and dorsum without interruption. On the hooks the interspaces are becoming somewhat wider with the exception of SK/SG/1992/16. This specimen has also a single constriction and a distinct collar rib. SK/SG/2006/42 is an elliptoidal fragment changing from narrow to wider spaced ribbing with age. None of the specimens has a visible suture.

Discussion: Corresponding shape and identic style of ribbing leads to the conclusion that all specimens belong together to a group of *Glyptoxoceras*, which is clearly separated from other heteromorphs of the Schattaugraben sequence.

Group 4

Pl. 13, Fig. 2

Material: A single fragment NHMW 2006z0203/0006 from the *Micraster* Bed of the Schattaugraben.

Description: NHMW 2006z0203/0006 is a straight fragment of 28.8 mm length. Wh_{rest} is from 5.1 to 5.9 mm. Rib density changes from rib index 4 to 6 towards the aperture. Ribs are circular, undivided and (due to deformation?) prorsiradiate. The preserved fragment of the shaft is characterised by a major change in ribbing. At the adapical part interspaces are rather wide. After a distinct constric-

| Inventory No. | Ribs on shaft | Ribs on hook | Index shaft | Index hook | W _{est} (mm) |
|---------------------|--------------------|--------------|-------------|------------|-----------------------|
| SK/SG/1992/13 | prorsiradiate | rectiradiate | 5–6 | 3–4 | 5 _{est} |
| SK/SG/1992/16 | prorsiradiate | recti/rursi | 4 | 5 | 4 _{est} |
| SK/SG/2002/34 | prorsiradiate | rectiradiate | 3 | 3–4 | 4 |
| NHMW 2011/0054/0002 | prorsiradiate def. | rursiradiate | 3 | 3–4 | > 3 |
| NHMW 2006z0203/0001 | rectiradiate | rectiradiate | 4 | 4 | 4.6 _{est} |
| NHMW 2006z0203/0002 | prorsiradiate | rectiradiate | 4 | 4 | 4–5 |
| SK/SG/1994/17 | rectiradiate | rursiradiate | 5 | 4 | 4 _{est} |

Tab. 12.

Rib direction and rib indices of *Glyptoxoceras* group 3 in relation to whorl height. est = estimated.

tion followed by a collar rib the ribs become successively denser towards the aperture. The adapertural end seems to be preserved.

Discussion: The unique case of denser ribbing towards the aperture is an indication to keep NHMW 2006z0203/0006 separated from the other representatives of the genus. Further studies might see this in a different light (pathological?).

Genus *Schlüterella* WIEDMANN, 1962

Type species: *Ancycloceras pseudoarmatum* SCHLÜTER (1872) by original designation.

Schlüterella sp. indet. 1

Pl. 14, Fig. 7

Material: MA 1976/17, a single specimen from the Schattaugraben section.

Description: MA 1976/17 is a hook-shaped laterally compressed fragment of the terminal part of the body chamber, with the aperture apparently preserved. The internal mould with adherent whitish shell measures about 70 mm in length, measured along the venter about 90 mm. Wh_{def} 26 mm, Wb_{def} about 15 mm. The restored section may have been rounded or slightly compressed oval and of approximately 20/22 : 18/20 mm. The shape of the complete shell cannot be established. The narrow sharp single ribs appear to have been rursiradiate, possibly a result of *post mortem* deformation. Ribs and interspaces are equal. The rib index is about 8 per cm, counted at midflank, and the rib distances are narrowing towards the dorsum (about 10/cm) and widening towards the venter (6/cm). The ribs are slightly curved with a convexity at midflank, crossing the dorsum and venter without effacing. Two wider interspaces indicate the proximity of the aperture. A few bases of spines are preserved, apparently indicating (Pl. 14, Fig. 7a) four irregular rows in a ventrolateral position without tuberculation on the flanks. The ribs are not arranged in looped pairs, but sometimes crowded at the position of the tubercles.

Discussion: Despite its bad preservation the distinct features of the sculpture separate the specimen from all the described heteromorphs of the Santonian Gosau Group. *Schlüterella compressum* KLINGER, 1976 from the early Santonian of Brandenberg (IMMEL et al., 1982: 25, Pl. 9, Fig. 3, Pl. 10, Figs. 1–4, Pl. 11, Fig. 3) differs in its coarser ribs which are connected in pairs by rib-loopings. Its narrowly spaced tubercles are arranged in four regular rows which are placed laterally and ventrolaterally. *Neocrioceras maderi* IMMEL et al., 1982 (24, Pl. 9, Fig. 2, Pl. 11, Figs. 1, 2) from the early Santonian of Brandenberg is more densely ribbed and tuberculated more regularly. An undescribed fragment (MA 1976/18) of loosely elliptoidal (cricone?) shape from the lower Santonian of the Tiefengraben (Gosau, Upper Austria) is distinguished by having only two rows of tubercles in more regular distances in ventrolateral position. SK/SG/1992/12 provisionally treated separately (see below) under *Schlüterella* sp. indet. 2 differs in its wider

spaced ribbing. *Neocrioceras (N.) spinigerum* (JIMBO, 1894) differs in its rapidly increasing whorl height and breadth and its coarse tuberculation.

Occurrence: Late Santonian Zone of *Placenticeras paraplanum* and *Boehmoceras arculus* (Hochmoos Formation, Gosau Group, Austria).

? *Schlüterella* sp. indet. 2

Pl. 14, Fig. 8

Material: A single fragment SK/SG/1992/12.

Description: SK/SG/1992/12 is a poor fragment of the terminal part of the body chamber of a loosely coiled heteromorph ammonite. It has about five sharp and undivided ribs per cm separated by somewhat wider interspaces. Only two tubercles or spine bases are visible without indication how they may have been arranged. It is not possible to restore the original shape of the shell.

Discussion: SK/SG/1992/12 is referred to *Schlüterella* with some doubt. It differs from *Schlüterella* sp. indet. One by its somewhat coarser ribbing.

Occurrence: Late Santonian Zone of *Placenticeras paraplanum* and *Boehmoceras arculus* (Hochmoos Formation, Gosau Group, Austria).

Subfamily Polyptychoceratinae MATSUMOTO, 1938

Genus *Polyptychoceras* YABE, 1927

Type species: *Ptychoceras pseudogaultinum* YOKOYAMA (1890) by original designation.

Polyptychoceras sp. indet.

Pl. 12, Figs. 4, 5

Material: Two specimens, MA 1976/14, 15 from the Hochmoos Formation of the Schattaugraben.

Description: Both specimens are small internal moulds with adherent whitish shell remnants. MA 1976/14 is a 15 mm long fragment of two parallel shafts with the connecting portion preserved, 37 mm measured around the curvature. The Wh is 7.4 / 4.4 mm, the distance between the shafts is 13.3 mm, all measurements modified by compaction. The original whorl section seems to have been circular in both specimens. In MA 1976/15 (length 16 mm) only one part of the adapertural limb is preserved together with one half of the curved part. Both specimens are sharply and distantly ribbed, the ribs rectiradiate on the adapertural limb, prorsiradiate – possibly as a result of *post mortem* deformation – on the preserved adapical limb of MA 1976/14. Increasing separation of the ribs on the adapertural portion suggests the proximity of the aperture. The ribbing of MA 1976/15 seems to be rectiradiate as far as observable.

Discussion: Both specimens seem to belong to the same taxon. Being so fragmentary reference to the genus *Polypty-*

choceras can only be tentative. No comparable material is recorded so far from other Gosau occurrences. *Polyptychoceras obliquecostatum* from the upper Campanian of the Gschliefgraben (Helvetic unit, Austria) is more densely ribbed, the ribs oblique and prorsiradiate with less sharp rib-section (KENNEDY & SUMMESBERGER, 1999: Pl. 2, Figs. 1, 2, 3, 7, 8). Another indeterminate representative of Polyptychoceratae from the Gschliefgraben (KENNEDY & SUMMESBERGER, 1999: Pl. 3, Fig. 6) differs in its narrower ribbing. Apart from ontogenetic changes in ornament described by OKAMOTO & SHIBATA (1997), which cannot be observed due to fragmentary preservation, specimens of *P. pseudogaultinum* (YOKOYAMA, 1890; OKAMOTO & SHIBATA, 1997) seem to differ in their wider spaced ribs in all ontogenetic stages.

Occurrence: Schattaugraben, *Paraplanum* Subzone (Hochmoos Formation, Gosau Group, Austria).

Family Baculitidae GILL, 1871

Genus *Baculites* LAMARCK, 1799

Type species: *Baculites vertebralis* LAMARCK (1799) by subsequent designation of MEEK (1876).

Baculites fuchsi REDTENBACHER, 1873

Pl. 15, Fig. 4

- 1873 *Baculites fuchsi* REDTENBACHER: 134, Pl. 30, Fig. 15.
- 1979 *Baculites fuchsi* REDTENBACHER; SUMMESBERGER: 113, Pl. 1, Figs. 2–4, Text-Figs. 2, 3 [with synonymy].
- ? 1979 *Baculites* cf. *fuchsi* REDTENBACHER; SUMMESBERGER: 115, Pl. 1, Figs. 5–7, Text-Fig. 4.
- 1982 *Baculites fuchsi* REDTENBACHER 1873; IMMEL et al.: 28, Pl. 11, Fig. 8.
- 1987 *Baculites fuchsi* REDTENBACHER 1873; IMMEL: 129.
- 2017b *Baculites fuchsi* REDTENBACHER, 1873; SUMMESBERGER et al.: 119, Pl. 10, Figs. 1–15, Text-Fig. 6.
- 2017c *Baculites fuchsi* REDTENBACHER, 1873; SUMMESBERGER et al.: 129, Fig. 7/2, 3.

Type: The holotype by monotypy is REDTENBACHER's original specimen (1873: 134, Pl. 30, Fig. 15) preserved in the collections of the NHMW (NHMW 1865/0001/0138) and refigured here (Pl. 15, Figs. 4a–c).

Material: Besides the type specimen: SK/1977/5, figured by SUMMESBERGER (1979: Pl. 1, Figs. 2–4, Text-Figs. 2, 3).

Description: The holotype is a crushed body chamber fragment, 63 mm long with the aperture and the original nacreous shell preserved. The whorl section appears to have been compressed, with a broadly rounded dorsum and a narrowly rounded venter, with traces of sulci parallel to the venter. SK/1977/5 is an internal mould and 200 mm long, the whorl section (SUMMESBERGER, 1979: Text-Fig. 2) is identical with that of the holotype. The restored shell must have measured 700 mm in length (SUMMESBERGER, 1979: 114) based on the 3° angle of taper. Ornament consists of growth striae and narrow ribs of variable strength. These form a strong convexity on the dorsum, strengthen-

ing across the dorsolateral shoulder into concave crescentic ribs and striae on the dorsal third of the flank (Pl. 15, Figs. 4a–b) eventually running subparallel to the venter. They then cross the venter in a narrow convexity (Pl. 15, Figs. 4a–c). The aperture runs parallel to these ribs and striae and in consequence bears a long ventral rostrum.

Discussion: *Baculites fuchsi* REDTENBACHER, 1873 differs from *Baculites* sp. indet. One described below by the smooth shell of the latter and its apparently compressed oval whorl section without keel. *Baculites* cf. *tanakae* MATSUMOTO & OABA, 1963, figured by SUMMESBERGER (1979: Pl. 2, Figs. 10–13, Text-Fig. 6) differs by its irregular ribbing and bullate tuberculation. *Baculites sulcatus* BAILY, 1855, which occurs in the *Micraster* Bed of the Bibereck Formation, differs in its much smaller and curved body chamber, much stronger bullate and U-shaped ribs. *Baculites* sp. from the Finstergrabenwandl (SUMMESBERGER, 1979: 116, Pl. 1, Figs. 8, 9, Text-Fig. 5) differs in delicate narrow ribs on the venter.

Occurrence: The type specimen is from the early or middle Santonian of the Tiefengraben (= Grabenbach) of Gosau (Upper Austria). Another individual from the early Santonian is described by IMMEL et al. (1982) from the Mühlbach locality at Brandenberg (Gosau Group, Tyrol). The specimen described by SUMMESBERGER (1979: Pl. 1, Figs. 2, 3, 4, Text-Figs. 2, 3) is from the late Santonian of the Fins-tergrabenwandl (Gosau, Upper Austria).

Baculites sulcatus BAILY, 1855

Pl. 16, Figs. 1–3, Tab. 13

- 1855 *Baculites sulcatus* BAILY: 457, Pl. 11, Fig. 5c.
- 1977 *Baculites sulcatus* BAILY, 1855; KLINGER & KENNEDY: 75, Figs. 3B–E, J–L.
- 1997a *Baculites sulcatus* BAILY, 1855; KLINGER & KENNEDY: 111, Figs. 63–66, 67A–D, 68–77, 78C [with full synonymy].

Type: The lectotype, designated by Woods (1906), is the specimen figured by BAILY (1855: Pl. 11, Fig. 5c). See the discussion of KLINGER & KENNEDY (1997a: 118ff.).

Material: Five individuals, SK/SG/1998/26, SK/SG/1996/21, NHMW 2006z 0203/0011 from the *Micraster* Bed of the Bibereck Formation (Gosau Group; Schattaugraben), NHMW 2006z0203/0013 apparently from the Sandkalkbank Member of the Schattau and SK/SG/1990/7 from the late Santonian of the Schattaugraben section without detailed information.

Description: All five specimens are small slightly curved fragments of internal moulds. All have adherent remnants of white or brownish shell remains. All are crushed to a certain degree. Measurements are nevertheless still useful. Wb/Wh values around 0.7 are not much compressed, whereas Wb/Wh values around 0.5 indicate considerable lateral compaction. The restored section is triangular/ovoid with rounded dorsum and a narrowly rounded venter accompanied or not by longitudinal sulci.

SK/SG/1998/26 is a fragment of the body chamber with preserved aperture and a distinct rostrum of about 10 mm length. It continues the narrow crenulated ventral keel. SK/

| Inventory No. | L _{frag} (mm) | Wh (mm) | Wb (mm) | Wb/Wh |
|---------------------|---------------------------|------------|------------|-------|
| SK/SG/1998/26 | 52.1 | 10.3 | 5.2 | 0.5 |
| SK/SG/1996/21 | 51.7 | 10.9 | 5.4 | 0.49 |
| SK/SG/1990/7 | 32 | 14.9 | 7.6 | 0.51 |
| NHMW 2006z0203/0011 | 30.7 | 10 | 7 | 0.7 |
| NHMW 2006z0203/0013 | 34.4 | 14.2 | 10.2 | 0.71 |

Tab. 13.
Measurements of *Baculites sulcatus* BAILY, 1855 fragments from the Schattau-graben, L = length.

SG/1998/26 and SK/SG/1990/7 are the only specimens with a distinct keel.

Most striking feature are the strong and characteristic ribs that arise strongly rursiradiate at the dorsolateral edge, sweep back across the dorsolateral margin and strengthen into concave lateral bullae. These project forwards and weaken across the flanks, producing a distinctive concave U-shaped flank ribbing, weakening and ending at the sulcus, but apparently connected with the crenulation of the ventral keel. The sculpture is relatively irregular. The dorsum may be smooth.

Discussion: *Baculites incurvatus* DUJARDIN, 1837 differs by its more or less straight shell with the exception of the body chamber close to the aperture. See the figures of DUJARDIN (1837) and d'ORBIGNY (1842) refigured by KENNEDY (1984: Text-Fig. 41) and the photographs of the lectotype: KENNEDY (1984: Pl. 33, Figs. 3–5). There is also a big difference in tuberculation as *B. incurvatus* has smaller, more widely separated dorsolateral conical tubercles (IMMEL et al., 1982: Pl. 10, Figs. 5–7) not comparable to the prominent bullate, laterally elongated and U-shaped (auriculate) ribs of *B. sulcatus*.

Baculites fuchsii REDTENBACHER, 1873 (Pl. 15, Figs. 4a–c) from the Santonian of the Gosau Group differs in its smooth flanks without tuberculation, the ornament limited to weak closely spaced lateral ribs that sweep over the flank in a distinct curvature, projecting strongly forward in the ventrolateral third, effacing close to the sulcus and re-strengthening over the crenulated keel, with weak ribbing over the venter (SUMMESBERGER, 1979: Pl. 1, Figs. 1–3).

Representatives of the genus *Boehmoceras* RIEDEL (1931) differ by the narrower radius of curvature of the shell combined with a greater whorl height and a more distinctly crenulated keel. Nevertheless, ornament is very close. Similarity between *Boehmoceras arculus* (MORTON, 1834) and *Baculites sulcatus* BAILY, 1855 led KLINGER & KENNEDY (1997a: 121) to their reflection about a phylogenetic relationship with *Baculites capensis* Woods, 1906 as ancestor. In short fragments differentiation from *B. arculus* is difficult to impossible.

