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Ammonoid taxonomy of the Carnian Polzberg *Konservat-Lagerstätte* in Austria

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4 Text-Figures, 5 Plates

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Content

Abstract

Although known for 150 years, the lower Carnian ammonoid fauna from the Polzberg *Konservat-Lagerstätte* (Lower Austria) has not previously been taxonomically described in detail. We here describe a new ammonoid fauna from the Northern Calcareous Alps in Austria, revealed by intensive sampling of a calcareous–argillaceous transition interval of the lowermost fossiliferous Reingraben Shales. A *c.* 4 m-thick section provided a rare opportunity to sample the impoverished ammonoid fauna across the Carnian Pluvial Episode (CPE), allowing a thorough taxonomic revision. The main faunal element (more than 10,000 specimens) within the cephalopods is the trachyceratid genus *Austrotrachyceras* reported in detail from the Northern Calcareous Alps for the first time. *Austrotrachyceras minor*, *Paratrachyceras haberfellneri*, *Carnites floridus* and *Simonyceras simonyi* occur in this section, directly above the black, organic-rich, laminated Göstling member of the Lunz Nappe, and were deposited during the CPE, a major, worldwide climate crisis. The episode is characterised by the demise of carbonate platforms of the Reifling Formation, passing through the Göstling Member into the argillaceous deposits of the Reingraben Shales. Ammonoid taxa suggest an Early Carnian age, within the *Austrotrachyceras austriacum* Zone (*A. minor* Biozone), including members of the families Trachyceratitidae, Carnitidae and Ussuritidae. The dominant genera, *Austrotrachyceras* and *Paratrachyceras*, are accompanied by rare but characteristic *Carnites* and *Simonyceras*. The low-diversity ammonoid fauna indicates a basinal environment within the Reifling Basin, occasionally influenced by open marine input. We propose an intraplatform basinal habitat with restricted conditions as depositional area. These conditions form the prerequisite for the autochthonous deposition of the dominating trachyceratids, *Austrotrachyceras* and *Paratrachyceras*, and the rare but drifted larger ammonoids as *Carnites* and *Simonyceras*.

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Ammoniten-Taxonomie der karnischen Polzberg *Konservat-Lagerstätte* in Österreich

Zusammenfassung

Obwohl schon seit 150 Jahren bekannt, wurde die früh-karnische Ammoniten-Fauna der Polzberg *Konservat-Lagerstätte* (Niederösterreich) bisher nicht im Detail taxonomisch beschrieben. Wir beschreiben hier eine neue Ammoniten-Fauna aus den Nördlichen Kalkalpen in Österreich, enthüllt durch intensive Aufsammlungen eines Überganges von kalkigen zu tonigen Bereichen der untersten fossilreichen Reingrabener Schiefer. Ein etwa 4 m mächtiger Abschnitt bietet dabei die rare Gelegenheit, eine verarmte Ammoniten-Fauna, abgelagert während der „Carnian Pluvial Episode" (CPE), gründlich taxonomisch zu überarbeiten. Das faunistische Hauptelement (über 10.000) innerhalb der Cephalopoden ist die trachyceratide Gattung *Austrotrachyceras*, die hier erstmals im Detail aus den Nördlichen Kalkalpen beschrieben wird. *Austrotrachyceras minor*, *Paratrachyceras haberfellneri*, *Carnites floridus* und *Simonyceras simonyi* treten im untersten kalkigen Bereich der Reingrabener Schiefer direkt über dem schwarzen, organisch reichen und laminierten Göstling Member auf und wurden während der CPE, einer bedeutenden, weltweiten Klimakrise abgelagert. Dieser Abschnitt ist durch den Untergang von Karbonatplattformen der Reifling-Formation definiert, übergehend in das Göstling Member in die tonigen Ablagerungen der Reingrabener Schiefer. Die Ammoniten-Taxa zeigen ein früh-karnisches Alter innerhalb der *Austrotrachyceras austriacum* Zone (*A. minor* Biozone) an, beinhaltend die Familien Trachyceratitidae, Carnitidae und Ussuritidae. Die dominierenden Gattungen *Austrotrachyceras* und *Paratrachyceras* werden durch seltene, aber charakteristische Gattungen wie *Carnites* und *Simonyceras* begleitet. Die gering diverse Ammoniten-Fauna zeigt eine beckenähnliche Umwelt innerhalb des Reiflinger Beckens an, bei gelegentlichem Einfluss von offen marinen Bereichen. Wir schlagen ein Intraplattform-Becken mit eingeschränkten Bedingungen als Ablagerungsbereich vor. Diese Verhältnisse bilden die Voraussetzung für die autochthone Ablagerung der dominanten Trachyceraten wie *Austrotrachyceras* und *Paratrachyceras*, und der raren, größeren aber verdrifteten Ammoniten wie *Carnites* und *Simonyceras*.

Introduction

Upper to Middle Triassic deposits, especially from the Anisian to Carnian stages, form a major element within the Lunz Nappe, one of the northernmost tectonic units of the Northern Calcareous Alps (NCA) of Lower Austria. The Polzberg area with the Reifling Formation, the Göstling Member and the fossiliferous Reingraben Shales has already been investigated by Stur (1874), Krystyn (1991), Lukeneder et al. (2020), Lukeneder & Lukeneder (2021, 2022a, b, 2023). Extensive systematic work on fossil fishes was done by Griffith (1977) accompanied by data on a single dipnoi member with *Ceratodus sturii* (Stur, 1886; Teller, 1891). Forchielli & Pervesler (2013) reported data on thylacocephalia from the historic Polzberg collections and Schädel et al. (2020) described isopods from the Polzberg area.

The Upper Ladinian to Lower Carnian section in the Polzberg ravine section displays a lithological change from pure carbonatic to argillaceous sedimentation (Lukeneder & Lukeneder, 2021). The change in lithology mirrors the platform drowning at that time, corresponding to the worldwide Carnian Pluvial Episode (CPE). The CPE (Breda et al., 2009; Lukeneder et al., 2012; Mueller et al., 2016; Dal Corso et al., 2018, 2021; Simms & Ruffell, 2018; Lukeneder & Lukeneder, 2021) occurs at least Tethyan-wide with a huge platform and reef demise replaced by basinal restricted conditions. The facies change occurs at Polzberg area in all localities during the Lower Carnian at the Julian 1/Julian 2 boundary by a transition from bright grey slope to basinal, cherty limestones of the Reifling Formation into black, laminated, partly bituminous limestones with marl intercalations of the Göstling Member. Calcareous deposits are fully replaced by argillaceous deposits of the Reingraben Shales within the *Austrotrachyceras austriacum* Zone (*A. austriacum* Subzone, *A. minor* Biohorizon). The succession is the local expression of the otherwise worldwide beginning of the CPE at the sections around Polzberg area and in the area from Grossreifling to the easternmost boarder of the NCA. Facies, microfacies and fabric change from open platform conditions, passing from deeper shelf and slope conditions, to finally occasionally open marine-influenced basinal conditions.

The enhanced humidity during the CPE caused an enormous siliciclastic input from the surrounding land masses into shelf areas along the entire northwestern branch of the Tethys (i.e. Meliata Ocean) and specifically argillaceous sediments accumulated in the Reifling Basin (Tollmann, 1976; Aigner & Bachmann, 1992; Hornung & Brandner, 2005). Subsequently reefs and carbonate platform ecosystems were harmed by the sediment coverage and turbidly water masses and the calcareous deposits vanish (Hornung & Brandner, 2005; Lukeneder & Lukeneder, 2021). During this time, the deposits comprising the mono- to pauci-specific ammonoid assemblage around Polzberg originated within the Reifling intraplatform basin in the Austroalpine region on the eastern end of the Mediterranean System (Stampfli & Borel, 2002; Stampfli et al., 2002; Lukeneder et al., 2012; Lukeneder & Lukeneder, 2021, 2022a).

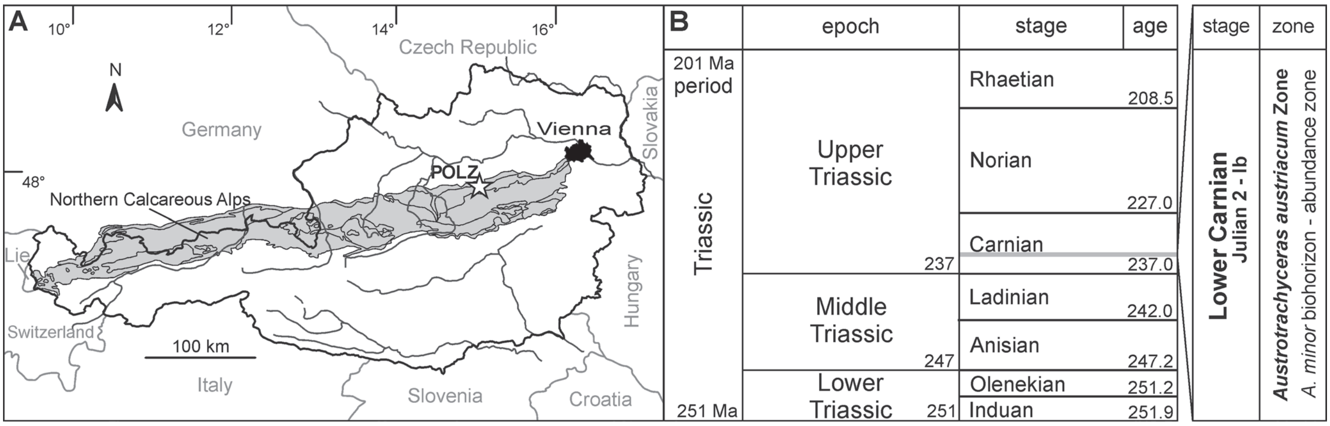
The Polzberg section is a key-section for detailed investigations of an ammonoid assemblage affected by these major environmental changes. Comparable Upper Triassic ammonite assemblages from the Tethyan Realm and North America were reported by Krystyn (1973, 1978, 1980, 1982, 1991), Tatzreiter (1982), Tozer (1971, 1980, 1981, 1984, 1994), Balini & Jenks (2007), and Balini et al. (2000, 2007) summarised by Lukeneder & Lukeneder (2015).

The Julian substage is dominated by the Trachyceratinae (especially *Trachyceras* and *Austrotrachyceras*) and Sirenitinae (e.g. *Sirenites*), subsequently marked by a major faunal incision and crisis in numerous trachyceratid members at the base of the Tuvalian.

The main aim of the present work is to describe in detail for the first time the important ecological harmed ammonoid assemblage from a *Konservat-Lagerstätte* deposited during the Lower Carnian worldwide CPE.

Geological Setting

The outcrop at Polzberg (Polzberggraben ravine) is situated on the western slope of Mount Schindelberg (1,066 m; Stur, 1874, 1886; Teller, 1891; Lukeneder & Lukeneder, 2021, 2022a, b), 4 km northeast of Lunz am See in Low-



Text-Fig. 1.
A: Indicated geographical position of the section Polzberg (POLZ) in the Northern Calcareous Alps (Lunz Nappe, Austria), adapted after Lukeneder & Lukeneder (2021: Fig. 1). B: Biostratigraphy of the Polzberg locality with the exact position of the Lower Carnian (Julian 2) Polzberg *Konservat-Lagerstätte* deposits marked by grey line, adapted after Lukeneder & Lukeneder (2021: Fig. 2). Lie = Liechtenstein.

er Austria (Lunz Nappe, NCA; geological map 1:50,000, sheet 71 Ybbsitz, Ruttner & Schnabel, 1988, and sheet 72 Mariazell, Bauer & Schnabel, 1997; Text-Fig. 1). Steep and weathered ravine walls at the western slope of the Polzberg ravine (25° towards WNW; i.e. 290°–300°) within the Lunz Nappe, about 4.5 km southeast from Gaming, in the vicinity of the lake Lunzer See. The section crops out near the small villages of Lunz am See and Gaming with the exact position of the fossiliferous the locality determined by GPS (global positioning system): N 47°53'4.98'' and E 15°4'28.15''. The Polzberg section is approximately at 710 m above sea level. Tectonically, the area around the locality is part of the Lunz Nappe (Ruttner & Schnabel, 1988; Bauer & Schnabel, 1997; Lukeneder & Lukeneder, 2021). The deposits of this section belong to two distinct lithological formations or members, comprising a deepening marine platform to basinal system. The deposits were part of the intraplatform basin, the Reifling Basin with the Polzberg Sub-Basin. The stratigraphically older Reifling Formation (Anisian to basal boundary of *Austrotrachyceras austriacum* Zone), the transitional Göstling Member (lowermost Carnian, *A. austriacum* Zone with *A. triadicum* Biohorizon) and the younger Reingraben Shales of restricted basinal facies (*A. austriacum* Zone with *A. minor* Biohorizon, Lukeneder & Lukeneder, 2021, 2022a). The lowermost 3–4 m of the Reingraben Shales at this section bear the fossiliferous part with abundant and unimodally distributed ammonoids (Text-Fig. 2) from the lowermost sample/layer number Po -50 cm up to the topmost layer with Po 340 cm of the section (Text-Fig. 2). These argillaceous and fossiliferous deposits were formed during the CPE (Mueller et al., 2016; Lukeneder & Lukeneder, 2021).

