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Middle Jurassic Assemblage of Calcareous Trochospiral Foraminifera from a Fissure Filling in the Vils Limestone at its Type Area (Tyrol, Austria)

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4 Text-Figures

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Northern Calcareous Alps
Middle Jurassic
Benthic Foraminifera
Systematics
Microfacies

Contents

Zusammenfassung 209
Abstract 209
Introduction. 210
Sample Location and Material. 210
Systematic Description 211
Acknowledgements. 214
References 215

Mitteljurassische Vergesellschaftung von kalkschalig trochospiralen Foraminiferen aus einer Spaltenfüllung im Vilser Kalk der Typusregion (Tirol, Österreich)

Zusammenfassung

Aus einer Spaltenfüllung des mitteljurassischen Vilser Kalks aus dem Steinbruch „Fall“ in der Typusregion südwestlich Vils (Außerfern, Tirol) wird eine Spirilliniden-Involutiniden-Vergesellschaftung (Gattungen *Paalzowella*, *Hungarillina*, *Trocholina*) beschrieben. Die Art *Hungarillina lokutiense* Blau & Wernli wird erstmalig aus den Nördlichen Kalkalpen bekannt gemacht. Vergleichbare Assoziationen vorwiegend kleinwüchsiger Arten kalkschaliger Benthosforaminiferen sind aus dem Mitteljura (Bajocium) von Ungarn und Frankreich beschrieben worden, wo sie in typisch offen-marinen echinodermen- und brachiopodenreichen Karbonaten auftreten.

Abstract

A characteristic Middle Jurassic small-sized spirillinid-involutinid assemblage (genera *Paalzowella*, *Hungarillina*, *Trocholina*) is described from a fissure filling of the Vils Limestone (Außerfern, Tyrol). The species *Hungarillina lokutiense* Blau & Wernli is reported for the first time from the Northern Calcareous Alps. This rare species of calcareous benthic foraminifera was previously known only from comparable associations of the Middle Jurassic (Bajocian) of Hungary and France, where it typically occurs in open marine limestones rich in echinoids and brachiopods.

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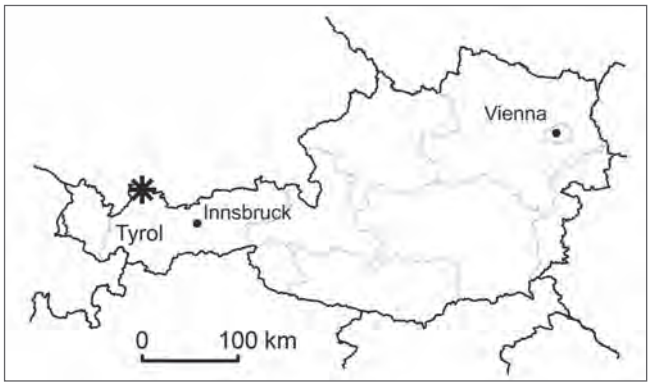
Introduction

In general, the Vils Limestone comprises massive to bedded crinoid-brachiopod-limestones, deposited on submarine highs or as allodapic resediment in basinal areas (HAUER, 1853; TRAUTH, 1922; TOLLMANN, 1976). The type locality is situated south of the municipality Vils in the western Northern Calcareous Alps (NCA) of Tyrol, but the formation is also widespread in the Bajuvaric Nappes of the northern part of the eastern NCA. The stratigraphic range of the Vils Limestone (with both diachronous base and top) is usually considered as Middle Jurassic (Late Bajocian to Callovian) (e.g. GAWLICK et al., 2009). The Austrian Stratigraphic Chart (2004) refers the Vils Limestone to the Latest Toarcian–Bajocian interval (PILLER et al., 2004). In the revisional framework of the Austroalpine Jurassic sedimentary sequences provided by GAWLICK et al. (2009), the Vils Limestone is regarded as an invalid lithostratigraphic name, needing revision and formalization. According to LEUPRECHT & MOSHAMMER (2010), the Vils Limestone (or Vils Formation) in its type locality was deposited on the "Vilser Schwelle", a submarine rise of Upper Triassic to Liassic carbonates which plunges deeply towards a northern basin. Condensed reddish limestones exhibiting a presumably Upper Toarcian hardground commonly form the base of the Vils Limestone. The swell underwent a long-lasting tectonic activity, notably expressed by synsedimentary resedimentation, breccia formation and multiphase fissure fillings (LEUPRECHT, 2003; LEUPRECHT & MOSHAMMER, 2006).