Baculites sp. indet. 1, described below, differs in its smooth shell surface. *Baculites* cf. *tanakae* MATSUMOTO & OBATA, 1963 described from the late Santonian of the Finstergrabenwandl (SUMMESBERGER, 1979) differs in its narrower and asymmetric ribbing and its larger Wb and Wh. The specimen from the Finstergrabenwandl is laterally compressed as a result of *post mortem* crushing.

Occurrence: *Baculites sulcatus* BAILY, 1855 was described from the early Campanian of South Africa (KLINGER & KENNEDY, 1997a: 120). Its occurrence in Madagascar (COLLIGNON, 1931) was doubted by KLINGER & KENNEDY (1997a: 118). In Austria it occurs in the late Santonian Sub-zone of *Placenticeras paraplanum* and *Boehmoceras arculus* (Hochmoos and Bibereck Formations, Gosau Group). Its co-occurrence in the Schattau-graben section with the closely related *Boehmoceras arculus* (MORTON, 1834) supports the idea of a common ancestor (see above).

Baculites sp. indet. 1

Pl. 15, Figs. 1–3

Material: Six fragments: SK/SG/1990/5, NHMW 2006z0203/0007–0010, 12, all from the Upper Santonian *Micraster* Bed of the Bibereck Formation of the Schattau-graben section, Rußbach, Salzburg, Austria.

Description: SK/SG/1990/5 is a slab of matrix with three fragments of internal moulds of apparently one individual, partially preserved with adherent whitish shell. A is a body chamber fragment 46 mm long, B is a body chamber fragment 70 mm long preserved together with a part of the phragmocone, C is a 15 mm long phragmocone fragment. Wh close to the aperture is 10 mm. The total length might have been 200 mm. The angle of taper is about 3–4°. All fragments are laterally compacted, the original section seems to have been high oval without a keel. The aperture is not preserved. The surface is smooth. Faint undulations on the dorsum apart about 3 mm are visible only in extremely oblique light (Pl. 15, Fig. 3). NHMW 2006z0203/0007–0010, 12 are smooth phragmocone fragments of 11 to 60 mm length.

Discussion: *Baculites fuchsii* REDTENBACHER, 1873 (Pl. 30, Fig. 15) from the Santonian of the Gosau Group, Upper Austria) differs in its fine but distinct concave ribs, which are projected ventrally, anticipating the partially preserved rostrum. This ribbing continues over the crenulated keel and is also present on the visible part of the internal mould. The internal mould of *B. fuchsii* REDTENBACHER figured by SUMMESBERGER (1979: Pl. 2, Figs. 2–4) from the late Santonian of the Sandkalkbank Member differs in its ornamentation too, which is more undulose and indistinct than that of the type specimen with preserved shell. Late Santonian *Baculites* sp. from the Sandkalkbank Member of the Hochmoos Formation (SUMMESBERGER, 1979: Pl. 1, Figs. 8, 9, Text-Fig. 5) differs in its faint and tight accentuated riblets on the ventral third of the flank, crossing the venter without interruption and projecting towards the aperture. No distinct keel associated by ventrolateral furrows. *Baculites* cf. *tanakae* MATSUMOTO & OBATA, 1963 figured by SUMMESBERGER (1979: Pl. 2, Figs. 10–13) differs in having concave ribs with a coarse tubercle in ventrolateral position.

Occurrence: *Baculites* sp. indet. 1 occurs frequently in the *Micraster* Bed of the Bibereck Formation of the Schattau-graben section.

***Baculites cf. tanakae* MATSUMOTO & OBATA, 1963**

not figured

Compare

- cf. 1963 *Baculites cf. tanakae* MATSUMOTO & OBATA: 51.
- cf. 1979 *Baculites cf. tanakai* [sic!] MATSUMOTO & OBATA, 1963; SUMMESBERGER: 116, Pl. 2, Figs. 10–13, Text-Fig. 6.
- cf. 1997a *Baculites menabensis* COLLIGNON, 1969; KLINGER & KENNEDY: 108.
- cf. 1997a *Baculites tanakae* MATSUMOTO & OBATA, 1963; KLINGER & KENNEDY: 109.

Description: See SUMMESBERGER (1979: 116).

Discussion: The single specimen from the Finstergrabenwandl is a poorly preserved fragment, we follow KLINGER & KENNEDY (1997a: 109), interpreting *B. tanakae* as a senior synonym of *B. menabensis* COLLIGNON, 1963. As the authors suggest, further investigation is necessary to differentiate *B. menabensis* COLLIGNON, 1963, which they believe to be synonymous with a number of Madagascan species erected by COLLIGNON (1963) and with *B. incurvatus* DUJARDIN, 1837.

Occurrence: Late Santonian Sandkalkbank Member (Hochmoos Formation, Gosau Group; Finstergrabenwandl, Gosau, Upper Austria).

***Baculites* sp.**

not figured

Material: SK/1977/7, a single fragment from the Sandkalkbank Member of the Finstergrabenwandl locality.

Description: SK/1977/7 (SUMMESBERGER, 1979: 116, Pl. 1, Figs. 8, 9, Text-Fig. 5) is a 42, 2 mm long fragment of an internal mould partially covered with white chalky shell remains. It is laterally compressed by *post mortem* compaction. The original section cannot be restored. Its well-preserved suture is figured by SUMMESBERGER (1979: Text-Fig. 5).

Discussion: SK/1977/7 differs from the above described *Baculites* sp. indet. 1 by its narrow ribbing projecting over the venter.

Occurrence: Late Santonian Sandkalkbank Member (Hochmoos Formation, Gosau Group) from the Finstergrabenwandl locality (Gosau, Upper Austria).

Genus *Boehmoceras* RIEDEL, 1931

Type species by subsequent designation of WRIGHT (1957: L 220) is *Ancyloceras krekeleri* WEGNER (1905: 210, Pl. 8, Fig. 2).

***Boehmoceras krekeleri* (WEGNER, 1905)**

Pl. 16, Figs. 4–6, Tab. 14

- 1905 *Ancyloceras Krekeleri* WEGNER: 210, Pl. 8, Fig. 2.
- 1931 *Böhmoceras Krekeleri* (WEGNER); RIEDEL: 691, Pl. 77, Figs. 3–5, Pl. 78, Figs. 1, 2.
- 1957 *B. krekeleri* (WEGNER); WRIGHT: 220, Fig. 247/2.
- 1979 *Boehmoceras krekeleri* (WEGNER); SUMMESBERGER: 118, Pl. 2, Fig. 14, Text-Figs. 7, 8.
- 1983 *Boehmoceras krekeleri* (WEGNER, 1905); KENNEDY & WRIGHT: 866.
- 1985 *Boehmoceras krekeleri* (WEGNER 1905); SCHÖNFELD: 33, Pl. 2, Fig. 4.
- 1987 *Boehmoceras krekeleri* (WEGNER); KENNEDY: 778, Text-Fig. 3b [only].
- 1993 *Boehmoceras krekeleri* (WEGNER, 1905); KENNEDY & CHRISTENSEN: 150, 154, Figs. 2D–H, 4C, D, H, J.
- 1995 *Boehmoceras krekeleri* (WEGNER, 1905); KENNEDY in KENNEDY et al.: 431, Pl. 30, Fig. 37, 38, 41, 42; Text-Fig. 37.
- 1996 *B. krekeleri* (WEGNER); WRIGHT: 258, Fig. 199, 4 a–c.
- 2000 *Boehmoceras krekeleri* (WEGNER); SUMMESBERGER in EGGER et al.: 26.
- 2000 *Boehmoceras krekeleri* (WEGNER, 1905); KENNEDY in KENNEDY & KAPLAN: 110, Pl. 36, Figs. 1–6, Pl. 37, Figs. 1, 2, Pl. 38, Figs. 5–7, 12.

Type: The holotype by monotypy is the original of WEGNER (1905: Pl. 8, Fig. 2).

Material: From the Schattaugraben section: NHMW 2011/0054/0008 (ex coll. Skoumal, 2007), SK/SG/1996/25, SK/SG/1998/28; from the Finstergrabenwandl: SK/1978/5.

Description: Three specimens from the Schattaugraben section allow additional observations to those from the previously described specimen (SUMMESBERGER, 1979: 118). NHMW 2010/0081/0008 is an almost complete specimen. It is laterally compressed as a result of *post mortem* crushing and somewhat distorted. The general outline is criocone. The body chamber is preserved with the aperture, the phragmocone is heavily corroded with the suture line visible. Ribs are concave at the adapical part of the phragmocone, narrowly spaced and faint. At Wh 10 mm ornament changes into the adult style of ribbing, ribs be-

| Inventory No. | D (mm) | Wh (mm) | Wb (mm) | Wb/Wh | U (mm) | U (%) |
|---------------------|--------|---------|---------|-------|--------|-------|
| NHMW 2011/0054/0008 | 65.5 | 17.7 | 8.8 | 0.5 | 40.6 | 62 |
| SK/SG/1998/28 | 55 | 16.8 | 6.9 | 0.41 | 31.7 | 57 |
| SK/SG/1996/25 | -- | 15 | 5.5 | 0.36 | -- | -- |

Tab. 14.

Boehmoceras krekeleri (WEGNER, 1905) from the Schattaugraben section. Wb values are reduced by compaction, Wh values are exaggerated. Tentatively corrected values lead to a Wb/Wh relation of about 0.6. U % of D.

coming coarser, but flattened by *post mortem* compaction on the body chamber. SK/SG/1998/28 is a body chamber fragment with about 15 mm of the phragmocone being preserved showing the same change from the juvenile to the adult ornament. All three specimens show the distinctly crenulated keel, the crenulation linking to the ribs. The keel is flanked by ventral sulci where the ribs are partially effaced.

Discussion: *B. krekeleli* differs from *B. arculus* (MORTON, 1834) in its greater Wh and denser ribbing, whereas *B. arculus* is smaller, has a lower Wh and wider spaced strongly concave ribbing. KENNEDY & COBBAN (1991) were inclined to discuss them as terminal members of a broad intraspecific variation, sexual dimorphism was discussed by SUMMESBERGER (1979). KENNEDY in KENNEDY & KAPLAN (2000: Pl. 36, Figs. 1–6, Pl. 37, Figs. 1, 2, Pl. 38, Fig. 12) suggested dimorphism within *B. krekeleli* between a macroconch (Pl. 36, Fig. 3, Pl. 37, Fig. 2) and a microconch form. In his opinion the Schattaugraben material NHMW 2011/0054/0008 could be the macroconch, SK/SG/1996/25 and SK/SG/1998/28 could be microconchs. As the differences in the collection from Westphalia are rather small (Pl. 36, Figs. 1–6 and 37, Figs. 1–3 in KENNEDY & KAPLAN, 2000), we doubt if sexual dimorphism within *B. krekeleli* should be adopted and applied to the poor Austrian material.

Occurrence: *Boehmoceras krekeleli* (WEGNER, 1905) was originally described from the upper Santonian Recklinghäuser Sandmergel (Recklinghausen, Münster Basin, Germany) and was subsequently found in the late Santonian Gosau Group (Sandkalkbank Member of the Hochmoos Formation) of Austria (SUMMESBERGER, 1979). It occurs (KENNEDY in KENNEDY & KAPLAN, 2000) in the Westphalian late Santonian (*B. arculus*, *M. testudinarius* Zone). It was not present in the late Santonian *Boehmoceras arculus* fauna of the American Gulf Coast (KENNEDY & COBBAN, 1991). And it was also absent in the type Santonian of the Aquitaine Basin (KENNEDY, 1986, 1987) where *B. arculus* occurs. All occurrences are within the *Paraplanum/Testudinarius* Zone of the late Santonian.

Boehmoceras arculus (MORTON, 1834)

Pl. 16, Fig. 7

- 1834 *Hamites arculus* MORTON: 44, Pl. 15, Figs. 1, 2.
- 1834 *Hamites arculus* var. A; MORTON: 45.
- 1931 *Böhmoceras löscheri*; RIEDEL: 692, Pl. 78, Figs. 3–6.
- 1971 *Böhmoceras löscheri* RIEDEL; ULRICH: Pl. 5, Fig. 6.
- 1979 *Boehmoceras loescheri* RIEDEL; SUMMESBERGER: 119, Pl. 2, Figs. 15, 16, 18, Text-Figs. 9–12.
- 1983 *B. loescheri* (RIEDEL, 1931); KENNEDY & WRIGHT: 866.
- 1985 *Boehmoceras* sp.; KENNEDY: Pl. 2, Fig. 1.
- 1987 *Boehmoceras krekeleli* (WEGNER); KENNEDY: 778, Text-Fig. 3a [only].
- 1987 *Boehmoceras loescheri* RIEDEL, 1931; KENNEDY: 777, Pl. 82, Figs. 4–16, Text-Fig. 2.
- 1991 *Boehmoceras arculus* (MORTON, 1834); KENNEDY & COBBAN: 182, Fig. 6: 2; Fig. 8: 9–15, 18–22; Fig. 9: 1, 2, 11–52; Fig. 10: 21, 22, 24–26; Fig. 12: 3.

- 1993 *Boehmoceras arculus* (MORTON, 1834); KENNEDY & CHRISTENSEN: 154, Figs. 3, 4 L.
- 1995 *Boehmoceras arculus* (MORTON, 1834); KENNEDY in KENNEDY et al.: 432, Pl. 30, Figs. 39, 40.
- 1996 *B. loescheri* RIEDEL; WRIGHT: 258, Fig. 199, 4d.
- 2000 *Boehmoceras arculus* (MORTON, 1834); KENNEDY in KENNEDY & KAPLAN: 112, Pl. 37, Fig. 3, Pl. 38, Figs. 10, 11.

Type: The lectotype designated by KENNEDY & CHRISTENSEN (1993: 155, Text-Fig. 3) is the specimen figured by MORTON (1834: Fig. 3) from the Tombigbee Sand Member (Upper Santonian) of the Eutaw Formation (USA).

Material: One specimen from the Schattaugraben section: NHMW 2010/0081/0009 and four specimens from the Finstergrabenwandl: SK/1977/1, SK/1978/9, 10, 22.

Description: NHMW 2010/0081/0009 is the external mould of a criocone specimen of about 48 mm in diameter. Wh as far as measurable is from 8–12.5 mm. Ornament consists of regular alternations between two prorsiradiate and concave ribs and a third strengthened one, strengthening increasing towards the adapical end of the fragment. Maximum thickness of the ribs is midflanks, diminishing towards the venter. The distinctly crenulated keel is hardly visible in this specimen.

Discussion: Co-occurrence of *B. krekeleli* (NHMW 2011/0054/0008, SK/SG/1996/25, SK/SG/1998/28) with *B. arculus* (= *loescheri*; NHMW 2011/0054/0007) in the Sandkalkbank Member was interpreted (SUMMESBERGER, 1979: 121–122) as a pair of sexual dimorphs, *B. krekeleli* being the macroconch, *B. arculus* being the microconch. They co-occur also in the *Micraster* Bed of the Bibereck Formation (Gosau Basin, Schattaugraben, Salzburg), in Nordlünen (Germany; KAPLAN in KENNEDY & KAPLAN, 2000: 24) and Rapen (Germany; RIEDEL, 1931: 617), in Ahaus in the Münster Basin (Germany; KAPLAN in KENNEDY & KAPLAN, 2000: 10). American occurrences in the Tombigbee Member of the Eutaw Formation (Mississippi, Alabama) and in Texas comprise numerous specimens of *B. arculus* only. The Swedish occurrences of both forms are described from different levels in a borehole (KENNEDY & CHRISTENSEN, 1993). Dimorphism was suggested within *B. krekeleli* by KENNEDY in KENNEDY & KAPLAN (2000).

Occurrence: *Boehmoceras arculus* (MORTON, 1834) occurs in the *Paraplanum* Subzone (Sandkalkbank Member of the Hochmoos Formation and in the *Micraster* Bed of the Bibereck Formation) of the Gosau Group of the Schattaugraben section and at the Finstergrabenwandl (Austria). It occurs in the *Boehmoceras arculus* Zone of the Münster Basin (Westphalia, Germany), in the *Paraplanum* Subzone of the Corbières (France), in the upper Santonian of the Tombigbee Member of the Eutaw Formation (Mississippi, Alabama) and in the Santonian of Sweden. Co-occurrence with *Placenticeras paraplanum* WIEDMANN, 1978, *Marsupites* and a narrow vertical range make it a marker fossil indicating the top of the Santonian. The same index fossils are also present in the *Paraplanum* Subzone (KENNEDY, 1995: 385) of Saintes in France. In the Corbières (KENNEDY, 1995) *B. arculus* occurs already in the middle Santonian *Gallicus* Subzone.

