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Article

Early Oxfordian radiolarians from the ammonite-bearing Fludergraben section (Northern Calcareous Alps, Austria)

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Abstract: A well-preserved and relatively rich radiolarian fauna is described from red to grey bedded radiolarites of the Fludergraben section in the Northern Calcareous Alps, Austria. These radiolarites were deposited just above the Klaus Formation, dated by ammonites as latest Callovian or the Callovian/Oxfordian boundary. The radiolarian fauna is therefore of an early Oxfordian age undoubtedly. Among long-lasting radiolarian species coming from the Callovian, we can distinguish some species that appeared in early Oxfordian time: *Kilinora spiralis*, *Fultacapsa sphaerica*, *Protunuma japonicus*, *Pseudoeucyrtis reticularis*. We discuss these results in the light of existing radiolarian zonations for the middle Callovian to Oxfordian, and redefined the *Williriedellum dierschei* Zone (lower-middle Oxfordian), which was previously ranked as subzone in the *Zhamoidellum ovum* Zone, on the basis of the new index species. These new findings fill a gap in the definition of the Oxfordian by radiolarians and result in a better resolution of the radiolarian biostratigraphy.

In the chapter of systematic part, we describe 37 genera, 67 species and 2 subspecies including diagnosis emendations of 2 genera (*Loopus* and *Pseudodictyomitra*) and 1 species (*Protunuma japonicus*). The type species of the genus *Loopus* is examined and redesignated.

Keywords: Western Tethys, biostratigraphy, radiolarians, Oxfordian, Fludergraben section, Northern Calcareous Alps

1. Introduction

The existing Middle to Late Jurassic radiolarian zonations (e.g. Pessagno *et al.*, 1993 for western North America; Matsuoka, 1995 for Japan and western Circum-Pacific region; Baumgartner *et al.*, 1995b; Beccaro, 2004, 2006; Suzuki and Gawlick, 2003a for Tethyan and central Atlantic regions) have been controversially discussed and several attempts were made to refine the stratigraphic ranges of radiolarian taxa (O'Dogherty *et al.*, 2011, 2017). However, until today most radiolarian workers dealing with the Tethyan/Atlantic region have still used in general the Unitary Association Zonation of Baumgartner *et al.* (1995b) without or with only moderate modifications of the age ranges of several radiolarian species. The biostratigraphic resolution of Middle to Late Jurassic radiolarians is not high and the existing biostratigraphic radiolarian zones exhibit relatively long-time duration. A main problem for a stable and precise radiolarian zonation with a much better biostratigraphic resolution is the worldwide scarcity of radiolaria-bearing sedimentary rocks in sections, where radiolarian associations can be correlated with other organisms, especially ammonoids.

In the Western Tethyan realm, and also in the Northern Calcareous Alps, radiolarian assemblages of the Callovian–Oxfordian contain species with relatively long biostratigraphic age ranges. Therefore, in most cases it cannot be decided, if a radiolarian assemblage is of Callovian or Oxfordian age, by use of the present radiolarian zonations.

Radiolarian species, which mark the beginning of the Oxfordian, are practically not known, because no successions, where radiolarian associations can be correlated with uppermost Callovian/lowermost Oxfordian ammonoids, have been worldwide known. In the radiolarian biozonation by Baumgartner *et al.* (1995b) the time span from middle Callovian to early Oxfordian is united in one radiolarian zone as the Unitary

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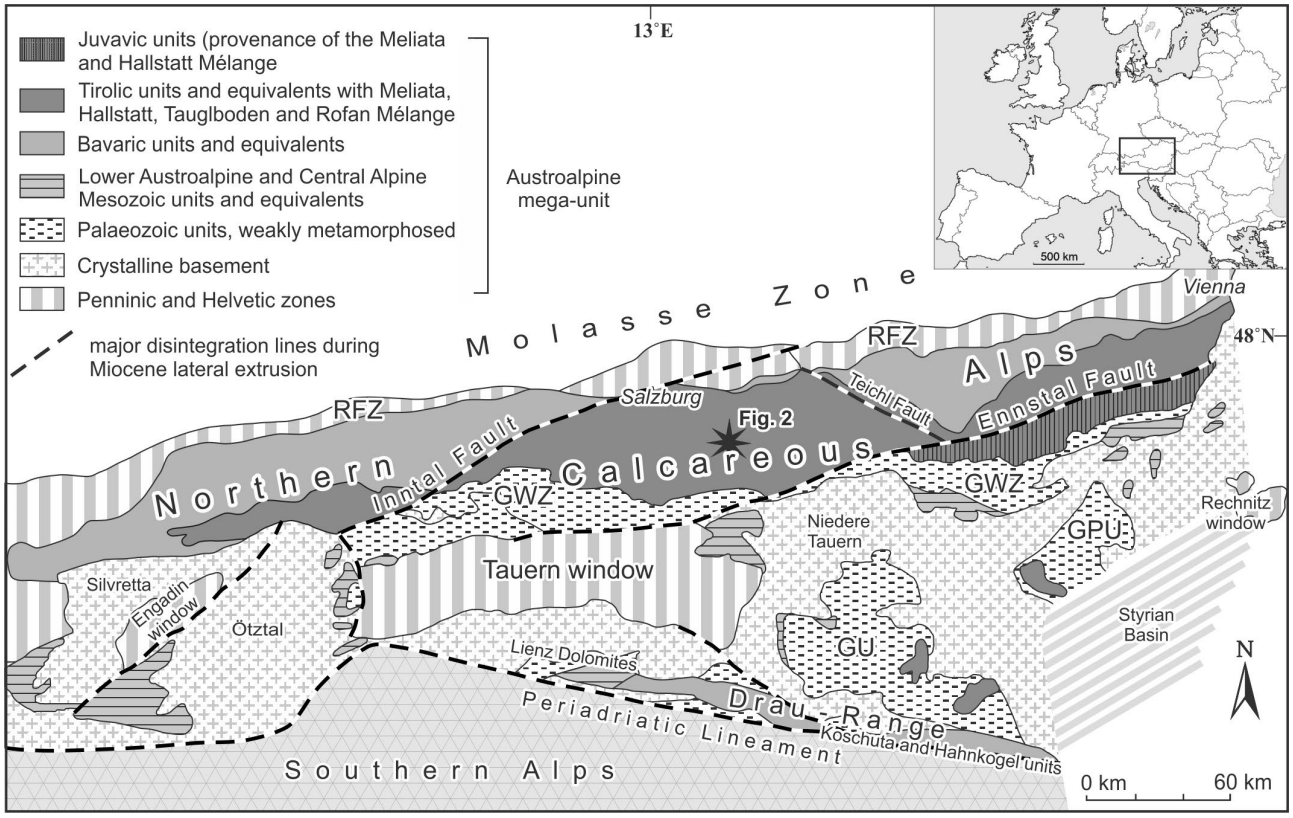

Fig. 1 Schematic tectonic map of the Eastern Alps (Tollmann, 1977; Frisch and Gawlick, 2003) and geographic position of the study area in the Northern Calcareous Alps. GPU: Graz Palaeozoic Unit, GU: Gurktal Unit, GWZ: Greywacke Zone, RFZ: Rhenodanubian Flysch Zone.

Association Zone 8. A more precise radiolarian zonation for the time around the Callovian/Oxfordian boundary is therefore highly needed. We analysed well-preserved Oxfordian radiolarian faunas from the base of a 900 m thick radiolarite succession (Gawlick *et al.*, 2007) in the Northern Calcareous Alps, i.e. the Fludergraben section near Altaussee, Austria (Figs. 1, 2). In the lowermost part of the section, red nodular limestones of the Klaus Formation were formed in the Middle Jurassic to the latest Callovian or to the Callovian/Oxfordian boundary, as proven by the following ammonites (Mandl, 1982): *Euaspidoceras* sp., *Holcophylloceras zignodianum* and fragments of ?*Nebrodites* sp. Therefore, the radiolarite succession of the Fludergraben section provides the best opportunity to search for early Oxfordian marker of radiolarian species. Beside this, the age range of several radiolarian species occurring in these radiolarites must be prolonged, if they are so far known only from lower levels than the Oxfordian. In this paper we present the early Oxfordian radiolarian fauna, which helps to refine the radiolarian zonation for the Callovian and Oxfordian.

2. Geologic setting

The studied Fludergraben section is located in the Fludergraben valley in the central Northern Calcareous Alps, southeast of Salzburg (Figs. 1, 2). The section belongs to the lowermost part of the Tauglboden Formation that overlies the Klaus Formation (Fig. 3). The Klaus Formation consists of red nodular limestone yielding ammonites of the latest Callovian to the Callovian/Oxfordian boundary. The Oxfordian to Tithonian Tauglboden Formation consists of up to 900 m thick grey to black siliceous to radiolaritic rocks (radiolarite) with intercalated simultaneous mass transport deposits (Gawlick and Frisch, 2003; Gawlick *et al.*, 2009). The base of the Tauglboden Formation starts with a red radiolarite followed by a grey to black radiolarite. The basal red radiolarite is up to 3 m thick and this part is distinguished from the main part of the Tauglboden Formation as the Fludergraben Member (Fig. 3a; Gawlick *et al.*, 2009). The sedimentary succession of the Tauglboden Formation was deposited in a trench-like foreland basin (Tauglboden Basin: Diersche, 1980) in front of a propagating nappe stack formed in Oxfordian time (Fig. 3b; Missoni and Gawlick, 2011; Gawlick and Missoni, 2019 and references therein). During the Middle to early Late Jurassic, the former passive continental margin of the Neo-Tethys attained a lower plate position due to ongoing ophiolite obduction. In the course of the ongoing ophiolite obduction, the former (Triassic–Middle Jurassic) outer passive margin became imbricated and a thin-skinned orogen was formed. In front of the

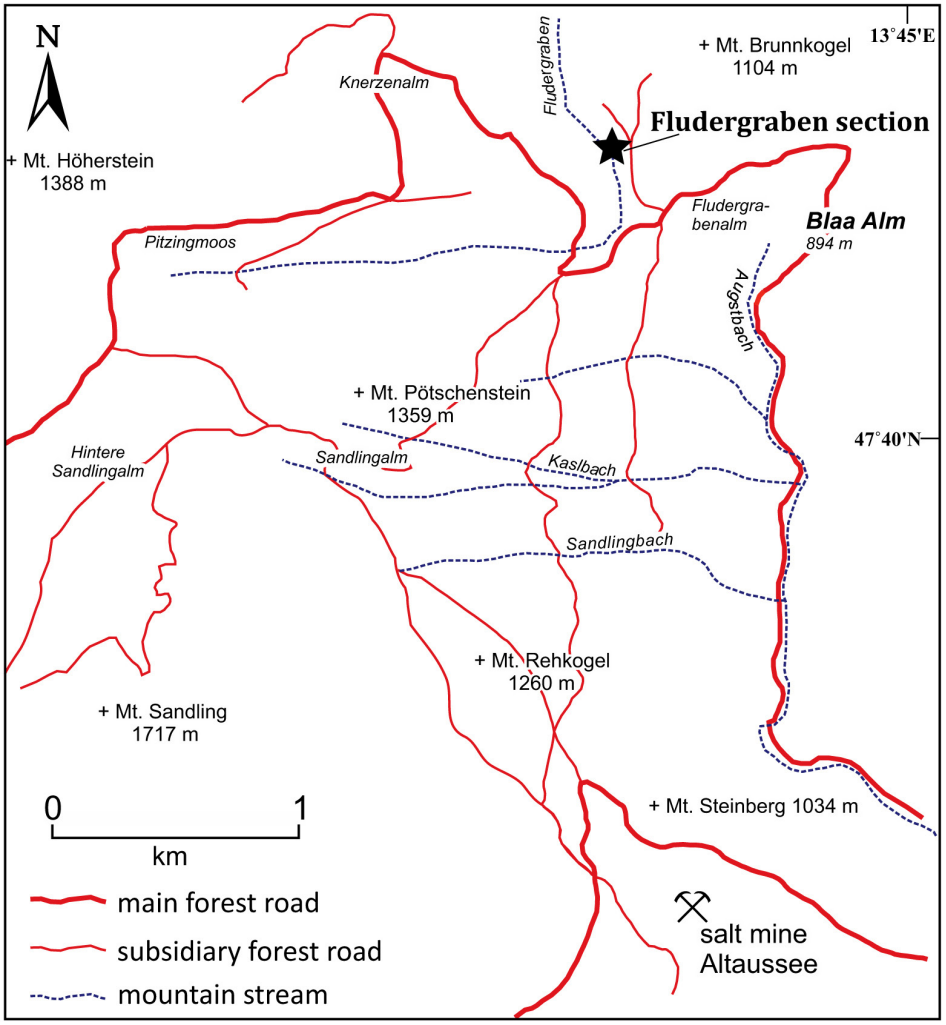

Fig. 2 Geographic position of the Fludergraben section (indicated by a star symbol) in the area of salt mine Altaussee–Mt. Sandling–Mt. Höherstein–Blaa Alm.

northwestward propagation thrust belt (nappe stack), the deep-water trench-like foreland basins were formed and incorporated into the thrust belt. In the early Oxfordian, the thrust belt reached the area of the Tauglboden Basin. Rapid deepening resulted first in the shift from carbonate to radiolarite deposition and later in deposition of mass transport deposits with its source in the adjacent nappe front (Trattberg Rise: Fig. 3b) (Gawlick and Missoni, 2019). A well-preserved section of the Tauglboden Formation is located in the Salzkammergut area, east of Salzburg.

3. Studied section and samples

The Fludergraben section in the Fludergraben valley (Fig. 2) consists of radiolarite, i.e. siliceous sedimentary rocks consisting of radiolarians. Radiolarite deposition of the Fludergraben section started almost instantaneously from the red nodular limestone containing ammonites (Fig. 4). The ammonite-bearing horizon of the uppermost Klaus Formation is only 10 cm below occurrence of the first radiolarite bed. A short-lasting stratigraphic gap on top of the ammonite-bearing layer cannot be excluded because of the bad preservation of the ammonites without their original shells. This indicates that there was an enough time to solve ammonite shells. However, because a serious hardground is not detectable, long-lasting subsolution can be excluded.