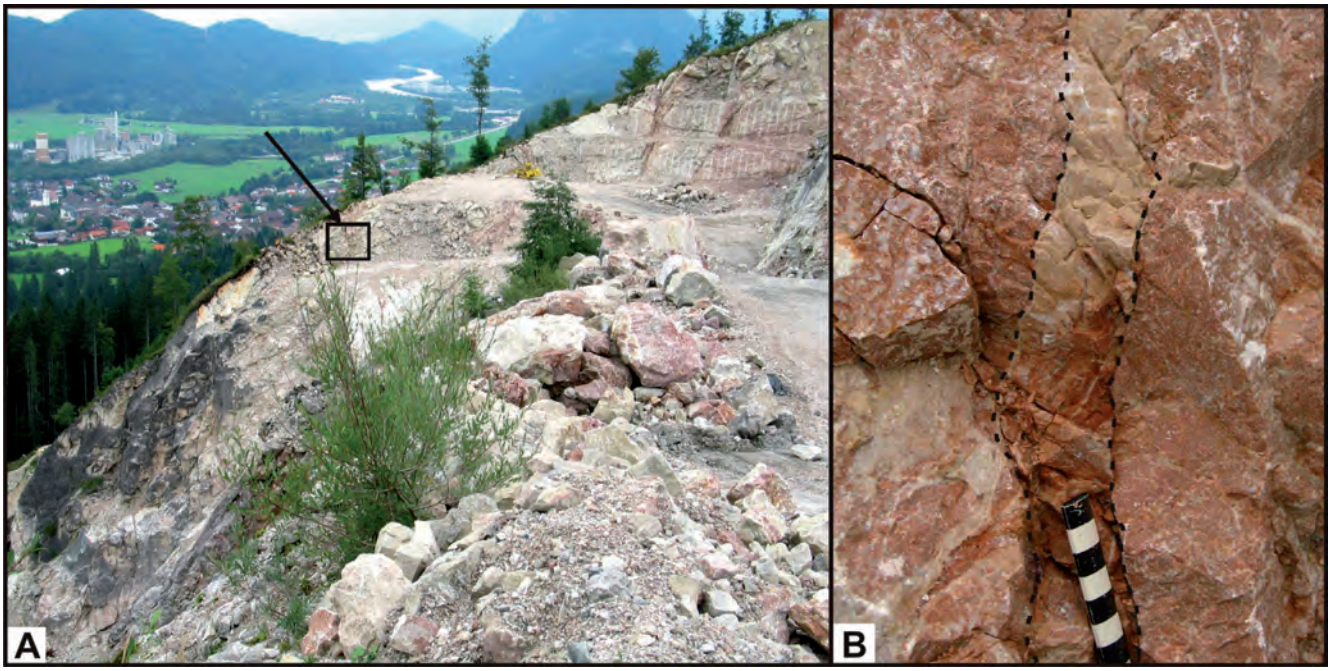
Concerning the microfaunistic association of the Vils Limestone, almost nothing is known. LEUPRECHT & MOSHAMMER (2010: 54) stated the rareness of foraminifera showing both low diversity and density. In the present contribution, however, a comparably rich association of typical Middle Jurassic benthic foraminifera is described from recently restudied thin-sections of a fissure filling in the Vils Limestone from its type area.



Text-Fig. 1.
Generalized geographic sketch map with the sample location of the Vils Limestone in the western part of Tyrol, near to the German border (further details, i.e. coordinates, in the text).