Conclusion of Cephalopoda

Earlier misinterpretation of the Schattau locality as being of “Campanian” in age was based on the misidentification of *Placenticeras polyopsis* DUJARDIN, 1837 as *Diplacmoceras bidorsatum* ROEMER, 1841 by SUMMESBERGER (1985). In fact, there is no evidence for a Campanian part of the sequence.

Long ignored Nautilidae are partially revised or described for the first time. Remarkable is the co-occurrence of three different species of the ammonite genus *Placenticeras*, each of them represented by a pair of dimorphs. Another point of interest is the disappearance of the genus *Texanites* with its last occurrence approximately in the middle Santonian (Neffgraben). In the late Santonian Sandkalkbank Member the genus is replaced by *Reginaites*, which is the last representative of the Texanitinae in the type region of the Gosau Group. A last representative of the Muniericeratidae is the occurrence of *Texasia* near the top of the Bibereck Formation. Muniericeratidae are common in the middle Santonian of the Gosau Group (Randograben section). Another – not completely solved phenomenon – is the co-occurrence of two taxa of the genus *Glyptoxoceras* (*G. souqueti*, *G. crispatum*), with four different forms of *Glyptoxoceras* provisionally described under *G.* group 1–4. The disappearance of the genus *Scaphites* – common in the Coniacian and Campanian of the Gosau Group – is interpreted here as due to palaeoclimatic differences to the possibly cooler periods before and after the Santonian. The last representative of the genus *Scaphites* in the Santonian occurs in the middle Santonian of the Neffgraben (GERTH, 1956).

Palaeogeographic connections

The highest degree of faunistic affinity is between the late Santonian assemblages of the Schattau graben section and the late Santonian Paraplanum Subzone of the Corbières: *Gaudryceras mite*, *Parapuzosia corbarica*, *Hauericeras lagarum*, *Nowakites savini*, *Eupachydiscus isculensis*, *Placenticeras polyopsis*, *Pl. paraplanum*, *Pl. maherndli*, *Eulophoceras jacobi*, *Amapondella amapondense*, *Glyptoxoceras souqueti*, *Gl. crispatum*, *Boehmoceras krekeleri*, *Boehmoceras arculus* are 14 species contemporaneously occurring in both areas. The absence of *Scaphites* in the late Santonian of the Gosau area indicates a position within the Tethys or at least closer to Tethyan influence, whereas the Corbières are within Boreal influence.

Taxa in common with the Aquitaine basin (France; KENNEDY, 1987) are *Placenticeras polyopsis*, *Placenticeras paraplanum*, *Eulophoceras jacobi* and *Boehmoceras arculus* which are ranging from middle to late Santonian in France. Diversity in Aquitaine seems to be rather poor compared with the Corbières and the Gosau.

The occurrence of *Parapuzosia seppenradensis*, *Scalarites sertae*, *Glyptoxoceras crispatum* *Boehmoceras krekeleri* and *B. arculus* indicate a palaeogeographic connection between the Gosau area and the Münster Basin in Germany (see also SUMMESBERGER, 1979). The presence of Scaphitids indicates Boreal influence in the Münster basin.

Few indications make also a Santonian connection of the Gosau with South Africa likely (e.g. *Hauericeras gardeni* (BAILY, 1855), *Baculites sulcatus* (BAILY, 1855)).

Palaeoclimatic approach

Few palaeoclimatic indicative taxa point towards a relative warm tropical to subtropical climate during the late Santonian in the studied region: The presence of rudist bioherms in the Hochmoos Formation, the absence of Scaphitids, typical for the Boreal Realm and widespread in the Coniacian and Campanian of the Gosau Group, the occurrence of *Pleurotomaria* in the Sandkalkbank Member of the Finstergrabenwandl (KOLLMANN, 1980) is in contrary indicating cooler temperature.

List of cephalopods described from the Late Santonian *Paraplanum/Arculus/Marsupites* Zone of the Schattau graben section (Rußbach, Salzburg, Austria) and the Finstergrabenwandl locality (Gosau, Upper Austria). In bold: described in this paper.

- Eutrephoceras cf. indicum* (d'ORBIGNY, 1850)
***Eutrephoceras montiscastoris* spec. nov.**
Cimomia gosavica (REDTENBACHER, 1873)
Gaudryceras mite (HAUER, 1866)
Anagaudryceras redtenbacheri (IMMEL, KLINGER & WIEDMANN, 1983)
Pseudophyllites loryi (KILIAN & REBOUL, 1909)
Parapuzosia (Parapuzosia) corbarica (DE GROSSOURE, 1894)
? *Parapuzosia (Parapuzosia) cf. seppenradensis* (LANDOIS, 1895)
Kitchinites stenomphalus SUMMESBERGER, 1979
Hauericeras (Gardeniceras) welschi DE GROSSOURE, 1894
Hauericeras (Gardeniceras) lagarum (REDTENBACHER, 1873)
Damesites sugata (FORBES, 1846)
Damesites cf. sugata (FORBES, 1846)
Nowakites draschei (REDTENBACHER, 1873)
Nowakites savini DE GROSSOURE, 1894
Eupachydiscus isculensis (REDTENBACHER, 1873)
Pachydiscus sp. indet. juv.
Texasia dentatocarinata (F. ROEMER, 1852)
Placenticeras polyopsis (DUJARDIN, 1837)
Placenticeras paraplanum WIEDMANN, 1978
Placenticeras maherndli SUMMESBERGER, 1979
Diaziceras austriacum (SUMMESBERGER, 1979)
Eulphoeras jacobi (HOURCQ, 1949)
Reginaites gappi WIEDMANN, 1978
Nostoceratidae gen. et sp. indet.
Amapondella amapondensis (VAN HOEPEN, 1921)
Scalarites sertae (MÜLLER & WOLLEMAN, 1906)
Glyptoxoceras souqueti (DE GROSSOURE, 1894)
Glyptoxoceras crispatum (MOBERG, 1885)
Glyptoxoceras, 4 groups
Schlüterella sp. indet. 1
? *Schlüterella* sp. indet. 2
Polyptychoceras sp. indet.

- Baculites fuchsii* REDTENBACHER, 1873
Baculites sulcatus BAILY, 1855
Baculites sp. indet. 1
Baculites cfr. *tanakae* (MATSUMOTO & OBATA, 1963)

- Baculites* sp.
Boehmoceras krekeleri WEGNER, 1905
Boehmoceras arculum (MORTON, 1834)

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Plate 1

Fig. 1: *Platyceramus ahnenensis* (SEITZ, 1961); NHMW 2010/0081/0012; Bibereck Formation, *Micraster* Bed.

Fig. 2: *Cordiceramus muelleri muelleri* (PETRASCHECK, 1906); SK/B/SG/1996/3, an articulated specimen with symmetric "endocostea scars"; Hochmoos Formation, Sandkalkbank Member.

All figures are natural size. All specimens are coated with ammonium chloride and from the Schattaugraben section.



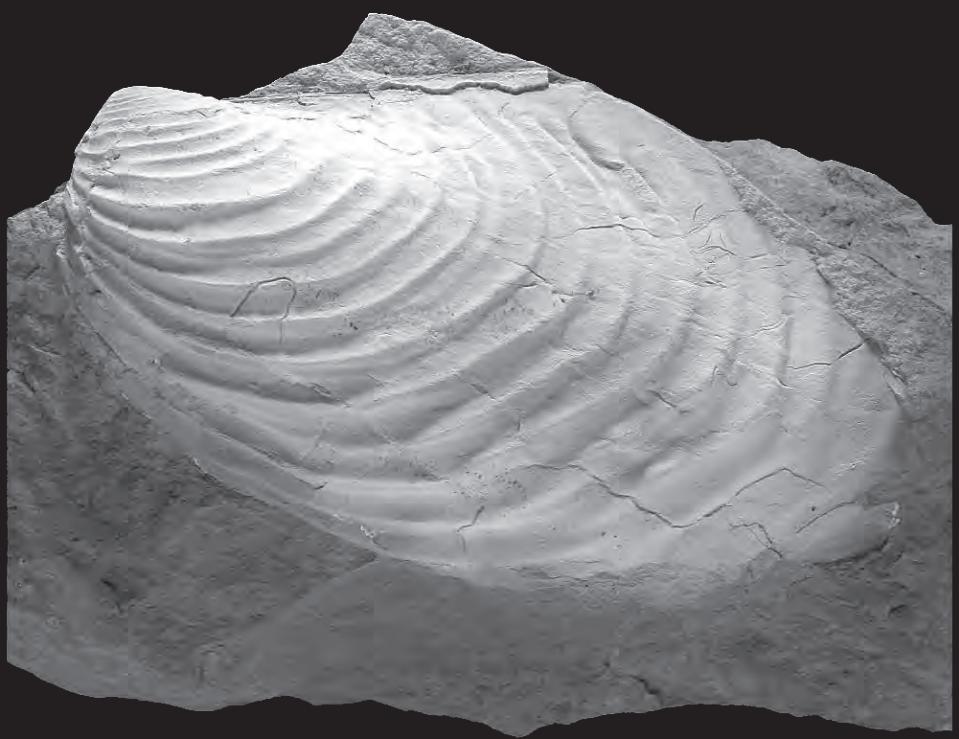
Plate 2

Fig. 1: *Cordiceramus germanicus* (HEINZ, 1928); NHMW 2010/0081/0010; Bibereck Formation, above the *Micraster* Bed on top of the section.

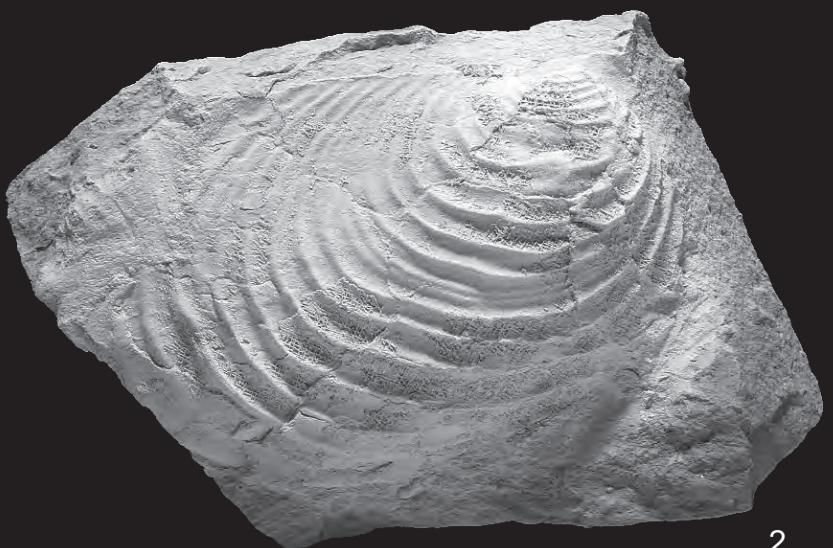
Fig. 2: *Cordiceramus bueltenensis* (SEITZ, 1961); NHMW 2010/0081/0011; Bibereck Formation, *Micraster* Bed.

Figs. 3a–b: *Sphenoceramus ex gr. cardisoides* (GOLDFUSS, 1835) / *pachti* (ARKHANGELSKY, 1916); NHMW 2010/0081/0013; Bibereck Formation, top of the section.

All figures are natural size. All specimens are coated with ammonium chloride and from the Schattaugraben section.



1



2



3a



3b

1 cm

Plate 3

- Figs. 1a–b: *Eutrephoceras cf. indicum* (d'ORBIGNY, 1850); NHMW 2009z0045/0001; Gosau Group, Schattaugraben section.
- Figs. 2a–b: *Eutrephoceras cf. indicum* (d'ORBIGNY, 1850); NHMW 2009z0046/0001; Gosau Group, without locality details.
- Figs. 3a–b: *Eutrephoceras cf. indicum* (d'ORBIGNY, 1850); NHMW 1990/0029/0515b; Hochmoos Formation, Sandkalkbank Member, Finstergrabenwandl.
- Figs. 4a–b: *Eutrephoceras cf. indicum* (d'ORBIGNY, 1850); SK/1983/14/1; Hochmoos Formation, Sandkalkbank Member, Finstergrabenwandl.
- Figs. 5a–c: *Eutrephoceras cf. indicum* (d'ORBIGNY, 1850); SK/1983/14/2; Hochmoos Formation, Sandkalkbank Member, Finstergrabenwandl.

All figures are natural size. All specimens are coated with ammonium chloride and from the upper Santonian of the Gosau Group.



— 1 cm

Plate 4

Figs. 1a–c: *Eutrephoceras cf. indicum* (d'ORBIGNY, 1850); SK/1983/14/5.

Figs. 2a–d: *Eutrephoceras cf. indicum* (d'ORBIGNY, 1850); SK/1983/14/3.

Fig. 3: *Eutrephoceras cf. indicum* (d'ORBIGNY, 1850); SK, 1983/10.

Fig. 4: *Eutrephoceras montiscastoris* spec. nov.; NHMW 2009z0048/0001; paratype.

Figs. 5a–d: *Eutrephoceras montiscastoris* spec. nov.; NHMW 1990/0029/0519/1; paratype.

Figs. 6a–c: *Eutrephoceras montiscastoris* spec. nov.; NHMW 2009z0047/0001; paratype.

All figures are natural size. All specimens (except 2d and 3) are coated with ammonium chloride and from the upper Santonian Sandkalk-bank Member of the Hochmoos Formation.

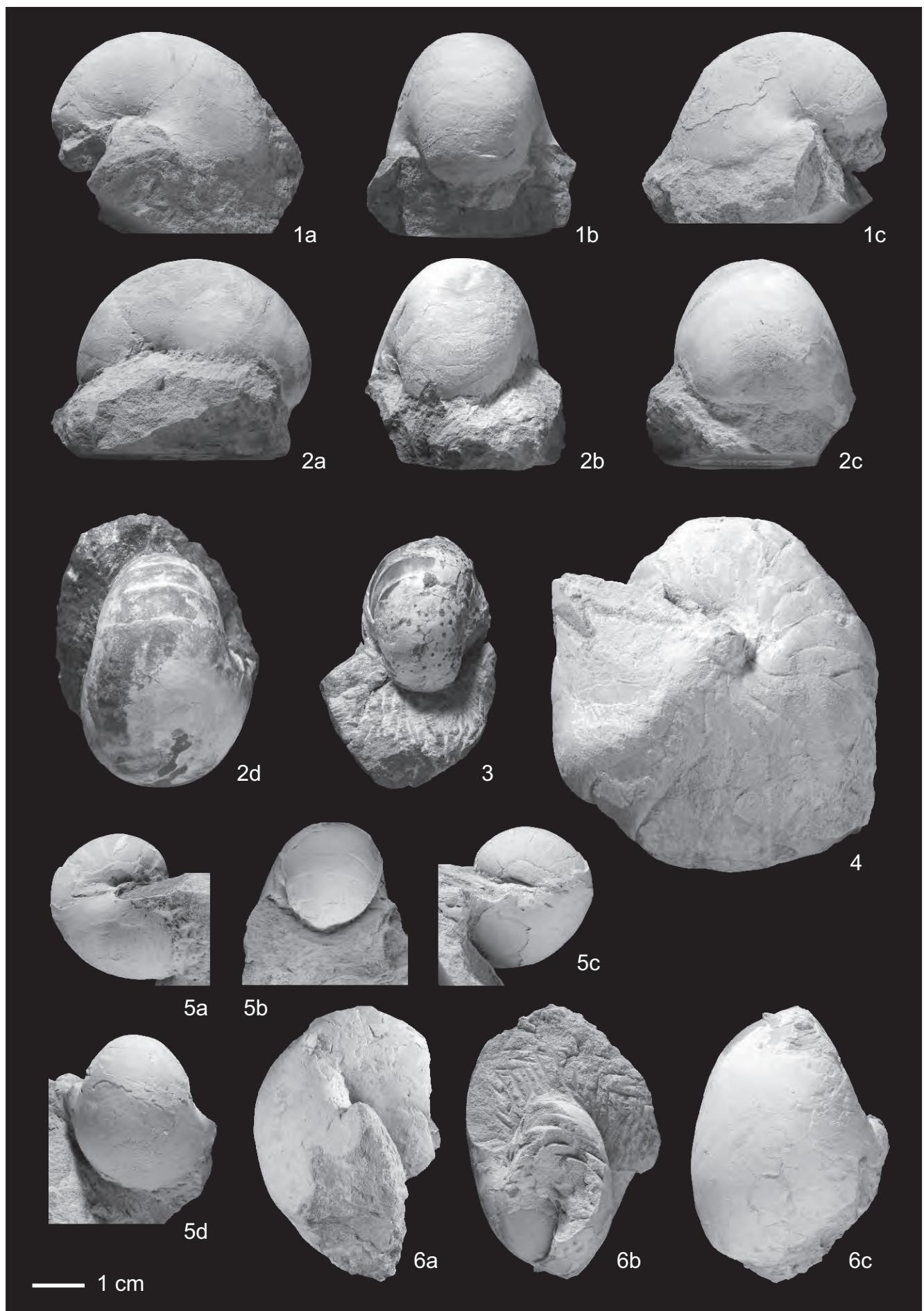


Plate 5

Figs. 1a–c: *Eutrephoceras monticastoris* spec. nov.; NHMW 1990/0029/0515a; the holotype; from Finstergrabenwandl.