Material and Methods

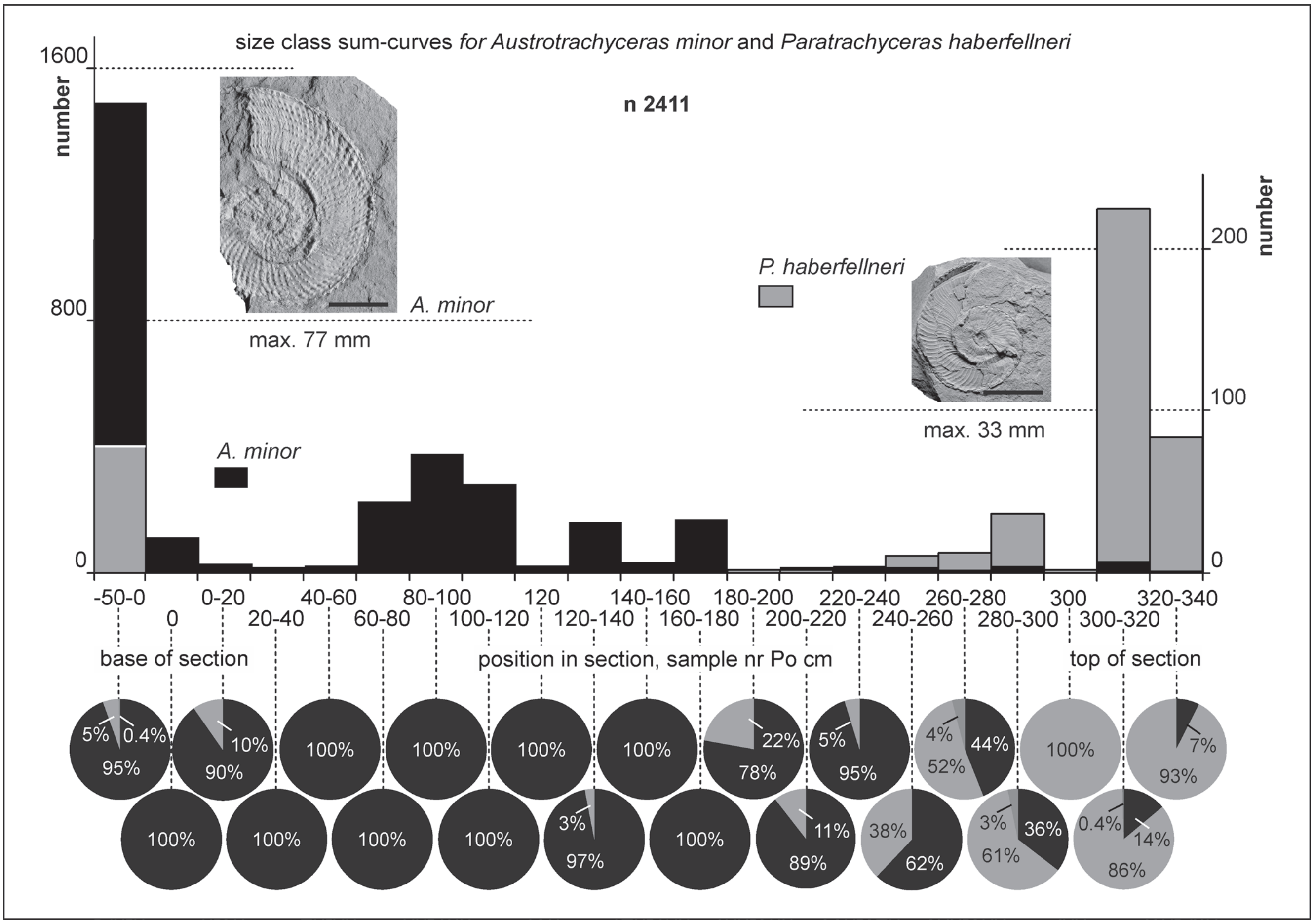
All specimens described within this study were extensively collected from the Reingraben Shales at the section Polzberg. The recent material (n 4,953 fossils) was collected in 2021 during five field campaigns by the authors. Additional material (n > 500, not horizonted) from the same site was collected by Birgitt and Karl Aschauer over the last two decades. Within the entire invertebrate fauna, the ammonoids dominate with 3,565 specimens comprising entire and fragmented specimens. Historical excavations were organised by the Geological Survey of Austria (GBA) in 1885 and the Natural History Museum Vienna (NHMW) in 1909. These historical collecting sites, today abandoned and collapsed mines were located at N 47°53'23.31'' and E 15°4'45.80''. The fossils (n 6,397 specimens) originated from the mining tunnels, were studied by the authors in detail (Lukeneder & Lukeneder, 2021) and are now correlated to the new fossils and section by recognition of the identical basal fossiliferous parts.

The ammonoids are well preserved, mostly with whitish primary aragonite shell. Only few specimens of the genera *Austrotrachyceras* and *Paratrachyceras* show suture lines.

The mono- to pauci-specific ammonoid assemblage consists of four genera and species *Austrotrachyceras minor*, *Paratrachyceras haberfellneri*, *Carnites floridus* and *Simonyceras simonyi*. Measurements were done by using a vernier micrometre. For the investigation of smaller structures or details as shell composition SEM pictures were used. Thin sections were made to investigate different ammonoid shell structures and ontogenetical stages. Suture lines were additionally drawn by using coated images with ammonium chloride for enhanced visibility. Photographed specimens shown on Text-Figure 2 and Plates 1–5 were coated with ammonium chloride. Additional facies investigations were conducted under a dissecting microscope (Zeiss Discovery V20) with attached digital camera (AxioCam MRc5). Sectioning, thin sectioning and photography were done by the authors at the Natural History Museum in Vienna

The collected material is stored within the systematic type collection of the Geological-Palaeontological Department of the NHMW, Vienna (historical material NHMW 2012/0228/0001–2233 new material NHMW 2021/0123/0001–3565), and the taxonomically compared type material at the collection of the GeoSphere Austria (former Geological Survey of Austria, GBA).

Statistical Methods: In addition to conventional methods, we conducted box plot analyses, bivariate plots and corresponding size curves. For the statistical analyses the software package PAST was used.



Text-Fig. 2.
Bar plots with indicated median values and curves. Size classes curves and quantity versus section and corresponding sampling numbers (-50 cm to the top Po 340 cm) of the main ammonite genera *Austrotrachyceras* and *Paratrachyceras* from the Polzberg section. Note the different scales and labelling of the axes for the number of specimens, adapted for each genus. The lower half of the section dominated by *A. minor* (max. 77 mm in diameter; black bars) replaced by the smaller *P. haberfellneri* (max. 33 mm in diameter; grey bars). See also Lukeneder & Lukeneder (2022a). Pie charts showing percentage of *A. minor* (black), *P. haberfellneri* (light grey) and *Carnites floridus* (dark grey). Figured *A. minor* (NHMW 2021/0123/0167) and *P. haberfellneri* (NHMW 2021/0123/0173). Scale bars: 10 mm.

Abbreviations: B = maximum breadth, D = maximum diameter (entire specimens), H = maximum height, L = length, MS = maximum size (for fragments), ST = shell thickness, WH = whorl height, U = umbilical width, U/D = proportional umbilical width, H/D = proportional height, H/U = degree of involution, mOF = measured original figure, NCA = Northern Calcareous Alps, SA = Southern Alps, NHMW = Natural History Museum Vienna, GBA = Geological Survey of Austria (since 2023 GeoSphere Austria), CPE = Carnian Pluvial Episode.

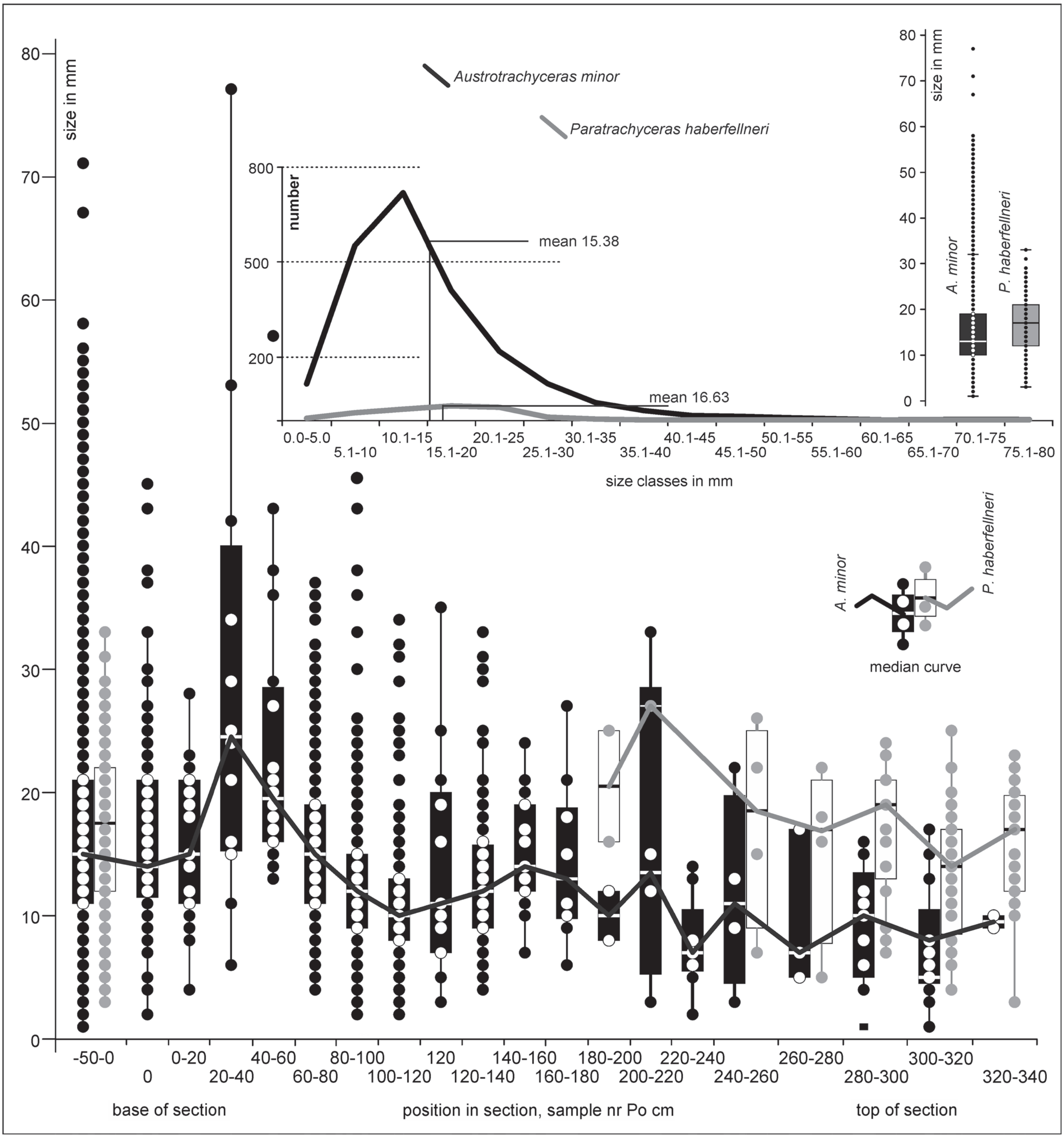
A. = *Austrotrachyceras*; *C.* = *Carnites*; *S.* = *Simonyceras*; *T.* = *Trachyceras*; *An.* = *Anaptychus*.

Taxonomic composition

Austrotrachyceras and *Paratrachyceras* ammonoid specimens (n 2,411, out of 3,565 ammonoid specimens) were measured (Text-Figs. 2, 3) from the Polzberg section (new collection in 2021) within the log of Po -50 cm up to Po 340 cm. 59 % of the entire fossils are within *Austrotrachyceras minor* and 9 % of *Paratrachyceras haberfellneri* (for other fossil groups see Lukeneder & Lukeneder, 2021). Within the trachyceratids *A. minor* dominates with 87 % over *P. haberfellneri* with 13 %. The majority of shells found within the Polzberg ammonoid assemblage at the section Polzberg (new collections from 2021) are identified as the ammonoid species *A. minor* (mean 15.38 mm, max. 77 mm in diameter; Pls. 1, 2) and *P. haberfellneri* (mean 16.63 mm, max. 33 mm in diameter; Pl. 3). The accompanying cephalopod fauna consists of the ammonites *Carnites floridus* (fragment max. size 123 mm; Pl. 4) and *Simonyceras simonyi* (fragment max. size 260 mm; Pl. 5) along with frequent members of the belemnoid species *Phragmoteuthis bisinuata* (Lukeneder & Lukeneder, 2022b). The paucispecific assemblage is documented by the assignment of 87 % of the cephalopod shells to *A. minor,* accompanied by the rare additional ammonite, belemnoid and gastropod specimens (Kidwell et al., 1986).

From Po -50–180 cm in the section *A. minor* is the dominant ammonite species with 95–100 % starting to be accompanied higher in the section from Po 180 cm onwards by 5–93 % of *P. haberfellneri*, in cases at Po 300 cm totally replaced by the new and smaller species with 100 %. The mean size values (max. diameter) differ only by 1.25 mm, but max. diameter sizes show a clear picture of twice the size in *A. minor* (77 mm vs. 33 mm). The enormous number of all, in details juvenile stages down to 1–2 mm, in *A. minor* compensates the few larger specimens. Morphological differentiation of the shell aperture, the ribbing style show an adult stage of most determined specimens (except fragments) in both species. Mean and median values decrease in both species from the bottom to top of the Polzberg section (Text-Fig. 3) reflecting the adaptive strategies in these trachyceratids, dwarfing due to the ecological pressure and environmental restrictions. The adaptation in size is due to the limited oxygenation and hostile environmental conditions at the time of deposition in r-strategists or opportunistic species of the genus *Austrotrachyceras* and *Paratrachyceras. A. minor* appears with the max. mean at Po 20–40 cm with 29.41 mm and the lowermost values at Po 220–240 cm with 7.66 mm. *P. haberfellneri* has its maxiumum value of 20.51 at Po 180–200 cm (27.0 at Po 200–220 is from a single specimen) and the minimum at Po 300–320 cm with 13.69 mm. The maxima of specimens appear in *A. minor* in size class 10.1–15.0 mm (n 753) and in *P. haberfellneri* from 15.1–20.0 mm (n 45; Text-Figs. 2, 3).

Comparable, the macrofauna of other localities (Grossaugraben, Lehen, Rehgraben, Saugraben, Scheiblingraben,



Text-Fig. 3.
Size classes versus section and corresponding samling numbers (Po -50 cm to the top Po 340 cm) of *A. minor* (black bars and curves) and *P. haberfellneri* (grey bars and curves) form the Polzberg section. *A. minor* (mean 15.39 mm) and *P. haberfellneri* (mean 16.63 mm) with detailed explanation of conch dimensions given in taxonomic composition. *A. minor* decreases in size up to the top of the section, gradually replaced by the constantly smaller *P. haberfellneri*. See upper right box plot for mean values and size ranges in *A. minor* and *P. haberfellneri*.