The lowermost bed of the radiolarite sequence is originally a *Bositra*-radiolarian-bearing siliceous limestone (Fig. 5a), later completely silicified (sample D1051). The following red radiolarite is well-bedded. The thickness of each bed is 3–10 cm, in some cases intercalated by up to 5 mm-thick reddish siliceous claystones (Diersche, 1980). The radiolarite is completely silicified, but the preservation of the radiolarians is in cases rather good. The microfacies show bioturbated radiolarian wackestones to packstones (Fig. 5b, 5c). All radiolarite beds of up to 10 cm thickness are massive and without sedimentary lamination, as well visible in the higher part of the Tauglboden Formation

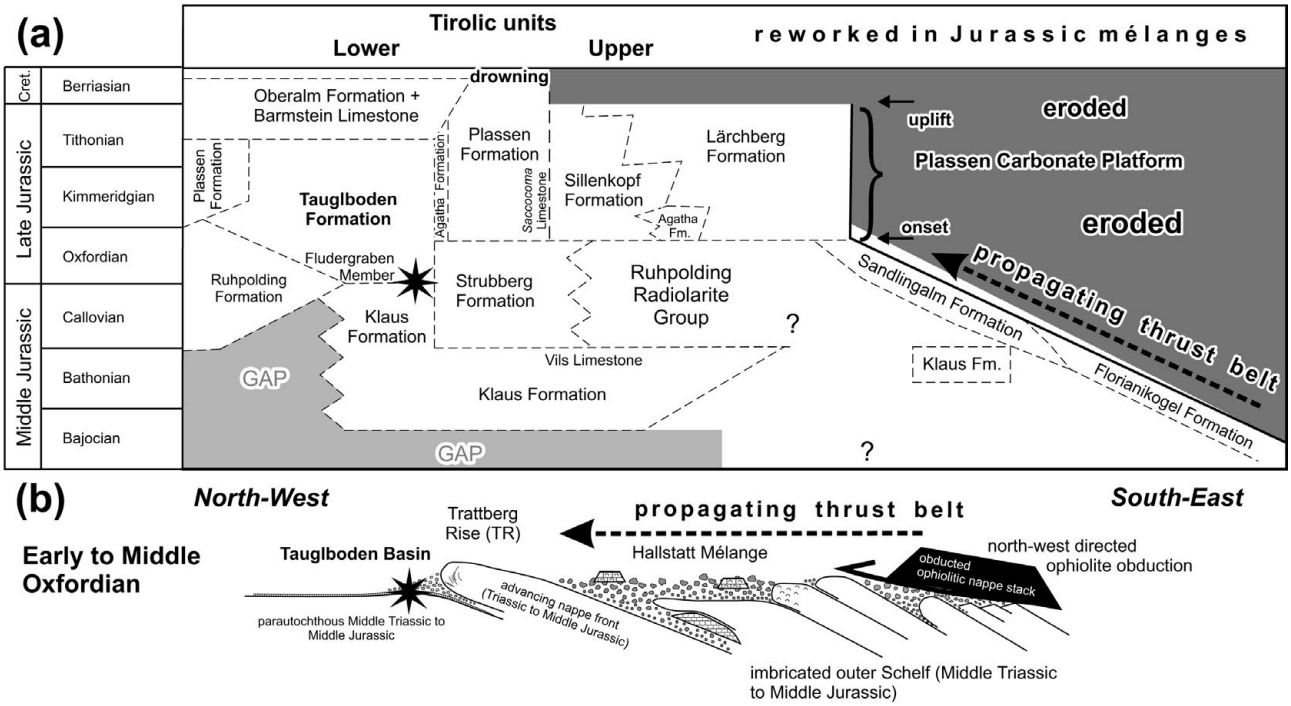

Fig. 3 (a) Simplified Middle to Late Jurassic stratigraphic table of the central Northern Calcareous Alps with an overview of common formation names after Gawlick *et al.* (2009) and stratigraphic and palaeotectonic position of the studied Fludergraben section (indicated by a star symbol). Cret.: Cretaceous, Fm.: Formation. (b) Early to Middle Oxfordian geodynamic reconstruction of the Northern Calcareous Alps according to Missoni and Gawlick (2011) and Gawlick and Missoni (2019). Due to ophiolite obduction since Middle Jurassic time the former northwestern passive continental margin attained a lower plate position and a thin-skinned orogen was formed. The Tauglboden Basin was generated in front of the propagating thrust belt (indicated by a star symbol).

(Gawlick *et al.*, 2012).

From the red radiolarites of the Fludergraben section, six radiolaria-bearing samples were collected in the first one metre just above the red condensed limestones with the ammonite horizon. The six samples are in ascending order as follows (Fig. 4): D1051, D1023, D1024, D1052, EW146, D1025.

4. Radiolarian fauna of the Fludergraben section

We have detected radiolarian species in all six samples with the methods of diluted hydrofluoric acid for decomposition and of hydrogen peroxide for residue cleaning. Their preservation is in some cases very poor, but also moderate to well-preserved radiolarians could be isolated. The radiolarian assemblages from all six samples are listed here, and are depicted in Plates 1–3.

D1051: *Archaeodictyomitra apiarium* (Rüst, 1885), *Williriedellum dierschei* Suzuki and Gawlick, 2004, *Striatojaponocapsa* sp.

D1023: *Acanthocircus* cf. *suboblongus* (Yao, 1972), *Archaeospongoprunum* cf. *elegans* Wu, 1993, *Tritrabs* cf. *exotica* (Pessagno, 1977a), *Archaeodictyomitra apiarium* (Rüst, 1885), *Archaeodictyomitra mirabilis* Aita, 1987, *Archaeodictyomitra rigida* Pessagno, 1977a, *Cinguloturris carpatica* Dumitrica, 1982, *Eucyrtidiellum circumperforatum* Chiari, Marcucci and Prela, 2002, *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo, 1974), *Fultacapsa sphaerica* (Ozvoldova, 1988), *Gongylothorax favosus favosus* Dumitrica, 1970, *Helvetocapsa matsuokai* (Sashida, 1999), *Hsuum brevicostatum* (Ozvoldova, 1975), *Hsuum maxwelli* Pessagno, 1977a, *Loopus doliolum* Dumitrica, 1997, *Neorelumbra skenderbegi* Chiari, Marcucci and Prela, 2002, *Parahsuum* sp. S sensu Matsuoka, 1986, *Protunuma japonicus* Matsuoka and Yao, 1985, *Pseudodictyomitra primitiva* Matsuoka and Yao, 1985, *Stichocapsa cicciona* Chiari, Marcucci and Prela, 2002, *Stichocapsa robusta* Matsuoka, 1984, *Stichomitra annibill* Kocher, 1981, *Striatojaponocapsa synconexa* O'Dogherty *et al.*, 2006, *Kilinora* cf. *spiralis* (Matsuoka, 1982), *Tricolocapsa tetragona* Matsuoka, 1983, *Tricolocapsa undulata* (Heitzer, 1930), *Takemuraella hexagonata* (Heitzer, 1930), *Takemuraella hungarica* (Kozur, 1985), *Unuma gordus* Hull, 1997, *Williriedellum dierschei* Suzuki and Gawlick, 2004, *Zhamoidellum ovum* Dumitrica, 1970, *Zhamoidellum ventricosum* Dumitrica, 1970.

D1024: *Archaeospongoprunum* cf. *elegans* Wu, 1993, *Cinguloturris carpatica* Dumitrica, 1982, *Cyrtocapsa* sp. B, *Dictyomitrella kamoensis* Mizutani and Kido, 1983, *Eucyrtidiellum nodosum* Wakita, 1988, *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo, 1974), *Eucyrtidiellum*

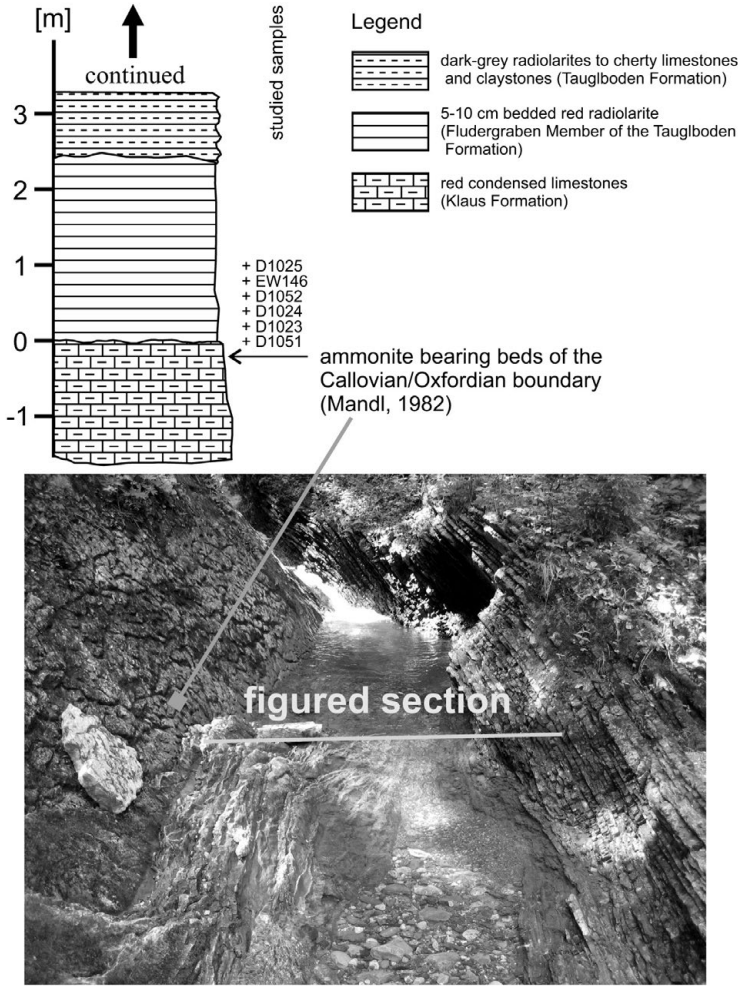

Fig. 4 Columnar section and photo show the lowermost part of the Fludergraben Member and position of studied samples.

unumaense (Yao, 1979), *Gongylothorax favosus favosus* Dumitrica, 1970, *Hsuum maxwelli* Pessagno, 1977a, *Loopus doliolum* Dumitrica, 1997, *Parahsuum* sp. S sensu Matsuoka, 1986, *Protunuma lanosus* Ozvoldova, 1996, *Striatojaponocapsa conexa* (Matsuoka, 1983), *Striatojaponocapsa riri* O'Dogherty *et al.*, 2006, *Striatojaponocapsa synconexa* O'Dogherty *et al.*, 2006, *Tricolocapsa tetragona* Matsuoka, 1983, *Unuma typicus* Ichikawa and Yao, 1976, *Williriedellum crystallinum* Dumitrica, 1970, *Williriedellum dierschei* Suzuki and Gawlick, 2004, *Williriedellum marcucciae* Cortese, 1993, *Zhamoidellum ovum* Dumitrica, 1970.

D1052: *Tritrabs exotica* (Pessagno, 1977a), *Cinguloturris carpatica* Dumitrica, 1982, *Dictyomitrella kamoensis* Mizutani and Kido, 1983, *Eucyrtidiellum circumperforatum* Chiari, Marcucci and Prela, 2002, *Eucyrtidiellum nodosum* Wakita, 1988, *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo, 1974), *Gongylothorax favosus oviformis* Suzuki and Gawlick, 2009, *Hsuum brevicostatum* (Ozvoldova, 1975), *Hsuum maxwelli* Pessagno, 1977a, *Loopus doliolum* Dumitrica, 1997, *Parahsuum* sp. S sensu Matsuoka, 1986, *Podobursa nodosa* (Chiari, Marcucci and Prela, 2002), *Pseudodictyomitra primitiva* Matsuoka and Yao, 1985, *Pseudoeucyrtis reticularis* Matsuoka and Yao, 1985, *Ristola altissima* (Rüst, 1885), *Stichocapsa robusta* Matsuoka, 1984, *Stichomitra annibill* Kocher, 1981, *Stichomitra* sp. A sensu Baumgartner *et al.*, 1995a, *Striatojaponocapsa conexa* (Matsuoka, 1983), *Striatojaponocapsa naradaniensis* (Matsuoka, 1984), *Striatojaponocapsa riri* O'Dogherty *et al.*, 2006, *Striatojaponocapsa synconexa* O'Dogherty *et al.*, 2006, *Tetracapsa* sp. A sensu Suzuki and Gawlick, 2003b, *Tricolocapsa undulata* (Heitzer, 1930), *Unuma gordus* Hull, 1997, *Williriedellum carpathicum* Dumitrica, 1970, *Williriedellum crystallinum* Dumitrica, 1970, *Williriedellum dierschei* Suzuki and Gawlick, 2004, *Williriedellum marcucciae* Cortese, 1993, *Williriedellum sujkowskii* Widz and De Wever, 1993, *Zhamoidellum ovum* Dumitrica, 1970.

EW146: *Archaeospongoprunum* cf. *imlayi* Pessagno, 1977a, *Archaeodictyomitra minoensis* (Mizutani, 1981), *Cinguloturris carpatica* Dumitrica, 1982, *Cinguloturris*

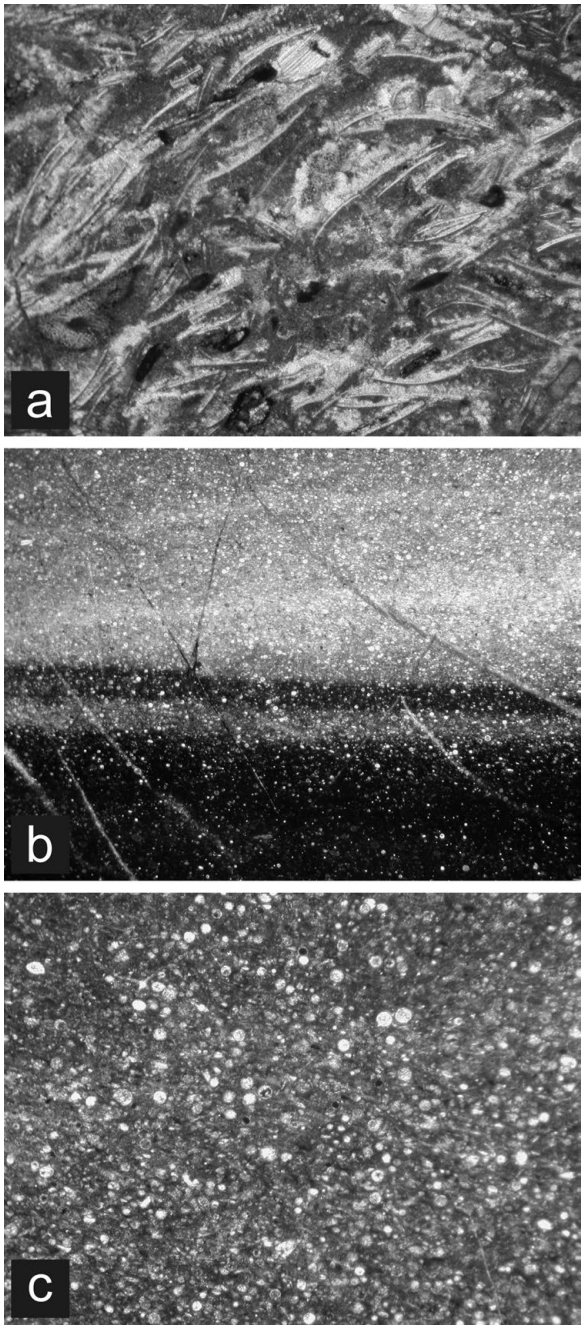

Fig. 5 Microfacies of the slightly siliceous red *Bositra*-bearing nodular limestone and the overlying red radiolarite of the Fludergraben section. (a) *Bositra* shells together with some crinoids and reworked hardground clasts. Width of the photo 0.5 cm. Sample D1051. (b) Red radiolarite above the red nodular limestone. Layered grey-red to red radiolarian wackestone to radiolarian packstone. In the basal radiolarian wackestone the radiolarians are well-preserved, in the upper radiolarian packstone the preservation of the radiolarians is moderate due to intense silification. Width of the photo 1.4 cm. Sample D1052. (c) Magnification of (b), upper part. The most radiolarians in this bioturbated red radiolarite are recrystallized and only some radiolarians are well-preserved. Width of the photo 0.5 cm.

primorika Kemkin and Taketani, 2004, *Dictyomitrella* cf. *kamoensis* Mizutani and Kido, 1983, *Eucyrtidiellum nodosum* Wakita, 1988, *Eucyrtidiellum* cf. *unumaense* (Yao, 1979), *Hsuum baloghi* Grill and Kozur, 1986, *Hsuum* cf. *brevicostatum* (Ozvoldova, 1975), *Hsuum maxwelli* Pessagno, 1977a, *Parvicingula spinata* Vinassa, 1899, *Tricolocapsa undulata* (Heitzer, 1930), *Takemuraella hungarica* (Kozur, 1985), *Williriedellum carpathicum* Dumitrica, 1970.