Sample Location and Material

The studied thin-sections (number NFR 91-o and NFR 91-u) belong to the collection of the Geological Survey of Austria and date back to a project on mineral resources and were published by MOSHAMMER (2009) and LEUPRECHT & MOSHAMMER (2010). The material in question comes from the Vils type area, and in particular from the quarry "Fall" of the company Schretter & Cie, located close to the German border (Text-Fig. 1). The sampling point is located on the topographic map of Austria, sheet no. 85 Vils, with BMN M28 coordinates measuring 171394 eastings and 267185 northings. The corresponding geographic coordinates are 47°32'36.932''N and 10°37'3.275''E. A picture of the sampling area at the upper eastern part of the quarry



Text-Fig. 2.
Location of the fissure in August 2005.
A: Upper eastern part of the quarry viewed in ENE direction. The town Vils and the cement factory where the quarry material is processed are seen to the left; river Lech in flood is in the rear back. B: Exposure of the upright fissure (dotted lines) of pale dense limestone, which contrasts the hosting vivid red sparry limestone.

taken in summer 2005 is provided in Text-Fig. 2A: The yellow drilling machine nearby the eastern quarry face marks the spaceous quarrying level at 1,020 m above sea level. This quarry face corresponds to the northern half of the section described in LEUPRECHT & MOSHAMMER (2010: Pl. 7). According to their interpretation, the whitish-greyish parts observed to the left (north) expose massive biodetritic limestones (Middle to Upper Dogger Vils Limestone types) whereas the pink parts to the right (south) represent crinoid-brachiopod dominated fans of the Lower Dogger Vils Limestone. Both lithologies are separated by a steeply north dipping fault following prominent fissures which contain Upper Jurassic to Lower Cretaceous sediments. However, the fissure in question was found near the northern rim of the narrow level below the drilling machine. It appeared rather inconspicuous in the surrounding lively flesh-coloured and beige alternating bioclastic brachiopod-crinoid grainstones with its few centimetres in width and a light peach-colour that is not uncommon in fissures of the Vils swell (Text-Fig. 2B). Its main attraction, however, lay in its faint oolithic-oncolithic texture. The previous authors' later microscopical investigations led to fundamental questions regarding the local palaeogeography of the Vils swell as similar yet thick sediments represent the Dogger in the southern facies realm (compare "Südlicher Faziesraum", LEUPRECHT & MOSHAMMER, 2010: Pl. 9, 17).

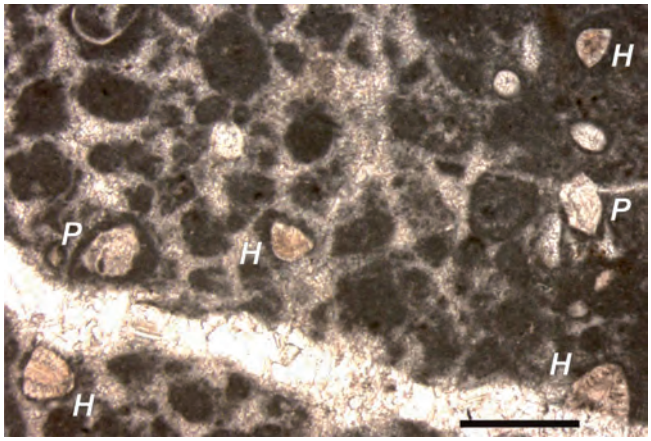
The microfacies of the sample comprises a grain- to packstone especially rich in ostracods and calcareous benthic foraminifera, sometimes surrounded by dense micritic envelopes (microbial coatings?) (Text-Fig. 3). Miliolid foraminifera are rare (*Ophthalmidium*? sp.) and agglutinated benthics are absent. The sediment is layered, displaying different packing densities and different sizes of the components. Concerning the stratigraphic position of the sample, no concrete data are available. An overall Middle Jurassic age (Bajocian?) is indicated by the presence of *Hungarillina lokutiense* (BLAU & WERNLI, 1999; PIUZ, 2004).

Systematic Description

The recent supraordinal classification of Foraminifera based on molecular phylogeny and supplementary morphological data of PAWLOWSKI et al. (2013) is used. The lower rank systematic follows LOEBLICH & TAPPAN (1987).