Figs. 2a–b: *Eutrephoceras monticastoris* spec. nov.; SK/SG/2007/49; paratype; from the Schattaugraben section.

Figs. 3a–d: *Eutrephoceras monticastoris* spec. nov.; SK/1978/23; paratype; from Finstergrabenwandl.

All figures are 90 % of natural size. All specimens are coated with ammonium chloride and from the upper Santonian Hochmoos Formation of the Gosau Group.

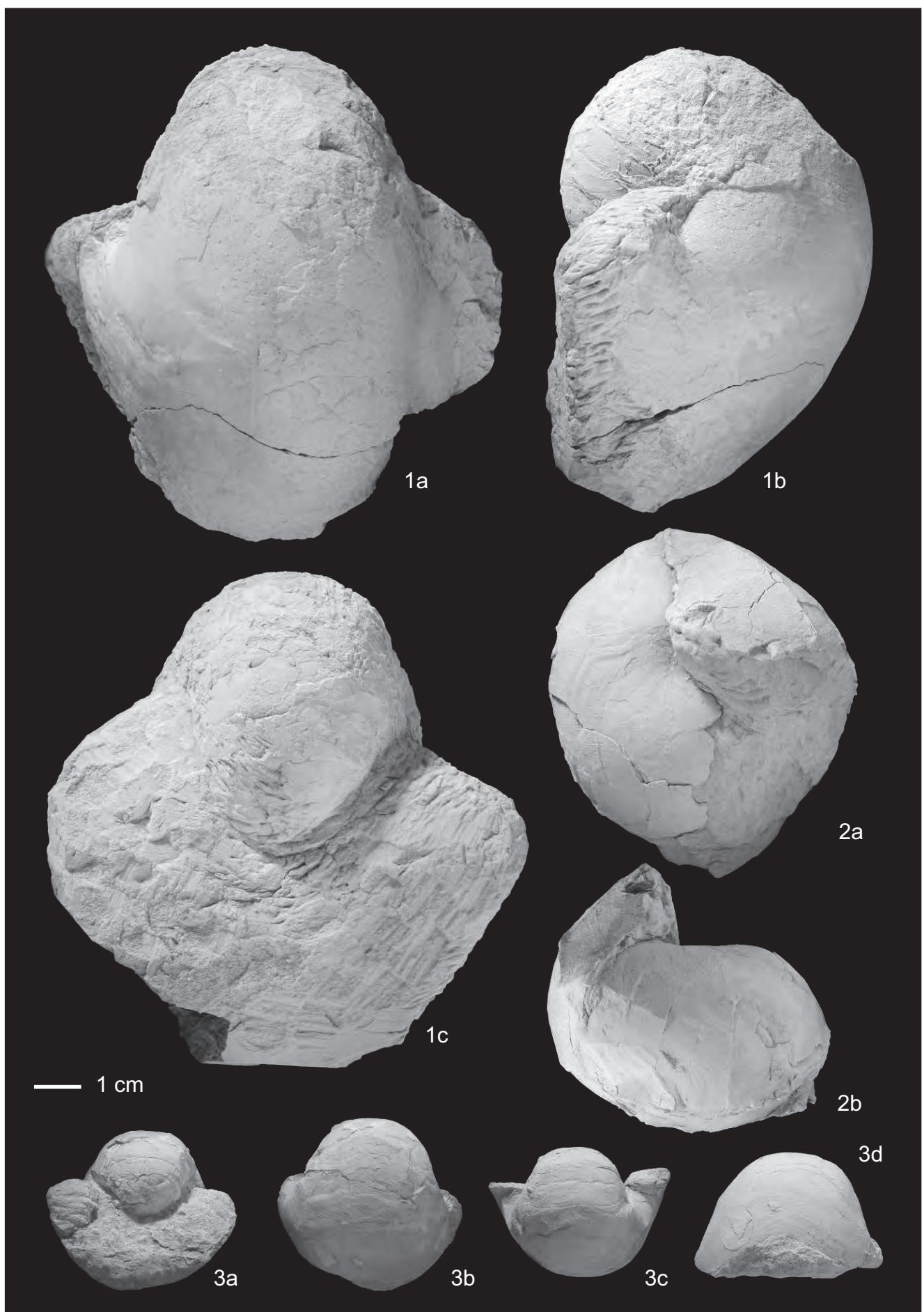


Plate 6

Figs. 1a–c: *Cimomia gosavica* (REDTENBACHER, 1873); NHMW 2009z0045/0002; from the Schattaugraben section.

Figs. 2a–d: *Cimomia gosavica* (REDTENBACHER, 1873); GBA 1873/0001/0003; the holotype of *Nautilus gosavicus* (REDTENBACHER, 1873: 96, Pl. 22, Fig. 2); from the Santonian Gosau Group of Neffgraben, Rußbach, Salzburg.

Fig. 3: *Cimomia gosavica* (REDTENBACHER, 1873); NHMW 1990/0029/0520; from the late Santonian Sandkalkbank Member of the Hochmoos Formation (Finstergrabenwandler, Gosau, Upper Austria).

All figures are 85 % of natural size. Figs. 2a–d and 3 are coated with ammonium chloride.

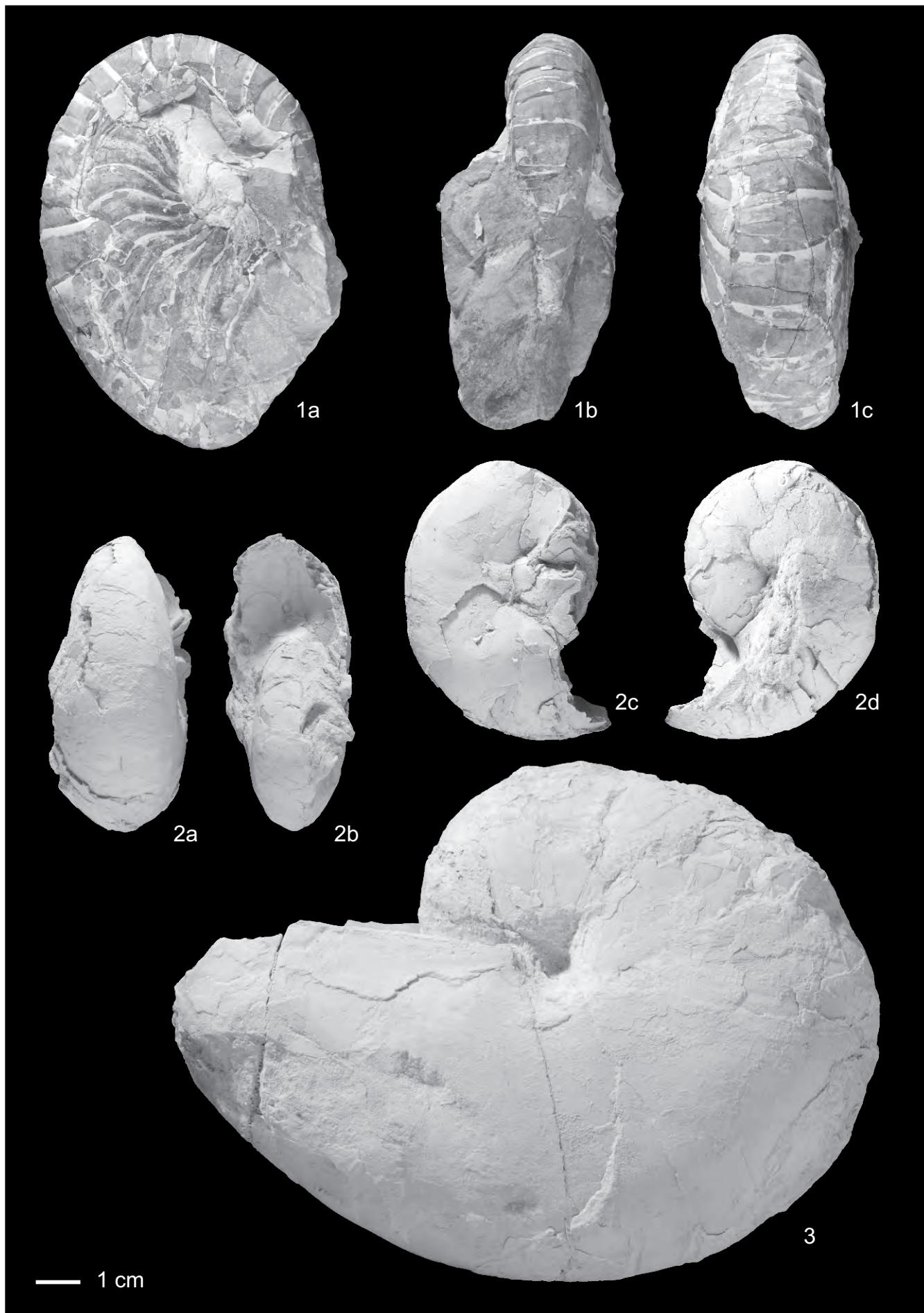
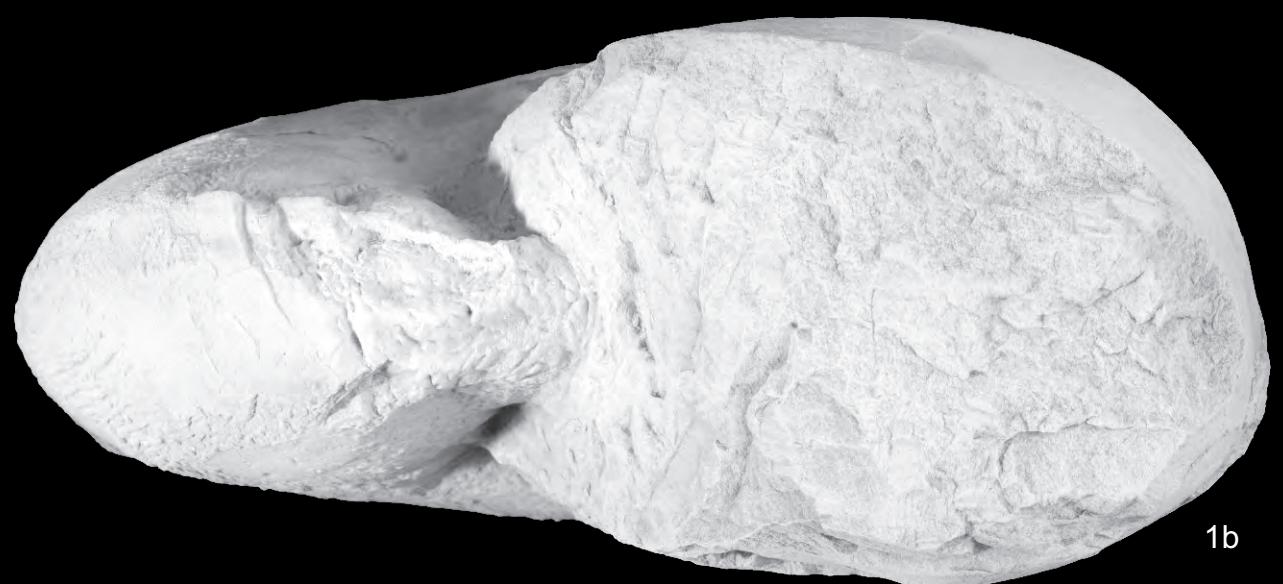
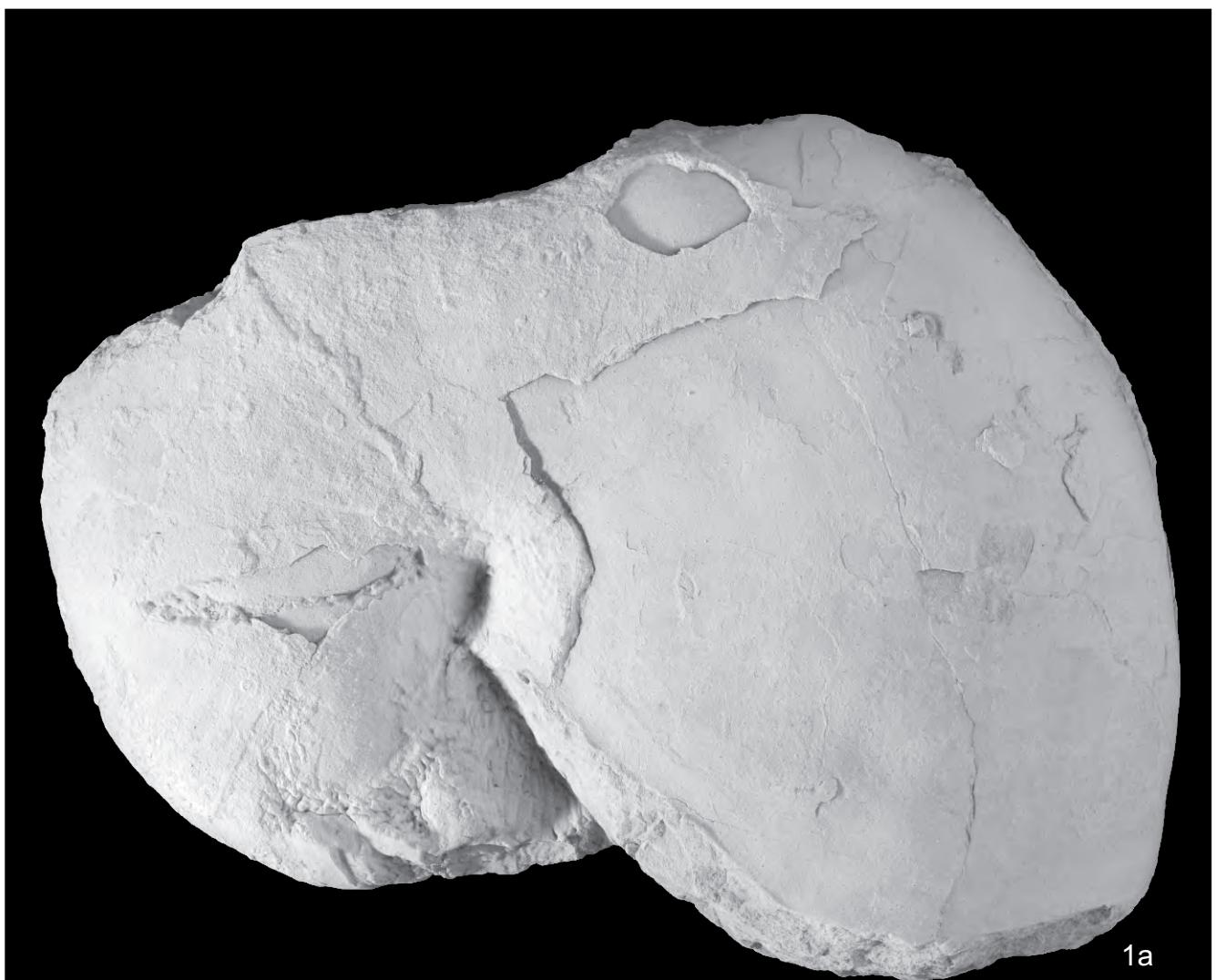


Plate 7

Figs. 1a–b: *Cinomia gosavica* (REDTENBACHER, 1873); NHMW 1990/0029/0514.

All figures are natural size. All specimens are coated with ammonium chloride and from the Upper Santonian of the Sandkalkbank Member of the Hochmoos Formation (Finstergrabenwandl, Gosau, Upper Austria).



— 1 cm

Plate 8

Figs. 1a–b: *Anagaudryceras redtenbacheri* (IMMEL, KLINGER & WIEDMANN, 1982); SK/SG/2003/38.

Figs. 2a–c: *Hauericeras (Gardeniceras) lagarum* (REDTENBACHER, 1873); NHMW 1978/1955/0001; from the Schattaugraben.

Fig. 3: *Hauericeras (Gardeniceras) lagarum* (REDTENBACHER, 1873); SK/SG/1984/3; from the *Micraster* Bed.

Figs. 4a–b: *Parapuzosia (Parapuzosia) corbarica* (DE GROSSOUVRE, 1894); NHMW 1978/1955/0003.