D1025: *Archaeospongoprunum* cf. *elegans* Wu, 1993, *Archaeodictyomitra sixi* Yang, 1993, *Spongotripus* sp. D sensu Suzuki and Gawlick, 2003b, *Archaeodictyomitra mirabilis* Aita, 1987, *Archaeodictyomitra patricki*, Kocher, 1981, *Cinguloturris carpatica* Dumitrica, 1982, *Droltus galerus* Suzuki, 1995b, *Eucyrtidiellum nodosum* Wakita, 1988, *Eucyrtidiellum unumaense* (Yao, 1979), *Gongylothorax favosus favosus* Dumitrica, 1970, *Gongylothorax favosus oviformis* Suzuki and Gawlick, 2009, *Gongylothorax* sp. C sensu Suzuki and Gawlick, 2003b, *Helvetocapsa matsuokai* (Sashida, 1999), *Japonocapsa fusiformis* (Yao, 1979), *Praewilliriedellum* aff. *spinosum* Kozur, 1984, *Protunuma fusiformis* Ichikawa and Yao, 1976, *Pseudodictyomitra primitiva* Matsuoka and Yao, 1985, *Saitoum pagei* Pessagno, 1977a, *Stichocapsa robusta* Matsuoka, 1984, *Japonocapsa tegiminis* (Yao, 1979), *Stichomitra annibill* Kocher, 1981, *Striatojaponocapsa naradaniensis* (Matsuoka, 1984), *Striatojaponocapsa synconexa* O'Dogherty *et al.*, 2006, *Stylocapsa oblongula* Kocher, 1981, *Tetracapsa* sp. A sensu Suzuki and Gawlick, 2003b, *Tricolocapsa undulata* (Heitzer, 1930), *Takemuraella hexagonata* (Heitzer, 1930), *Unuma typicus* Ichikawa and Yao, 1976, *Williriedellum dierschei* Suzuki and Gawlick, 2004, *Williriedellum marcucciae* Cortese, 1993, *Williriedellum* sp. C sensu Gawlick *et al.*, 2018, *Zhamoidellum ovum* Dumitrica, 1970.

5. Systematic part

We describe radiolarian species from the Fludergraben section systematically. Radiolarian taxonomic classification shown here is in principle based on Takemura (1986), Suzuki *et al.* (2002), Suzuki and Gawlick (2003b) and Suzuki and Gawlick (2009). The familial classification of Nassellaria of these publications considers the cephalic skeletal elements which construct the fundamental structure of nassellarians (e.g. Takemura, 1986).

In the synonym lists, we use following mark and abbreviations. Astarisk: first description of taxon name, aff.: affinis, cf.: confer, non: not, pt.: partial.

Subclass **RADIOLARIA** Müller, 1858

Order **POLYCYSTIDA** Ehrenberg, 1839; emend. Riedel, 1967b

Suborder **ENTACTINARIA** Kozur and Mostler, 1982

Family **SATURNALIDAE** Deflandre, 1953

Genus ***Acanthocircus*** Squinabol, 1903; emend. Donofrio and Mostler, 1978

Type species: ***Acanthocircus irregularis*** Squinabol, 1903 (Campbell, 1954)

Acanthocircus* cf. *suboblongus (Yao, 1972)
(Plate 1, fig. 14)
cf. *1972 *Spongosaturnalis*? *suboblongus* – Yao, p. 29, pl. 3, figs. 1–6, pl. 10, figs. 3a–3c.
Remarks: Only one part of the ring of this species preserved, so that we identify here with "cf."

Suborder **SPUMELLARIA** Ehrenberg, 1876

Family **SPONGULIDAE** Haeckel, 1862

Genus ***Archaeospongoprunum*** Pessagno, 1973; emend. Kozur and Mostler, 1981

Type species: ***Archaeospongoprunum venadoensis*** Pessagno, 1973

Archaeospongoprunum* cf. *elegans, Wu, 1993
(Plate 1, fig. 3; Plate 2, fig. 1; Plate3, fig. 21)
cf. 1930 *Ellipsoxiphus asper* Rüst – Heitzer, p. 389, pl. 27, fig. 17.
cf.*1993 *Archaeospongoprunum elegans* – Wu, p. 118, pl. 1, figs. 5, 7, 23.

Archaeospongoprunum* cf. *imlayi Pessagno, 1977a
(Plate 3, fig. 8)
cf.*1977a *Archaeospongoprunum imlayi* – Pessagno, p. 73, pl. 3, figs. 2–4; ? pl. 3, fig. 1.
cf. 2003b *Archaeospongoprunum imlayi* Pessagno – Suzuki and Gawlick, p. 171, fig. 5.6; fig. 6.9. (detailed synonymy until 2003)

Genus ***Spongotripus*** Haeckel, 1881

Type species: ***Spongotripus pauper*** Rüst, 1888 (Kiessling, 1999)

***Spongotripus* sp. D** sensu Suzuki and Gawlick, 2003b
(Plate 3, fig. 22)
*2003b *Spongotripus* sp. D – Suzuki and Gawlick, p. 172, fig. 5.7.
2018 *Spongotripus* sp. D sensu Suzuki and Gawlick – Gawlick *et al.*, fig. 18.29.

Family **HAGIASTRIDAE** Riedel, 1971; emend. Baumgartner, 1980

Genus ***Tritrabs*** Baumgartner, 1980

Type species: ***Paronaella? casmaliaensis*** Pessagno, 1977a

Tritrabs exotica Pessagno, 1977a
(Plate 1, fig. 8; Plate 2, fig. 22)
*1977a *Paronaella*? *exotica* – Pessagno, p. 70, pl. 1, figs. 12, 13.
1980 *Tritrabs exotica* (Pessagno) – Baumgartner, p. 294, pl. 4, fig. 16.
1995a *Tritrabs exotica* (Pessagno) – Baumgartner *et al.*, p. 608, pl. 3119, figs. 1–3.
2006 *Tritrabs exotica* (Pessagno) – O'Dogherty *et al.*, p. 472, pl. 11, fig. 38.
2013 *Tritrabs exotica* (Pessagno) – Krische *et al.*, pl. 3, fig. 18.

Suborder **NASSELLARIA** Ehrenberg, 1876

Family **POULPIDAE** De Wever, 1981

Genus ***Saitoum*** Pessagno, 1977a

Type species: ***Saitoum pagei*** Pessagno, 1977a

Saitoum pagei Pessagno, 1977a
(Plate 3, fig. 18)
*1977a *Saitoum pagei* – Pessagno, p. 98, pl. 12, figs. 11–14.
2003b *Saitoum pagei* Pessagno – Suzuki and Gawlick, p. 175, fig. 5.38.
2018 *Saitoum pagei* Pessagno – Gawlick *et al.*, fig. 12.18.

Family **THEOPERIDAE** Haeckel, 1881; emend. Takemura, 1986

Genus ***Cinguloturris*** Dumitrica, 1982

Type species: ***Cinguloturris carpatica*** Dumitrica, 1982

Cinguloturris carpatica Dumitrica, 1982
(Plate 1, fig. 15; Plate 2, fig. 3; Plate 3, figs. 6, 9)
*1982 *Cinguloturris carpatica* – Dumitrica in Dumitrica and Mello, p. 23, pl. 4, figs. 7–11.
1994 *Cinguloturris carpatica* Dumitrica – Ishida, fig. 3.2.
2003b *Cinguloturris carpatica* Dumitrica – Suzuki and Gawlick, p. 189, fig. 5.28; fig. 6.50. (detailed synonymy between 1994 and 2003)
2003 *Cinguloturris carpatica* Dumitrica – Wegerer *et al.*, fig. 7.13; fig. 11.5.
2006 *Cinguloturris carpatica* Dumitrica – Auer *et al.*, fig. 6.9.
2007 *Cinguloturris carpatica* Dumitrica – Auer *et al.*, fig. 6.14.
2009 *Cinguloturris carpatica* Dumitrica – Suzuki and Gawlick, p. 167, fig. 5.2; fig. 6.1A, 6.1B.
Remarks: *Cinguloturris carpatica* has tiny circular dents on the solid horizontal ridges of each post-thoracic segment.

Cinguloturris primorika Kemkin and Taketani, 2004
(Plate 3, fig. 10)
2001 *Cinguloturris* cf. *cylindra* Kemkin and Rudenko – Missoni *et al.*, fig. 3.9.
*2004 *Cinguloturris primorika* – Kemkin and Taketani, p. 333, fig. 4.1–4.3.
2006 *Cinguloturris* cf. *cylindra* Kemkin and Rudenko – Gawlick *et al.*, fig. 8a.8.
2009 *Cinguloturris primorika* Kemkin and Taketani – Suzuki and Gawlick, p. 167, fig. 5.3A, 5.3B.
2011 *Cinguloturris primorika* Kemkin and Taketani – Gawlick *et al.*, fig. 3.11.
Remarks: *Cinguloturris primorika* has short costae- or node-like structures on the solid horizontal ridges of each post-thoracic segment, which are not arranged regularly.

Genus ***Parahsuum*** Yao, 1982

Type species: ***Parahsuum simplum*** Yao, 1982

Parahsuum sp. S sensu Matsuoka, 1986
(Plate 1, fig. 7; Plate 2, figs. 2, 24)
*1986 *Parahsuum* sp. S – Matsuoka, pl. 2, fig. 13; pl. 3, fig. 14.
pt. 1995a *Parahsuum* sp. S – Baumgartner *et al.*, p. 384, pl. 3240, figs. 2, 4, 5; non pl. 3240, figs. 1, 3 [= *Parahsuum carpathicum* Widz and De Wever, 1993].
2003b *Parahsuum* sp. S sensu Matsuoka – Suzuki and Gawlick, p. 182, fig. 6.70. (detailed synonymy between 1994 and 2002)
2004 *Parahsuum*? sp. – Ishida, fig. 7.4.
2009 *Parahsuum* sp. S sensu Matsuoka – Suzuki and Gawlick, p. 167, fig. 5.5.
Remarks: *Parahsuum* sp. S has a short conical test and a slender, short apical horn.

Genus ***Hsuum*** Pessagno, 1977a

Type species: ***Hsuum cuestaensis*** Pessagno, 1977a

Hsuum brevicostatum (Ozvoldova, 1975)
(Plate 1, fig. 12; Plate 2, fig. 37)
*1975 *Lithostrobus brevicostatus* – Ozvoldova, p. 84, pl. 102, fig. 1.
1994 *Transhsuum brevicostatum* (Ožvoldová) gr. – Goričan, p. 91, pl. 18, figs. 6–8. (detailed synonymy until 1993)
2003b *Hsuum brevicostatum* (Ozvoldova) – Suzuki and Gawlick, p. 184; fig. 5.33; fig. 6.62. (detailed synonymy between 1994 and 2002)
2004 *Hsuum brevicostatum* (Ozvoldova) – Gawlick *et al.*, fig. 3a.11.
2004 *Hsuum brevicostatum* (Ozvoldova) – Ishida, fig. 7.2; fig. 8.8.
2005 *Hsuum brevicostatum* (Ozvoldova) – Missoni *et al.*, fig. 10.16.
2006 *Hsuum brevicostatum* (Ozvoldova) – Gawlick *et al.*, fig. 8.18; fig. 9.15.
2009 *Hsuum brevicostatum* (Ozvoldova) – Suzuki and Gawlick, p. 168, fig. 5.6.
2014 *Hsuum brevicostatum* (Ozvoldova) – Suzuki *et al.*, p. 11, pl. 4, fig. 11.

Hsuum maxwelli Pessagno, 1977a
(Plate 1, fig. 4; Plate 2, fig. 15)
*1977a *Hsuum maxwelli* – Pessagno, p. 81, pl. 7, figs. 14–16.
1994 *Transhsuum maxwelli* (Pessagno) gr. – Goričan, p. 92, pl. 18, figs. 1–4. (detailed synonymy until 1993)
2003b *Hsuum maxwelli* Pessagno –Suzuki and Gawlick, p. 183, fig. 5.32; fig. 6.64. (detailed synonymy between 1994 and 2002)
2004 *Hsuum maxwelli* Pessagno – Gawlick *et al.*, fig. 3b.26.
2004 *Hsuum maxwelli* Pessagno – Ishida, fig. 7.1; fig. 8.7.
2005 *Hsuum maxwelli* Pessagno – Missoni *et al.*, fig. 7.11; fig. 13.3.
2006 *Hsuum maxwelli* Pessagno – Gawlick *et al.*, fig. 8b.19; fig. 9a.16.
2009 *Hsuum maxwelli* Pessagno – Suzuki and Gawlick, p. 168, fig. 5.7.
2018 *Hsuum maxwelli* Pessagno – Gawlick *et al.*, fig. 12.11; fig. 18.11.

Hsuum baloghi Grill and Kozur, 1986
(Plate 3, fig. 7)
*1986 *Hsuum baloghi* – Grill and Kozur, p. 254, pl. 3, figs. 3–6.
2003b *Hsuum baloghi* Grill and Kozur – Suzuki and Gawlick, p. 182, fig. 5.31.
Remarks: *Hsuum baloghi* has weakly developed longitudinal costae on the post-abdominal segments. In case of *Hsuum maxwelli*, longitudinal costae are strongly developed.

Genus ***Dictyomitrella*** Haeckel, 1887

Type species: ***Eucyrtidium articulatum*** Ehrenberg, 1876 (Campbell, 1954)

Dictyomitrella kamoensis Mizutani and Kido, 1983
(Plate 2, fig. 4; Plate 3, figs. 5, 15)
*1983 *Dictyomitrella*? *kamoensis* – Mizutani and Kido, p. 258, pl. 53, figs. 2–4b.
1994 *Dictyomitrella*? *kamoensis* Mizutani and Kido – Goričan, p. 66, pl. 24, fig. 1. (detailed synonymy until 1993)
2003b *Dictyomitrella kamoensis* Mizutani and Kido – Suzuki and Gawlick, p. 188, fig. 6.49. (detailed synonymy between 1994 and 2002)
2015 *Dictyomitrella*? *kamoensis* Mizutani and Kido – Ishida, pl. 4, figs. 37–42; pl. 11, figs. 1–5.
2018 *Dictyomitrella kamoensis* Mizutani and Kido – Gawlick *et al.*, fig. 12.5.

Genus ***Archaeodictyomitra*** Pessagno, 1976

Type species: ***Archaeodictyomitra squinaboli*** Pessagno, 1976

Archaeodictyomitra apiarium (Rüst, 1885)
(Plate 1, figs. 2, 11)
*1885 *Litocampium apiarium* – Rüst, p. 314, pl. 39, fig. 8.
1977b *Archaeodictyomitra apiara* (Rüst) – Pessagno, p. 41, pl. 6, figs. 6, 14.
1981 *Archaeodictyomitra apiarium* (Rüst) – Kocher, p. 56, pl. 12, fig. 13.
1985 *Archaeodictyomitra apiara* (Rüst) – Matsuoka and Yao, pl. 2, fig. 4.
1999 *Archaeodictyomitra apiarium* (Rüst) – Gawlick and Suzuki, fig. 12.4.
2004 *Archaeodictyomitra apiarium* (Rüst) – Ishida, fig. 10.7.
2004 *Archaeodictyomitra apiarium* (Rüst) – Gawlick *et al.*, fig. 3a.10.
2014 *Archaeodictyomitra apiarium* (Rüst) – Suzuki *et al.*, p. 10, pl. 4, fig. 10; pl. 5, fig. 10.
2020 *Archaeodictyomitra apiarium* (Rüst) – Suzuki *et al.*, p. 107, fig. 3.5.

Archaeodictyomitra minoensis (Mizutani, 1981)
(Plate 3, fig. 11)
*1981 *Pseudodictyomitra minoensis* – Mizutani, p. 178, pl. 58, fig. 4; pl. 63, figs. 9, 10.
1985 *Archaeodictyomitra minoensis* (Mizutani) – Matsuoka and Yao, pl. 2, fig. 5.
1999 *Archaeodictyomitra minoensis* (Mizutani) – Gawlick and Suzuki, fig. 12.2.
1999 *Archaeodictyomitra minoensis* (Mizutani) – Gawlick *et al.*, fig. 8.5.
2006 *Archaeodictyomitra minoensis* (Mizutani) – Auer *et al.*, fig. 6.3.
2009 *Archaeodictyomitra minoensis* (Mizutani) – Auer *et al.*, fig. 9.4.

Archaeodictyomitra mirabilis Aita, 1987
(Plate 1, fig. 17; Plate 3, fig. 20)
*1987 *Archaeodictyomitra*? *mirabilis* – Aita, p. 71, pl. 1, figs. 14a, 14b; pl. 9, figs. 7, 8.
1995a *Archaeodictyomitra*? *mirabilis* Aita – Baumgartner *et al.*, p. 104, pl. 3236, figs. 1–4.
2001 *Archaeodictyomitra*? *mirabilis* Aita – Nishizono, pl. 2, fig. 2.
2003b *Archaeodictyomitra mirabilis* Aita – Suzuki and Gawlick, p. 178, fig. 6.21.
2009 *Archaeodictyomitra mirabilis* Aita – Auer *et al.*, fig. 11.1.