Phylum	**Foraminifera D´ORBIGNY, 1826.**
Class	**Tubothalamea PAWLOWSKI et al., 2013.**
Order	**Spirillinida HOHENEGGER & PILLER, 1975.**
Family	**Placentulinidae KASIMOVA, POROSHINA & GEODAKCHAN, 1980.**
Subfamily	**Ashbrookiinae LOEBLICH & TAPPAN, 1984.**
Genus	***Paalzowella* CUSHMAN, 1933.**

Remarks: *Paalzowella* represents a multiloculine and trochospirally coiled benthic foraminifera displaying a calcitic hyaline, monocrystalline wall (LOEBLICH & TAPPAN, 1987). It is worth a mention that *Paalzowella* CUSHMAN, 1933 was considered a synonym of *Coronipora* KRISTAN, 1958 by BLAU & HAAS (1991). This view is incorrect and was already corrected in a later work by BLAU & WERNLI (1999) as *Coronipora*, besides morphological differences, has an aragonitic lamellar test (see the revision of RIGAUD et al., 2013).



Text-Fig. 3.
Microfacies of the studied sample. Grain- to packstone with benthic foraminifera displaying micritic envelopes. *H* = *Hungarillina lokutiense* BLAU & WERNLI, *P* = *Paalzowella* sp. aff. *turbinella* (GÜMBEL). Scale bar: 0.5 mm.

All *Paalzowella* species (and subspecies) were described from isolated specimens obtained from Middle to Early Late Jurassic marly lithologies (GÜMBEL, 1862; PAALZOW, 1932; LUTZE, 1960; SEIBOLD & SEIBOLD, 1960; BIELECKA & STYK, 1969; LEVCHUK, 2009). Therefore, determination of thin-section material usually does not permit determinations free of doubt. The quite poor preservation of the material represents a further reason that only tentative attributions, partly with open nomenclature, are provided for our specimens.

Based on material from the Lower Cretaceous of Romania, NEAGU & CÎRNARU (2001: 287) elevated the previously defined subspecies and assigned most of the former *Paalzowella* species to the genus *Rumanolina*, which would differ from *Paalzowella* in "*the early planispiral chambers and irregularly biserial disposition of the adult (last chambers)*". Only the type species *P. turbinella* (GÜMBEL) was not assigned to *Rumanolina* by NEAGU & CÎRNARU (2001). The homeomorphic *Patellina* WILLIAMSON, to which some *Paalzowella* species were assigned in some papers (e.g. DIENI & MASSARI, 1965; SZYDŁO, 2005) is differentiated from the latter by its exoskeletal elements, namely radial septula at the chamber periphery (LOEBLICH & TAPPAN, 1987). LOEBLICH & TAPPAN (1987: 543) indicate the range of *Paalzowella* as Bajocian to Oxfordian but its total vertical distribution is still poorly constrained, for the genus itself as well as for its different species. For example, a Kimmeridgian species was recently described by LEVCHUK (2009). PETROVA et al. (2012) raised the last occurrence of *P. feifeli* up to the lowermost Cretaceous (Berriasian); NEAGU & CÎRNARU (2001) reported the species in the Valanginian.

Paalzowella? sp. aff. *turbinella* (GÜMBEL, 1862)

(Text-Figs. 3 pars, 4a–f)

* 1862 *Rotalina turbinella* n. sp. – GÜMBEL, p. 230, Pl. 4, Fig. 10a–b.

1955 *Paalzowella turbinella* (GÜMBEL) – SEIBOLD & SEIBOLD, p. 126, Text-Figs. 5i–m, Pl. 13, Fig. 12.

Description: Test a low to medium conical spire (apical angle ~ 120 to ~ 140°) with numerous chambers arranged in 4 to 6 whorls, visible on the spiral side. The umbilical side

is convex often displaying a central flattened part and giving rise to a boat-like outline of the test in axial sections (e.g. Text-Fig. 4e). A slight central concave depression may be observed (Text-Fig. 4b). Some specimens seem to display a papillose umbilical side (e.g. Text-Fig. 4f). Chamber periphery ornamented with upward directed elevated keels giving the test a spinose appearance in axial sections. Internal structure and number of trochospirally coiled chambers per whorl as well as aperture unclear due to the lack of basal and transverse sections. Wall calcareous, monocrystalline calcitic, with a translucent yellowish appearance.