Schöckelreith; TRAUTH, 1948; KRYSTYN, 1978, 1991), however not or badly exposed outcrops, show nearly the same assemblage composition as noticed at Polzberg. Besides the dominance of the nektonic ammonoid *Autrotrachyceras* in the water column, thin-shelled halobiid bivalves appear in rock forming mass-event beds (oxygen related), hence throughout the section, accompanied by frequent, small benthic gastropods and crustaceans.

Systematic Palaeontology

Order Ceratitida HYATT, 1884
Suborder Trachyceratina KRYSTYN, 1978
Superfamily Trachyceratoidea HAUG, 1894
Family Trachyceratitidae HAUG, 1894
Subfamily Trachyceratinae HAUG, 1894

Genus *Austrotrachyceras* KRYSTYN, 1978

1978 *Trachyceras* (*Austrotrachyceras* n. subgen.) KRYSTYN, p. 68.
1991 *Austrotrachyceras* KRYSTYN, p. 35.
1994 *Austrotrachyceras* TOZER, p. 4.
1994 *Trachyceras* (*Austrotrachyceras*) URLICHS, p. 39.
2007 *Austrotrachyceas* DOGUZHAEVA et al., p. 211.
2007 *Trachyceras* (*Austrotrachyceras*) HORNUNG et al., p. 277.
2013 *Austrotrachyceras* sp. FORCHIELLI & PERVESLER, p. 46.
2015 *Austrotrachyceras* LUKENEDER & LUKENEDER, p. 358.
2020 *Austrotrachyceras* LUKENEDER et al., p. 1.
2021 *Austrotrachyceras* LUKENEDER & LUKENEDER, p. 1.
2022a *Austrotrachyceras* LUKENEDER & LUKENEDER, p. 1.
2023 *Austrotrachyceras* LUKENEDER & LUKENEDER, p. 1.

Type species: *Trachyceras austriacum* MOJSISOVICS, 1893 (p. 677, Pl. 184, Fig. 1a, b), from red condensed cephalopod limestones of the Feuerkogel near the Röthelstein, Northern Calcareous Alps, Styria, Austria; holotype GBA 1893/001/0611/01.

Remarks: In accordance to the original description by KRYSTYN (1978), the genus *Austrotrachyceras* was firstly described as subgenus and trachyceratid member of *Trachyceras* LAUBE, 1869. The genus *Austrotrachyceras* is characterised by a *Trachyceras*-like form (involute to moderately evolute coiling) bearing nodose ribs. The venter is externally interrupted by a broad furrow (sulcus in TOZER, 1994) accompanied on each side by two adjacent double rows of ventral tubercles located on the centralmost edges of the falcoid ribbing. In contrast to *Trachyceras*, the spiral double row tubercles appear directly on the opposite side without any angle on a straight line. In *Trachyceras* s. str. the ribbing ends with angle between 90° and 120° to the ventral furrow, identified as obtuse angle by URLICHS (1994). *Trachyceras* shows a row of double-pointed nodes, inclined and shifted toward the aperture, on both sides of the venter (KRYSTYN, 1978). An additional feature for *Austrotrachyceras* was given in TOZER (1994) with feeble projection of growth lines and tubercle spirals on the venter. KRYSTYN (1978) introduced the *Austrotrachyceras austriacum* Zone as topmost ammonoid Zone of the Carnian Julian 2, with *A. austriacum* as type ammonoid species.

Stratigraphic range: Upper Triassic, Lower Carnian, Julian 2, *Austrotrachyceras austriacum* Zone.

Austrotrachyceras minor (MOJSISOVICS, 1893)

(Pl. 1, Figs. A–O; Pl. 2, Figs. A–N)

1874 *Trachyceras aon* MÜNSTER; STUR, p. 273.
*1893 *Trachyceras triadicum* var. *minor* MOJSISOVICS, p. 682, Pl. 186, Figs. 1–3.
1935 *Trachyceras austriacum* MOJSISOVICS; TRAUTH, p. 471.
1935 *Trachyceras triadicum* MOJSISOVICS; TRAUTH, p. 471.
1948 *Trachyceras triadicum* MOJSISOVICS; TRAUTH, p. 39, 73, 87, Pl. 12, Fig. 4.
1976 *Trachyceras triadicum* MOJSISOVICS; TOLLMANN, p. 136.
1976 *Trachyceras austriacum* MOJSISOVICS; TOLLMANN, p. 136.
1978 *Trachyceras* (*Austrotrachyceras* n. subgen.) *triadicum* MOJSISOVICS, 1893; KRYSTYN, p. 70, Pl. 5, Fig. 7.
1991 *Austrotrachyceras minor*; KRYSTYN, p. 37, Text-Figs. 11, 12.
2007 *Austrotrachyceras* sp.; DOGUZHAEVA et al., p. 211, Text-Fig. 11A, D.
2008 *Trachyceras* (*Austrotrachyceras*) *austriacum*; HORNUNG, p. 113, Text-Figs. 9j, k.
2020 *Austrotrachyceras austriacum*; LUKENEDER et al., p. 2, Text-Figs. 4A–F.
2021 *Austrotrachyceras minor*; LUKENEDER & LUKENEDER, p. 1, Text-Figs. 2B, 3A.
2022a *Austrotrachyceras minor* LUKENEDER & LUKENEDER, p. 1.
2023 *Austrotrachyceras minor* LUKENEDER & LUKENEDER, p. 2.

Material from Polzberg: 2,251 specimens from the lowermost three metres of the Reingraben Shales at Polzberg, Polzberggraben, from sequence Po -50 cm to Po 320 cm (Text-Figs. 2, 3): NHMW 2021/0123/0001–2251.

Measurements: NHMW 2012/0228/1926, D: 91 mm, U: 25 mm, WH: 39, U/D: 0.27, H/D: 0.42, H/U: 1.56 (Pl. 1, Fig. A); NHMW 2012/0228/1890, max. S: 62 mm (Pl. 1, Fig. B); NHMW 2012/0228/2225, D: 78 mm, U: 11 mm, H: 36 mm, U/D: 0.14, H/D: 0.46, H/U: 3.27 (Pl. 1, Fig. C), D: 37 mm, U: 7 mm, H: 18 mm, U/D: 0.19, H/D: 0.49, H/U: 2.57 (Pl. 1, Fig. C same specimen); NHMW 2012/0228/1855, D: 60 mm, U: 10 mm, H: 27 mm, U/D: 0.17, H/D: 0.30, H/U: 2.7 (Pl. 1, Figs. D, E); NHMW 2012/0228/1927, D: 56 mm, U: 6 mm, H: 28 mm, U/D: 0.11, H/D: 0.50, H/U: 4.67 (Pl. 1, Figs. F, G); NHMW 2012/0228/1856, D: 42 mm, U: 9 mm, H: 19 mm, U/D: 0.21, H/D: 0.45, H/U: 2.11 (Pl. 1, Figs. H, I); NHMW 2021/0123/0131, D: 56 mm (Pl. 1, Fig. J); NHMW 2021/0123/0167, D: 37 mm (Pl. 2, Fig. A); NHMW 2021/0123/0140, D: 25 mm, U: 5 mm, H: 12 mm, U/D: 0.20, H/D: 0.48, H/U: 2.40 (Pl. 2, Fig. B); NHMW 2021/0123/0132, D: 38 mm (Pl. 2, Fig. C); NHMW 2021/0123/0141, D: 28 mm (Pl. 2, Fig. D); NHMW 2012/0228/2227, D: 25 mm (max. 42 mm), U: 4 mm, H: 14 mm, U/D: 0.16, H/D: 0.56, H/U: 3.50 (Pl. 2, Figs. E, F); NHMW 2012/0228/1730, D:

18 mm (Pl. 2, Fig. G); NHMW 2012/0228/1836, D: 20 mm (Pl. 2, Fig. H); NHMW 2012/0228/1861, D: 19 mm (Pl. 2, Fig. I); NHMW 2021/0123/0168, D: 12 mm (Pl. 2, Fig. J); NHMW 2012/0228/2226, D: 14 mm, U: 2 mm, H: 8 mm, U/D: 0.14, H/D: 0.57, H/U: 4.00 (Pl. 2, Figs. K–N).

Description: Mesodome shells with generally moderate involute whorls, almost straight flanks, with a narrow umbilicus (Pls. 1, 2). The venter bears a broad and deep furrow, which is bordered by two coarse, spirally arranged external double-tubercle-rows. Radial ribs are slightly sinuously curved on flanks, but appear with an adapical bow (proverse towards aperture) at the upper third of the flanks. Up to a D of approx. 25–30 mm, ribs are coarse and strong, stronger than spiral ribs. Ribbing starts at umbilical shoulder. In juveniles stages up to 30 mm in D tuberculation is strong, pointed and uniform. On earliest whorls of WH 2–3 mm 4–5 tubercles appear on every single rib, at WH 4–5 mm with 10–12 tubercles, at WH 10–14 mm with heterogeneous (pointed and radially elongated) and weakening 10–14 tubercles, at D of 18–20 mm approx. 14–16 elongated tubercles on stronger spiral ribs, starting from swollen umbilical tubercles. Irregular bifurcation occurs in juveniles at the umbilical shoulder, in adult stages on body chamber stronger sinuously curved finer radial ribs on flanks, stronger spiral ribbing, at D of 28–35 mm approx. 14–16 spiral rows of elongated tubercles. As described from the type material (Mojsisovics, 1893) for *Austrotrachyceras minor* ribs start to become more distinct, finer and heavily crowded from at different ontogenetical stages of shells, mostly two times on a single whorl in adults, the second time near or at the final third of the body chamber (Pl. 1). These morphological crowding intervals appear with very fine and elongated tuberculation; crowded intevals are of 2–3 cm breadth approx. with double number of radial ribbing than normal ribbing phases. The external smooth furrow is bordered by two external tubercle-lines; the external double row tubercles show wider interspace to the next double row on outer flank in adults. Double spiral rows with wider interspacing are a characteristic feature in adult specimens. Spiral tubercle-lines from umbilicus to mid-flank are equally spaced, whereas on the outer flank and venter the tubercle lines are arranged in double rows of tubercles. Tubercles on the ventral double rows appear on adult stages as fine, spirally elongated ridges. On adult stages and body chambers fine growth lines are intercalated throughout. Suture line is trachyceratid (ammonitic) with single-pointed lobes on lower flank (Pl. 2, Figs. F, L–N), three-pointed lateral lobes, ventral straight saddle bordered by deep and acute ventral lobes.

Discussion: The specimens from Polzberg resemble mostly the type material from the Feuerkogel in the Northern Calcareous Alps from Austria described by Mojsisovics (1893: p. 683, Pl. 186, Figs. 1–3) as *Trachyceras triadicum var. minor* being a member of the "*Trachycerata duplica*" morphogroup. According to Mojsisovics (1893) *Austrotrachyceras minor* is comparable to *Austrotrachyceras austriacum* but differs in whorl section as *A. minor* has straighter flanks with slightly sigmoidal ribbing. As originally described by Mojsisovics (1893: p. 683) the periodical crowding of radial ribbings distinguishes *A. minor* from all other members of *A. triadicum*.

Stratigraphic range: Upper Triassic, Lower Carnian, Julian 2, *Austrotrachyceras austriacum* Zone, *Austrotrachyceras minor* Biohorizon.

Regions: Bakony Mountains, Hungary (Mojsisovics, 1893); Feuerkogel, NCA, Austria (Mojsisovics, 1893; Kittl, 1903; Geyer, 1915, Krystyn, 1978); Polzberg, NCA, Austria (Krystyn, 1978, 1991; Lukeneder et al., 2020; Lukeneder & Lukeneder, 2021, 2022a).

Genus *Paratrachyceras* Arthaber v., 1915a

1915a *Paratrachyceras* Arthaber v., p. 136.

1915b *Paratrachyceras* Arthaber v., p. 57.

1915 *Paratrachyceras* Diener, p. 366.

1948 *Trachyceras (Paratrachyceras)* Trauth, p. 37, 39.

1951 *Paratrachyceras* Spath, p. 42.

1957 *Trachyceras* (*Paratrachyceras*) Arkell et al., p. L158.

1972 *Paratrachyceras* Kozur, p. 383.

2022a *Paratrachyceras* Lukeneder & Lukeneder, p. 1.

2023 *Paratrachyceras* Lukeneder & Lukeneder, p. 1.

Type species: *Trachyceras hofmanni* Böckh, 1872 (p. 155, Pl. 9, Fig. 11; = Mojsisovics, 1882, p. 135, Pl. 29, Fig. 13; = Arthaber, 1915a, p. 136, Fig. 11), *Trachyceras aonoides* Zone, from Veszprém, limestones of Vöröstö, Bakony Mountains, Hungary.

Remarks: The genus *Paratrachyceras* is based on type *Trachyceras hofmanni* in Böckh (1872). Böckh characterized *T. hofmanni* as small and very involute shells, fast expanding whorl height, with dense and numerous highly sigmoidal ribbing (Arkell et al., 1957), without bundling. Ribs are rarely dichotomous branching from umbilical edge or slightly distant from the umbilicus. The type species appears with no tuberculation on flanks and umbilical edge (Böckh, 1872). The narrow venter shows a tight and deep furrow flanked by tuberculate rows, depicting the swollen ends of ventrolateral ribs. Ribs are broader and shallow on the outermost part of flanks, starting to be convexly arched being fine on the venter, which the cross in an apertural bow. As noted by Spath (1951) the genus *Paratrachyceras* was created by Arthaber (1915a) for ribbed trachyceratid forms without or little tuberculation, one or maximum two rows on the ventrolateral or ventral area, almost smooth to weakly ribbed morphotypes, revising the taxonomic assignment of these not or little tuberculated members by Mojsisovics (1882) to the contrastingly strong tuberculated genus *Trachyceras*. In accordance to Spath (1951), the type ranges longer from up to almost lower Carnian, not only appearing in lower Ladinian to middle Carnian as suggested by Arthaber (1915a).

Stratigraphic range: Upper Triassic, Lower Carnian, Julian 2, *Austrotrachyceras austriacum* Zone, *Austrotrachyceras minor* Biohorizon.

Paratrachyceras haberfellneri (Mojsisovics, 1882)

(Pl. 3, Figs. A–Q)

*1882 *Trachyceras haberfellneri* Mojsisovics, p. 691, Pl. 186, Figs. 6, 7; Pl. 187, Figs. 1, 2.

1931 *Trachyceras haberfelneri* Mojsisovics; Glaessner, p. 469.