Archaeodictyomitra patricki Kocher, 1981
(Plate 3, fig. 23)
* 1981 *Archaeodictyomitra patricki* – Kocher, p. 57, pl. 12, figs. 14–17.
1997 *Archaeodictyomitra* sp. – Suzuki and Nakae, pl. 1, fig. 7.
2003b *Archaeodictyomitra patricki* Kocher – Suzuki and Gawlick, p. 178, fig. 5.19. (detailed synonymy until 2002)

Archaeodictyomitra rigida Pessagno, 1977a
(Plate 1, fig. 10)
*1977a *Archaeodictyomitra rigida* – Pessagno, p. 81, pl. 7, figs. 10, 11.
2003b *Archaeodictyomitra rigida* Pessagno – Suzuki and Gawlick, p. 179, fig. 5.18; fig. 6.20. (detailed synonymy until 2002)
2004 *Archaeodictyomitra rigida* Pessagno – Gawlick *et al.*, fig. 3b.17.
2004 *Archaeodictyomitra* sp. – Ishida, fig. 7.8; fig. 10.10.
2005 *Archaeodictyomitra rigida* Pessagno – Missoni *et al.*, fig. 7.9; fig. 10.9
2006 *Archaeodictyomitra rigida* Pessagno – Gawlick *et al.*, fig. 8.3; fig. 9.4.
2006 *Archaeodictyomitra rigida* Pessagno – Auer *et al.*, fig. 6.4.
2007 *Archaeodictyomitra rigida* Pessagno – Auer *et al.*, fig. 6.10.
2009 *Archaeodictyomitra rigida* Pessagno – Suzuki and Gawlick, fig. 5.9.

Archaeodictyomitra sixi Yang, 1993
(Plate 3, fig. 50)
*1993 *Archaeodictyomitra sixi* – Yang, p. 122, pl. 19, figs. 3, 19; pl. 20, figs. 9, 10, 19.
2003b *Archaeodictyomitra sixi* Yang – Suzuki and Gawlick, p. 180, fig. 5.17; fig. 6.23. (detailed synonymy until 2003)
2007 *Archaeodictyomitra sixi* Yang – Auer *et al.*, fig. 6.11.
2007 *Archaeodictyomitra sixi* Yang – Gawlick *et al.*, fig. 17.5.
2010 *Archaeodictyomitra sixi* Yang – Gawlick *et al.*, fig. 22.2.
2011 *Archaeodictyomitra sixi* Yang – Gawlick *et al.*, fig. 1.6; fig. 2.5.

Genus ***Neorelumbra*** Kiessling, 1995

Type species: ***Neorelumbra tippitae*** Kiessling, 1995

Neorelumbra skenderbegi Chiari, Marcucci and Prela, 2002
(Plate 1, fig. 9)
*2002 *Neorelumbra skenderbegi*. – Chiari *et al.*, p. 68, pl. 1, figs. 14–21.
2003b *Neorelumbra skenderbegi* Chiari, Marcucci and Prela – Suzuki and Gawlick, p. 190, fig. 6.32. (detailed synonymy until 2002)
2007 *Neorelumbra skenderbegi* Chiari, Marcucci and Prela – Auer *et al.*, fig. 6.48.
2009 *Neorelumbra skenderbegi* Chiari, Marcucci and Prela – Suzuki and Gawlick, p. 169, fig. 5.11.

2011 *Neorelumbra skenderbegi* Chiari, Marcucci and Prela – Gawlick *et al.*, fig. 2.23.

Genus ***Parvicingula*** Pessagno, 1977a

Type species: ***Parvicingula santabarbaraensis*** Pessagno, 1977a

Parvicingula spinata Vinassa, 1899
(Plate 3, fig. 13)
*1899 *Lithocampe spinata* – Vinassa, p. 237, pl. 2, fig. 40.
1995a *Parvicingula*? *spinata* (Vinassa) – Baumgartner *et al.*, p. 412, pl. 3187, figs. 1–3.
2003b *Parvicingula spinata* (Vinassa) – Suzuki and Gawlick, p. 187, fig. 5.34. (detailed synonymy until 2002)
2007 *Parvicingula spinata* (Vinassa) – Auer *et al.*, fig. 6.56.
2014 *Parvicingula spinata* (Vinassa) – Suzuki *et al.*, p. 13, pl. 4, fig. 9.

Genus ***Loopus*** Yang, 1993; emend. herein

*1993 *Loopus* – Yang, p. 123.
1997 *Loopus* Yang – Dumitrica *et al.*, p. 30.
2003b *Loopus* Yang – Suzuki and Gawlick, p. 185.
2009 *Loopus* Yang – Suzuki and Gawlick, p. 170.
Type species: ***Loopus doliolum*** Dumitrica, 1997 (redesignation herein)
Emended diagnosis: Conical to subcylindrical multicyrtid test, in case more or less constricted in distal portion. Cephalis with or without horn. Each segment of abdomen and postabdominal chambers is divided by single transverse row of pores. Boundary of each segment is constricted or not. Rims of pores extend on to the surface of each chamber to make short discontinuous costae. Each costa is usually not highly reliefed and sometimes no costae are developed on the surface of chambers. In the latter case, test surface is smooth.
Remarks: *Pseudodictyomitra primitiva*, the type species of the genus *Loopus* Yang, 1993, should be attributed to the genus *Pseudodictyomitra*, to which Matsuoka and Yao (1985) assigned the species in their original description. Dumitrica *et al.* (1997) stated that fine bifurcating costae just above single row of pores on each segment is too detailed structure to be of a generic diagnosis. We agree with the opinion of Dumitrica *et al.* (1997), and the genus *Loopus* is used in the sense of Dumitrica *et al.* (1997), namely single row of pores on each segment with or without short costae that are not bifurcate above each pore. In these generic features, we redesignate the type speies here, *Loopus doliolum* Dumitrica, 1997.

Loopus doliolum Dumitrica, 1997
(Plate 1, fig. 5; Plate 2, fig. 29)
1982 *Dictyomitra* sp. C – Yao *et al.*, pl. 4, fig. 28.
*1997 *Loopus doliolum* – Dumitrica in Dumitrica *et al.*, p. 30, pl. 5, figs. 3, 5, 14.
2003b *Loopus doliolum* Dumitrica – Suzuki and Gawlick, p. 186, fig. 6.92, 6.93. (detailed synonymy until 2002)
2004 *Loopus nudus* (Schaaf) – Ishida, fig. 8.4; fig. 10.3.
2009 *Loopus doliolum* Dumitrica – Suzuki and Gawlick, p. 170, fig. 6.5.
2011 *Loopus doliolum* Dumitrica – Gawlick *et al.*, fig. 3.24.
2014 *Loopus doliolum* Dumitrica – Suzuki *et al.*, p. 12, pl. 5, fig. 11.
Remarks: *Loopus doliolum* differs from *Pseudodictyomitra primitiva* in having no distinct short costae or very weak short costae, which don't bifurcate just above pores on each segment.

Genus ***Pseudodictyomitra*** Pessagno, 1977b; emend. herein

Type species: ***Pseudodictyomitra pentacolaensis*** Pessagno, 1977b
Emended diagnosis: Multicyrtid test is conical or subcylindrical, in case more or less constricted in distal portion. Cephalis with or without horn. Thorax or abdomen and postabdominal chambers are divided each other by single or double transverse row of pores. In case of single pore rows, imperforate circular dents are arranged below perforate pore rows. Boundary of each postabdominal segment is constricted or not. On the surface of each chamber short discontinuous costae are developed. Each costa is bifurcating downwards to form a rim of pores. Such bifurcating structure is not conspicuous, when chamber surface has robust costae or no costae and smooth.
Remarks: After the original generic definition of Pessagno (1977b) *Pseudodictyomitra* has two transvers rows of primary pores. But many species which can be attributed to the genus *Pesudodictyomitra* has single row of pores with imperforate circular dents. Such character is visible in such species as *Pseudodictyomitra venusta* (Chiari *et al.*, 1997) [as *Cinguloturris*? *venusta*], *Pseudodictyomitra primitiva* Matsuoka and Yao, 1985, *Pseudodictyomitra conicostriata* Dumitrica, 1997, *Pseudodictyomitra lilyae* (Tan, 1927) in sense of Dumitrica *et al.* (1997) etc. Therefore, we change the type species of the genus *Loopus* from *Pseudodictyomitra primitiva* to *Loopus doliolum* (see remarks of the genus *Loopus*).

Pseudodictyomitra primitiva Matsuoka and Yao, 1985
(Plate 1, fig. 6; Plate 2, fig. 38; Plate 3, fig. 19)
*1985 *Pseudodictyomitra primitiva* – Matsuoka and Yao, p. 131, pl. 1, figs. 1–6; pl. 3, figs. 1–4.
1996 *Pseudodictyomitra primitiva* Matsuoka and Yao – Nishizono, pl. 29, figs. 16–19.
2001 *Loopus primitivus* (Matsuoka and Yao) – Nishizono, pl. 2, fig. 10.
2002 *Loopus primitivus* (Matsuoka and Yao) – Hori *et al.*, pl. 11, fig. 25.
2004 *Loopus primitivus* (Matsuoka and Yao) – Ishida and

Kozai, fig. 6.5, 6.9, 6.10.
2004 *Loopus primitivus* (Matsuoka and Yao) – Kozai *et al.*, fig. 7.13, 7.14.
2007 *Pseudodictyomitra primitiva* Matsuoka and Yao – Auer *et al.*, fig. 6.65.
2011 *Pseudodictyomitra primitiva* Matsuoka and Yao – Gawlick *et al.*, fig. 3.29.
2014 *Pseudodictyomitra primitiva* Matsuoka and Yao – Suzuki *et al.*, p. 11, pl. 5, fig. 1.
Remarks: We place this species not in the genus *Loopus*, but in the genus *Pseudodictyomitra*, as mentioned above.

Genus ***Pseudoeucyrtis*** Pessagno, 1977b

Type species: ***Eucyrtis? zhamoidai*** Foreman, 1973

Pseudoeucyrtis reticularis Matsuoka and Yao, 1985
(Plate 2, fig. 18)
*1985 *Pseudoeucyrtis reticularis* – Matsuoka and Yao, p. 132, pl. 1, figs. 16–21; pl. 3, figs. 14–17.
2001 *Pseudoeucyrtis reticularis* Matsuoka and Yao – Missoni *et al.*, fig. 3.12.
2007 *Pseudoeucyrtis reticularis* Matsuoka and Yao – Gawlick *et al.*, fig. 19.31.

Genus ***Ristola*** Pessagno and Whalen, 1982; emend. Baumgartner, 1984

Type species: ***Parvicingula? procera*** Pessagno, 1977a

Ristola altissima (Rüst, 1885)
(Plate 2, fig. 17)
*1885 *Lithocampe altissima* – Rüst, p. 315, pl. 40, fig. 2.
1984 *Ristola altissima* (Rüst) – Baumgartner, p. 783, pl. 8, figs. 3, 4, 9.
2001 *Ristola altissima* (Rüst) – Missoni *et al.*, p. 783, fig. 3.1.
2001 *Ristola altissima* (Rüst) – Nishizono, pl. 3, fig. 9.
2015 *Ristola altissima* (Rüst) – Ishida, pl. 5, figs. 17, 18.

Family **AMPHIPYNDACIDAE** Riedel, 1967a

Genus ***Takemuraella*** O'Dogherty, Goričan and Gawlick, 2017

non 1974 *Triversus* – Sher, p. 323. (Nematoda)
1986 *Triversus* – Takemura, p. 62.
2003b *Triversus* Takemura – Suzuki and Gawlick, p. 194.
*2017 *Takemuraella* – O'Dogherty, Goričan and Gawlick, p. 57.
Type species: ***Triversus japonicus*** Takemura, 1986
Remarks: O'Dogherty *et al.* (2017) pointed out that the genus name "*Triversus*" is preoccupied by the nematoid genus *Triversus* Sher, and they renamed *Takemuraella*.

Takemuraella hungarica (Kozur, 1985)
(Plate 1, fig. 16; Plate 3, fig. 12)
*1985 *Eoxitus hungaricus* – Kozur, p. 216, figs. 1a, 1b, 1d, 1e.
1986 *Triversus spinifer* – Takemura, p. 63, pl. 10, figs. 21–23; pl. 11, figs. 1, 2.
1995a *Parvicingula dhimenaensis* ssp. A – Baumgartner *et al.*, p. 406, pl. 4071, figs. 1–4.
2003b *Triversus hungaricus* (Kozur) – Suzuki and Gawlick, p. 195, fig. 60.58–60.60. (detailed synonymy until 2002)
pt. 2004 *Parvicingula dhimenaensis* Baumgartner – Ishida, fig. 7.9, 7.10; fig. 8.20; non fig. 10.13 [= *Parvicingula dhimenaensis* Baumgartner].
2007 *Triversus hungaricus* (Kozur) – Gawlick *et al.*, fig. 7.10; fig. 8.26; fig. 18.7.
2009 *Triversus hungaricus* (Kozur) – Suzuki and Gawlick, p. 170, fig. 5.14; fig. 6.6–6.8.

Takemuraella hexagonata (Heitzer, 1930)
(Plate 1, fig. 18; Plate 3, figs. 28, 29)
*1930 *Cyrtocalpis hexagonata* – Heitzer, p. 391, pl. 28, fig. 26.
1986 *Pseudodictyomitrella hexagonata* (Heitzer) – Grill and Kozur, pl. 4, figs. 2, 4.
2003b *Triversus hexagonatus* (Heitzer) – Suzuki and Gawlick, p. 194, fig. 5.48; fig. 6.61. (detailed synonymy until 2002)
2004 *Parvicingula* sp. – Ishida, fig. 7.13; non 12.20.
2005 *Triversus hexagonatus* (Heitzer) – Suzuki and Kuwahara, p. 50, pl. 1, fig. 8.
2006 *Triversus hexagonatus* (Heitzer) – Gawlick *et al.*, fig. 8c.40; fig. 9b.20.
2006 *Triversus hexagonatus* (Heitzer) – Auer *et al.*, fig. 6.48.
2009 *Triversus hexagonatus* (Heitzer) – Suzuki and Gawlick, p. 170, fig. 5.15; fig. 6.11A, 6.11B.
2009 *Stichomitra*? spp. – Ishida *et al.*, fig. 6.12, 6.13.
2011 *Triversus hexagonatus* (Heitzer) – Gawlick *et al.*, fig. 1.24; fig. 3.38.

Genus ***Stichomitra*** Cayeux, 1897

Type species: ***Stichomitra bertrandi*** Cayeux, 1897. The type species was subsequently designated by O'Dogherty (1994).

Stichomitra annibill Kocher, 1981; emend. Suzuki and Gawlick, 2003b
(Plate 1, fig. 13; Plate 2, figs. 19, 25; Plate 3, fig. 24)
*1981 *Stichomitra annibill* – Kocher, p. 96, pl. 16, figs. 24–26.
1987 *Stichomitra*? *tairai* – Aita, p. 72, pl. 3, figs. 7–9; pl. 10, figs. 3, 4.
1997 *Xitus singularis* – Hull, p. 138, pl. 47, figs. 1, 7, 20.
1999 *Xitus reticulatus* – Hori, p. 76, fig. 7.1–7.5.
1999 *Xitus singularis* Hull – Hori, p. 76, fig. 7.6.
2003a *Stichomitra annibill* Kocher – Suzuki and Gawlick, p. 119, pl. 1, fig. 14.
2003b *Stichomitra annibill* Kocher – Suzuki and Gawlick,

p. 192, fig. 6.35, 6.36. (detailed synonymy until 2002)
2004 *Xitus spicularius* (Aliev) – Ishida, fig. 7.19; fig. 8.25.
2004 *Xitus* sp. – Ishida, fig. 8.26; ? fig. 7.18.
2005 *Stichomitra annibill* Kocher – Missoni *et al.*, fig. 13.4.
2006 *Stichomitra annibill* Kocher – Gawlick *et al.*, fig. 8b.30.
2006 *Stichomitra annibill* Kocher – Auer *et al.*, fig. 6.37.
2009 *Stichomitra annibill* Kocher – Suzuki and Gawlick, p. 176, fig. 5.16; fig. 6.16A, 6.16B.
2011 *Stichomitra annibill* Kocher – Gawlick *et al.*, fig. 3.32.
2014 *Stichomitra annibill* Kocher – Suzuki *et al.*, p. 15, pl. 5, figs. 5, 9.
2015 *Stichomitra annibill* Kocher – Ishida, pl. 10, figs. 30–36.