Dimensions:
Diameter (D) = 0.23–0.34 mm.
Height (H) = 0.16–0.24 mm.
D/H = 1.4–1.85.
Proloculus diameter ~ 0.02 mm.

Remarks: The test morphology of our forms typically recalls that of *Paalzowella*. With this respect, our specimens correspond to illustrations of the type species *Paalzowella turbinella* (GÜMBEL) provided by MORYCOWA & OLSZEWSKA (2013) from coral-bearing limestones of the Pieniny Klippen Belt of Slovakia. The age of this facies is still a matter of debate, e.g. Bajocian or Late Jurassic (Oxfordian). It is worth mentioning that as one hint for an Upper Jurassic age of these limestones, the occurrence of *P. turbinella* is indicated by MORYCOWA & OLSZEWSKA (2013).

In comparison to the re-illustrations of isolated specimens provided by LOEBLICH & TAPPAN (1987: Pl. 588, Figs. 24–35, Pl. 589, Figs. 1–4) from different localities (Upper Jurassic of Belarus and Germany), *P. turbinella* seems to be a variable-shaped species wherein our thin-section specimens might possibly be accommodated. For further information about *P. turbinella* see GÜMBEL (1862), SEIBOLD & SEIBOLD (1960), WINTER (1970: Kimmeridgian material), GÖRÖG (1995: Bathonian material) and GÖRÖG et al. (2012: Callovian material). *Paalzowella*? sp. aff. *turbinella* (GÜMBEL, 1862) represents a common taxon in the studied two thin-sections.

The existence of papillose lamellae on the umbilical side, as described by RIGAUD et al. (2013) from different representatives of the aragonitic, tubular involutinids has never been mentioned in the genus *Paalzowella* (e.g. LOEBLICH & TAPPAN, 1987). The umbilical mass of *Paalzowella* is very narrow and this structure might have been overlooked. However, if the type material of *Paalzowell*a lacks papillose lamellae, then our specimens should be assigned to a new genus.

Paalzowella? sp. 1

(Text-Fig. 4g–h, i?)

Description: Test small, a conical spire (apical angle about 90°) with rounded apex and consisting of 5 whorls visible on the spiral side. The height is slightly larger than the diameter. The umbilical side is convex throughout, with or without a small central depression. Spiral side rather smooth; chamber periphery lacking elevated flange-like keels. Internal structure and number of trochospirally coiled chambers as well as aperture unclear. Wall calcareous, monocrystalline calcitic, with a translucent yellowish appearance.

Dimensions (2 specimens):
Diameter (D) = 0.27 mm / 0.28 mm.
Height (H) = 0.20 mm / 0.24 mm.
D/H = 1.35/1.20.
Proloculus diameter ~ 0.025 mm.

Remarks: With its biconvex test morphology, our specimens morphologically resemble *Paalzowella pazdroae* from the Bathonian of Poland and described on the basis of isolated specimens (BIELECKA & STYK, 1969). It differs, however, from the latter by its larger size (twice as big). With the lack of elevated keels in both the Alpine and Polish specimens, the attribution to *Paalzowella* is doubtful (see genus diagnosis in LOEBLICH & TAPPAN, 1987: 543). *Paalzowella*? sp. 1 is very rare in the two studied thin-sections.

Paalzowella? sp. 2

(Text-Fig. 4j-k)

Description: Test small, trochospirally coiled, high conical in shape (apical angle ~ 25 to ~ 30°) with flat to slightly convex base. Chambers arranged in up to 9 whorls; periphery with short keels. Internal structure and number of trochospirally coiled chambers as well as aperture unclear. Wall calcareous, monocrystalline calcitic, with a translucent yellowish appearance.

Dimensions (3 specimens):
Diameter (D) = 0.1 mm / 0.12 mm / 0.12 mm.
Height (H) = 0.12 mm / 0.17 mm / 0.19 mm.
D/H = 0.83 / 0.7 / 0.63.