1935 *Trachyceras haberfelneri* Mojsisovics; Trauth, p. 470, Pl. 1, Figs. 7, 13.

1948 *Trachyceras (Paratrachyceras) haberfelneri* Mojsisovics; Trauth, p. 37, 39, 41.

1976 *Trachyceras haberfellneri* Mojsisovics; Tollmann, p. 136.

1978 *Neoprotrachyceras? haberfellneri*, 1893; Krystyn, p. 47.

1991 *Neoprotrachyceras haberfelneri*; Krystyn, p. 37.

2022a *Paratrachyceras haberfellneri* Lukeneder & Lukeneder, p. 3.

2023 *Paratrachyceras haberfellneri* Lukeneder & Lukeneder, p. 2.

Material from Polzberg: 160 specimens from the lowermost three metres of the Reingraben Shales at Polzberg, Polzberggraben, from sequence Po -50 cm to Po 320 cm (Pl. 3): NHMW 2012/0228/2228–2233, NHMW 2021/0123/0169–0324.

Measurements: NHMW 2021/0123/0153, D: 31 mm, U: 6 mm, H: 15, U/D: 0.19, H/D: 0.48, H/U: 2.5 (Pl. 3, Fig. A); NHMW 2021/0123/0144, D: 30 mm, U: 5 mm, H: 15, U/D: 0.17, H/D: 0.50, H/U: 0.50 (Pl. 3, Fig. B); NHMW 2021/0123/0154, D: 25 mm, U: 4 mm, H: 12 mm, U/D: 0.16, H/D: 0.48, H/U: 3.0 (Pl. 3, Fig. C); NHMW 2021/0123/0169, D: 31 mm (Pl. 3, Fig. D); NHMW 2021/0123/0170, H: 16 mm (Pl. 3, Fig. E); NHMW 2021/0123/0171, H: 8 mm (Pl. 3, Fig. F); NHMW 2021/0123/0172, H: 13 mm (Pl. 3, Fig. G); NHMW 2021/0123/0173, D: 20 mm, U: 2.5 mm, H: 10 mm, U/D: 0.13, H/D: 0.50, H/U: 4.00 (Pl. 3, Fig. H); NHMW 2021/0123/0174, D: 23 mm, U: 2 mm, H: 14 mm, U/D: 0.10, H/D: 0.60, H/U: 7.0 (Pl. 3, Fig. I); NHMW 2021/0123/0175, D: 21 mm, U: 2 mm, H: 11 mm, U/D: 0.10, H/D: 0.52, H/U: 5.5 (Pl. 3, Fig. J); NHMW 2021/0123/0176, D: 31 mm (Pl. 3, Fig. K); NHMW 2021/0123/0177, D: 23 mm (Pl. 3, Fig. L); NHMW 2021/0123/0178, D: 18 mm (Pl. 3, Figs. Ma, Mb); NHMW 2021/0123/0179, max. S: 18 mm (Pl. 3, Fig. N); NHMW 2021/0123/0180, max. S: 19 mm (Pl. 3, Fig. O); NHMW 2021/0123/0181, max. S: 12 mm (Pl. 3, Fig. P); NHMW 2021/0123/0182, max. S: 25 mm (Pl. 3, Fig. Q).

Description: Brevidome to mesodome shells with generally involute whorls, almost straight to convex flanks, with a narrow umbilicus (Pl. 3). The venter bears a broad and deep furrow. The furrow is bordered by the thickened endings of proverse single ribs, in adults by two spirally arranged external very fine double-tubercle/ridges-rows. In numerous adult specimens, a second double row of fine ridges occurs on the outer flank, mostly on the body chamber. Radial ribs are strong sinuously curved on flanks, crossing in adults and towards aperture the venter in an adapical bow (proverse towards aperture). Ribbing starts at the steep umbilical edge. Ribs are thin on inner flank, bifurcating on the lower third of flank, broadening on the outer flank, being twice as thick as interspace. Fine elongated ridges are full the length of rib breadth. Broad ribs appear on the outer half of flank frequently with rib-parallel sigmoidal shallow indentions in the middle of ribs. Up to a D of approx. 10–12 mm, ribs are coarse and sharp, same thickness as interspace. From that size on up to maximum sizes of 31 mm ribbing starts thickening on mid flank to venter of mid aged to adult specimens. Shells are preserved as original shell material (whitish) in the calcareous lower parts of section and being dissolved and replaced in the upper more argillaceous layers. As described from the type material for "*Trachyceras" haberfellneri* (= *Paratrachyceras haberfellneri*) from the same locality ribs are provers at the ventral shoulders and appear with double rows of fine tubercles or ridges, progressing up to the final stage of aperture. As in the type material two to three more tubercle/ridges spiral rows can appear in specimens. The external smooth furrow is bordered by single thickened endings of main proverse ribs, passing into finer and double rows of elongated ridges on the body chambers and towards the aperture. On the flank no spiral tubercle-lines from umbilicus to midflank are visible, ribs are smooth. Tubercles on the ventrolateral and ventral double rows appear on adult stages as fine, spirally elongated ridges. On adult stages and body chambers fine growth lines are intercalated throughout, crossing the venter parallel to main ribs. Suture lines are mostly not preserved, but in single specimens partly visible as trachyceratid (ammonitic) with single-pointed lobes on lower flank, three-pointed lateral lobes, and an almost straight and broad umbilical saddle.

Discussion: The newly collected specimens from Polzberg resemble mostly the type material from the same locality at Polzberg in the Northern Calcareous Alps from Austria described by Mojsisovics (1893: p. 691, Pl. 186, Figs. 6, 7) as *Trachyceras haberfellneri* being a member of the "*Trachycerata duplica"* morphogroup. *T. haberfellneri* (p. 691, Pl. 187, Figs. 1, 2) specimens shown by Mojsisovics (1893) from the "*Trachyceras*-Schiefer" of Hinterbrühl near Mödling (Lower Austria) were included in a different "*Trachycerata falcosa"* morphogroup. The assignment of *A. minor* to the same morphogroups has to be questioned. According to Mojsisovics (1893) "*Trachyceras" haberfellneri* (= *Paratrachyceras haberfellneri*) is comparable to "*Trachyceras" medusae* (= *Paratrachyceras medusae*) but differs in a finer sculpture and absence of tuberculation on flanks and umbilical edge in *P. haberfellneri*. According to Mojsisovics (1893) it resembles "*Protrachyceras" hofmanni* from Vöröstó (*Trachyceras aonoides* Zone, Bakony mountains, Hungary) but differs in the presence of tuberculation which is absent in *P. hofmanni* (*Trachyceras hofmanni* in Mojsisovics, 1882: p. 135, Pl. 29, Fig. 13). "*Protrachyceras" hofmanni* was incorporated in the genus *Paratrachyceras* as *P. hofmanni* by Arthaber (1915a) as *"Trachyceras" dichotomum* was adapted to *P. dichotomum*. A comparable species, but contrastingly without external tuberculation in adults is *"Trachyceras" dichotomum* (Mojsisovics, 1882: p. 132, Stuores Wiesen, Italy; Pl. 24, Fig. 14; St. Cassian, Italy, Pl. 29, Figs. 11, 12, all *Trachyceras aon* Zone). *Paratrachyceras regoledanum* (Mojsisovics, 1882: p. 132, Prezzo and Val Paludina, Italy; Pl. 29, Figs. 6–8, all *Protrachyceras archelaus* Zone), is more evolute as *P. haberfellneri*, and appears with only one tubercle spire near ventral furrow. Suture parts visible in the Polzberg material is clearly different to given ones for *P. dichotomum* (Mojsisovics, 1882: Pl. 29, Fig. 11c). We follow the idea of Arthaber (1915a) to include almost smooth members, with sigmoidal dichotomous ribbing and narrow umbilicus to *Paratrachyceras*, as applicated for *P. haberfellneri*.

Stratigraphic range: Upper Triassic, Lower Carnian, Julian 2, *Austrotrachyceras austriacum* Zone, *Austrotrachyceras minor* Biohorizon.

Regions: Polzberg, NCA, Austria (Mojsisovics; 1893; Kittl, 1903; Geyer, 1915; Krystyn, 1978), Lukeneder et al., 2020; LUKENEDER & LUKENEDER, 2021, 2022a); Hinterbrühl, NCA, Austria (MOJSISOVICS, 1893); Scheiblinggraben, NCA, Austria (MOJSISOVICS, 1893); Grossaugraben, Lechnergraben and Schöckelreith, NCA, Austria (TRAUTH, 1948).

Family Carnitidae ARTHABER, 1911

Genus *Carnites* MOJSISOVICS, 1879a

1879a *Carnites* MOJSISOVICS, p. 68.
1879b *Carnites* MOJSISOVICS, p. 135.
1882 *Carnites* MOJSISOVICS, p. 277.
1895 *Carnites* WAAGEN, p. 140.
1897 *Carnites* DIENER, p. 61.
1902 *Carnites* MOJSISOVICS, p. 311
1989 *Carnites* NIEDERMAYR, p. 49.
1951 *Carnites* SPATH, p. 26.
1957 *Carnites* ARKELL et al., p. L157.
1994 *Carnites* TOZER, p. 76.
2021 *Carnites* LUKENEDER & LUKENEDER, p. 1.
2022a *Carnites* LUKENEDER & LUKENEDER, p. 1.
2023 *Carnites* LUKENEDER & LUKENEDER, p. 1.

Type species: *Nautilus floridus* WULFEN, 1793 (p. 113, Fig. 16), from the "Muschelmarmor", dark shales and limestones with iridescent ammonites of Bad Bleiberg, Carinthia, Austria.

Remarks: Medium- to large-sized, involute shells with oxycone whorl section. *Carnites* has almost smooth shells with fine growth lines visible, on the flanks with swollen radially orientated ridges. Venter is keeled and tricarinate in juvenile stages, later in ontogeny bicarinate and sharply edged (ARKELL et al., 1957). Umbilicus narrow with rounded but steep wall. MOJSISOVICS (1873) first included *Carnites* in Pinacoceratidae and separated later into Carnitidae (MOJSISOVICS, 1882), based on the stronger ornamentation in *Carnites*.

Stratigraphic range: Upper Triassic, Lower Carnian.

Carnites floridus (WULFEN, 1793)

(Pl. 4, Figs. A–D)

*1793 *Nautilus floridus* WULFEN, p. 113, Fig. 16.
1846 *Ammonites floridus* sp. WULFEN; HAUER, p. 44.
1847 *Ammonites floridus* sp. WULFEN; HAUER, p. 22, Pl. 1, Figs. 5–14.
1855 *Ammonites floridus* sp. WULFEN; HAUER, p. 150.
1873 *Pinacoceras floridum* WULFEN; MOJSISOVICS, p. 58, Pl. 25, Figs. 1–6, Pl. 22, Figs. 15, 16.
1879b *Carnites floridus* WULFEN, MOJSISOVICS, p. 135.
1882 *Carnites floridus* (WULFEN); MOJSISOVICS, p. 228, Pl. 50, Figs. 5–8, Pl. 51, Figs. 1–8.
1902 *Carnites floridus* (WULFEN); MOJSISOVICS, p. 312.
1924 *Carnites floridus* WULFEN; SCHAFFER, p. 313, Fig. 392.
1957 *Carnites floridus* (WULFEN); ARKELL et al., p. L157, Fig. 185-5a, b.
1976 *Carnites floridus* (WULFEN); TOLLMANN, p. 140.
1977 *Carnites floridus*; GRIFFITH, p. 2.
1978 *Carnites floridus*; KRYSTYN, p. 63, Fig. 13.
2005 *Carnites floridus*; PRETO et al., p. 274, Fig. 6A
2007 *Carnites floridus* (WULFEN 1793); HORNUNG et al., p. 277, Fig. 6b.
2018 *Carnites floridus* (WULFEN 1793); DOJEN, p. 236, Figs. 1–5.
2021 *Carnites floridus*; LUKENEDER & LUKENEDER, p. 8, table 1.
2022a *Carnites floridus* LUKENEDER & LUKENEDER, p. 3.
2023 *Carnites floridus* LUKENEDER & LUKENEDER, p. 5.

Material from Polzberg: 20 specimens from the lowermost three metres of the Reingraben Shales at Polzberg, Polzberggraben, from sequence Po -50 cm to Po 320 cm (Pl. 4); NHMW 2012/0228/0226, NHMW 2012/0228/0360, NHMW 2021/0123/0183, NHMW 2012/0228/0230, NHMW 2012/0228/0227, NHMW 2012/0228/0224, NHMW 2012/0228/0510, NHMW 2012/0228/0229, NHMW 2021/0123/0184, NHMW 2021/0123/0185, NHMW 2021/0123/0186, NHMW 2021/0123/0187, NHMW 2021/0123/0188, NHMW 2021/0123/0189, NHMW 2021/0123/0190, NHMW 2021/0123/0191, NHMW 2021/0123/0192, NHMW 2021/0123/0193, NHMW 2021/0123/0194, NHMW 2012/0228/0525, NHMW 2012/0228/0470 and NHMW 2005z0005/0005 from historical collections and new excavations in 2021.

Measurements: NHMW 2012/0228/0226, max. D: 123 mm, max. H: 60 mm, max. B: 30 mm, max. UW: 10 mm, ST: 2 mm (Pl. 4, Figs. A, B); NHMW 2021/0123/0183, max. S: 138 mm, max. H: 93 mm, ST: 2 mm (Pl. 4, Fig. C); NHMW 2012/0228/0230 max. S: 59 mm, max. H: 61 mm, max. B: 30 mm, shell TH: 1 mm (Pl. 4, Fig. D); NHMW 2012/0228/0227, max. S: 82 mm, max. H: 59 mm, max. B: 32 mm, shell TH: 2 mm; NHMW 2012/0228/0224, max. S: 107 mm, ST: 1 mm; NHMW 2012/0228/0510, max. S: 77 mm, max. H: 78 mm, shell TH: 2 mm; NHMW 2012/0228/0229: max. S: 70 mm, S: 2 mm; NHMW 2021/0123/184, fragment, max. S: 29 mm; NHMW 2021/0123/0185, fragment max. S 18 mm; NHMW 2021/0123/0186, fragment, max. D: 9 mm; NHMW 2021/0123/0187, juvenile, max. D: 8 mm; NHMW 2012/0228/0470, fragment, max. D: 15 mm; NHMW 2021/0123/0188, juvenile, max. D: 4 mm; NHMW 2021/0123/0189, fragment, max. D: 4 mm; NHMW 2021/0123/0190, fragment, max. S: 27 mm; NHMW 2021/0123/0191, fragment, max. S: 40 mm; NHMW 2021/0123/0192, juvenile, max. D: 3 mm; NHMW 2021/0123/0193, fragment, max. S: 2 mm; NHMW 2021/0123/0194, juvenile, max. D: 4 mm; NHMW 2012/0228/0525, mid aged, max. D: 41 mm, max. UW: 3 mm; NHMW 2005z0005/0005, mid aged, max. S: 36 mm, max. H: 54 mm.