***Stichomitra* sp. A** sensu Baumgartner *et al.*, 1995a
(Plate 2, fig. 34)
*1995a *Stichomitra* sp. A – Baumgartner *et al.*, p. 528, pl. 3192, figs. 1–3.

Genus ***Unuma*** Ichikawa and Yao, 1976

Type species: ***Unuma typicus*** Ichikawa and Yao, 1976

Unuma typicus Ichikawa and Yao, 1976
(Plate 2, fig. 6)
*1976 *Unuma* (*Unuma*) *typicus* – Ichikawa and Yao, p. 112, pl. 1, figs. 1–3.
1994 *Unuma typicus* Ichikawa and Yao – Goričan, p. 96, pl. 10, fig. 13.
1995a *Unuma typicus* Ichikawa and Yao – Baumgartner *et al.*, p. 622, pl. 4059, figs. 1, 2. (detailed synonymy until 1991)
2009 *Unuma typicus* Ichikawa and Yao – Suzuki and Gawlick, p. 177, fig. 5.19.
cf. 2016 *Unuma* cf. *typicus* Ichikawa and Yao – Suzuki and Nakai, pl. 1, figs. 4a, 4b.

Unuma gordus Hull, 1997
(Plate 1, fig. 29; Plate 2, fig. 41)
*1997 *Unuma gorda* – Hull, p. 172, pl. 43, figs. 9, 11, 12.
2003b *Unuma gorda* Hull – Suzuki and Gawlick, p. 198, fig. 5.36; fig. 6.68. (detailed synonymy until 2002)
2007 *Unuma gorda* Hull – Gawlick *et al.*, fig. 7.21; fig. 8.44; fig. 17.30; fig. 18.13.
2009 *Unuma gordus* Hull – Suzuki and Gawlick, p. 177, fig. 6.2A, 6.2B.

Genus ***Protunuma*** Ichikawa and Yao, 1976

Type species: ***Protunuma fusiformis*** Ichikawa and Yao, 1976

Protunuma fusiformis Ichikawa and Yao, 1976
(Plate 3, fig. 27)
*1976 *Protunuma fusiformis* – Ichikawa and Yao, p. 116, pl. 2, figs. 1–4b.

Protunuma lanosus Ozvoldova, 1996
(Plate 2, fig. 8)
*1996 ?*Protunuma lanosus* – Ožvoldová in Sykora and Ozvoldova, p. 23, pl. 2, fig. 13; pl. 3, figs. 1–6.
2003a *Protunuma lanosus* Ozvoldova – Suzuki and Gawlick, p. 119, pl. 1, fig. 12.
2007 *Protunuma lanosus* Ozvoldova – Gawlick *et al.*, fig. 7.12.

Protunuma japonicus Matsuoka and Yao, 1985; emend. herein
(Plate 1, fig. 30)
non 1930 *Cenellipsis multicostatus* – Heitzer, p. 388, pl. 17, fig. 13.
*1985 *Protunuma japonicus* – Matsuoka and Yao, p. 130, pl. 1, figs. 11–15; pl. 3, figs. 6–9.
2001 *Protunuma japonicus* Matsuoka and Yao – Wegerer *et al.*, fig. 4b.16; fig. 5.11.
2007 *Protunuma multicostatus* (Heitzer) – Gawlick *et al.*, fig. 7.13; ? fig. 19.30.
2011 *Protunuma multicostatus* (Heitzer) – Gawlick *et al.*, fig. 3.28; ? fig. 2.28.
2013 *Protunuma multicostatus* (Heitzer) – Krische *et al.*, pl. 3, fig. 6.
non 2015 *Protunuma japonicus* Matsuoka and Yao – Ishida, pl. 3, fig. 16; pl. 8, fig. 15 [= *Protunuma multicostatus*].
Emended diagnosis: *Protunuma* species, which possesses not only two, but also three or four rows of pores between neighbouring two longitudinal plicae.
Remarks: Suzuki and Gawlick (2003b) regarded *Protunuma japonicus* as a younger synonym of *Protunuma multicostatus* (Heitzer, 1930) (= *Cenellipsis multicostatus*). If we follow the original description of Matsuoka and Yao (1985) "Two to four rows of pores present between neighbouring two longitudinal plicae", namely including a specimen having "only two rows of pores between neighbouring two longitudinal plicae", *Protunuma japonicus* should be a younger synonym of *Protunuma multicostatus* (Heitzer). Our careful observation of specimens of *Protunuma multicostatus* clarifies that it has only two rows of pores between neighbouring two longitudinal plicae (Fig. 6a). If a specimen having three rows of pores between two longitudinal plicae even in one portion, it should be *Protunuma japonicus* (Fig. 6b; Plate 1, fig. 30). Therefore, we separate *Protunuma japonicus* from the previously synonymized "*Protunuma multicostatus*".

Genus ***Podobursa*** Wisniowski, 1889; emend. Foreman, 1973

Type species: ***Podobursa dunikowskii*** Wisniowski, 1889. Monotype.

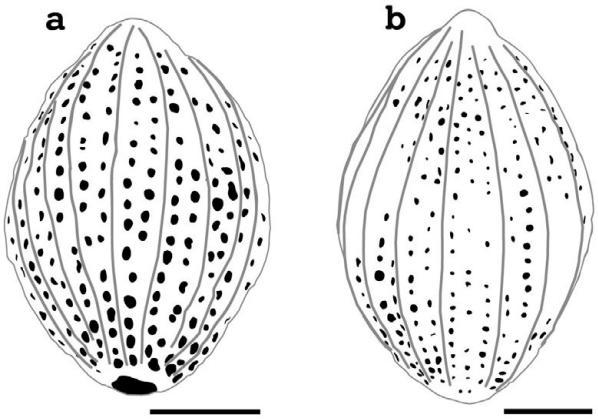

Fig. 6 Sketches of two *Protumuna* species. a: *Protunuma multicostatus* (Heitzer, 1930), from the Brielgraben section, b: *Protunuma japonicus* Matsuoka and Yao, 1985, from the Fludergraben section (Plate 1, fig. 30). *Protunuma japonicus* differs from *P. multicostatus* in having not only two, but also three longitudinal pore rows. Each scale bar is 30 μm.

Podobursa nodosa (Chiari, Marcucci and Prela, 2002)
(Plate 2, fig. 31)
1997 *Podobursa*? sp. B. – Hull, p. 108, pl. 43, figs. 5, 18, 19.
*2002 *Williriedellum nodosum* – Chiari *et al.*, p. 84, pl. 5, figs. 15–19.
2009 *Podobursa nodosa* (Chiari, Marcucci and Prela) – Suzuki and Gawlick, p. 178, fig. 5.20, 5.21.

Genus ***Droltus*** Pessagno and Whalen, 1982

Type species: ***Droltus lyellensis*** Pessagno and Whalen, 1982.
Remarks: Suzuki *et al.* (2002) demonstrated a VB (branch of vertical spine) ring as the cephalic skeletal elements in their specimen of *Droltus hecatensis* Pessagno and Whalen. We, therefore, classify the genus *Droltus* into the family Amphipyndacidae.

Droltus galerus Suzuki, 1995b
(Plate 3, fig. 49)
1995a *Droltus* sp. – Suzuki, fig. 4.15.
*1995b *Droltus galerus* – Suzuki, p. 284, fig. 5.5–5.7; fig. 7.1a, 7.1b.
2006 *Droltus galerus* Suzuki – Auer *et al.*, fig. 6.11.
2007 *Droltus galerus* Suzuki – Auer *et al.*, fig. 6.17.
2009 *Droltus galerus* Suzuki – Suzuki and Gawlick, p. 177, fig. 6.3A–6.4B.
Remarks: Our specimen from the Fludergraben section exhibits sharp pointed cephalis rather than rounded one that seen in type specimens from the Lower Jurassic chert in the Umenoki Unit of Shikoku, Japan (Suzuki, 1995b).

Family **WILLIRIEDELLIDAE** Dumitrica, 1970

Genus ***Williriedellum*** Dumitrica, 1970

Type species: ***Williriedellum crystallinum*** Dumitrica, 1970

Williriedellum crystallinum Dumitrica, 1970
(Plate 2, figs. 16, 36)
*1970 *Williriedellum crystallinum* – Dumitrica, p. 69, pl. 10, figs. 60a–60c, 62, 63.
1994 *Williriedellum crystallinum* Dumitrica – Goričan, p. 96, pl. 12, figs. 1, 2a–2c. (detailed synonymy until 1993)
2003b *Williriedellum crystallinum* Dumitrica – Suzuki and Gawlick, p. 199, fig. 6.76.
2005 *Williriedellum crystallinum* Dumitrica – Missoni *et al.*, fig. 7.23.
2006 *Williriedellum crystallinum* Dumitrica – Gawlick *et al.*, fig. 8c.41.
2006 *Williriedellum crystallinum* Dumitrica – Auer *et al.*, fig. 6.51.
2009 *Williriedellum crystallinum* Dumitrica – Suzuki and Gawlick, p. 178, fig. 5.24.
2011 *Williriedellum crystallinum* Dumitrica – Gawlick *et al.*, fig. 1.26; fig. 2.36; fig. 3.40.

Williriedellum sujkowskii Widz and De Wever, 1993
(Plate 2, fig. 32)
*1993 *Williriedellum sujkowskii* – Widz and De Wever, p. 88, pl. 2, figs. 7–10.
2007 *Williriedellum sujkowskii* Widz and De Wever – Auer *et al.*, fig. 6.123.
2010 *Williriedellum sujkowskii* Widz and De Wever – Gawlick *et al.*, fig. 27.22.
2011 *Williriedellum sujkowskii* Widz and De Wever – Gawlick *et al.*, fig. 1.27; fig. 3.42.

Williriedellum carpathicum Dumitrica, 1970
(Plate 2, fig. 20; Plate 3, fig. 16)
*1970 *Williriedellum carpathicum* – Dumitrica, p. 70, pl. 9, figs. 56a, 56b, 57–59; pl. 10, fig. 61.
2003b *Williriedellum carpathicum* Dumitrica – Suzuki and Gawlick, p. 200, fig. 6.74. (detailed synonymy until 2003)
2004 *Tricolocapsa yaoi* Matsuoka – Ishida, fig. 8.33.
2007 *Williriedellum carpathicum* Dumitrica – Auer *et al.*, fig. 6.120.
2010 *Williriedellum carpathicum* Dumitrica – Gawlick *et al.*, fig. 16A.8; fig. 16B.13; fig. 19.43; fig. 22.6; fig. 50.3.
2011 *Williriedellum carpathicum* Dumitrica – Gawlick *et al.*, fig. 1.25; fig. 3.39.
2015 *Williriedellum* sp. 2 – Ishida, pl. 6, fig. 50.

Williriedellum marcucciae Cortese, 1993
(Plate 2, fig. 10; Plate 3, fig. 44)
1983 *Williriedellum* sp. A gr. – Matsuoka, p. 23, pl. 4, figs. 1–3; pl. 8, figs. 11–15.

*1993 *Williriedellum marcuccii* – Cortese, p. 180, pl. 7, figs. 6, 7.
1994 *Williriedellum* sp. A sensu Matsuoka – Goričan, p. 96, pl. 12, figs. 9a–9c, 10a–10c, 11a, 11b. (detailed synonymy until 1993)
2003b *Williriedellum* sp. A sensu Matsuoka – Suzuki and Gawlick, p. 201, fig. 6.77. (detailed synonymy between 1994 and 2003)
2004 *Williriedellum* sp. A sensu Matsuoka – Gawlick *et al.*, fig. 3b.19.
2005 *Williriedellum* sp. A sensu Matsuoka – Missoni *et al.*, fig. 7.25.
2006 *Williriedellum* sp. A sensu Matsuoka – Auer *et al.*, fig. 6.53.
2006 *Williriedellum* sp. A sensu Matsuoka – Gawlick *et al.*, fig. 8c.43; fig. 9b.24.
2009 *Williriedellum marcucciae* Cortese – Suzuki and Gawlick, p. 179, fig. 5.25; fig. 6.49A, 6.49B.
2015 *Williriedellum marcucciae* Cortese – Ishida, pl. 1, figs. 51, 52; pl. 6, figs. 46–48.
2016 *Williriedellum marcucciae* Cortese – Suzuki and Nakai, pl. 1, figs. 1a, 1b
2018 *Williriedellum marcucciae* Cortese – Gawlick *et al.*, fig. 14.10; fig. 18.39.

Williriedellum dierschei Suzuki and Gawlick, 2004
(Plate 1, figs. 1, 27; Plate 2, figs. 12, 30; Plate 3, fig. 45)
*2004 *Williriedellum dierschei* – Suzuki and Gawlick in Gawlick *et al.*, p. 311, fig. 4.1–4.6. (detailed synonymy until 2001)
2005 *Williriedellum dierschei* Suzuki and Gawlick – Missoni *et al.*, fig. 7.24; fig. 10.35.
2005 *Williriedellum dierschei* Suzuki and Gawlick – Suzuki and Kuwahara, p. 52, pl. 1, figs. 18, 19.
2006 *Williriedellum dierschei* Suzuki and Gawlick – Auer *et al.*, fig. 6.52.
2006 *Williriedellum dierschei* Suzuki and Gawlick – Gawlick *et al.*, fig. 9b.23.
2009 *Williriedellum dierschei* Suzuki and Gawlick – Suzuki and Gawlick, p. 179, fig. 5.27A, 5.27B, 5.28; fig. 6.48A, 6.48B.
2015 *Williriedellum dierschei* Suzuki and Gawlick – Ishida, pl. 1, figs. 47, 48; pl. 6, figs. 43–45.
2018 *Williriedellum dierschei* Suzuki and Gawlick – Gawlick *et al.*, fig. 14.9; fig. 18.37; cf. fig. 25.4.

***Williriedellum* sp. C** sensu Gawlick *et al.*, 2018
(Plate 3, fig. 43)
1992 *Tricolocapsa* sp. A – Ozvoldova, p. 115, pl. 2, figs. 6, 7.
2007 *Tricolocapsa* sp. A sensu Ozvoldova – Auer *et al.*, fig. 6.109.
*2018 *Williriedellum* sp. C – Gawlick *et al.*, fig. 18.40.
Remarks: Depicted specimen exhibits a three-chambered test with a large globose abdomen, which possesses a projected short tube-like aperture on its base. Somewhat large pores are scattered on a smooth surfaced abdomen.

Genus ***Praewilliriedellum*** Kozur, 1984

Type species: ***Praewilliriedellum cephalospinosum*** Kozur, 1984
Remarks: Kozur (1984) mentioned that the thorax of this genus is not or very slightly depressed into the abdomen, although the genus is classified into the family Williriedellidae by Kozur (1984). If the thorax is not depressed into the abdomen commonly, this genus should be classified into the family Arcanicapsidae.

Praewilliriedellum* aff. *spinosum Kozur, 1984
(Plate 3, fig. 46)
aff. *1984 *Praewilliriedellum spinosum* – Kozur, p. 52, pl. 1, figs. 1–3.
Remarks: Our specimens from the Fludergraben section have a slightly elongated test in comparison with the type specimens depicted by Kozur (1984). Thus, we describe here as *Praewilliriedellum* aff. *spinosum*.