Fig. 5: *Pachydiscus* sp. indet. juv.; NHMW 2010/0081/0002; from the *Micraster* Bed.

Fig. 6: *Damesites cf. sugata* (FORBES, 1846); SK/SG/1992/15; from the Schattaugraben section (probably from the Sandkalkbank Member).

Figs. 7a–b: *Eupachydiscus isculensis* (REDTENBACHER, 1873); SK/SG/1990/4; from the *Micraster* Bed.

Figs. 8a–b: *Nowakites draschei* (REDTENBACHER, 1873); OÖLM 1938/30; the holotype of REDTENBACHER (1873: Pl. 30, Figs. 1a–b).

Fig. 9: *Nowakites savini* (DE GROSSOUVRE, 1894); NHMW 2010/0081/0001; from the *Micraster* Bed.

All figures are natural size and coated with ammonium chloride. All but Fig. 8 are from the *Paraplanum*-Zone of the Schattaugraben section, Fig. 8 is from the Santonian of Neffgraben west of Schattaugraben, Rußbach, Salzburg.

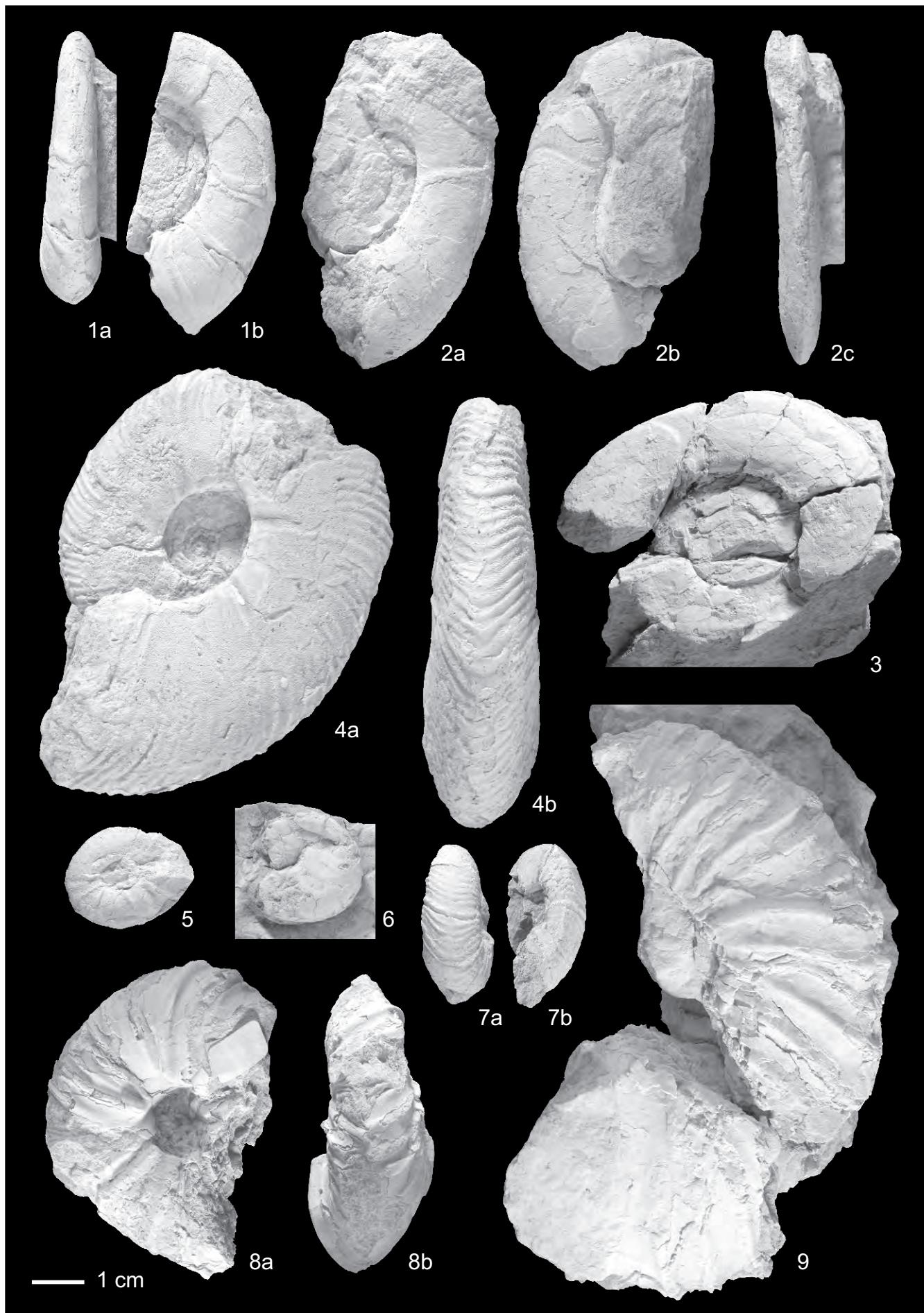


Plate 9

- Fig. 1: *Texasia dentatocarinata* (F. ROEMER, 1852); NHMW 1998z0013/0001.
- Figs. 2a–b: *Placenticeras Maherndli* SUMMESBERGER, 1979; SK/SG/1981/1; probably from the Sandkalkbank Member.
- Fig. 3: *Placenticeras polyopsis* (DUJARDIN, 1837), juv.; SK/SG/2002/35; probably from the Sandkalkbank Member.
- Fig. 4: *Placenticeras polyopsis* (DUJARDIN, 1837), juv.; SK/SG/1998/30; probably from the Sandkalkbank Member.
- Figs. 5a–c: *Placenticeras paraplanum* WIEDMANN, 1978; CG, 1978/01; the holotype of WIEDMANN (1978, Pl. 1, Figs. 3, 4).
- Figs. 6a–b: *Placenticeras polyopsis* (DUJARDIN, 1837); CG, 1978/02; the original of *Stantonoceras depressum* (HYATT) of WIEDMANN (1978: Pl. 1 Figs. 1, 2).
- Figs. 7a–b: *Hauericeras (Gardeniceras) lagarum* (REDTENBACHER, 1873); the lectotype; HNS 6391 from the Coniacian of Glanegg.

All figures are 80 % natural size and coated with ammonium chloride. All are from the *Paraplanum* Zone. Figs. 2–6 are from the Sandkalkbank Member, Figs. 1–4 are from the Schatttaugraben, from above the *Micraster* Bed, Figs. 5–6 are from the Finstergrabenwandl.

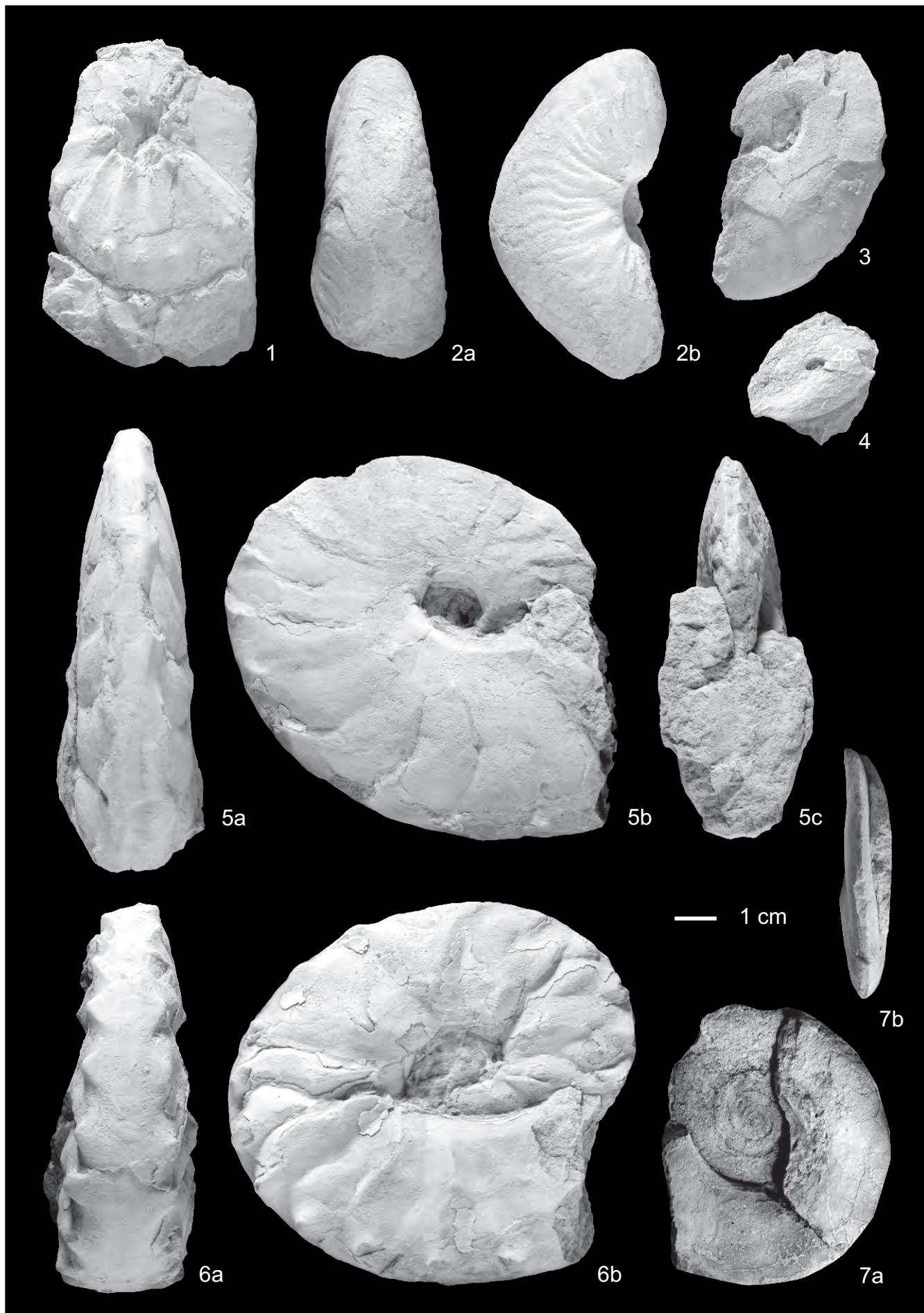


Plate 10

- Fig. 1: *Placenticeras polyopsis* (DUJARDIN, 1837); SK/SG/1998/29.
- Fig. 2: *Eulophoceras jacobi* (HOURCQ, 1949); SK/SG/1998/31.
- Fig. 3: *Eulophoceras jacobi* (HOURCQ, 1949), juv.; SK/SG/2007/44.
- Fig. 4: *Eulophoceras jacobi* (HOURCQ, 1949), juv.; SK/SG/2007/45.
- Fig. 5: *Eulophoceras jacobi* (HOURCQ, 1949), juv.; SK/SG/2002/32.
- Figs. 6a–b: *Placenticeras polyopsis* (DUJARDIN, 1837); MA 1976/19.
- Figs. 7a–b: *Reginaites gappi* WIEDMANN, 1978; NHMW 1990/0029/0526.
- Figs. 8a–b: *Reginaites gappi* WIEDMANN, 1978; the holotype; CG 03.

All figures are 75 % natural size, except Figs. 3–5, which are 150 % natural size. All are coated with ammonium chloride. Figs. 1–6 are from the Schattaugraben section, Figs. 1, 6a–b are from the Sandkalkbank Member, Figs. 2–5 are from the *Micraster* Bed, Figs. 7–8 are from the Sandkalkbank Member of the Finstergrabenwandl site. Scale bar labelled “1 cm” is valid for Figs. 1–2 and 6–8. Scale bars of Figs. 3–4 equal 5 mm.

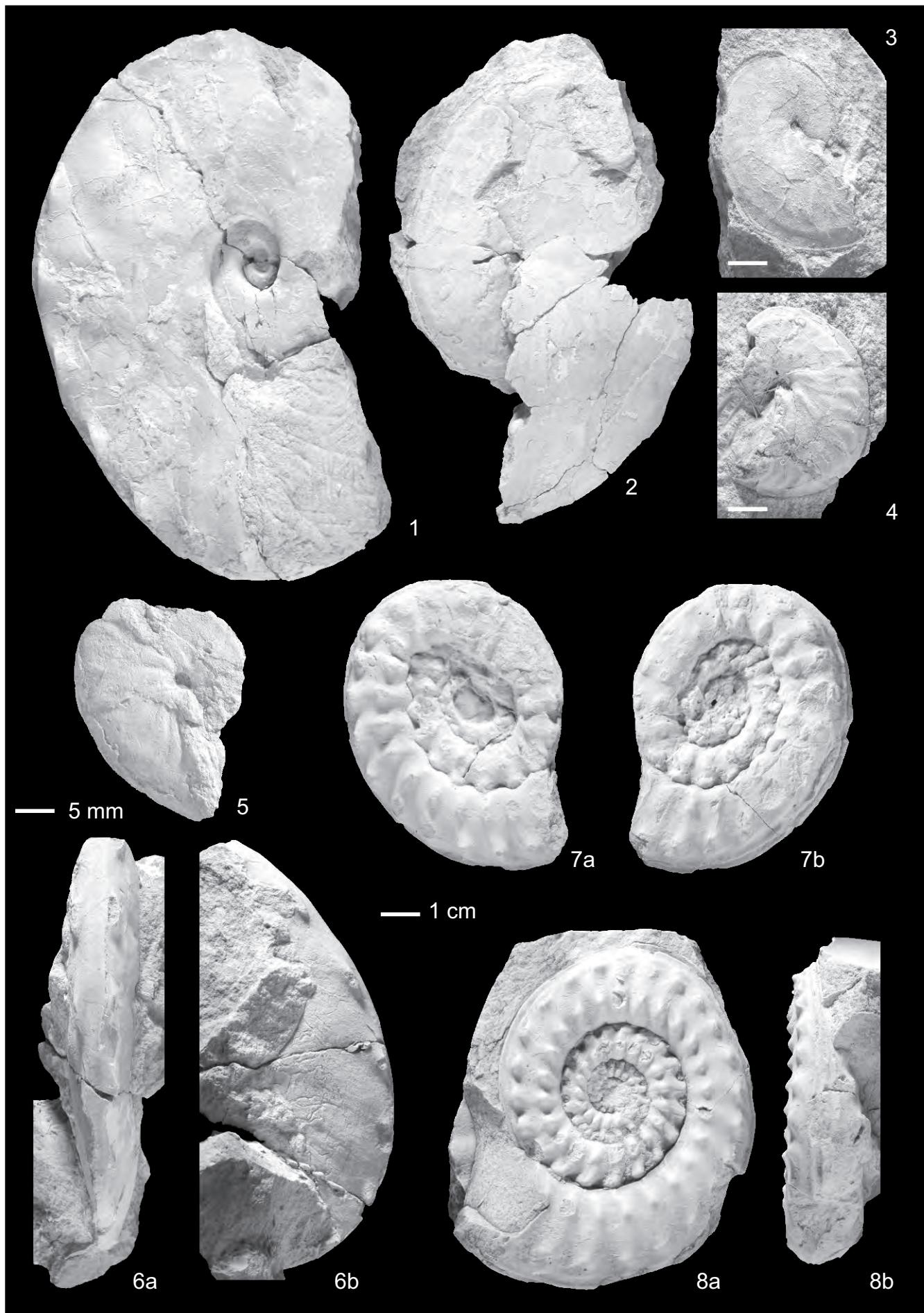


Plate 11

Figs. 1–11: *Amapondella amapondensis* (VAN HOEPEN, 1921); 1a–b: SK 2000/1; 2: MA 1976/12; 3: SK/SG/2003/37; 4: MA 1976/13; 5: NHMW 2010/0081/0003; 6: SK/SG/1992/14; 7: SK/SG/2003/36; 8: NHMW 1978/1963/0028, the original of SUMMESBERGER (1979: Pl. 3, Figs. 22, 23); 9: SK/SG/2005/39; 10a–b: SK/SG/1996/24; 11: SK/SG/1996/23.

Fig. 1 (SK 2000/1) is from the forest road at the Tauerngraben below the Finstergrabenwandl, Figs. 2–7 are from the Sandkalkbank Member in the Schattaugraben section, Fig. 8 is from the Sandkalkbank Member exposed at the Finstergrabenwandl, Figs. 9–11 are from the *Micraster* Bed in the Schattaugraben section.

All specimens coated with ammonium chloride. 1 cm-scale bar valid for Figs. 1–9 (natural size), 5 mm-scale-bar valid for Figs. 10–11 (200 %).