Remarks: *Paalzowella*? sp. 2 is rather rare in the two studied thin-sections, and our material, poorly preserved, does not allow clearly distinguishing individual chambers. The high-conical morphology and the dimensions compare to *P. elevata* (or *P. feifeli elevata*) (e.g., LUTZE, 1960). In addition, we mention similarities of our specimens to those illustrated by PIUZ (2004, e.g. Pl. 4, Fig. 17) as *P. feifeli* aff. *elevata* from the Bajocian of France. It is worth mentioning that the specimens of *R.*? *elevata* described from the Valanginian of Romania by NEAGU & CÎRNARU (2001) are two to three times the size of the Middle and Late Jurassic specimens, raising some doubts about their identity.

Family **Spirillinidae REUSS & FRITSCH, 1861.**
Genus ***Hungarillina* BLAU & WERNLI, 1999.**

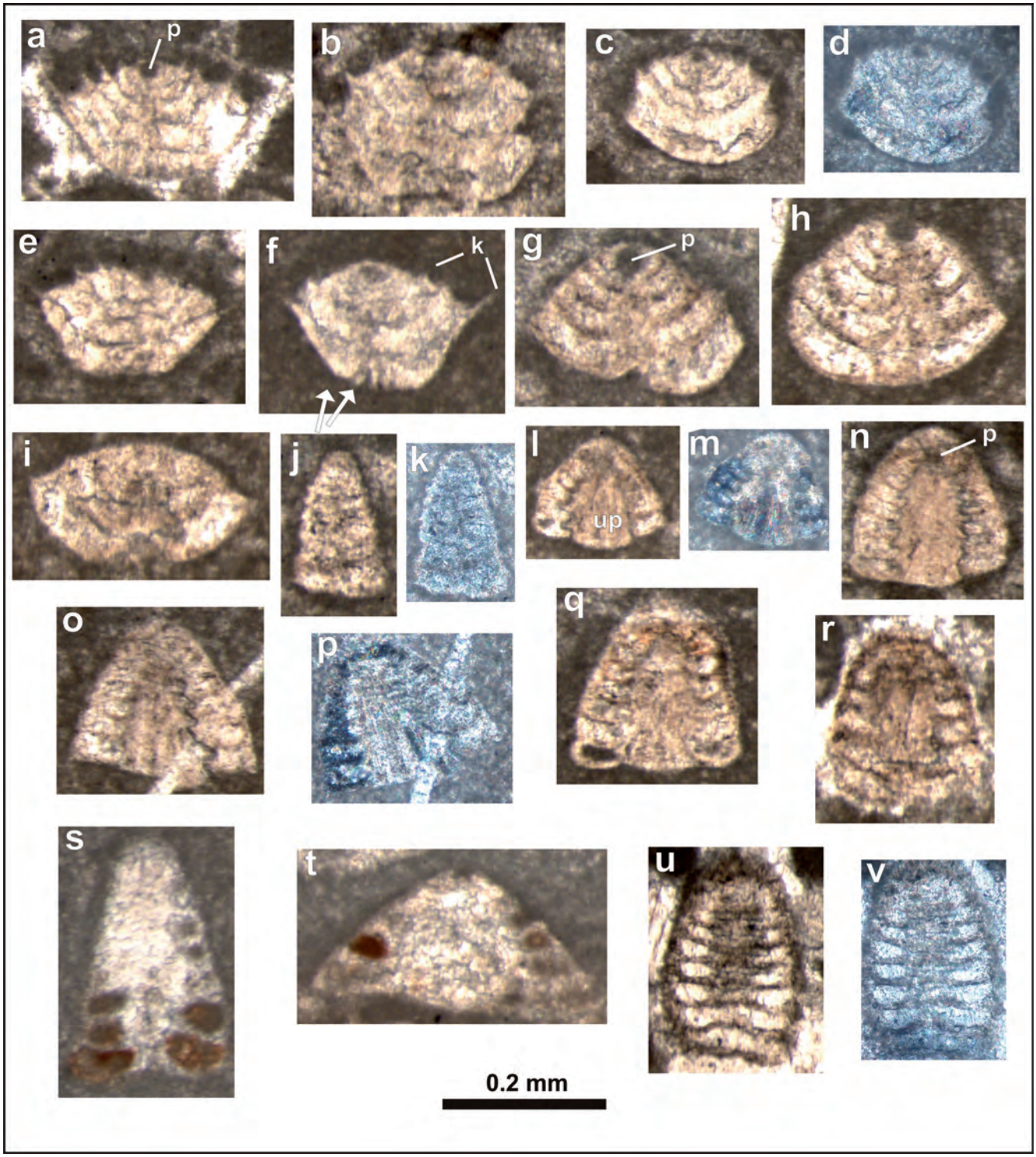
Hungarillina lokutiense BLAU & WERNLI, 1999