Genus ***Zhamoidellum*** Dumitrica, 1970

Type species: ***Zhamoidellum ventricosum*** Dumitrica, 1970

Zhamoidellum ventricosum Dumitrica, 1970
(Plate 1, fig. 25)
*1970 *Zhamoidellum ventricosum* – Dumitrica, p. 79, pl. 9, figs. 55a, 55b.
2003b *Zhamoidellum ventricosum* Dumitrica – Suzuki and Gawlick, p. 202, fig. 6.57. (detailed synonymy until 2002)
2005 *Zhamoidellum ventricosum* Dumitrica – Missoni *et al.*, fig. 13.6.
2006 *Zhamoidellum ventricosum* Dumitrica – Auer *et al.*, fig. 6.57.
2009 *Zhamoidellum ventricosum* Dumitrica – Suzuki and Gawlick, p. 179, fig. 5.29.
2018 *Zhamoidellum ventricosum* Dumitrica – Gawlick *et al.*, fig. 18.41.
Remarks: A depicted specimen shows lager pores and pore frames on globous abdomen than those of other specimens showed previously.

Zhamoidellum ovum Dumitrica, 1970
(Plate 1, fig. 20; Plate 2, figs. 13, 35; Plate 3, fig. 26)
*1970 *Zhamoidellum ovum* – Dumitrica, p. 79, pl. 9, figs. 52a, 52b, 53, 54.
1994 *Zhamoidellum ovum* Dumitrica – Goričan, p. 97, pl. 13, figs. 3–7. (detailed synonymy until 1993)
2003b *Zhamoidellum ovum* Dumitrica – Suzuki and Gawlick, p. 203, fig. 6.56.
2004b *Zhamoidellum ovum* Dumitrica – Suzuki *et al.*, p. 385, fig. 5.3. (detailed synonymy between 1994 and 2003)
2004 *Zhamoidellum ovum* Dumitrica – Gawlick *et al.*, fig. 3b.27.
2004 *Zhamoidellum ovum* Dumitrica – Ishida, fig. 8.32;

fig. 10.22.
2005 *Zhamoidellum ovum* Dumitrica – Missoni *et al.*, fig. 7.28; fig. 13.7.
2006 *Zhamoidellum ovum* Dumitrica – Auer *et al.*, fig. 6.56.
2006 *Zhamoidellum ovum* Dumitrica – Gawlick *et al.*, fig. 8c.45.
2009 *Zhamoidellum ovum* Dumitrica – Suzuki and Gawlick, p. 179, fig. 5.30A, 5.30B; fig. 6.33A, 6.33B.
2009 *Williriedellum yaoi* (Kozur) – Ishida *et al.*, fig. 6.2.
2011 *Zhamoidellum ovum* Dumitrica – Gawlick *et al.*, fig. 1.28; fig. 2.39; fig. 3.45.
2014 *Zhamoidellum ovum* Dumitrica – Suzuki *et al.*, p. 16, pl. 4, fig. 2; pl. 5, fig. 16.
2015 *Zhamoidellum ovum* Dumitrica – Ishida, pl. 1, fig. 62; pl. 6, figs. 59, 60.

Family **ARCANICAPSIDAE** Takemura, 1986

Genus ***Stylocapsa*** Principi, 1909; emend. Tan, 1927

Type species: ***Stylocapsa exagonata*** Principi, 1909

Stylocapsa oblongula Kocher, 1980
(Plate 3, fig. 34)
* 1980 *Stylocapsa oblongula* – Kocher in Baumgartner *et al.*, p. 62, pl. 6, fig. 1.
2001 *Stylocapsa oblongula* Kocher – Suzuki *et al.*, fig. 5.10.
2001 *Stylocapsa oblongula* Kocher – Wegerer *et al.*, fig. 4a.18; fig. 6.3.
2007 *Stylocapsa oblongula* Kocher – Auer *et al.*, fig. 6.86.
2015 *Kilinora*? *oblongula* (Kocher) – Ishida, pl. 1, figs. 7, 8.

Genus ***Kilinora*** Hull, 1997

Type species: ***Stylocapsa*? *spiralis*** Matsuoka, 1982
Remarks: We agree with the establishment of the genus *Kilinora* by Hull (1997), to separate the species having a thorax with costae ornamentation from that with a latticed thorax.

Kilinora* cf. *spiralis (Matsuoka, 1982)
(Plate 1, fig. 31)
cf. *1982 *Stylocapsa*? *spiralis* – Matsuoka, p. 77, pl. 3, figs. 1–8.
Remarks: Our single specimen is poorly preserved and only a part of peculiar ornamentation, i.e. oblique plicae, can be observed.

Genus ***Gongylothorax*** Foreman, 1968; emend. Dumitrica, 1970

Type species: ***Dicolocapsa verbeeki*** Tan, 1927. Suzuki and Gawlick (2003b) discussed in detail.

Gongylothorax favosus Dumitrica, 1970
Remarks: *Gongylothorax favosus* is subdivided into two subspecies, namely the nominate subspecies *Gongylothorax favosus favosus* Dumitrica and the subspecies *Gongylothorax favosus oviformis* Suzuki and Gawlick.

Gongylothorax favosus favosus Dumitrica, 1970
(Plate 1, fig. 26; Plate 2, figs. 7, 28; Plate 3, fig. 35)
*1970 *Gongylothorax favosus* – Dumitrica, p. 56, pl. 1, figs. 1a–1c, 2.
1994 *Gongylothorax favosus* Dumitrica – Ishida, fig. 3.5.
2003a *Gongylothorax favosus* Dumitrica – Suzuki and Gawlick, p. 119, pl. 1, fig. 13.
2003b *Gongylothorax favosus* Dumitrica – Suzuki and Gawlick, p. 205, fig. 6.96. (detailed synonymy until 2002)
2005 *Gongylothorax favosus* Dumitrica – Missoni *et al.*, fig. 7.30; fig. 13.8.
2006 *Gongylothorax favosus* Dumitrica – Auer *et al.*, fig. 6.17.
2006 *Gongylothorax favosus* Dumitrica – Gawlick *et al.*, fig. 8a.16; fig. 9a.13.
2009 *Gongylothorax favosus favosus* Dumitrica – Suzuki and Gawlick, p. 180, fig. 5.31A–5.31C, 5.32A, 5.32B; fig. 6.21A, 6.21B.
2009 *Gongylothorax favosus* Dumitrica – Ishida *et al.*, fig. 6.9, 6.10.
2014 *Gongylothorax favosus favosus* Dumitrica – Suzuki *et al.*, p. 17, pl. 4, fig. 8; pl. 5, fig. 14.
Remarks: *Gongylothorax favosus favosus* differs from *Gongylothorax favosus oviformis* in having a spherical thorax with a depressed cephalis.

Gongylothorax favosus oviformis Suzuki and Gawlick, 2009
(Plate 2, fig. 23; Plate 3, fig. 36)
1994 *Gongylothorax* aff. *favosus* Dumitrica – Goričan, p. 70, pl. 13, figs. 9a–9c, 11a–11c. (detailed synonymy until 1993)
cf. 2005 *Gongylothorax* aff. *favosus* Dumitrica – Suzuki and Kuwahara, p. 55, pl. 2, figs. 9, 10. (detailed synonymy between 1994 and 2004)
2006 *Gongylothorax* aff. *favosus* Dumitrica – Gawlick *et al.*, fig. 8a.17; fig. 9a.12.
*2009 *Gongylothorax favosus oviformis* – Suzuki and Gawlick, p. 180, fig. 5.33A–5.34C; fig. 6.22A–6.26B.
Remarks: *Gongylothorax favosus oviformis* differs from *Gongylothorax favosus favosus* in having an elliptical test outline with a not so depressed cephalis. In case of *Gongylothorax favosus oviformis*, penta- or hexagonal pore frames become lager down to thoracic base.

***Gongylothorax* sp. C** sensu Suzuki and Gawlick, 2003b
(Plate 3, fig. 42)
1997 *Gongylothorax siphonofer* Dumitrica – Yao, pl. 9, fig. 417.
*2003b *Gongylothorax* sp. C – Suzuki and Gawlick, p. 206, fig. 6.98.

2009 *Gongylothorax* sp. C sensu Suzuki and Gawlick– Suzuki and Gawlick, p. 181, fig. 5.35, 5.36.
2016 *Gongylothorax* sp. C sensu Suzuki and Gawlick – Gawlick *et al.*, fig. 11g.
Remarks: Our single specimen possesses a projected tube-like aperture on a base of bulbous thorax, on which somewhat lager pores are more sparsely distributed in comparison with the materials from north side of Mt. Loser (Suzuki and Gawlick, 2003b) and Hallstatt salt mine (Suzuki and Gawlick, 2009).

Genus ***Tricolocapsa*** Haeckel, 1881

Type species: ***Tricolocapsa theophrasti*** Haeckel, 1887

Tricolocapsa tetragona Matsuoka, 1983
(Plate 1, fig. 32; Plate 2, fig. 9)
*1983 *Tricolocapsa tetragona* – Matsuoka, p. 22, pl. 3, figs. 8–12; pl. 8, figs. 4–10.
cf. 1994 *Tricolocapsa* cf. *tetragona* Matsuoka – Ishida, fig. 3.13.
1994 *Tricolocapsa tetragona* Matsuoka – Goričan, p. 94, pl. 13, figs. 8, 10. (detailed synonymy until 1993)
1999 *Tricolocapsa tetragona* Matsuoka – Wegerer *et al.*, fig. 5.1.
2007 *Tricolocapsa tetragona* Matsuoka – Gawlick *et al.*, fig. 18.40.
2009 *Tricolocapsa tetragona* Matsuoka – Suzuki and Gawlick, p. 183, fig. 5.43.
2010 *Tricolocapsa tetragona* Matsuoka – Gawlick *et al.*, fig. 19.40; fig. 27.19.
2011 *Tricolocapsa tetragona* Matsuoka – Gawlick *et al.*, fig. 3.36.

Tricolocapsa undulata (Heitzer, 1930)
(Plate 1, fig. 22; Plate 2, fig. 27; Plate 3, figs. 17, 33)
*1930 *Lithobotrys undulata* – Heitzer, p. 390, pl. 28, fig. 22.
1987 *Sethocapsa funatoensis* – Aita, p. 73, pl. 2, figs. 6a–b, 7a–b; pl. 9, figs. 14, 15.
1987 *Sethocapsa yahazuensis* – Aita, p. 73, pl. 2, figs. 8a–b, 9a–b; pl. 9, figs. 16, 17.
1993 *Tricolocapsa undulata* (Heitzer) – Ozvoldova and Faupl, pl. 3, fig. 12.
2005 *Tricolocapsa undulata* (Heitzer) – Suzuki and Kuwahara, p. 59, pl. 2, fig. 3. (detailed synonymy until 2004)
2005 *Tricolocapsa undulata* (Heitzer) – Missoni *et al.*, fig. 7.37; fig. 10.45.
2006 *Tricolocapsa undulata* (Heitzer) – Auer *et al.*, fig. 6.44.
2006 *Tricolocapsa undulata* (Heitzer) – Gawlick *et al.*, fig. 8c.36; fig. 9b.21.
2009 *Tricolocapsa undulata* (Heitzer) – Suzuki and Gawlick, p. 183, fig. 5.44A, 5.44B, 5.45A, 5.45B; fig. 6.18A, 6.18B, 6.19A, 6.19B.
2011 *Tricolocapsa undulata* (Heitzer) – Gawlick *et al.*, fig. 2.34; fig. 3.37.
2015 *Zhamoidellum undulata* (Heitzer) – Ishida, pl. 1, figs. 55–59; pl. 6, figs. 52–55.
Remarks: We integrate two species of Aita (1987), i.e. *Sethocapsa funatoensis* and *Sethocapsa yahazuensis*, into *Tricolocapsa undulata* (Heitzer, 1930) as younger synonyms (see Suzuki and Gawlick, 2003b; Suzuki and Kuwahara, 2005).

Genus ***Striatojaponocapsa*** Kozur, 1984

Type species: ***Tricolocapsa plicarum*** Yao, 1979

Striatojaponocapsa conexa (Matsuoka, 1983)
(Plate 2, fig. 39; Plate 3, fig. 31)
*1983 *Tricolocapsa conexa* – Matsuoka, p. 20, pl. 3, figs. 3–7; pl. 7, figs. 11–14.
1994 *Tricolocapsa conexa* Matsuoka – Goričan, p. 94, pl. 11, figs. 7a–b, 8, 9, 10a–b. (detailed synonymy until 1993)
1997 *Striatojaponicapsa conexa* (Matsuoka) – Hull, p. 166, pl. 37, fig. 20.
2003b *Tricolocapsa conexa* Matsuoka – Suzuki and Gawlick, p. 208, fig. 5.42; fig. 6.43–6.45.
2005 *Tricolocapsa conexa* Matsuoka – Missoni *et al.*, fig. 10.44.
2007 *Striatojaponocapsa conexa* (Matsuoka) – Hatakeda *et al.*, p. 54, pl. 2, figs. 1–10.
2009 *Striatojaponocapsa conexa* (Matsuoka) – Suzuki and Gawlick, p. 182, fig. 5.40; fig. 6.32A, 6.32B.
2015 *Striatojaponocapsa conexa* (Matsuoka) – Ishida, pl. 1, figs. 16–19; pl. 6, figs. 21–25.

Striatojaponocapsa riri O'Dogherty, Goričan and Dumitrica, 2006
(Plate 2, figs. 11, 40)
1994 *Tricolocapsa* sp. A – Goričan, p. 9, pl. 11, figs. 11–13.
*2006 *Striatojaponocapsa riri* – O'Dogherty, Goričan and Dumitrica, p. 447, pl. 8, figs. 14, 15.
2007 *Striatojaponocapsa riri* O'Dogherty, Goričan and Dumitrica – Hatakeda *et al.*, p. 55, pl. 2, figs. 11–20.
2007 *Tricolocapsa* sp. A sensu Goričan – Auer *et al.*, fig. 6.108.
2015 *Striatojaponocapsa riri* O'Dogherty, Goričan and Dumitrica – Ishida, pl. 1, figs. 20–24; pl. 6, figs. 26–32.

Striatojaponocapsa synconexa O'Dogherty, Goričan and Dumitrica, 2006
(Plate 1, fig. 24; Plate 2, fig. 33; Plate 3, fig. 30)
*2006 *Striatojaponocapsa synconexa* – O'Dogherty, Goričan and Dumitrica, p. 447, pl. 10, figs. 9–17. (Detailed synonymy)
2007 *Striatojaponocapsa synconexa* O'Dogherty, Goričan and Dumitrica – Hatakeda *et al.*, p. 54, pl. 1, figs. 11–20.
2015 *Striatojaponocapsa synconexa* O'Dogherty, Goričan and Dumitrica – Ishida, pl. 1, figs. 13–15; pl. 6, figs.

19, 20.

Striatojaponocapsa naradaniensis (Matsuoka, 1984)
(Plate 2, fig. 21; Plate 3, fig. 40)
*1984 *Stichocapsa naradaniensis* – Matsuoka, p. 145, pl. 1, figs. 1–5; pl. 2, figs. 1–6.
1994 *Stichocapsa naradaniensis* Matsuoka – Goričan, p. 88, pl. 11, fig. 6. (detailed synonymy until 1993)
2003b *Stichocapsa naradaniensis* Matsuoka – Suzuki and Gawlick, p. 213, fig. 6.53, 6.54a, 6.54b. (detailed synonymy between 1994 and 2002)
2005 *Stichocapsa naradaniensis* Matsuoka – Missoni *et al.*, fig. 7.43; fig. 10.55; fig. 13.12.
2009 *Stichocapsa naradaniensis* Matsuoka – Suzuki and Gawlick, p. 186, fig. 5.57A, 5.57B, 5.58; fig. 6.38A, 6.38B, 6.42A, 6.42B.
2009 *Stichocapsa naradaniensis* Matsuoka – Ishida *et al.*, fig. 6.3; fig. 7.9.