Description: Only one entire large specimen with the body chamber preserved was found at Polzberg (Pl. 4, Figs. A, B). Although diagenetically compressed, the sculpture is unique and characterises *Carnites floridus* (WULFEN, 1793) unequivocally. The specimen bears the typical, fine growth lines and hardly visible radial swellings. Umbilicus is narrow and appears with rounded shoulder. No suture observable. NHMW 2021/0123/0183 is a body chamber fragment with typical swellings (n 5) from umbilicus to half flank, venter sharply edged, growth lines visible throughout specimen (Pl. 4, Fig. C). NHMW 2012/0228/0230 is a fragment with three main thickened ribs visible, growth lines throughout (Pl. 4, Fig. D). NHMW 2012/0228/0224 shows six main ribs on the fragment. NHMW 2012/0228/0510 fragment with growth lines.

Discussion: The typical morphology and sculpture of the specimen from Polzberg (Pl. 4, Fig. A) is unique and closely resembles the specimens figured by WULFEN (1793: p. 113, Fig. 16) as *Nautilus floridus* from the type area of Bleiberg in Carinthia, Austria. DOJEN (2018) figured several specimens from the type rea and type formation of the original material of WULFEN (1793). The material from Polzberg, although partly fragmented and diagenetically compressed, shows identical features as the growth line striation, the sharp arched venter, and most consistent sculpture elements as swolling main ribs. We follow the assumption by MOJSISOVICS (1882) and later SPATH (1951) who revised the taxonomical relations of *Pinacoceras* and *Carnites* to separate the two members on evidence from suture and sculpture.

Stratigraphic range: Upper Triassic, Lower Carnian.

Regions: Austria (WULFEN, 1793; HAUER, 1847, 1855; MOJSISOVICS, 1873, 1882; SCHAFFER, 1924; KRYSTYN, 1978; LUKENEDER & LUKENEDER, 2021, 2022a); Germany (HORNUNG et al., 2007); Italy (PRETO et al., 2005).

Order Phylloceratitida ZITTEL, 1885
Suborder Phylloceratina ARKELL, 1950
Superfamily Ussuritaceae HYATT, 1900
Family Ussuritidae HYATT, 1900
Subfamily Monophyllitinae SMITH, 1913

Genus *Simonyceras* WIEDMANN, 1970

1970 *Simonyceras* WIEDMANN, p. 970.

1981 *Simonyceras* TOZER, p. 99.

2002 *Simonyceras* SEPKOSKI, JR., p. 132.

2015 *Simonyceras* LUKENEDER & LUKENEDER, p. 384.

2022a *Simonyceras*; LUKENEDER & LUKENEDER, p. 1.

2023 *Simonyceras*; LUKENEDER & LUKENEDER, p. 1.

Type species: *Ammonites simonyi* HAUER, 1847 (p. 14, Pl. 9, Figs. 4–6), from the red limestones of Bad Aussee, Styria, Austria.

Remarks: Medium- to large-sized, evolute shells with subrounded whorl section. *Simonyceras* exhibits a distinct biconcave striation, passing the round venter without interruption. WIEDMANN (1970) established the new genus *Simonyceras* based on the coexistence of sculptural characteristics of the real *Monophyllites* and the suture characteristics of *Eopsiloceras* (SPATH, 1930). ARKELL et al. (1957) included the genus *Monophyllites* in the family Ussuritidae HYATT, 1900, which is a synonym of the family Monophyllitidae SMITH, 1913. See WIEDMANN (1970) and RAKÚS (1993) for a more detailed discussion on the genus *Simonyceras* WIEDMANN, 1970.

Stratigraphic range: Upper Triassic, Lower Carnian.

Simonyceras simonyi (HAUER, 1847)

(Pl. 5, Figs. A–E)

*1847 *Ammonites simonyi* HAUER, p. 270, Pl. 9, Figs. 4–6.

1847 *Ammonites monophyllus* QUENSTEDT, p. 256, Pl. 19, Fig. 11.

1866 *Ammonites Simonyi* HAUER; DITTMAR, p. 360, Pl. 13, Figs. 22–24.

1873 *Lytoceras simonyi* HAUER; MOJSISOVICS, p. 32, Pl. 17, Fig. 1–6, Pl. 18, Fig. 1.

1902 *Monophyllites Simonyi* HAUER; MOJSISOVICS, p. 316.

1906 *Monophyllites Simonyi* HAUER; ARTHABER; p. 5, Pl. 44.

1908 *Monophyllites* sp. ind. aff. *Simonyi* HAUER; DIENER, p. 72, Pl. 12, Fig. 7.

1909 *Monophyllites* cf. *Simonyi* HAUER; DIENER, p. 14, Pl. 4, Fig. 3.

1910 *Monophyllites Simonyi* HAUER; RENZ, p. 530, Pl. 19, Fig. 6.

1911 *Monophyllites Simonyi* HAUER; RENZ, p. 67, Pl. 6, Fig. 2, Text-Fig. 10.

1915 *M. (Monophyllites) Simonyi* HAUER; DIENER, p. 203.

1915 *Monophyllites Simonyi* HAUER; WELTER, p. 96, Pl. 86, Figs. 2, 3.

1927 *Monophyllites Simonyi* HAUER; ARTHABER; p. 140.

1932 *Monophyllites simonyi* HAUER; KUTASSY, p. 593.

1934 *Monophyllites simonyi* (HAUER); SPATH, p. 291, Text-Fig. 101.

1968 *Monophyllites simonyi* (HAUER); ALLASINAZ, p. 357, Pl. 26, Fig. 7.

1970 *Simonyceras simonyi* (HAUER); WIEDMANN, p. 970, Pl. 2, Fig. 1, 2, Pl. 3, Text-Figs. 4b, 30B.

1973 *Monophyllites simonyi* (HAUER); ANDRUSOVOVÁ, p. 95.

1993 *Simonyceras simonyi* (HAUER, 1847); RAKÚS, p. 636, Pl. 1, Figs. 1, 2, 4, Pl. 5, Fig. 1, Text.-Fig. 3.

2015 *Simonyceras simonyi* (HAUER, 1847); LUKENEDER & LUKENEDER, p. 284, Fig. 11A.

2022a *Simonyceras* simonyi; LUKENEDER & LUKENEDER, p. 3.

2023 *Simonyceras* simonyi; LUKENEDER & LUKENEDER, p. 2.

Material from Polzberg: Two specimens NHMW 2012/0228/0225 and NHMW 2012/0228/0360 from historical collections and new excavations in 2021, Reingraben Shales, lowermost calcareous three metres (Text-Fig. 1).

Measurements: NHMW 2012/0228/0360, MS: 260 mm, H: 75 mm, B: 28 mm, ST: 1 mm, 142 ribs (Pl. 5, Figs. A–D); NHMW 2012/0228/0225, MS: 80 mm, H: 34 mm, B: 17 mm, ST: 2 mm, 25 ribs (Pl. 5, Fig. E).

Description: A large fragment of the body chamber (length 260 mm) and a fragmented phragmocone (80 mm) was found at Polzberg ravine (Pl. 5, Fig. E). Both fragments show unequivocally the characteristic undulating ribbing style of *Simonyceras simonyi* (HAUER, 1847). The specimen bears the typical, distinct sigmoidal-biconcave ribbing of *S. simonyi.* A strong, adapical bow of ribbing is present on the rounded venter. Rib thickness and rib interspace are equal and constant on the preserved fragments.

Discussion: The typical, distinctly sigmoidal-biconcave sculpture of the specimen from Polzberg (Pl. 5, Figs. A–E) is unique and closely resembles the specimens figured by RAKÚS (1993) as *S. simonyi* (HAUER, 1847). The specimens reinvestigated and figured by RAKÚS (1993) are the originals of MOJSISOVICS (1873, GBA 1873/005/0048/01 and GBA 1873/005/0048/02) along with one additional specimen (GBA 1993/003/0001/01) from the same Lower Carnian locality of the Feuerkogel (Styria, Austria). The specimen from Polzberg is similar in ribbing to specimens figured by MOJSISOVICS (1873); WIEDMANN (1970), and RAKÚS (1993) from the type locality. 56 additional specimens from the Feuerkogel could be compared from the collections of the NHMW. The compared material was originally collected at the same locality at Feuerkogel as the material of Mojsisovics were described from there, as was the type material after HAUER (1847; locality Aussee = Feuerkogel).

Stratigraphic range: Upper Triassic, Lower Carnian.

Regions: NCA, Austria (HAUER, 1847; DITTMAR, 1866; MOJSISOVICS, 1873, 1879a, b, 1882, 1893, 1902; NEUMAYR, 1879; ARTHABER, 1906; KUTASSY, 1932; SPATH, 1934; LUKENEDER & LUKENEDER, 2022a); St. Cassian, SA (QUENSTEDT, 1846–1849); Western Carpathians (ANDRUSOVOVÁ, 1973); Romania (SHEVYREV, 1990); Greece (RENZ, 1909, 1910, 1911; KUTASSY, 1932); Lombardy (ALLASINAZ, 1968); Aşağiyaylabel, Taurus Mountains, Turkey, Himalaya and Timor (DIENER, 1908, 1909; WELTER, 1915; ARTHABER, 1927; WIEDMANN, 1970; KUTASSY, 1932; LUKENEDER & LUKENEDER, 2015).

Parataxonomy

Anaptychus lunzensis TRAUTH, 1935

(Text-Figs. 4A–D)

Type species: *Anaptychus lunzensis* TRAUTH, 1935 (p. 468, Pl. 1, Figs. 7–15), from argillaceous laminated deposits of Polzberg, Lower Austria, Austria.

1931 *Aptychus* GLAESSNER, p. 470.

*1935 *Anaptychus lunzensis* n.f., f. typ.; TRAUTH, p. 468, Pl. 1, Figs. 7–10.

2021 *Anaptychus lunzensis* TRAUTH; LUKENEDER & LUKENEDER, p. 5, Fig. 3E.

2022a *Anaptychus lunzensis* TRAUTH; LUKENEDER & LUKENEDER, p. 5, Fig. 3E.

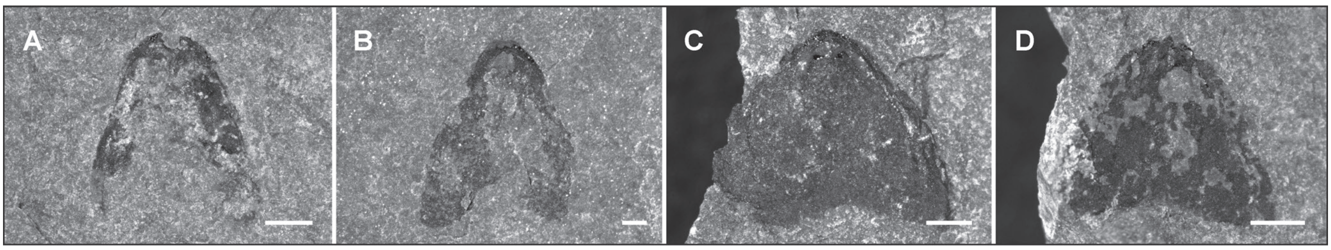
2023 *Anaptychus lunzensis*; LUKENEDER & LUKENEDER, p. 8, Table 1.

Material from Polzberg: 281 isolated specimens NHMW 2012/0228/0001–0129 and NHMW 2021/0123/2252–2404 from historical collections and new excavations in 2021, Reingraben Shales, lowermost calcareous five metres. Frequently (n 57) preserved buccal apparatuses of anaptychus-type lower jaws in or near body chambers.

Measurements: Upper jaws: NHMW 2021/0123/0151, L: 4.0 mm, B: 3.5 mm (Text-Fig. 4A); NHMW 2021/0123/0152, L: 5.0 mm, B: 4.6 mm (Text-Fig. 4B); Lower jaws: NHMW 2021/0123/0149, L: 4.1 mm, B: 4.9 mm (Text-Fig. 4C); NHMW 2021/0123/0150, L: 3.5 mm, B: 4.1 mm (Text-Fig. 4D).

Description and discussion: Ammonoids are frequently (n 57) partly preserved with buccal apparatuses of black, carbonised anaptychus-type lower jaws *Anaptychus lunzensis*. The lower jaw *An. lunzensis* was recorded with 281 isolated specimens throughout the section. These anaptychi represent lower jaws in buccal masses of trachyceratid ammonites (TRAUTH, 1935). Anaptychi are rarely reported from Upper Triassic deposits because they are primarily chitinous; when present they are preserved as black, thin, univalve sub-triangular to triangular plates. Analyses show that the black substance consists almost exclusively of enriched carbon (C) altered from a chitinous substance by carbonisation in early diagenetic stages. Both species *A. minor* and *P. haberfellneri* exhibit in situ anaptychi in the innermost third of the body chamber. Anaptychi of two morphological groups with *An. lunzensis forma longa* (Text-Figs. 4A, B; TRAUTH, 1935) and *An. lunzensis forma typica* (Text-Figs. 4C, D; TRAUTH, 1935) were detected isolated from ammonoid shells.