(Text-Figs. 3 pars, 4l–r)

* 1999 *Hungarillina lokutiense* n. sp. – BLAU & WERNLI, p. 539–540, Pl. 1, Figs. 1–17.

2004 *Hungarillina lokutiense* BLAU & WERNLI – PIUZ, p. 46, Pl. 3, Figs. 3, 6, 9, 12.

Description: Test small, conical to bell-shaped, biloculine, consisting of a spherical proloculus followed by a trochospirally coiled tubular enrolled chamber in up to 8–9 whorls. The umbilical side is mostly slightly convex, more rarely planar. During ontogeny the tubular chamber becomes successively flattened and may become up to 3 times wid-



Text-Fig. 4.
Benthic foraminifera from the Middle Jurassic Vils Limestone. Thin-sections NFR 91o (a–c, r) and NFR 91u (d–q, s–v). Abbreviations: p = proloculus, k = (elevated) keels, up = umbilical plug of hyaline-radiate calcite crystals; arrows = possible papillae. Scale bar: 0.2 mm. d, k, m, p and v with polarized light (crossed Nichols).

a–f *Paalzowella*? sp. aff. *turbinella* (GÜMBEL), (sub)axial sections.
g–h, i? *Paalzowella*? sp. 1, axial sections.
j–k *Paalzowella*? sp. 2, axial sections.
l–r *Hungarillina lokutiense* BLAU & WERNLI, l–q axial sections, r oblique section.
s *Trocholina turris* FRENTZEN, axial section.
t *Trocholina conica* (SCHLUMBERGER), axial section.
u–v Gen. et sp. indet., tangential section.

er than high. The tubular chamber wall is monocrystalline calcitic, whereas the central umbilical plug is hyaline-radiate. Viewed under polarized light, the radiate microstructure of the umbilical plug is well discernible, contrasting the total extinction displayed by the tubular chamber wall (Text-Fig. 4m, p). The boundary between the umbilical plug and the surrounding whorls shows a zagged, interfingering appearance in axial sections (Text-Fig. 4l, n, o).

Dimensions:
Height (H) = 0.13–0.25 mm (most values around 0.2 mm).
Diameter (D) = 0.17–0.24 mm.
D/H = 0.8–1.2 (Blau & Wernli, 1999: 0.8–1.1, mean 1.0).
Apical angle = 30–70°.

Unfortunately, no values for test height and diameter that could be used for comparison were provided by Blau & Wernli (1999).

Remarks: The occurrence in the fissure filling of the Vils Limestone represents the third record of *H. lokutiense*. The type species of *Hungarillina* was described by Blau & Wernli (1999) from middle? Bajocian limestone blocks resedimented within a late Bajocian megabreccia near Lókút, in the Transdanubian Range of Hungary. The microfauna at the type locality includes an association of spirillinids, epistominids, protoglobigerinids, lenticulinids, nodosariids, and others. Apart from these foraminifera, microgastropods, ammonites, ostracods, aptychi, crinoids, brachiopods, *Globochaete*, *Bositra* filaments and "ferrugineous microstromatolites" were reported. Piuz (2004: microfaunistic association AF1) reported *H. lokutiense* from the Bajocian of the Southern Jura of France (Burgundy and Subalpine mountain range). The micropaleontological association includes sprillinids, ostracodes, filaments, calcispheres, sponge spicules, microbialites, and crinoids ("calcaires à entroques" = crinoids limestones). For the fissure filling of the Vils Limestone, a source area with similar or equivalent palaeoenvironmental demands and (micro)palaeontological assemblage can be assumed.