Genus ***Japonocapsa*** Kozur, 1984

Type species: ***Tricolocapsa fusiformis*** Yao, 1979

Japonocapsa fusiformis (Yao, 1979)
(Plate 3, figs. 47, 48)
*1979 *Tricolocapsa*? *fusiformis* – Yao, p. 33, pl. 4, figs. 12–18; pl. 5, figs. 1–4.
1994 *Tricolocapsa*? *fusiformis* Yao – Goričan, p. 94, pl. 9, fig. 14. (detailed synonymy until 1993)
2009 *Tricolocapsa fusiformis* Yao – Suzuki and Gawlick, p. 183, fig. 5.41, 5.42A, 5.42B, 5.57A, 5.57B; fig. 6.13A, 6.13B, 6.14, 6.17.
Remarks: In case of depicted specimens, a basal dish-like appendage is torn off.

Japonocapsa tegiminis (Yao, 1979)
(Plate 3, fig. 41)
*1979 *Stichocapsa tegiminis* – Yao, p. 34, pl. 5, figs. 5–13.
2002 *Stichocapsa tegiminis* Yao – Nakae, fig. 3m.
2009 *Stichocapsa tegiminis* Yao – Suzuki and Gawlick, p. 186, fig. 5.55A, 5.55B.
2018 *Stichocapsa tegiminis* Yao – Gawlick *et al.*, fig. 12.24.
Remarks: *Japonocapsa tegiminis* differs from *Japonocapsa fusiformis* in having four chambers (exclusive of an appendage). A depicted specimen has a wide basal dish-like appendage.

Genus ***Tetracapsa*** Haeckel, 1881

*1881 *Tetracapsa* – Haeckel, p. 438.
pt. 1887 *Stichocapsa* – Haeckel, p. 1515.
pt. 1981 *Tetracapsa* Haeckel – Petrushevskaya, p. 185.
1993 *Tetracapsa* Haeckel – Widz and De Wever, p. 86.
2003b *Tetracapsa* Haeckel – Suzuki and Gawlick, p. 211.
2004b *Tetracapsa* Haeckel – Suzuki *et al.*, p. 387.
2014 *Tetracapsa* Haeckel – Suzuki *et al.*, p. 18.
Type species: ***Tetracapsa pilula*** Rüst, 1885. This type species was subsequently designated by Campbell (1954) (Petrushevskaya, 1981).
Remarks: Morphotypes having latticed four-chambered test with closed base appeared frequently in Middle and Late Jurassic time. These morphotypes have been described under the genus *Sethocapsa* or *Stichocapsa*. However, their four-chambered feature is conspicuous to separate from two-chambered *Sethocapsa* and five- or more chambered *Stichocapsa*.

***Tetracapsa* sp. A** sensu Suzuki and Gawlick, 2003b
(Plate 3, figs. 1, 32)
1997 *Stichocapsa* sp. A sensu Matsuoka and Yao – Suzuki and Nakae, pl. 2, fig. 11.
2001 *Stichocapsa* sp. A sensu Matsuoka and Yao – Miyamoto *et al.*, pl. 7, fig. 8.
2002 *Arcanicapsa* sp. 2 – Hori *et al.*, pl. 8, fig. 24.
*2003b *Tetracapsa* sp. A – Suzuki and Gawlick, p. 211, fig. 5.24.
2004b *Tetracapsa* sp. A – Suzuki *et al.*, p. 387, fig. 5.1a, 5.1b.
2007 *Tetracapsa* sp. A sensu Suzuki and Gawlick – Auer *et al.*, fig. 6.92.
2009 *Tetracapsa* sp. A sensu Suzuki and Gawlick – Suzuki and Gawlick, p. 185, fig. 6.37A, 6.37B.

Genus ***Stichocapsa*** Haeckel, 1881

Type species: ***Stichocapsa jaspidea*** Rüst, 1885 (Campbell, 1954)

Stichocapsa cicciona Chiari, Marcucci and Prela, 2002
(Plate 1, fig. 28)
*2002 *Stichocapsa cicciona* – Chiari *et al.*, p. 76, pl. 3, figs. 8–12.
2007 *Stichocapsa cicciona* Chiari, Marcucci and Prela – Auer *et al.*, fig. 6.78.
2011 *Stichocapsa cicciona* Chiari, Marcucci and Prela – Gawlick *et al.*, fig. 3.31.
Remarks: This species has a test with a wide basal aperture, so that its generic attribution to the genus *Stichocapsa*, which has a closed base, is questionable. Here we tentatively attribute the species to the genus *Stichocapsa*.

Stichocapsa robusta Matsuoka, 1984
(Plate 1, fig. 23; Plate 2, fig. 26; Plate 3, fig. 25)
*1984 *Stichocapsa robusta* – Matsuoka, p. 146, pl. 1, figs. 6–13; pl. 2, figs. 7–12.
2007 *Stichocapsa robusta* Matsuoka – Auer *et al.*, fig. 6.81.

Genus ***Cyrtocapsa*** Haeckel, 1881

Type species: ***Cyrtocapsa ovalis*** Rüst, 1885

***Cyrtocapsa* sp. B**
(Plate 2, fig. 14)
2003 *Cyrtocapsa* sp. – Wegerer *et al.*, fig. 9.18.

Remarks: Four or five chambered tests with a robust horn. Proximal three or four segments make a conical portion, and a final segment exhibits a globous ball-form with larger pores than those of conical portion.

Genus ***Fultacapsa*** Ozvoldova, 1997

Type species: ***Acotripus sphericus*** Ozvoldova, 1988

Fultacapsa sphaerica (Ozvoldova, 1988)
(Plate 1, fig. 21)
* 1988 *Acotripus sphericus* – Ozvoldova, p. 376, pl. 5, figs. 1–5, 7.
1997 *Fultacapsa sphaerica* (Ozvoldova) – Ozvoldova and Frantova, p. 59, pl. 5, figs. 1, 2.
cf. 2003b *Acotripus* cf. *sphaericus* Ozvoldova – Suzuki and Gawlick, p. 191, fig. 5.29.
2010 *Fultacapsa sphaerica* (Ozvoldova) – Gawlick *et al.*, fig. 37B.1.
Remarks: A specimen from the Fludergraben section differs from specimens of Ozvoldova (1988) and Ozvoldova and Frantova (1997) in having weak constriction between a proximal part and a last globous segment.

Genus ***Helvetocapsa*** O'Dogherty, Goričan and Dumitrica, 2006

Type species: ***Tricolocapsa matsuokai*** Sashida, 1999

Helvetocapsa matsuokai (Sashida, 1999); emend. Suzuki and Gawlick, 2009
(Plate 1, fig. 19; Plate 3, fig. 39)
1930 *Cenellipsis* aff. *perspicua* Rüst – Heitzer, p. 388, pl. 27, fig. 11.
*1999 *Tricolocapsa matsuokai* – Sashida in Sashida *et al.*, p. 566, pl. 1, figs. 4, 5.
2003b *Tricolocapsa matsuokai* Sashida – Suzuki and Gawlick, p. 209, fig. 6.38. (detailed synonymy until 2002)
2006 *Helvetocapsa matsuokai* (Sashida) – O'Dogherty *et al.*, p. 452, pl. 7, figs. 19–24.
2009 *Helvetocapsa matsuokai* (Sashida) – Suzuki and Gawlick, p. 187, fig. 5.61A, 5.61B; fig. 6.40, 6.46A, 6.46B.
2018 *Helvetocapsa matsuokai* (Sashida) – Gawlick *et al.*, fig. 14.3.
Remarks: Sashida *et al.* (1999) described this species for the first time under the genus *Tricolocapsa*, a three-chamberd genus. O'Dogherty *et al.* (2006) erected a new genus *Helvetocapsa* and attributed this species to their new genus, although the number of the segments of this species were not observed. Suzuki and Gawlick (2009) observed the inner structure of it with a transmitted light microscope and clarified that *Helvetocapsa matsuokai* has five segments.

Family **EUCYRTIDIELLIDAE** Takemura, 1986

Genus ***Eucyrtidiellum*** Baumgartner, 1984

Type species: ***Eucyrtidium? unumaensis*** Yao, 1979

Eucyrtidiellum circumperforatum Chiari, Marcucci and Prela, 2002
(Plate 1, fig. 33; Plate 3, fig. 3)
*2002 *Eucyrtidiellum*? *circumperforatum* – Chiari *et al.*, p. 65, pl. 1, figs. 2–9.
2007 *Eucyrtidiellum circumperforatum* Chiari, Marcucci and Prela – Auer *et al.*, fig. 6.22.
2007 *Eucyrtidiellum circumperforatum* Chiari, Marcucci and Prela – Gawlick *et al.*, fig. 8.12.
2009 *Eucyrtidiellum circumperforatum* Chiari, Marcucci and Prela – Suzuki and Gawlick, p. 189, fig. 5.64.

Eucyrtidiellum unumaense (Yao, 1979)
(Plate 1, figs. 35, 36; Plate 3, figs. 14, 37)
*1979 *Eucyrtidium*? *unumaensis* – Yao, p. 39, pl. 9, figs. 1–11.
1994 *Eucyrtidiellum unumaense* (Yao) – Goričan, p. 69, pl. 9, figs. 5, 6. (detailed synonymy until 1993)
2003a *Eucyrtidiellum unumaense* (Yao) – Suzuki and Gawlick, p. 119, pl. 1, fig. 9.
2003b *Eucyrtidiellum unumaense* (Yao) – Suzuki and Gawlick, p. 215, fig. 5.21. (detailed synonymy between 1994 and 2002)
2005 *Eucyrtidiellum unumaense* ssp. (Yao) – Missoni *et al.*, fig. 10.62.
2006 *Eucyrtidiellum unumaense* ssp. (Yao) – Gawlick *et al.*, fig. 8a.14; fig. 9a.8.
2009 *Eucyrtidiellum unumaense* (Yao) – Suzuki and Gawlick, p. 188, fig. 5.62.
Remarks: *Eucyrtidiellum unumaense* is subdivided into the three subspecies, i.e. *E. unumaense unumaense* Yao, *E. unumaense dentatum* Baumgartner and *E. unumaense pustulatum* Baumgartner (Baumgartner *et al.*, 1995a; Suzuki and Gawlick, 2003b). Because our specimens possess not so conspicuous features of ornamentation on upper abdomen surface to identify subspecies, we describe them only as *Eucyrtidiellum unumaense*.

Eucyrtidiellum ptyctum (Riedel and Sanfilippo, 1974)
(Plate 1, fig. 34; Plate 3, fig. 4)
*1974 *Eucyrtidium ptyctum* – Riedel and Sanfilippo, p. 778, pl. 5, fig. 7; pl. 12, fig. 14; non pl. 12, fig. 15.
2003b *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) – Suzuki and Gawlick, p. 218, fig. 6.26, 6.27. (detailed synonymy between 1998 and 2002)
2005 *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) – Suzuki and Kuwahara, p. 65, pl. 2, fig. 17.
2005 *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) – Missoni *et al.*, fig. 7.48; fig. 10.61; fig. 13.5.
2006 *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) – Gawlick *et al.*, fig. 8.10; fig. 9.7.
2006 *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) – Auer *et al.*, fig. 6.14.

2009 *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) – Suzuki and Gawlick, p. 188, fig. 5.63.
2014 *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) – Suzuki *et al.*, p. 19, pl. 5. fig. 4.
2018 *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) – Gawlick *et al.*, fig. 14.12.

Eucyrtidiellum nodosum Wakita, 1988
(Plate 2, fig. 5; Plate 3, figs. 2, 38)
*1988 *Eucyrtidiellum nodosum* – Wakita, p. 408, pl. 4, fig. 29; pl. 5, fig. 16.
2001 *Eucyrtidiellum nodosum* Wakita – Nishizono, pl. 2, fig. 8.
2003b *Eucyrtidiellum nodosum* Wakita – Suzuki and Gawlick, p. 217, fig. 6.30. (detailed synonymy between 1994 and 2003)
2007 *Eucyrtidiellum nodosum* Wakita – Auer *et al.*, fig. 6.23.
2009 *Eucyrtidiellum nodosum* Wakita – Auer *et al.*, fig. 9.22; cf. fig. 13.3.

6. Discussion – Radiolarian zonation for the lower Oxfordian and correlation

Because radiolarian fauna from the lower Oxfordian that is calibrated by ammonite has hitherto not known all over the world, the Fludergraben fauna is a key for understanding Oxfordian marker species of radiolarians. Previously proposed radiolarian zonations have a relatively long-lasting period for the Callovian and Oxfordian. For example, the U. A. Zone 8 of Baumgartner *et al.* (1995b) ranges in age from middle Callovian to early Oxfordian. Thus, we can distinguish the Oxfordian radiolarian fauna from the Callovian one to make a comparison of faunal contents between Callovian and Oxfordian. In this chapter we discuss the first appearance horizons of possible marker species for the lower Oxfordian with descriptions of the middle and upper Callovian sections in the Northern Calcareous Alps.

6. 1 Radiolarians from the middle Callovian Brielgraben section

In the Brielgraben section of the Northern Calcareous Alps, the Klaus Formation yields middle Callovian ammonites (Krystyn, 1971) from strata that underlie a radiolarite succession. We have detected radiolarians from the radiolarite of the Brielgraben section, which are partly listed in Suzuki and Gawlick (2006, 2009). We show the revised inventory of radiolarians from the sample BT1 in the appendix 1.

6. 2 Radiolarians from the lower part of the Knallalm-Neualm section – upper Callovian

From the lower part of the Knallalm-Neualm section, Auer *et al.* (2007) reported radiolarian assemblages containing *Williriedellum carpathicum* from the samples MR149 and MR175. Gawlick *et al.* (2009) invented a new subzone of the *Zhamoidellum ovum* Zone, i.e. the *Williriedellum carpathicum* Subzone, based on the lower part of the Knallalm-Neualm section that is situated below the *Kilinora spiralis*-bearing radiolarite. If the first appearance horizon of *Kilinora spiralis* can be placed in the lowermost Oxfordian, the *Williriedellum carpathicum* Subzone is correlated to the upper Callovian (see discussion in the section 6. 4). We show the lists of radiolarian species from samples MR149 and MR175 in the appendix 2 (Auer *et al.*, 2007).

6. 3 Marker species for the base of Oxfordian

To compare the above-mentioned radiolarian faunas from the middle and upper Callovian with the Fludergraben fauna, it should be made clear what are the marker species for the base of Oxfordian (Fig. 7). We choose four species, i.e. *Kilinora spiralis* (Matsuoka), *Fultacapsa sphaerica* (Ozvoldova), *Protunuma japonicus* Matsuoka and Yao and *Pseudoeucyrtis reticularis* Matsuoka and Yao. *Kilinora spiralis* occurs, however, very rare in the Northern Calcareous Alps. From the Fludergraben section, we found a single specimen from the sample D1023, identified as *Kilinora* cf. *spiralis*. It is poorly preserved, and its surface ornamentation is ambiguous (Plate 1, fig. 31). Other three marker species, *Fultacapsa sphaerica* (Ozvoldova), *Protunuma japonicus* Matsuoka and Yao and *Pseudoeucyrtis reticularis* Matsuoka and Yao, also occur as a single specimen, respectively. *Pseudodictyomitra primitiva* Matsuoka and Yao has also potential to be a marker, but a forerunner occurrence is known from the upper Callovian of the Knallalm-Neualm section (Auer *et al.*, 2007). In the following three sections, we discuss ranges of these species in detail.