An. lunzensis (TRAUTH 1935) was described from the Polzberg deposits as being the lower jaws of *Paratrachyceras haberfellneri* (= "*Trachyceras haberfelneri* with *An. lunzensis forma typica*" TRAUTH, 1935: Pl. 1, Figs. 7–10). TRAUTH was uncertain in other form types as *forma longa* (TRAUTH, 1935: Pl. 1, Figs. 13, 14), *forma lata* (TRAUTH 1935: Pl. 1, Figs. 11, 12) and *forma carinifera* (TRAUTH, 1935: Pl. 1, Fig. 15) in his *A. lunzensis*



Text-Fig. 4.
A–D: upper and lower jaws (anaptychi) of *Austrotrachyceras minor* and *Paratrachyceras haberfellneri*. A: upper jaw, positive, lateral view, isolated specimen, NHMW 2021/0123/0151. B: upper jaw, positive, lateral view, isolated specimen, NHMW 2021/0123/0152. C: *Anaptychus lunzensis*, lower jaw, positive, lateral view, isolated specimen, NHMW 2021/0123/0149. D: *A. lunzensis*, lower jaw, positive, lateral view, isolated specimen, NHMW 2021/0123/0150. Text-Figs. 4A (Fig. 5K), 4B (Fig. 5L), 4C (Fig. 5I) and 4D (Fig. 5J), refigured after not coated specimens in LUKENEDER & LUKENEDER (2022a). Scale bars: 1,000 µm.

taxonomy. He mentioned a possible connection to "*Trachyceras" triadicum* and "*Trachyceras austriacum*". As TRAUTH (1935) meant the species from the lower Reingraben Shales, even from the same localities as described herein, both of his assigned "*T." triadicum* and "*T." austriacum* are considered as being synonyms of *A. minor*. We assume that the different morphologies depict lower jaws with *An. lunzensis* and upper jaws (open nomenclature) of the described ammonite taxa *A. minor* and *P. haberfellneri*. Upper and lower jaws appear with different ratios of length and breadth of univalves. In upper jaws, the length exceeds the breadth, in contrast to lower jaws showing a larger maximum breadth. Paired inner lamellae; a thickened apical area and a narrower angle of outer surface lines strengthen the assignment of the narrower specimens as upper jaws (Text-Figs. 4C, D).

Stratigraphic range: Upper Triassic, Lower Carnian.

Regions: Polzberg, NCA, Austria (GLAESSNER, 1931; TRAUTH, 1935; LUKENEDER & LUKENEDER, 2021, 2022a).

Biostratigraphy and Chronostratigraphy

The Reingraben Shales of Polzberg (NCA, Austria) consist of a single ammonoid assemblage, representing the Lower Carnian *Austrotrachyceras austriacum* Zone (Julian 2; Text-Fig. 1). The lowermost, fossiliferous part of the Reingraben Shales can be dated, due to the occurrence of *Austrotrachyceras minor*, *Paratrachyceras haberfellneri* and the accompanying *Carnites floridus* and *Symoniceras simonyi* as Julian 2 (Julian 2/Ib). The occurrence of these ammonoid members together with the mass occurrence of the benthic bivalve *Halobia rugosa* within the fossiliferous layers strengthens the biostratigraphical assignment with Julian age (LUKENEDER & LUKENEDER, 2021). The appearance of the abundant index ammonite *A. minor* (Pls. 1, 2) within the fossiliferous interval (= abundance zones, characterized by abundance or mass-occurrence of specific ammonite species) is crucial for understanding the biostratigraphy of the lower Carnian Polzberg *Konservat-Lagerstätte*. Although there are still biostratigraphical inconsistencies (i.e. possible hiatus) at the lower boundary to the underlying Göstling Member, the *A. minor* to the lower *A. triadicum* Biohorizon boundary (Julian 2/Ia to 2/Ib, both *A. austriacum* Subzone; MUELLER et al., 2016; LUKENEDER & LUKENEDER, 2021, 2022a) could be identified at Polzberg exactly between the Reifling Member and the Reingraben Shales.

Taphonomy of the ammonoid fauna

The ammonoid fauna of Polzberg appears with different quantities of taxonomic groups and qualities in preservation through the entire section. Here we present only a short overview and basic points of the taphonomy with aspects of biostratinomy and fossil diagenesis from the Polzberg ammonoid assemblages, since taphomomic issues and the detailed analyses were recently topic in LUKENEDER & LUKENEDER (2022a).

Important information on ammonoid taphonomy is gained from the fossiliferous *Konservat-Lagerstätte* at the Polzberg site (Text-Fig. 1). The Lower Carnian palaeobiota from the *Austrotrachyceras austriacum* Zone was deposited during the initial phase of the Reingraben Shales. This basal interval at Polzberg of approx. 4 m is marked by finely, millimetre-laminated argillaceous deposits without bioturbation. This lowermost fossiliferous part comprises the main faunal elements with mass occurrences of halobiids and abundant trachyceratid ammonoids. *Halobia rugosa*, dominate within the invertebrates, followed by the abundant trachyceratid ammonoids *Austrotrachyceras* and frequent *Paratrachyceras* (LUKENEDER & LUKENEDER, 2021, 2022a). The nektic cephalopod assemblage is completed by rare ammonoids with *Carnites* and *Simonyceras*, accompanied by the belemnoid *Phragmoteuthis* (LUKENEDER & LUKENEDER, 2022b). Frequent vertebrate actinopterygian fish occur as entire carcasses or in coprolites as densely packed isolated fish scales.

Austrotrachyceras minor occurs with high abundances by forming fossiliferous deposits (Text-Fig. 2) within the lowermost three, more calcareous metres of the otherwise very argillaceous Reingraben Shales (i.e. Po -50 cm to Po 340 cm). The quantity of *A. minor* has been extrapolated from the lateral expansion of the outcrop area along the stream (approx. 130 m), a width of approx. 30 m (on both stream slopes) and the thickness of the fossiliferous parts (approx. 3 m) and calculated from the known distribution of the species and specimens from the excavations from historical collections and from recent field campaigns. At Polzberg within its 11,700 m^3 bed the estimation appears with approximations, which yields more than 100,000 ammonoids at this site.

Ammonoids show different kind of preservation of *Austrotrachyceras* and *Paratrachyceras* within the lower more calcareous parts and in the upper more argillaceous parts. Almost every single ammonoid is compressed by diagenetical processes but appears with original aragonite shell in the lowermost 3 m. Layers within the deposit show 'normal' sedimentation, without ammonoid 'event beds' where masses of biogenic fragments or shells are accumulated. No traces of transport of the incorporated ammonoid shells, gastropods, bivalves or fish carcasses and subsequent orientated shells by currents (turbidity or water currents) are observed.

All ammonoids show compressed-preservation, in which the flanks (= lateral shell walls) are attached to the other shell wall, only fine sediment remnants are observed between squeezed shell layers. Quite frequent the phragmocones are less compressed and show septal walls and suture lines. Nevertheless, the ammonoids are generally well preserved (e.g. original shell material, phragmocone with body chamber, in situ aptychi, soft body preservation, rare suture; LUKENEDER & LUKENEDER, 2022a) with shell preservation, without borings, not secondary replaced by calcite.

Numerous vertically oriented fragments of ammonoid shells (ventral side horizontal to bedding plane) hint a deposition after lethal fish or coleoid attacks (LUKENEDER et al., 2020), deposited under calm and dysoxic conditions in finely-laminated marlstones and shales. This occurs in the Lower Carnian deposits of the Polzberg Sub-Basin within the Polzberg *Konservat-Lagerstätte*.

Discussion

Ammonoid assemblage composition of the Polzberg Konservat-Lagerstätte in context to the Tethyan Realm

The lowermost meters of the section at Polzberg, located within the Lunz Nappe (Northern Calcareous Alps, Lower Austria), consists of the Reingraben Shales (Julian 2–Ib, Lower Carnian; LUKENEDER et al., 2020, LUKENEDER & LUKENEDER, 2022a). New taxonomic data led to a revised composition of the Polzberg ammonoid fauna concerning the different trachceratid members. *Austrotrachyceras* and *Paratrachyceras* are presented with their morphological details and additionally *Simonyceras simonyi* and *Carnites floridus* are figured from the Polzberg *Konservat-Lagerstätte* for the first time.

The lowermost 3 m of the log are abundant in ammonoids (n 2,411) *Austrotrachyceras* and *Paratrachyceras*, sampled bed-by-bed. Historical material (> 4,000 ammonoids) was collected in mine tunnels located in the vicinity of the recent locality, not bed-by-bed sampled, hence not included in detailed conclusions. Within the trachyceratids *Austrotrachyceras minor* dominates with 87 % over *Paratrachyceras haberfellneri* with 13 %. The accompanying cephalopod fauna consists of rare *C. floridus* and *S. simonyi* along with frequent members of the belemnoid species *Phragmoteuthis bisinuata*. The fact that nearly 90 % of the cephalopod shells belong to *A. minor* and the rare additional ammonoid, belemnoid and gastropod specimens document a paucispecific assemblage (KIDWELL et al., 1986; LUKENEDER & LUKENEDER, 2021, 2022a).

A. minor dominates from Po -50–180 cm in the section with 95–100 % starting to be accompanied higher in the section from Po 180 cm onwards by 5–93 % of *P. haberfellneri*, in cases at Po 300 cm totally replaced by the new and smaller species with 100 % (Text-Fig. 2). The enormous number of all, in details juvenile stages down to 1–2 mm, in *A. minor* compensates the few larger specimens. Mean and median values decrease in both species from the bottom to top of the Polzberg section (Text-Fig. 3) reflecting the adaptive strategies in these trachyceratids, hence possible dwarfing due to the ecological pressure and environmental restrictions. The adaptation in size is due to the limited oxygenation and hostile environmental conditions during the deposition in r-strategists or opportunistic species of the genus *Austrotrachyceras* and *Paratrachyceras*.

The ammonoid fauna from Polzberg embraces a time interval around the *Austrotrachyceras austriacum* Zone in the Lower Carnian within the Upper Triassic. The Polzberg locality offers an opportunity to investigate a Carnian ammonoid fauna and its cephalopod members in detail. Due to the abundance and the presence of all ontogenetic stages in the trachyceratids a detailed picture can be drawn from that time slice deposited in changing environmental conditions during the worldwide Carnian Crisis. Hence, the section at Polzberg represents a key-section for marine Carnian deposits in the Austrian Northern Calcareous Alps affected by a major environmental turnover. It is one of the few historical sections encompassing an interval in the Carnian Pluvial Episode, well documented by trachyceratid assemblages possible to reinvestigate by new material worldide. The Polzberg section appears with well-preserved ammonoids, appropriate to be used for taxonomy and biostratigraphy. As most of Carnian sections from Austria and Italy are only being dated by the use of conodonts (e.g. Lagonegro Basin; RIGO et al., 2007; LUKENEDER et al., 2012). Records of Julian as well as of Tuvalian ammonoids are dated from the Heiligenkreuz Formation (Dolomites, Southern Alps; KEIM et al., 2006; BREDA et al., 2009). Well known, but historical type localities within the NCA as the Carnian from the Feuerkogel (Styria) generally bear abundant excellent and not compressed ammonoids, but are usually strongly condensed in lenses and fissures (MOJSISOVICS, 1873, 1879, 1882, 1893; KRYSTYN, 1973, 1978, 1991; RAKUS, 1993).

Within the Tethyan Realm, the Lower Carnian is characterised by an intense facies replacement with concomitant carbonate platform vanishing and reef demise, the so-called Carnian Pluvial Episode or Carnian Crisis (HORNUNG et al., 2007; BREDA et al., 2009; LUKENEDER et al., 2012; SIMMS & RUFFELL 2018; LUKENEDER & LUKENEDER, 2021). Within the deposits of the Polzberg *Konservat-Lagerstätte* this crisis is documented from the lower boundary of the *A. austriacum* Zone, lasting the entire *A. autriacum* Subzone. Exactly at the Julian 1/Julian 2 boundary, shallow water limestones of the Reifling Formation without ammonoids show a transition into black, laminated limestones of the Göstling Member with rare trachyceratid ammonoids (*A. patroclum*) grading into the argillaceous Reingraben Shales form the *A. minor* abundance Zone with abundant trachyceratids (*A. minor* and *P. haberfellneri*). The facies alteration is reflected by a turnover from an open platform margin to deeper basinal conditions (Polzberg Sub-Basin, Reifling Basin). Newly figured and described Lower Carnian ammonoids detected at Polzberg are *A. minor*, *P. haberfellneri*, *C. floridus* and *S. simonyi*.

In contrast, the macrofauna of other localities in Lunz am See region (Grossaugraben, Lehen, Rehgraben, Saugraben, Scheiblingraben, Schöckelreith; TRAUTH, 1948; KRYSTYN, 1978, 1991), however no or badly exposed outcrops, show nearly the same assemblage composition as recorded at Polzberg. Besides the dominance of the nektonic ammonoid *Autrotrachyceras* in the water column, thin-shelled halobiid bivalves appear in rock forming mass-event beds, hence throughout the Polzberg section, accompanied by frequent, small benthic gastropods and crustaceans.

The more detailed taxonomy presented herein results in a better understanding and wider context of the Upper Triassic biostratigraphy with the corresponding stages of Lower Carnian (Julian 2–Ib), zones (*A. austriacum* Zone) and abundance biohorizons (*A. minor* abundance Zone). The taxonomy from the Polzberg ammonoids is adapted to modern taxonomy (KRYSTYN, 1973, 1978; MIETTO et al., 2008; LUCAS, 2010; BALINI et al., 2010; LUKENEDER et al., 2012; LUKENEDER & LUKENEDER, 2021, 2022a) and compared to Upper Triassic ammonoid faunas from the Tethyan Realm and North America (KRYSTYN & SCHLAGER, 1971; KRYSTYN, 1973, 1978, 1980, 1982; TATZREITER, 1982; TOZER, 1971, 1981, 1984, 1994; BALINI et al., 2007; BALINI & JENKS, 2007).

Conclusions

The macrofauna of the lowermost Reingraben Shales at the Polzberg section (Northern Calcareous Alps, Austria) is dominated by halobiid bivalves, trachyceratid ammonoids and actinopterygiid fish. The benthic bivalves demonstrate intense sea floor colonisation depending on the fluctuating oxygen content within the bottom water masses and at the sediment surface. The abundant nektonic ammonoid fauna and fish are almost independent of those environmental conditions. The recently collected material (bed-by-bed sampling)is dominated by 3,565 ammonoids and comprises entire and fragmented specimens. Ammonoids from historical excavations in 1885 and 1909 originate from nearby located abandoned and collapsed mines. Recent findings and historical collections from the identical basal fossiliferous parts were correlated.