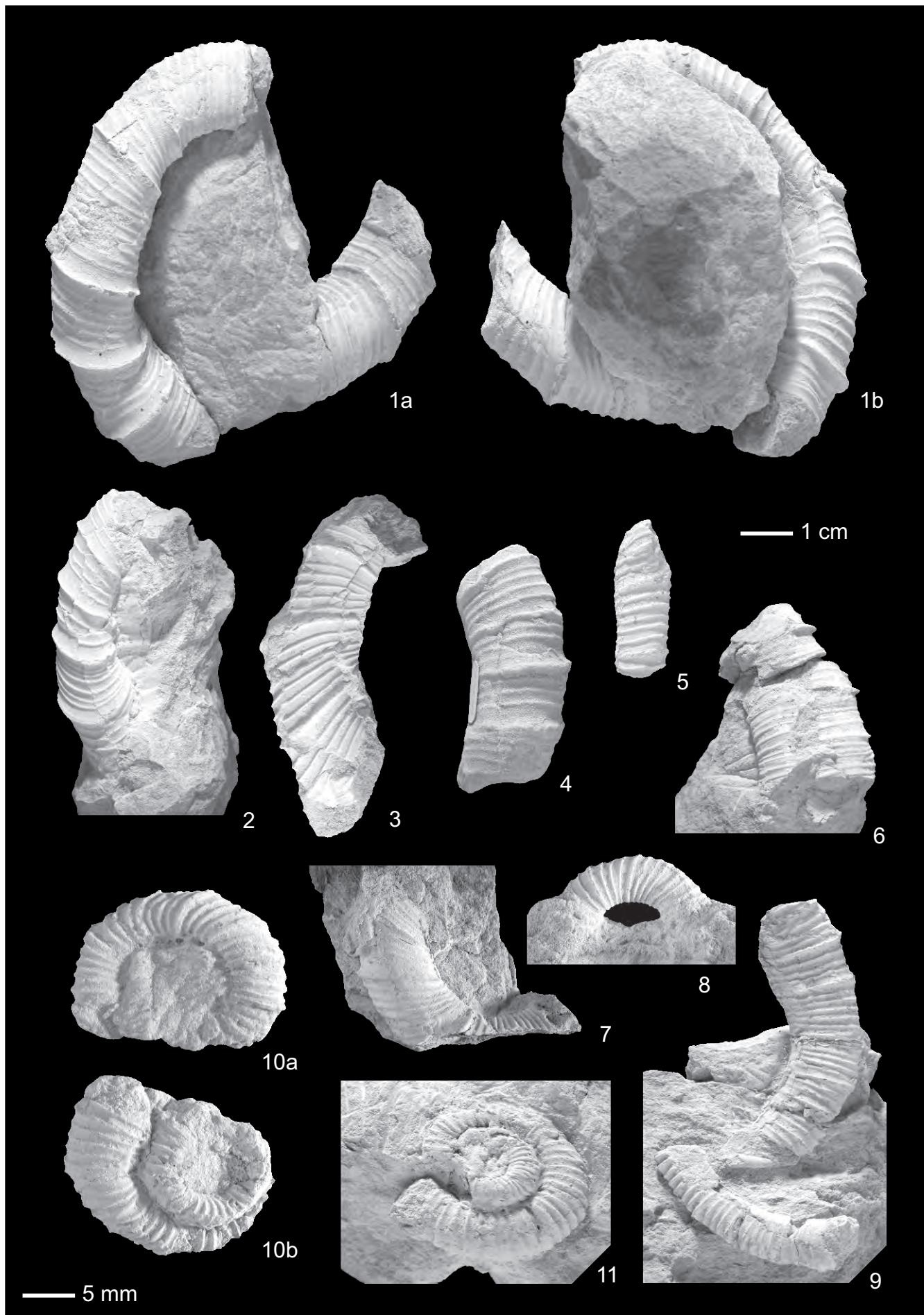


Plate 12

- Figs. 1a–b: *Glyptoxoceras souqueti* COLLIGNON, 1983; SK/SG/2007/47; from the *Micraster* Bed in the Schattaugraben section.
- Fig. 2: *Scalarites sertiformis* (MÜLLER & WOLLEMAN, 1906); SK/SG/1981/2; from the *Micraster* Bed in the Schattaugraben section.
- Fig. 3: Nostoceratidae gen. et sp. indet.; NHMW 1978/1963/0027; from the Finstergrabenwandl (Sandkalkbank Member), figured in SUMMESBERGER (1979: Pl. 3, Fig. 20).
- Figs. 4–5: *Polyptychoceras* sp. indet.; 4: MA1976/14, 5: MA1976/15; both from the Schattaugraben section (Sandkalkbank Member).
- Figs. 6–13: *Glyptoxoceras crispatum* (MOBERG, 1885); 6: SK/SG/1992/11; 7: NHMW 2011/0054/0006; 8: SK/SG/1996/22; 9: SK/SG/2006/41; 10: NHMW 1978/1963/0029, figured in SUMMESBERGER (1979: Pl. 3, Fig. 21); 11a, b: SK/SG/1996/18; 12: SK/SG/1996/20; 13: SK/SG/2002/33.
- Figs. 6, 9, 11, 13 are from the Sandkalkbank Member of the Schattaugraben section, Fig. 10 is from the Sandkalkbank Member of the Finstergrabenwandl, Fig. 7 is from the Hochmoos Formation of Gosauschmied, Figs. 8 and 12 are from the *Micraster* Bed.
All specimens coated with ammonium chloride. 10 mm-scale bar valid for Figs. 1–2, 6–8, 12 (150 %), 5 mm-scale bar (200 %) valid for Figs. 3–5, 1-cm-scale bar valid for Figs. 9–11, 13 (natural size).

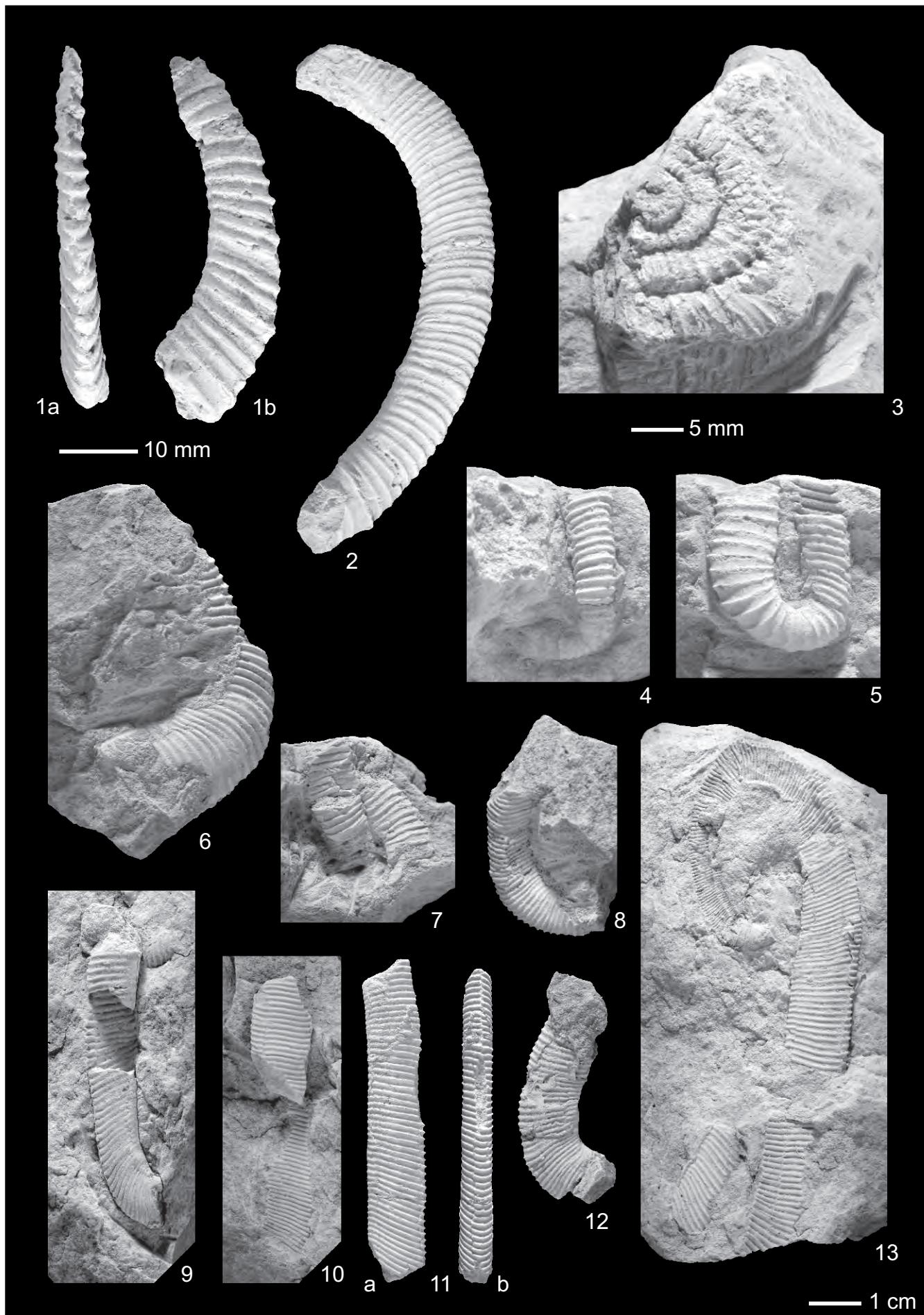


Plate 13

Figs. 1a–b: *Glyptoxoceras* group 1; MA 1976/16.

Figs. 2a–b: *Glyptoxoceras* group 4; NHMW 2006z0203/0006; from the *Micraster* Bed (Schattaugraben section).

Figs. 3–9: *Glyptoxoceras* group 2; 3: NHMW 2006z0203/0005; 4: NHMW 2011/0054/0005; 5: NHMW 2011/0054/0004; 6: SK/SG/2007/48; 7a–b: NHMW 2006z0203/0004; 8: SK/SG/2006/40; 9: SK/SG/1998/27, initial coil.

Figs. 10–15: *Glyptoxoceras* group 3; 10: NHMW 2011/0153/0001; 11: SK/SG/2002/34; 12: SK/SG/1992/16; 13: NHMW 2011/0054/0002; 14: SK/SG/2006/42; 15: SK/SG/1994/17.

Figs. 1a–b, 6, 15 are from the Sandkalkbank Member of the Schattaugraben section, Figs. 5 and 8 are from the Hochmoos Formation of the Schattaugraben, Figs. 3, 4 and 10 are from the Hochmoos Formation of Gosauschmied, Figs. 2a–b, 7a–b, 9, 11–15 are from the *Micraster* Bed.

All specimens coated with ammonium chloride. All are enlarged x 1,5.

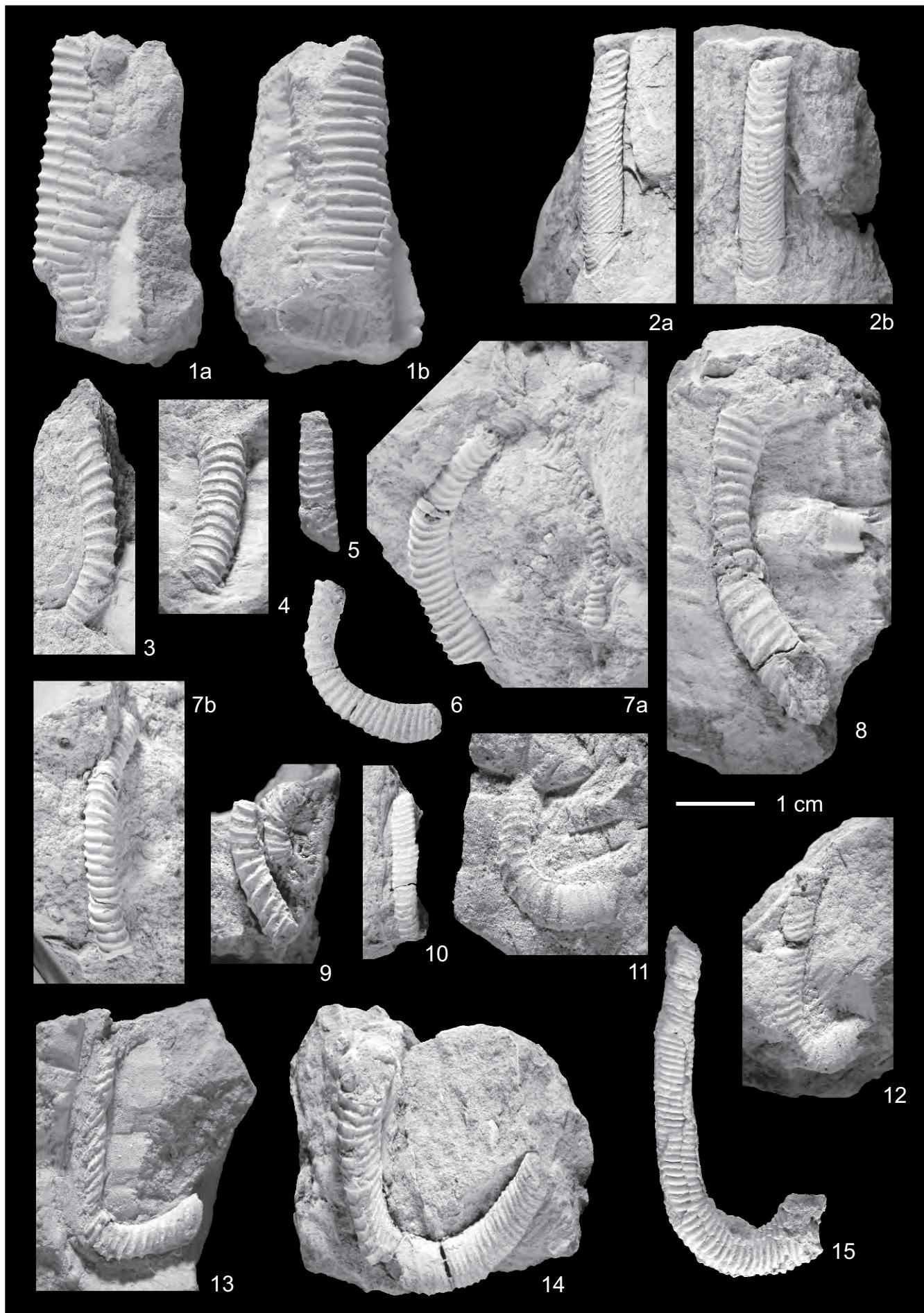


Plate 14

Figs. 1–6: *Glyptoxoceras* group 3; 1: SK/SG/1992/13; 2: NHMW 2006z0203/0001; 3: SK/SG2009/50; 4: NHMW 2006z0203/0007; 5: SK/SG/2006/43; 6: NHMW 2006z0203/0002.

Figs. 7a–b: *Schlueterella* sp. indet. 1; MA 1976/17.

Fig. 8: *Schlueterella* sp. indet. 2; SK/SG/1992/12.

Figs. 1–6 are from the *Micraster* Bed (Schattaugraben section), Figs. 7a–b and 8 are from the Hochmoos Formation of the Schattaugraben section.

All specimens coated with ammonium chloride. All specimens are enlarged x 1.5.