It is worth mentioning that *Hungarillina media* Blau & Wernli associated with small calcareous benthic foraminifera (*Spirillina*, *Tethysiella*, *Paalzowella*) was reported by Ivanova et al. (2015) from the Bajocian–Bathonian of the Pieniny Klippen Belt, Slovakia.

Order **Involutinida Hohenegger & Piller, 1977.**
Suborder **Involutinina Hohenegger & Piller, 1977.**
Superfamily **Involutinoidea Bütschli, 1880.**
Family **Trocholinidae Kristan-Tollmann, 1963, emend. Rigaud et al., 2013.**
Subfamily **Trocholininae Kristan-Tollmann, 1963, emend. Rigaud et al., 2013.**
Genus ***Trocholina* Paalzow, 1922.**

Trocholina turris Frentzen, 1941

(Text-Fig. 4s)

* 1941 *Trocholina turris* n. sp. – Frentzen, p. 306, Pl. 1, Fig. 13a–c.

1962 *Trocholina* (*Trocholina*) *turris* Frentzen – Kristan-Tollmann, p. 232, Pl. 2, Figs. 14–22.

1978 *Trocholina turris* Frentzen – Piller, p. 83–84, Pl. 20, Figs. 12, 15, 18 (with synonymy).

1987 *Trocholina turris* Frentzen – Blau, p. 8, Pl. 2, Figs. 9–13.

1990 *Trocholina turris* Frentzen – Kristan-Tollmann, p. 238–239, Fig. 13.1–4, Pl. 12, Figs. 1–3.

1991 *Trocholina turris* Frentzen – Blau & Haas, p. 12, Figs. 3E, G.

1997 *Trocholina turris* Frentzen – Ebli, p. 98, Pl. 28, Figs. 13–15, Pl. 35, Fig. 16.

2010 *Trocholina turris* Frentzen – Senowbari-Daryan et al., Figs. 3/j, 5, 6l–n, 12e–k, 20n (with synonymy).

Remarks: One specimen with a diameter (D) of 0.2 mm, height (H) of 0.3 mm (ratio D/H = 0.67) and an apical angle of ~ 30°. The dimensions of our specimen are in the ranges indicated by Piller (1978), Blau (1987) or Ebli (1997). Chamber lumen of the high trochospirally coiled test is filled with reddish micrite. *T. turris* is widespread in the Liassic of the Northern Calcareous Alps, e.g. Adnet Limestone or Enzesfeld Limestone (Kristan-Tollmann, 1962; Piller, 1978; Ebli, 1997), but also reported from the Late Triassic, e.g. Rhaetian of Papua-New Guinea (Kristan-Tollmann, 1990).

Trocholina conica Schlumberger, 1898

(Text-Fig. 4t)

* 1898 *Involutina conica* n. sp. – Schlumberger, p. 151.

1955 *Trocholina conica* (Schlumberger) – Reichel, Fig. 1 (drawing of lectotype), Pl. 14, Figs. 1, 3–4 (lectotype and topotype).

2013 *Trocholina conica* (Schlumberger) – Rigaud et al., Fig. 4/1–2.

Remarks: One specimen with a diameter (D) of 0.36 mm, height (H) of 0.22 mm (ratio D/H = 1.6) and apical angle of ~ 95° exhibiting 5 (?6) whorls. It falls into the overall morphology and value range of the Bathonian holotype and topotype illustrated by Reichel (1955, see synonymy) with values (measured from the illustrations) for D (0.41 mm and 0.28 mm) and H (0.2 mm and 0.14 mm), and 95° for the apical angle. Only the D/H ratio (2.05 and 2.0) is slightly differing.

Gen. et sp. indet.

(Text-Fig. 4u–v)

Remarks: It refers to a single tangential section of a biloculine high-conical foraminifer cutting 9 whorls. As the test microstructure does not display extinction in polarized light, it might belong to a trocholinid.

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