The mono- to pauci-specific ammonite assemblage consists of four genera and species *Austrotrachyceras minor*, *Paratrachyceras haberfellneri*, *Carnites floridus* and *Simonyceras simonyi*. The biostratigraphic ammonoid zonation is based on the presence of index taxa as *A. minor*, assemblage data and composition of the corresponding ammonoid taxa (*Carnites*, *Simonyceras*). The Lower Carnian (*Austrotrachyceras austriacum* Zone) was confirmed by the ammonoid biostratigraphy. The basal part (approx. 3.4 m) of the Reingraben Shales at the Polzberg consists of a single ammonoid assemblage. The fossiliferous part can be dated, due to the occurrence of *A. minor*, *P. haberfellneri* and the accompanying *C. floridus* and *S. simonyi* as Julian 2 (Julian 2/Ib, *A. austriacum* Zone). The occurrence of these ammonoid members together with the mass occurrence of bivalve *Halobia rugosa* strengthens the biostratigraphical assignment with Julian age. The appearance of the abundant index ammonite *A. minor* (*A. minor* Biohorizon/Abundance Zone) within the fossiliferous interval is crucial for understanding the biostratigraphy of the lower Carnian Polzberg *Konservat-Lagerstätte*. Although there are still biostratigraphical inconsistencies (i.e. possible hiatus) at the lower border to the underlying Göstling Member, the *A. minor* to the lower *A. triadicum* Biohorizon boundary (Julian 2/Ia to 2/Ib, both *A. austriacum* Subzone) could be identified at Polzberg exactly between the Reifling Member and the Reingraben Shales.

The locality offers one of the few opportunities to investigate ammonoid faunas across the Lower–Upper Carnian boundary. Hence, the section at Polzberg with the special conditions offered by the deposits of the *Konservat-Lagerstätte* represents a key-section for a detailed investigation of an ammonoid fauna affected by an environmental turnover during the Carnian Pluvial Episode. It is one of the few sections worldwide, which bears a record of abundant and well preserved (entire specimens with original shell, full ontogentical spectra) Lower Carnian ammonoids.

The Lower Carnian cephalopod fauna drastically changed within the lowermost *A. austriacum* Zone in the *A. austriacum* Subzone. Rare trachyceratid ammonoids (*A. patroclum*) from the *A. triadicum* Biohorizon are replaced by abundant austrotrachyceratids with paratrachyceratids at the base of the *A. minor* Biohorizon, accompanied by rare carnitids and scattered ussuritids. Environmental modifications going along with adaptions in the ammonoid assemblages during the Lower Carnian (Julian 2) at Polzberg, are also recognised throughout the Tethyan Realm. The Polzberg ammonoid assemblages indicate a Mediterranean–Tethyan–Andean affinity, as reported by numerous authors from comparable Carnian localities in East-Central Europe (Austria, Germany, Hungary, Italy), Eastern Europe (Bosnia and Herzegovina, Bulgaria, Romania), Asia (India, Timor, Turkey), Central America (Mexico) as well as North America (Canada, USA).

The abundant ammonoid fauna appears at the basal layers of a basinal environment of the Reifling Basin, in the Polzberg Subbasin with stagnate conditions. This change of lithology corresponds to an environmental adaptation during the worldwide Carnian Pluvial Episode. In the Polzberg section the gradual platform demise shifting into a basinal environment with water depths between 200 and 500 m. The main faunal differences between Polzberg and all other known Lower Carnian ammonoid faunas are the excellent preservational features (e.g. soft parts) with in the deposits of the *Konservat-Lagerstätte* and the abundance of few members (*Austrotrachyceras*, *Paratrachyceras*). The taxonomic ammonoid data from Polzberg are the first step in producing a detailed picture for the Polzberg *Konservat-Lagerstätte* linked to a wide range of isochronic ammonoid assemblages worldwide form Europe, Africa and Asia. Forthcoming analyses will include palaeomagnetic-, isotope- and geochemical analyses.

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Author contribution

Both authors contributed equally to all aspects of the study from conception, writing to completion of the submission and edited the final version of the manuscript.

Competing interests

The authors declare no competing interests.

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Plates

Plate 1

Austrotrachyceras minor **(Mojsisovics, 1893)**

Figs. A–O: different ontogenetic stages, morphological details of *Austrotrachyceras minor* in lateral and ventral views.

Fig. A: lateral view of an adult specimen with spiral tuberculation, note typical crowding of finer ribbing on last part of body chamber and double ventral tuberculation, NHMW 2012/0228/1926.

Fig. B: lateral view of a body chamber fragment, adult specimen, note typical crowding of finer ribbing on body chamber with fine intercalated striae, external side with imprint of smooth ventral furrow adjacent double row with tubercles, NHMW 2012/0228/1890.

Fig. C: lateral view of an adult specimen with original shell, note typical temporary crowding of finer ribbing on body chamber, strong compression of body chamber, phragmocone almost unaffected, NHMW 2012/0228/2225.

Fig. D: lateral view of an adult specimen, note typical temporary crowding of finer ribbing on body chamber, strong compression of body chamber, note strong radial ribbing in early stages weakening on body chamber, stronger spiral ribbing on body chamber, NHMW 2012/0228/1855.

Fig. E: magnification of Fig. D, early ontogenetical stages with strong ribbing, NHMW 2012/0228/1855.

Fig. F: lateral view of an adult specimen, note typical temporary crowding of finer ribbing on body chamber, NHMW 2012/0228/1927.

Fig. G: magnification of Fig. F, apertural crowding of ribbing on adult stage, NHMW 2012/0228/1927.

Fig. H: lateral view of a mid-aged specimen, strong ribbing and tuberculation, note occasional bifurcation from umbilical nodes, NHMW 2012/0228/1856.

Fig. I: magnification of Fig. H, strong and bifurcating ribbing style, NHMW 2012/0228/1856.

Fig. J: lateral view of a mid-aged specimen with original shell, note occasional crowding of ribbing, NHMW 2021/0123/0131.

Fig. K: ventral view, ventrolaterally oriented body chamber fragment, original shell, NHMW 2021/0123/0160.

Fig. L: ventral view, ventrally oriented body chamber fragment, original shell, NHMW 2021/0123/0157.

Fig. M: ventral view, ventrally oriented body chamber fragment, original shell, NHMW 2021/0123/0158.

Fig. N: ventrolateral view, note smooth and deep ventral furrow, original shell, specimen with suture line, NHMW 2012/0228/2226.

Fig. O: ventral view, double row of tubercles adjacent to the ventral furrow, original shell, NHMW 2012/0228/1894.

White asterisk at the edge of body chamber to phragmocone.
Fig. J (Fig. 3A), Fig. K (Fig. 6H), Fig. L (Fig. 6E) and Fig. M (Fig. 6F), refigured after uncoated specimens in Lukeneder & Lukeneder (2022a).

Scale bars: 10 mm.


A
B
C
D
E
F
G
H
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J
K
L
M
N
O

Plate 2

Austrotrachyceras minor **(MOJSISOVICS, 1893)**

Figs. A–N: different ontogenetic stages, morphological details and suture of *Austrotrachyceras minor* in lateral views, all with original shell.

Fig. A: lateral view of an adult specimen with spiral tuberculation, note typical crowding of finer ribbing on last part of body chamber, NHMW 2021/0123/0167.

Fig. B: lateral view of an adult specimens, note typical change in ribbing and tuberculation, NHMW 2021/0123/0140.

Fig. C: lateral view of an adult specimen with original shell, note crowding of finer ribbing on final body chamber, NHMW 2021/0123/0132.

Fig. D: lateral view of an adult specimen, note crowding of finer ribbing on final body chamber, with in situ *Anaptychus*, NHMW 2021/0123/0141.

Fig. E: lateral view of an adult specimen with suture line; inside of original shell, note compressed body chamber hidden in deposit, NHMW 2012/0228/2227.

Fig. F: magnification of Fig. E, note trachyceratid style of suture, NHMW 2012/0228/2227.

Fig. G: lateral view of a juvenile specimen, strong ribbing and tuberculation, note crowding of finer ribbing on final body chamber, NHMW 2012/0228/1730.

Fig. H: lateral view of a juvenile specimen, strong ribbing and tuberculation, note crowding of finer ribbing on final body chamber, NHMW 2012/0228/1836.

Fig. I: lateral view of a juvenile specimen, strong ribbing and tuberculation, note crowding of finer ribbing on final body chamber, NHMW 2012/0228/1861.

Fig. J: lateral view of a juvenile specimen, strong ribbing and tuberculation, note crowding of finer ribbing on final body chamber, with in situ *Anaptychus*, NHMW 2021/0123/0168.

Fig. K: lateral view of a juvenile specimen strong ribbing and tuberculation, note suture line, NHMW 2012/0228/2226.

Fig. L: magnification of Fig. K, coated, NHMW 2012/0228/2226.

Fig. M: line drawing of suture line of Fig. K, NHMW 2012/0228/2226.

Fig. N: magnification of Fig. K, not coated, NHMW 2012/0228/2226.

Black asterisks mark position of sutures of magnifications in Fig. F from Fig. E, and in Figs. L–N from Fig. K. Figs. F, N are uncoated.
White asterisks mark position of last suture, start of body chamber.
White arrow (a) position of *Anaptychus*.
Fig. C (Fig. 3C) and Fig. D (Fig. 5A), refigured after uncoated specimens in LUKENEDER & LUKENEDER (2022a).

Scale bars: 10 mm, except Figs. L–N: 1 mm.

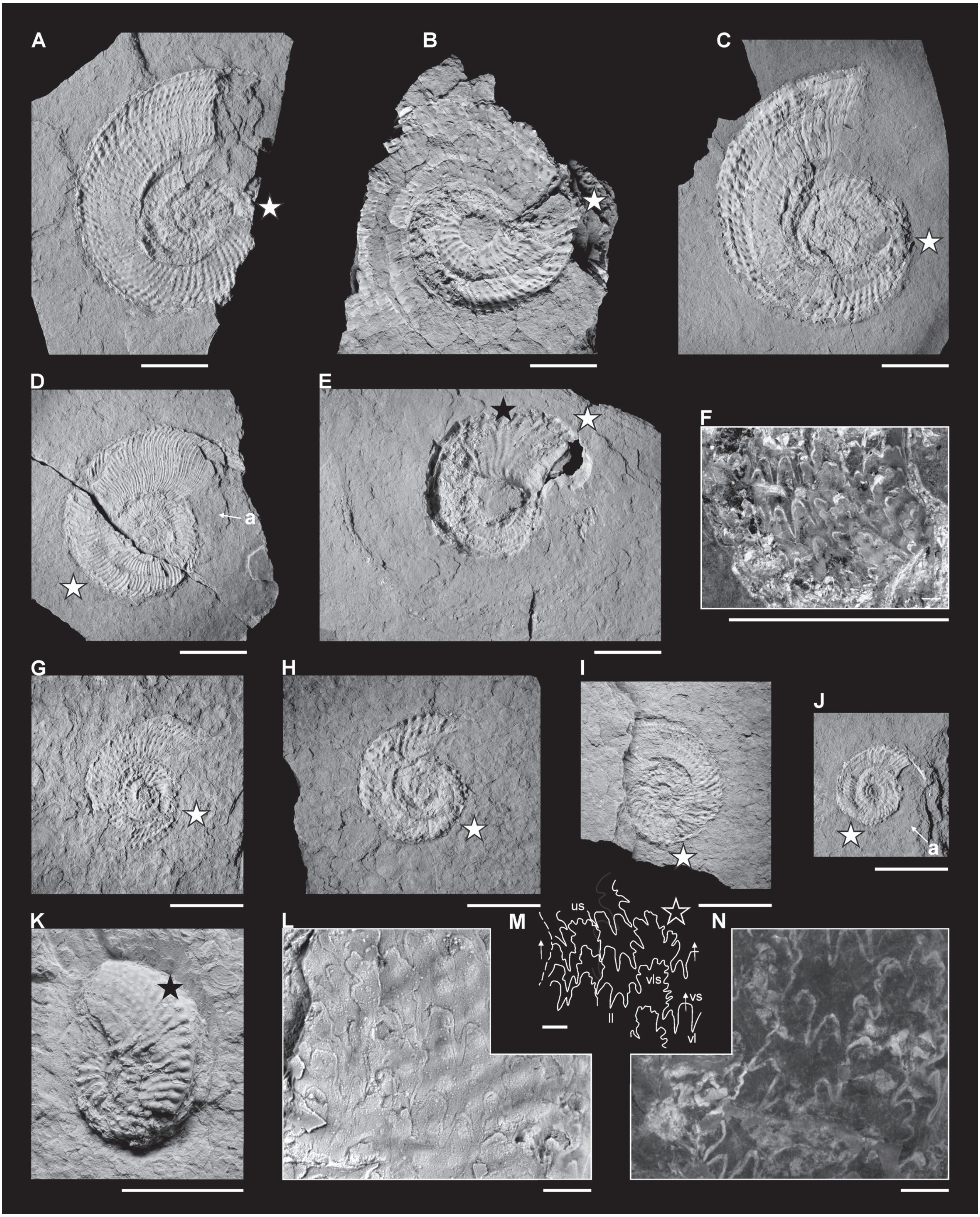
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Plate 3

Paratrachyceras haberfellneri **(Mojsisovics, 1882)**

Figs. A–Q: different ontogenetic stages, morphological details and suture of *Paratrachyceras haberfellneri* in lateral and ventral views.

Fig. A: lateral view of an adult fragmented specimen with sigmoidal ribbing, note weak ventrolateral tuberculation, with in situ *Anaptychus*, NHMW 2021/0123/0153.

Fig. B: lateral view of an adult specimens, note typical change in ribbing and weak ventrolateral tuberculation, with in situ *Anaptychus*, NHMW 2021/0123/0144.

Fig. C: lateral view of a fragmented specimen, NHMW 2021/0123/0154.

Fig. D: lateral view of an adult specimen, note weak ventrolateral tuberculation a ventral furrow, NHMW 2021/0123/0169.

Fig. E: ventrolateral view of a fragment, note weak ventrolateral tuberculation and ventral furrow, adult specimen, NHMW 2021/0123/0170.

Fig. F: ventrolateral view of a fragment, note ventral thickening of proverse ribbing and tuberculation with ventral furrow, adult specimen, NHMW 2021/0123/0171.