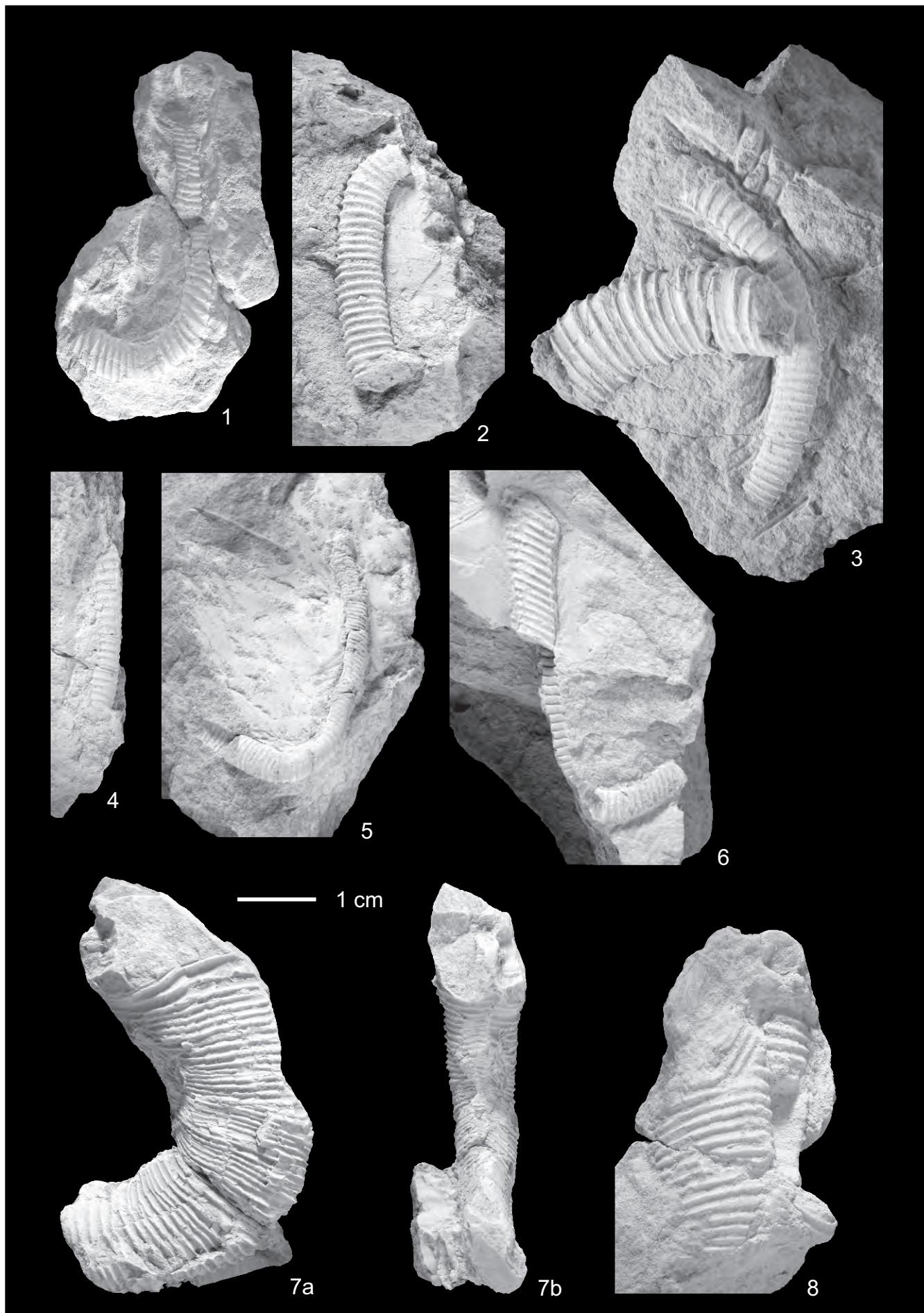


Plate 15

Figs. 1–3: *Baculites* sp. indet. 1; 1: NHMW 2006z0203/0007; 2: NHMW 2006z0203/0008; 3: SK/SG/1990/5; all are from the *Micraster* Bed (Schattaugraben section).

Figs. 4a–c: *Baculites fuchsii* REDTENBACHER, 1873 (Pl. 30, Fig. 15); NHMW 1865/0001/0138; the holotype; from the lower to middle Santonian of the Tiefengraben (= Grabenbach, Gosau, Upper Austria).

All specimens coated with ammonium chloride. All specimens are enlarged x 1.5.

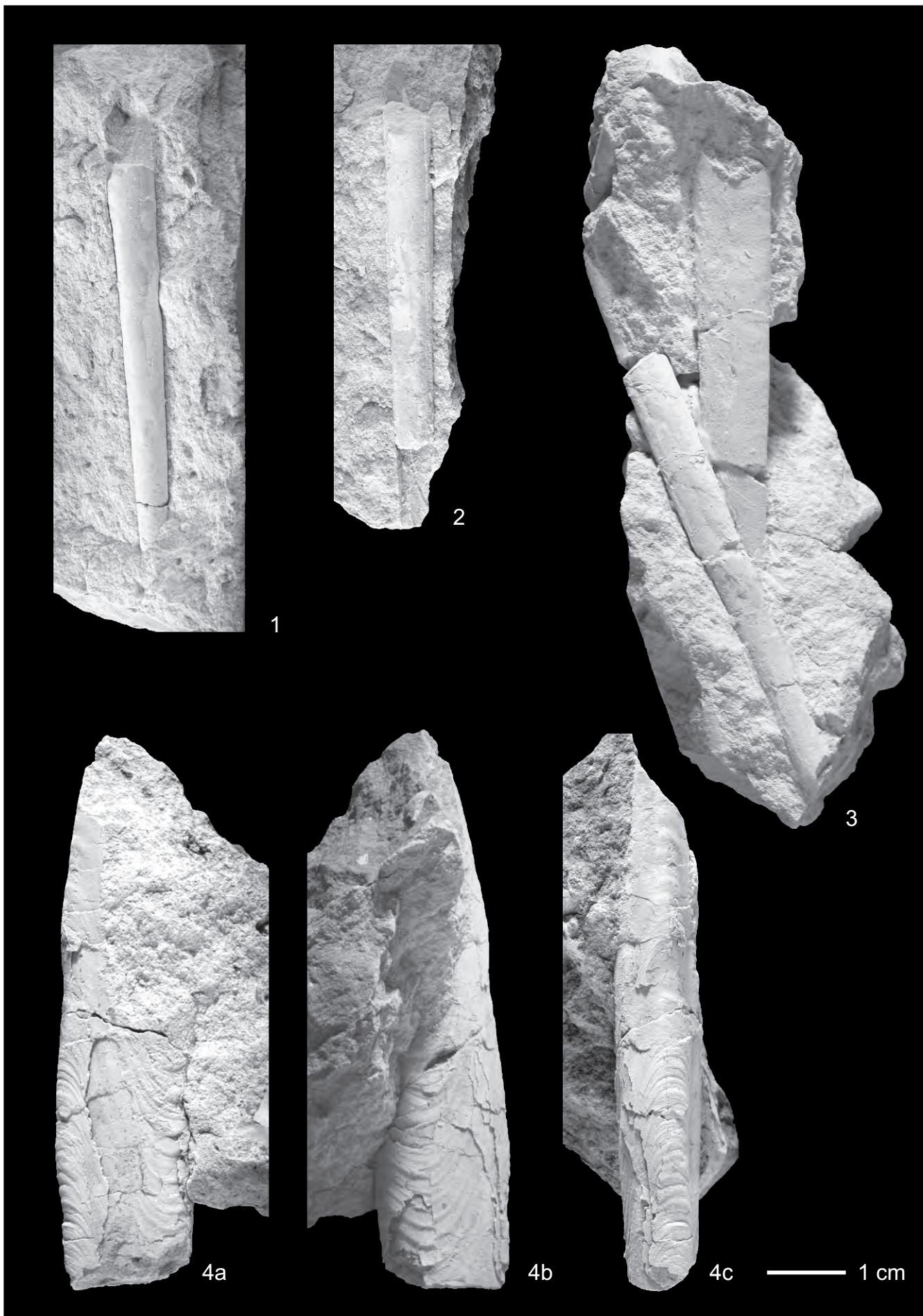


Plate 16

Figs. 1–3: *Baculites sulcatus* BAILY, 1855; 1a–b: SK/SG/1998/26; 2: SK/SG/1990/7; 3: SK/SG/1996/21.

Figs. 4–6: *Boehmoceras krekeleri* (WEGNER, 1905); 4a–d: SK/SG/1998/28; 5: NHMW 2011/0054/0008 (ex Skoumal collection); 6: SK/SG/1996/25.

Fig. 7: *Boehmoceras arculus* (MORTON, 1834); NHMW 2010/0081/0009.

All specimens are from the Schattaugraben section. Figs. 4–6 are from the Sandkalkbank Member, Figs. 1, 3, 7 are from the *Micraster* Bed, Fig. 2 is from the Hochmoos Formation.

All specimens coated with ammonium chloride. 5 mm-scale bar valid for Figs. 1–3 (x 1,5), 1 cm-scale bar valid for Figs. 4–7 (natural size).

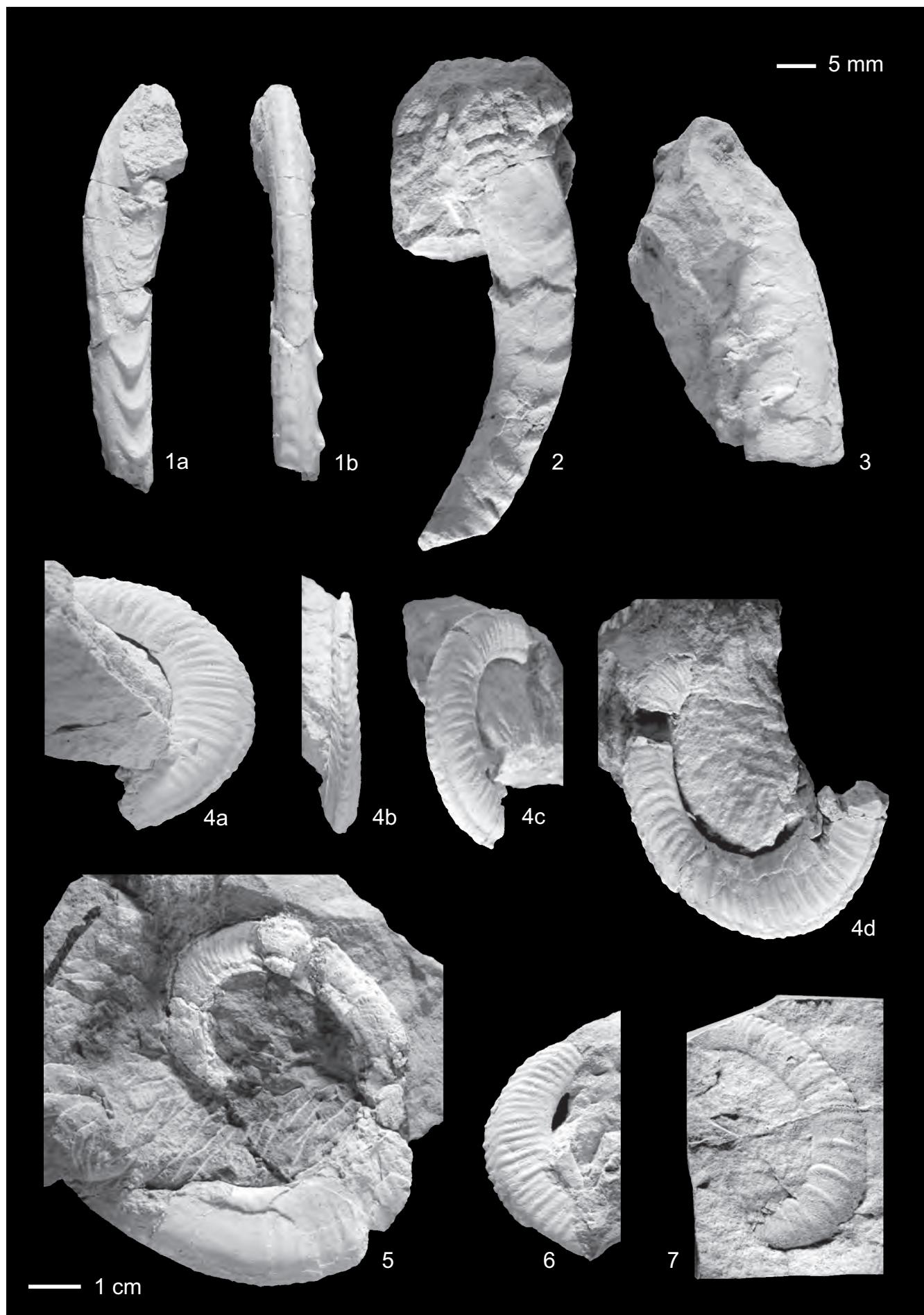


Plate 17

Fig. 1: *Spiroloculina fassistomata* GRZYBOWSKI, 97/16.

Figs. 2a–b: *Nummofallotia cretacea* (SCHLUMBERGER), 97/07.

Figs. 3a–b: *Quinqueloculina aspera* D'ORBIGNY (?), 97/07.

Fig. 4: *Dentalina communis* D'ORBIGNY, 06/02.

Fig. 5: *Pyramidulina* sp., 97/13.

Fig. 6: *Nodosaria* cf. *vertebralis* D'ORBIGNY, 97/13.

Figs. 7a–b: *Lenticulina secans* (REUSS), 06/04.

Figs. 8a–b: *Lenticulina secans* (REUSS), 06/04.

Figs. 9a–b: *Frondicularia angusta* (NILSSON), 97/16.

Figs. 10a–b: *Ramulina* sp., 06/04.

Fig. 11: *Neoflabellina laterecompressa* TOLLMANN, 06/10.

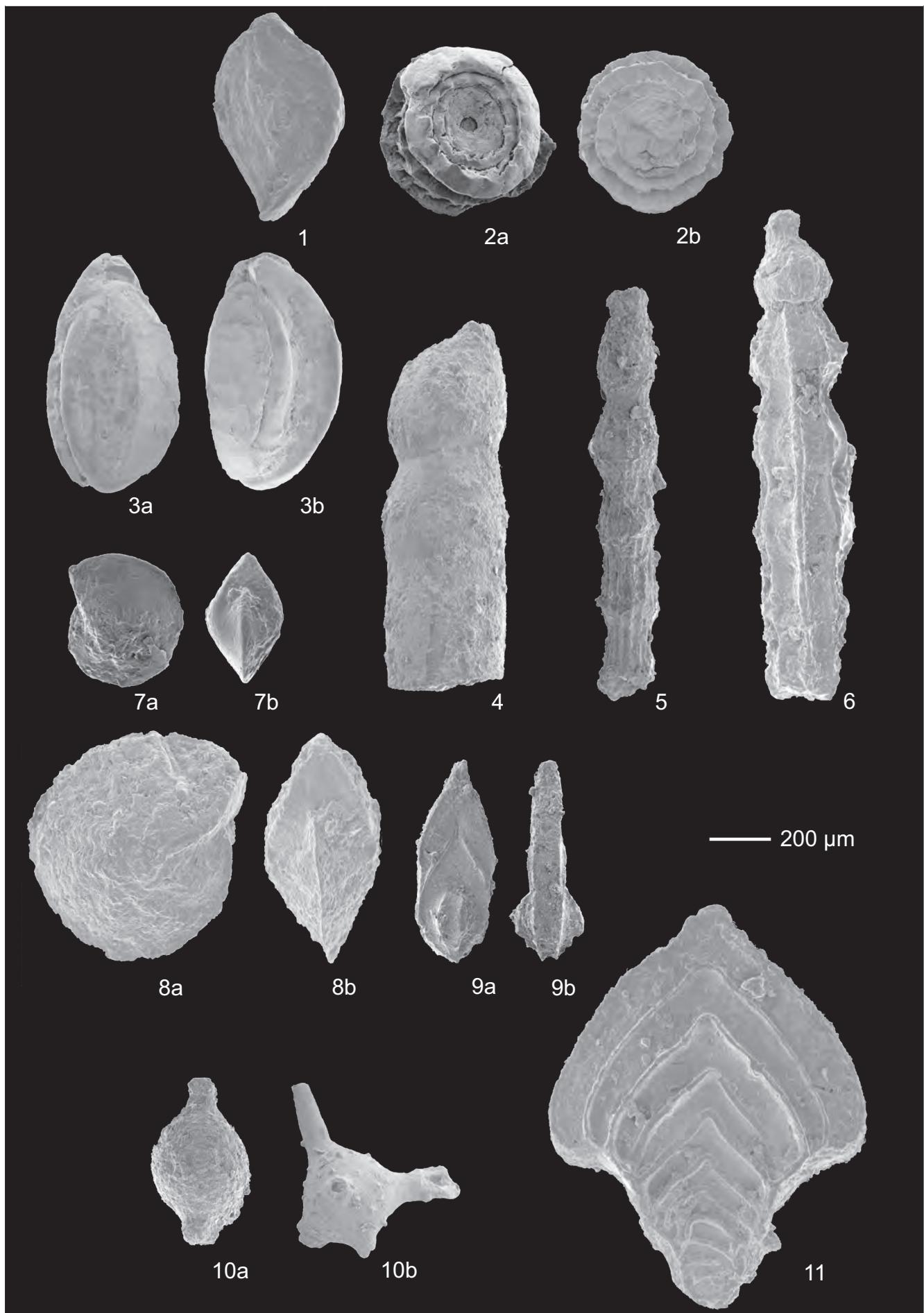


Plate 18

- Fig. 1: *Haplophragmium aequale* (ROEMER), 97/13.
- Fig. 2: *Ammobaculites agglutinans* (D'ORBIGNY), 97/11.
- Fig. 3: *Subreophax scalaris* (GRZYBOWSKI), 06/04.
- Fig. 4: *Spiroplectammina praelonga* (REUSS), 06/04.
- Fig. 5: *Gaudryina cf. reicheli* BARTENSTEIN, 97/13.
- Fig. 6: *Dorothia bulletta* CARSEY.
- Fig. 7: *Dorothia biformis* FINLAY.
- Figs. 8, 9: *Dorothia oxycona* (REUSS), 06/04.
- Fig. 10: *Dorothia trochus* (D'ORBIGNY).
- Fig. 11: *Tritaxia tricarinata* (REUSS).
- Fig. 12: *Tritaxia trilatera* (CUSHMAN).
- Fig. 13: *Gaudryina pyramidata* CUSHMAN, 06/04.
- Fig. 14: *Gaudryina* sp., 06/10.