Fig. G: ventrolateral view of a fragment, note furcation in ribbing and weak ventrolateral tuberculation, inside view of original shell, adult specimen, NHMW 2021/0123/0172.

Fig. H: lateral view of an adult specimen, furcating and sigmoidal ribs and thickening on flank, NHMW 2021/0123/0173.

Fig. I: lateral view of an adult specimen, furcating and sigmoidal ribs and thickening on flank, NHMW 2021/0123/0174.

Fig. J: lateral view of an adult specimen, furcating and sigmoidal ribs and thickening on flank, note fine tuberculation on ventrolateral shell and suture on juvenile stage, NHMW 2021/0123/0175.

Fig. K: lateral view of an adult specimen, furcating and sigmoidal ribs and thickening on flank, note fine tuberculation on ventrolateral original shell, NHMW 2021/0123/0176.

Fig. L: lateral view of an adult specimen, furcating and sigmoidal ribs and thickening on flank, note fine tuberculation on ventrolateral original shell, NHMW 2021/0123/0177.

Fig. M: lateral view of an adult specimen, furcating and sigmoidal ribs note finer ribs and crowding on lateral part near aperture, Ma positive, Mn negative, NHMW 2021/0123/0178.

Fig. N: ventrolateral view of an adult specimen, note fine ribs thickening on venter, crossing in a bow ventral furrow near aperture, NHMW 2021/0123/0179.

Fig. O: ventrolateral view of an adult specimen, note fine ribs thickening on venter, crossing in a bow ventral furrow near aperture, NHMW 2021/0123/0180.

Fig. P: ventrolateral view of an adult specimen, note fine ribs thickening on venter, crossing in a bow ventral furrow near aperture, NHMW 2021/0123/0181.

Fig. Q: view of numerous fragments in a bromalite mass, note typical features as thickening ribs, and ventrolateral tuberculation, NHMW 2021/0123/0182.

Black asterisk marks position of suture of magnification Fig. A.
White asterisks mark position of last suture, start of body chamber.
White arrow (a) position of *Anaptychus*.
Fig. A (Fig. 6A), Fig. B (Fig. 5D) and Fig. C (Fig. 6B), refigured after not coated specimens in Lukeneder & Lukeneder (2022a).

Scale bars: 10 mm, except suture drawing with 1 mm.

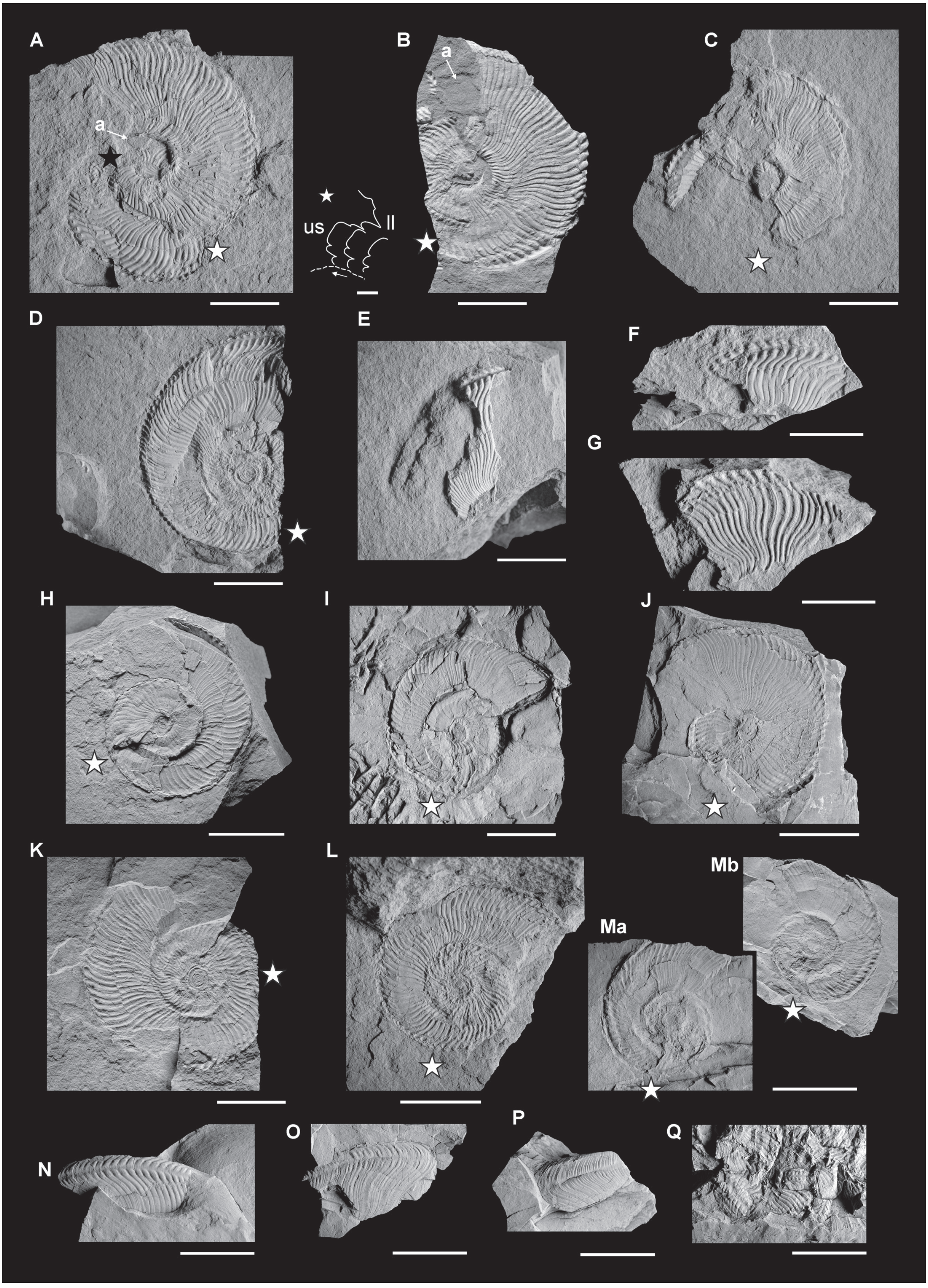
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Plate 4

Carnites floridus (Wulfen, 1793)

Figs. A–D: different preservations and typical shell ornamentation in *Carnites floridus*, all with original shell.

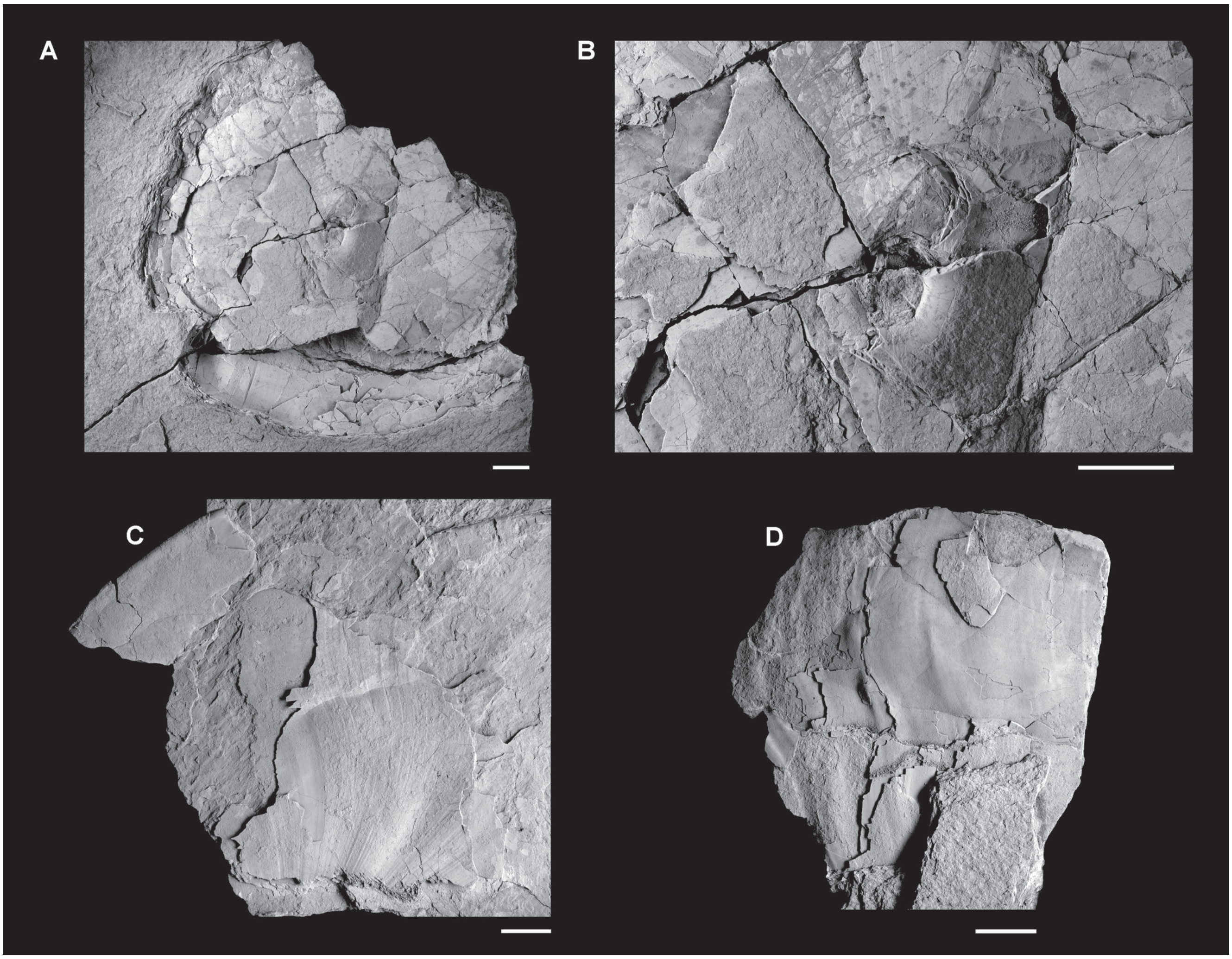
Fig. A: lateral view of an adult entire specimen with narrow umbilicus with rounder shoulder, note fine growth lines on body chamber, NHMW 2012/0228/0226.

Fig. B: magnification of Fig. A, with details of umbilical area, NHMW 2012/0228/0226.

Fig. C: lateral view of an adult fragment, note growth lines, typical swellings of ribs on lower flank and acute venter, NHMW 2021/0123/0183.

Fig. D: lateral view of an adult fragment with growth lines, typical swellings of ribs on lower flank and acute venter, NHMW 2012/0228/0230.

Scale bars: 10 mm.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B
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D

Plate 5

Simonyceras simonyi **(HAUER, 1847)**

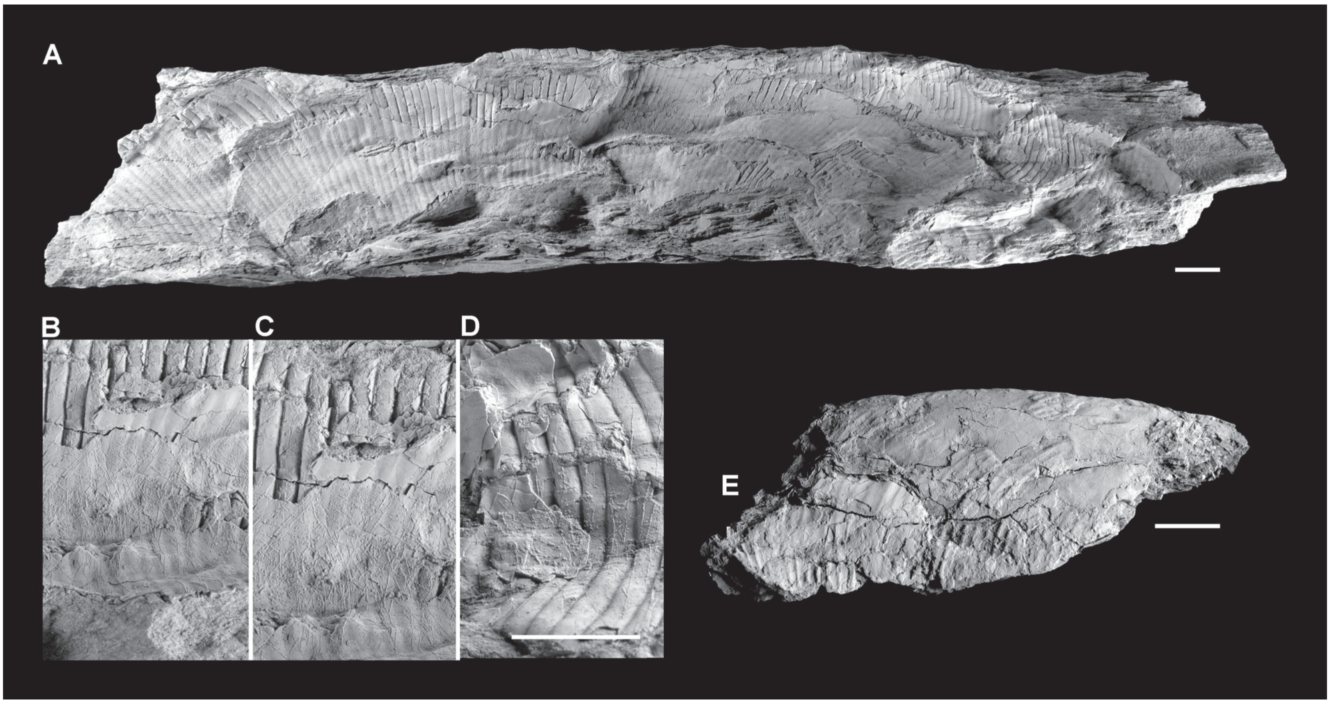
Figs. A–D: fragmented specimens with typical shell ornamentation in *Simonyceras simonyi*, all with original shell.

Fig. A: ventrolateral view of an adult fragmented specimen with narrow round flank and venter, NHMW 2012/0228/0360.

Figs. B–D: magnifications of Fig. A, with details of typical ribbing and shell morphology, NHMW 2012/0228/0360.

Fig. E: lateral view of an adult fragment, with rounded venter, NHMW 2012/0228/0225.

Scale bars: 10 mm.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