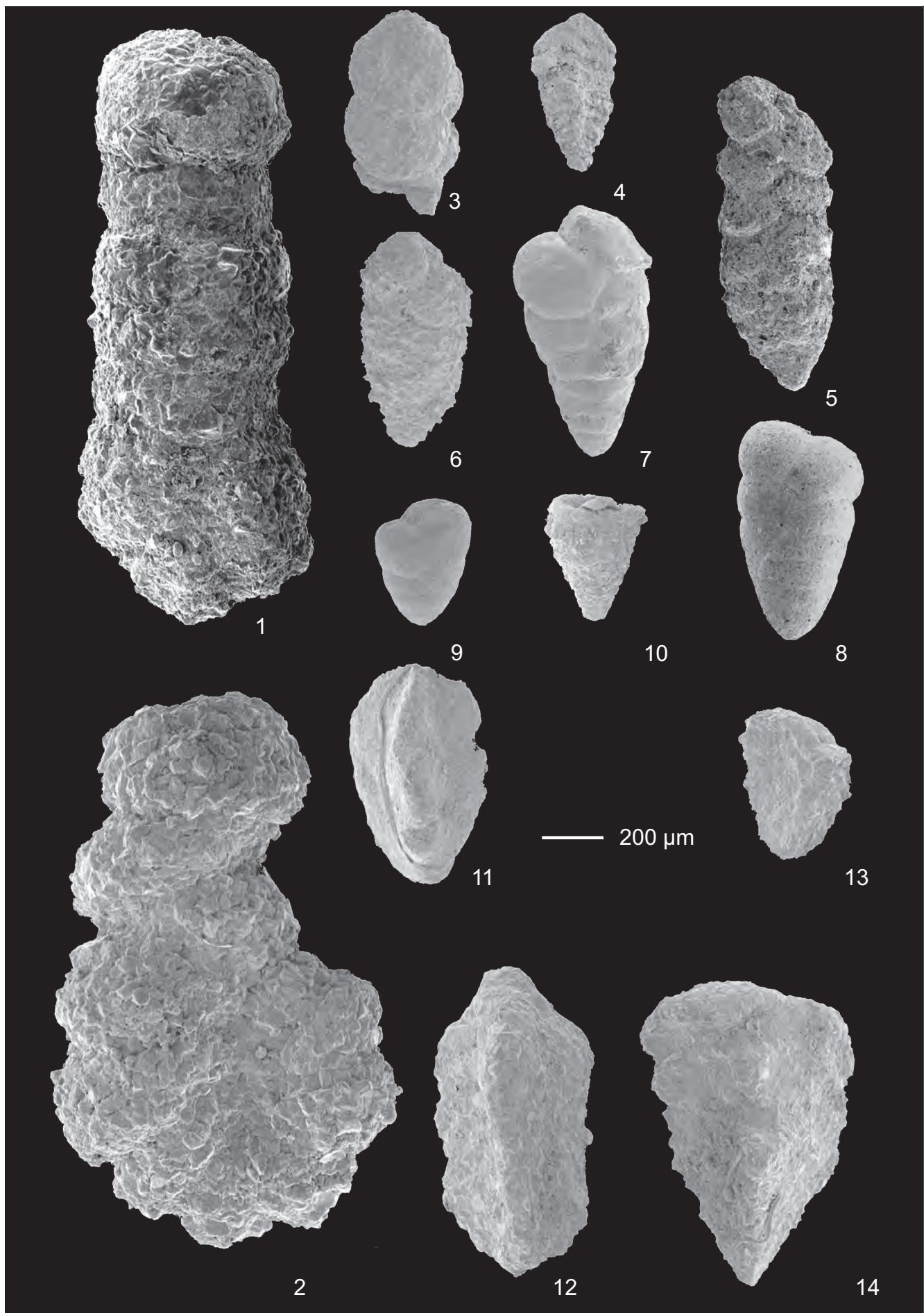


Plate 19

Figs. 1a–c: *Epistomina cf. colomi* DUBOURDIEU & SIGAL, 97/17.

Figs. 2a–b: *Osangularia* sp., 06/04.

Figs. 3a–c: *Hoeglundina cf. supracretacea* (TEN DAM), 97/11.

Figs. 4a–c: *Globorotalites michelinianus* (D'ORBIGNY), 06/05.

Figs. 5a–c: *Gavelinella lorneiana* (D'ORBIGNY), 06/04.

Figs. 6a–c: *Valvularia lenticula* (REUSS), 06/10.

Figs. 7a–c: *Gavelinella stelligera* (MARIE) (?), 97/13.

Figs. 8a–b: *Stensioeina exsculpta* (REUSS), 06/06.

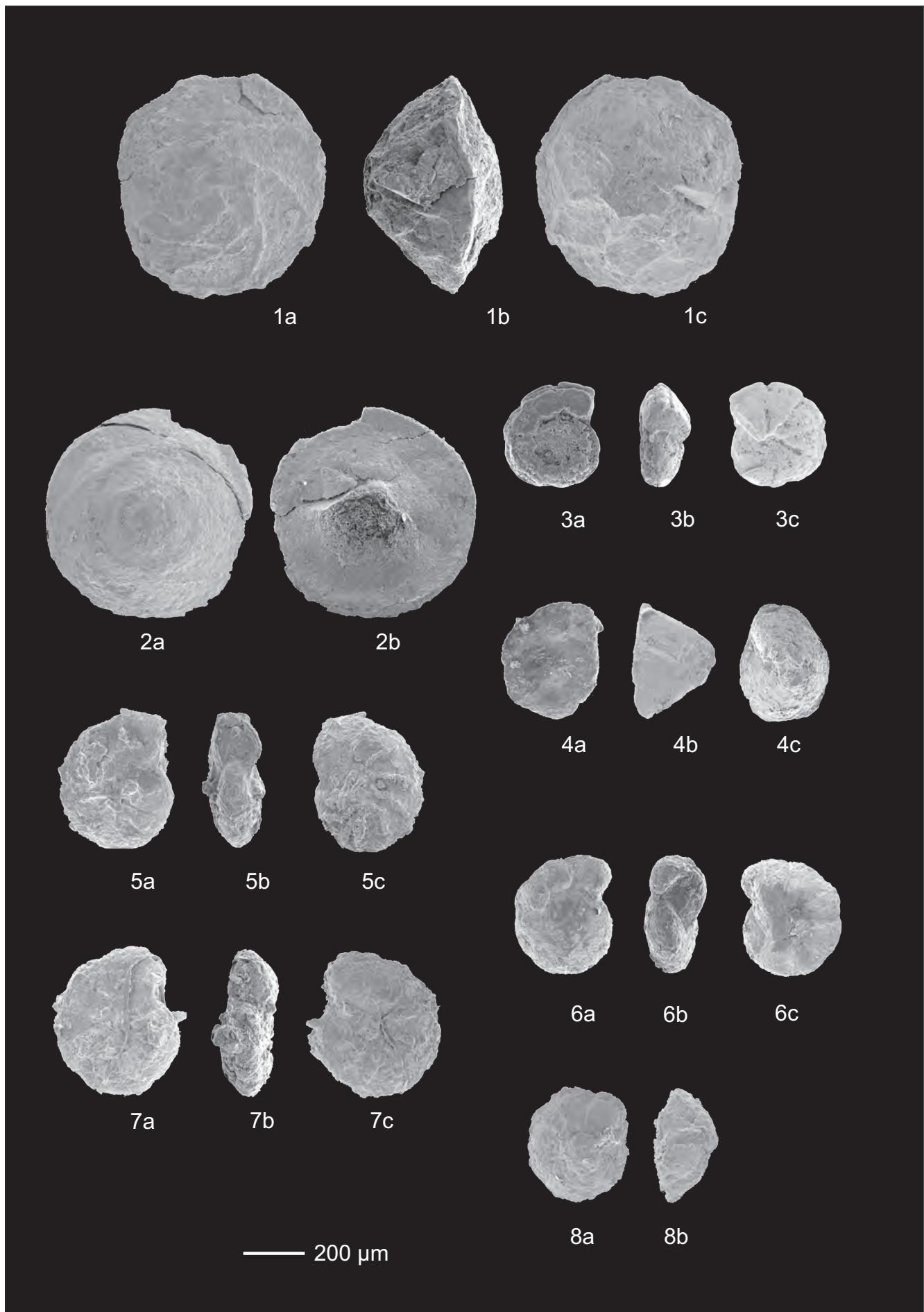


Plate 20

Figs. 1a–c: *Dicarinella asymetrica* (SIGAL), 06/04.

Figs. 2a–c: *Dicarinella asymetrica* (SIGAL), 06/04.

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Figs. 7a–c: *Marginotruncana sinuosa* PORTHAULT, 06/04.

Figs. 8a–c: *Marginotruncana undulata* (LEHMANN), 06/04.

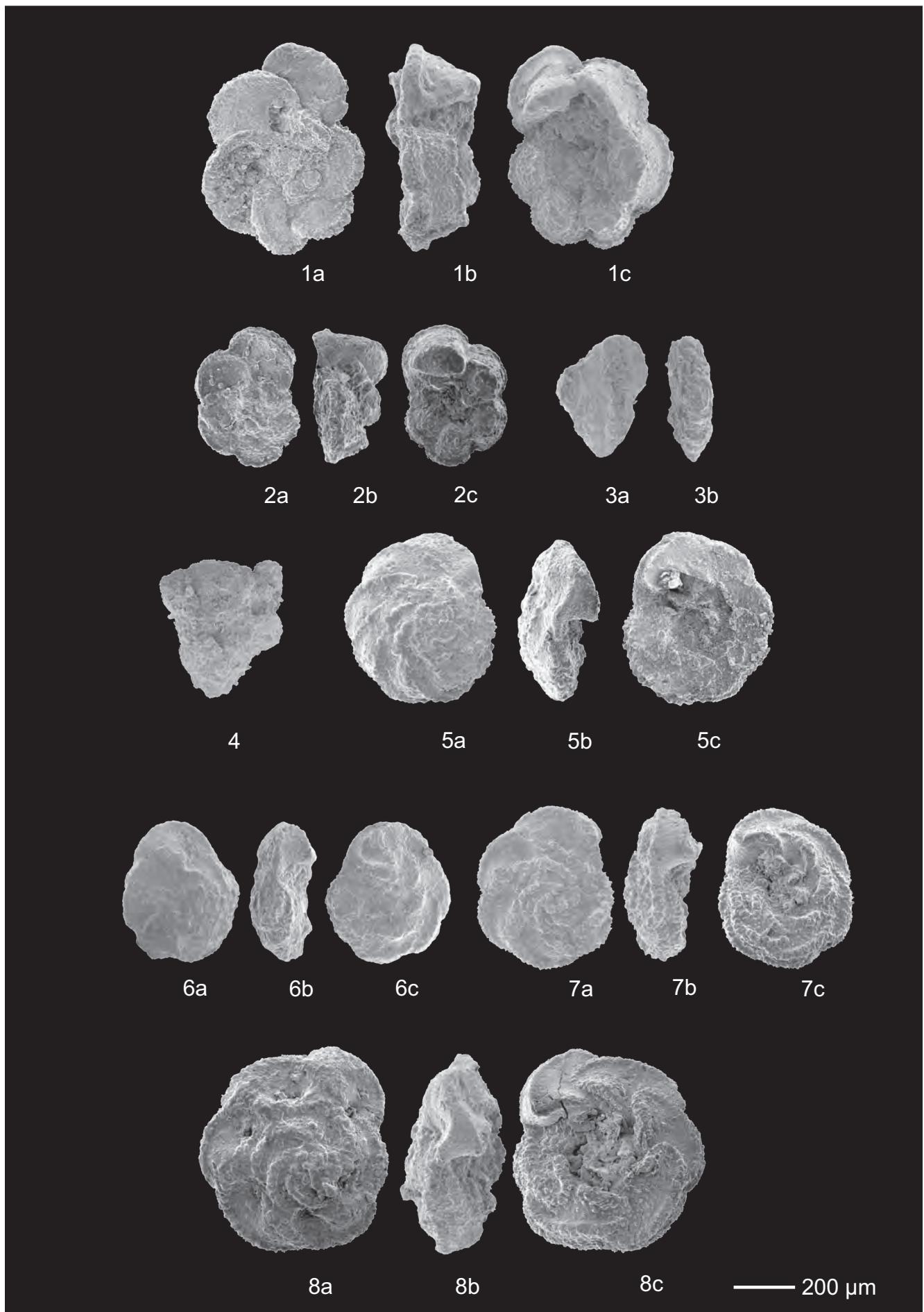


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Figs. 2a–c: *Globotruncana bulloides* (VOGLER), 06/04.

Figs. 3a–c: *Globotruncana bulloides* (VOGLER), 06/04.

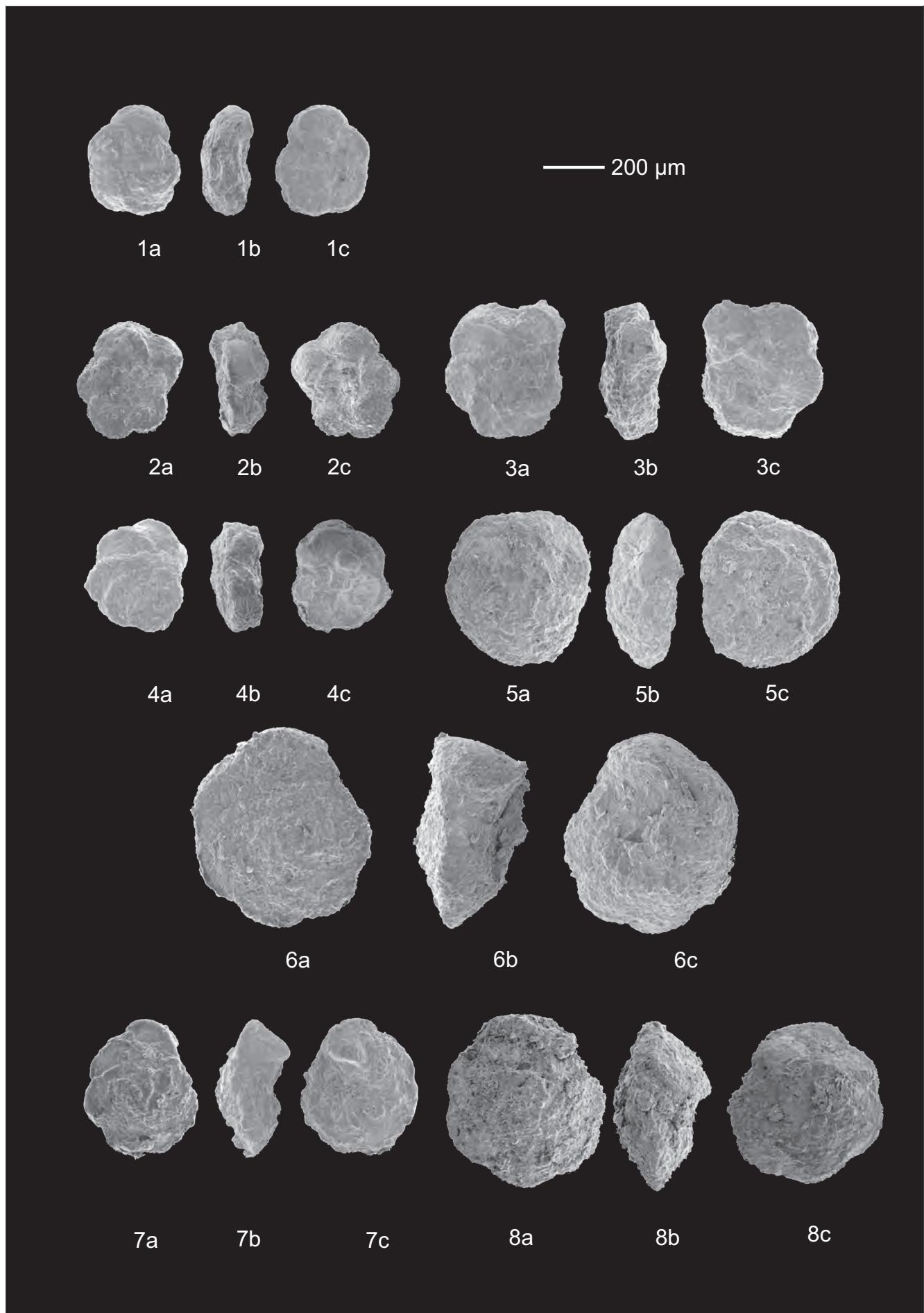
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