6. 4 Stratigraphic range of *Kilinora spiralis* — lower Oxfordian to lower Kimmeridgian

There is stratigraphical discrepancy of the first appearance horizon of *Kilinora spiralis* between Matsuoka (1995) and Baumgartner and Matsuoka (1995) (*Stylocapsa*? *spiralis* in their publications), although both used the same marker species of calcareous nannoplankton, *Stephanolithion hexum* Rood and Barnars, 1972, as discussed in Suzuki *et al.* (2004a). Matsuoka (1995) placed the first appearance horizon of *Kilinora spiralis* to the upper Callovian, based on the last occurrence of *Stephanolithion hexum* in the core 124 of the Site 534 in the Blake Bahama Basin (DSDP Leg 76). The last occurrence horizon of *Stephanolithion hexum*, which is correlated to the boundary between the middle and upper Callovian with the calibration of magnetostratigraphy (Roth, 1983), lies just above the first appearance horizon of *Kilinora spiralis* (Baumgartner and Matsuoka, 1995). On the other side, Baumgartner and Matsuoka (1995) reinterpreted the horizon of the last occurrence of *Stephanolithion hexum* in the core as a preservational bias, and its horizon was correlated to the upper Bathonian to lower Callovian (U. A. Zone 7) on the basis of a radiolarian age assignment. This is a circular

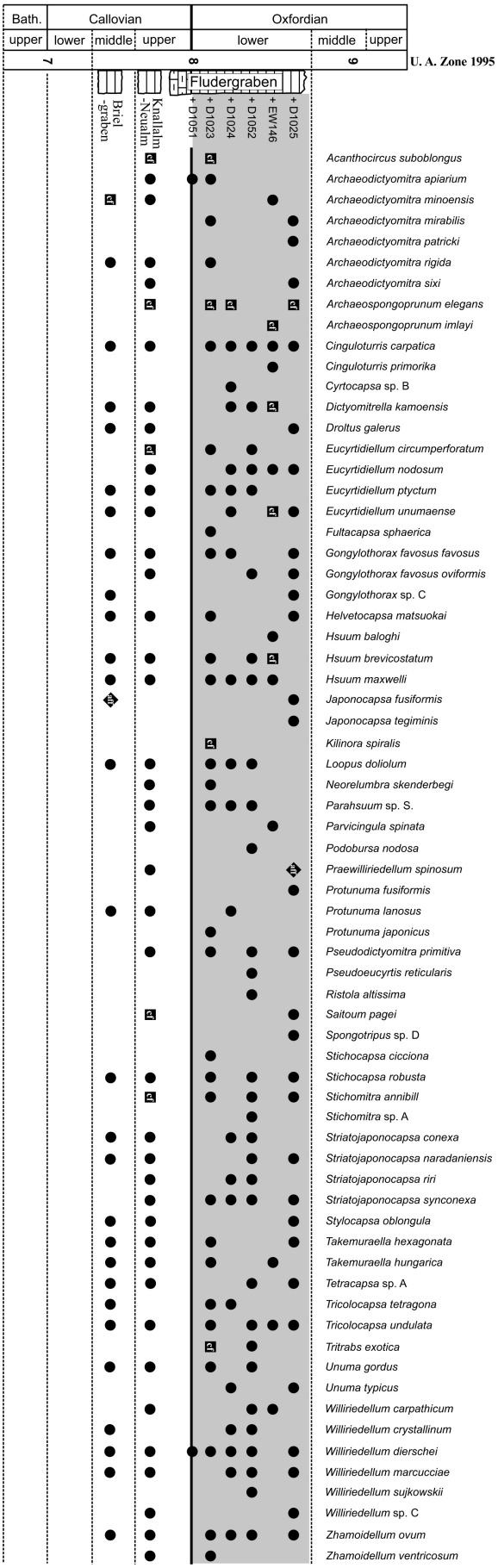

Fig. 7 Stratigraphic distributions of radiolarian species occurring in the lower Oxfordian Fludergraben section with the occurrences in the upper Callovian Knallalm-Neualm section (Auer *et al.*, 2007) and middle Callovian Brielgraben section (Suzuki and Gawlick, 2009 and unpublished data). Bath.: Bathonian, U. A. Zone 1995: Unitary Association Zones by Baumgartner *et al.* (1995b).

argument, because the radiolarian assemblage was used for the radiolarian age calibration. Of course, it is very difficult to determine the last occurrence horizon, if it is really the last occurrence or not, due to preservational condition like dissolution. Our data from the Northern Calcareous Alps support the interpretation of Matsuoka (1995). *Kilinora* cf. *spiralis* occurs in the early Oxfordian Fludergraben section, but not in the Brielgraben section of the middle Callovian (Suzuki and Gawlick, 2009 and data herein). Furthermore, Medd (1982) reported *Stephanolithion hexum* from the lower Oxfordian and also from the Kimmeridgian sporadically. This report suggests that the last occurrence horizon of *Stephanolithion hexum* extends into the lower Oxfordian or higher. In this context, the first appearance horizon of *Kilinora spiralis* can also be shifted upwards around the boundary between Callovian and Oxfordian as demonstrated in the Fludergraben section.

On the other hand, the last occurrence horizon of *Kilinora spiralis* is demonstrated in the Kurisaka Formation of eastern Shikoku, Japan, with the correlation of the ammonite zonation (Ishida *et al.*, 2009). *Kilinora spilaris* occurs in the horizon just below the first appearance horizon of the ammonite *Ataxioceras* (*Ataxioceras*) *kurisakaense* Kobayashi and Fukuda, 1947, indicating a lower Kimmeridgian horizon (Sato *et al.*, 2008).

Consequently, *Kilinora spiralis* occurs in the range from the boundary between Callovian and Oxfordian to the lower Kimmeridgian. Thus, the U. A. Zone 6 (middle Bathonian) to 7 (late Bathonian–early Callovian) attributed to the range of *Kilinora spiralis* by Baumgartner *et al.* (1995b) is too old to be used anymore.

6. 5 Stratigraphic range of *Fultacapsa sphaerica*

Fultacapsa sphaerica was first described by Ozvoldova (1988) as *Acotripus spherica* from the Pienniny Klippen Belt of West Carpatians (Turá Lúka, northeast Slovakia). Although her age determination was based only on radiolarian association, a *Fultacapsa sphaerica*-bearing sample (TL-2) yields also *Podocapsa amphitreptera* Foreman, an index species of Kimmeridgian. Ozvoldova and Frantova (1997) reported *Fultacapsa sphaerica* from a sample bearing also *Podocapsa amphitreptera* Foreman (SJP-4) from the Pieniny Klippen Belt of West Carpathians, and also from another sample (Ps-14) dated only by radiolarians as late Oxfordian–early Kimmeridgian, i.e. the U. A. Zone 10 of Baumgartner *et al.* (1995b). In the Northern Calcareous Alps *Fultacapsa sphaerica* occurs

not frequently, but until now we have detected it only from the Oxfordian to Kimmeridgian.

6. 6 First appearance horizon of *Protunuma japonicus*, *Pseudoeucyrtis reticularis* and *Pseudodictyomitra primitiva*

Protunuma japonicus, *Pseudoeucyrtis reticularis* and *Pseudodictyomitra primitiva* were first described from the Torinosu Group of the Island Shikoku and Kii-Yura areas, Southwest Japan (Matsuoka and Yao, 1985). Matsuoka and Yao (1985) inferred the age of the *Pseudodictyomitra primitiva–Pseudodictyomitra* sp. A assemblage to the Tithonian, and this assemblage acts as the type of the *Pseudodictyomitra primitiva* Zone in Japan. According to Matsuoka (1995) the *Pseudodictyomitra primitiva* Zone is defined as the zone between the last occurrence horizon of *Hsuum maxwelli* and the first occurrence horizon of *Pseudodictyomitra carpatica*. Our early Oxfordian samples yield *Hsuum maxwelli* commonly, so that the correlation of our samples to the *Pseudodictyomitra primitiva* Zone of Japan cannot be made. However, some constituents of the *Pseudodictyomitra primitiva–Pseudodictyomitra* sp. A assemblage can be found in our samples, i.e. *Pseudodictyomitra primitiva*, *Pseudoeucyrtis reticularis*, *Protunuma japonicus*, *Archaeodictyomitra apiarium*, *Archaeodictyomitra minoensis*, *Cinguloturris carpatica*, *Eucyrtidiellum ptyctum* and *Zhamoidellum ovum* (= *Tricolocapsa* sp. A). Thus, the *Pseudodictyomitra primitiva–Pseudodictyomitra* sp. A assemblage contains many species determined in the Fludergraben fauna. It should pay attention that the first appearance horizon of *Pseudodictyomitra primitiva* is in the upper Callovian, as demonstrated in Fig. 7. Important is the absence of *Hsuum maxwelli* as the criterion, whether a radiolarian assemblage is attributed to the *Pseudodictyomitra primitiva* Zone or not. As *Protunuma japonicus* and *Pseudoeucyrtis reticularis* were found in our Fludergraben samples, these two species appeared already in early Oxfordian time.

6. 7 Shift of some radiolarian age ranges

Stratigraphic ranges of several species of the Fludergraben fauna, which are so far known in the Callovian or lower, have to be prolonged into the lower Oxfordian. These species are as follows (with previous age assignment).

Dictyomitrella kamoensis (U. A. Zone 3–7: Baumgartner *et al.*, 1995b)
Eucyrtidiellum circumperforatum (U. A. Zone 5–7: Chiari *et al.*, 2002)
Helvetocapsa matsuokai (*Striatojaponocapsa plicarum* Zone – upper Bajocian-lower Bathonian: Sashida *et al.*, 1999; U. A. Zone 6: O'Dogherty *et al.*, 2006)
Hsuum baloghi (lower *Unuma echinatus* Zone – Aalenian to lower Bajocian: Grill and Kozur, 1986)
Japonocapsa fusiformis (U. A. Zone 3–5: Baumgartner *et al.*, 1995b)
Neorelumbra skenderbegi (U. A. Zone 5–7: Chiari *et al.* 2002)
Protunuma fusiformis (Bajocian: Yao, 1997)
Protunuma lanosus (Callovian: Suzuki and Gawlick, 2003a)
Stichocapsa cicciona (U. A. Zone 5–7: Chiari *et al.* 2002)
Stichocapsa robusta (U. A. Zone 5–7: Baumgartner *et al.*, 1995b)
Japonocapsa tegiminis (Bajocian: Yao, 1979, 1997)
Tricolocapsa tetragona (upper *Striatojaponocapsa plicarum* Zone to lower *Striatojaponocapsa conexa* Zone – Bathonian: Matsuoka, 1995)
Unuma gordus (as *Unuma* sp. A, U. A. Zone 4–6: Baumgartner *et al.*, 1995b)
Unuma typicus (Bajocian: Yao, 1997; Callovian: Suzuki and Gawlick, 2009)

Among them we make comments on two important species, i.e. *Protunuma lanosus* and *Tricolocapsa tetragona*. *Protunuma lanosus*, which is the index species of the Callovian *Protunuma lanosus* Subzone of the *Zhamoidellum ovum* Zone of Suzuki and Gawlick (2003a), extends its range upwards into the Oxfordian. Consequently, the previous definition of the base of the *Williriedellum dierschei* Subzone, the last occurrence horizon of *Protunuma lanosus*, has to be changed. Another important species is *Tricolocapsa tetragona*, which was considered having a short stratigraphic range within the Bathonian (Matsuoka, 1983, 1995). As we demonstrate by the Fludergraben fauna, *Tricolocapsa tetragona* occurs in the lower Oxfordian strata. This stratigraphic range prolongation is supported by the occurrence of *Tricolocapsa tetragona* in the Torinosu-type limestone of east Shikoku, Japan (Ishida, 1994). This fauna yields also *Kilinora spiralis*, suggesting an Oxfordian age. Although Ishida (1994) mentioned that the stratigraphic range of *Tricolocapsa tetragona* was not consistent with those of other early Late Jurassic radiolarian species, its occurrence is now regarded not as an exception but as the reflection of its real stratigraphic range.

6. 8 Redefinition of the *Williriedellum dierschei* Zone

In the Jurassic radiolarian zonation of the Northern Calcareous Alps the *Williriedellum dierschei* Subzone of the *Zhamoidellum ovum* Zone was first established by Suzuki and Gawlick (2003a) as the partial-range zone of the species *Williriedellum dierschei* Suzuki and Gawlick, and it is defined by the last occurrence horizon of *Protunuma lanosus* for the base and the last occurrence horizon of *Eucyrtidiellum unumaense* for the top, indicating an early to middle Oxfordian age (Auer *et al.*, 2007). However, as we demonstrate here, *Protunuma lanosus* occurs also in the lower Oxfordian Fludergraben section, so that the base of the *Williriedellum dierschei* Subzone lies within the lower Oxfordian or higher, if we follow the above-mentioned definition. Our purpose of the radiolarian zonation is to distinguish the lower Oxfordian radiolarian zone from the Callovian one. And to make an age determination, it is better to take a positive criterion, i.e. the first appearance

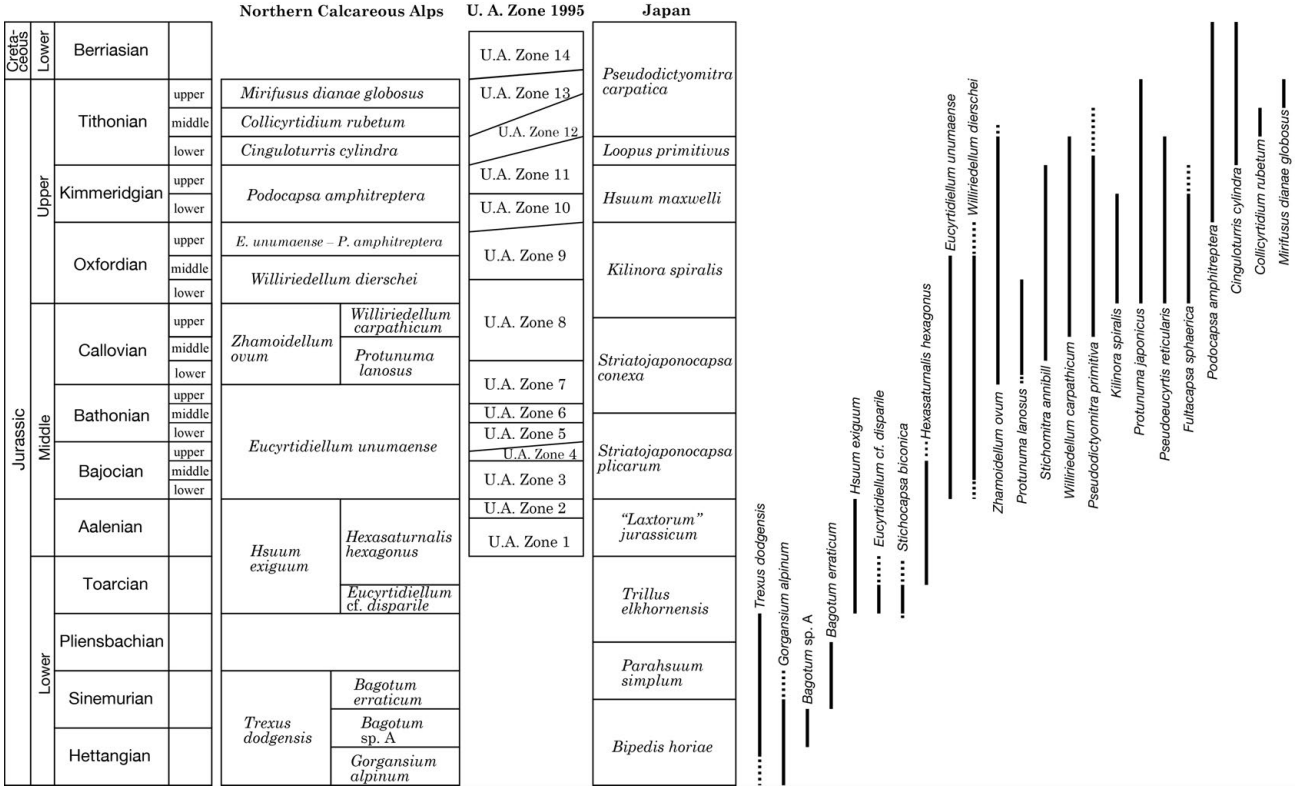

Fig. 8 Modified Jurassic radiolarian zonation for the Northern Calcareous Alps according to Suzuki and Gawlick (2003a), Steiger (1992), Gawlick *et al.* (2009) and this study. The U. A. Zone 1995 for the Western Tethyan realm of Baumgartner *et al.* (1995b) and the Japanese zonation of Matsuoka and Ito (2019) are shown on the side for comparison.

horizon, rather than a negative one, i.e. the last occurrence horizon. In this context, here we take the first appearance horizon of *Protunuma japonicus* as the definition of the base of the *Williriedellum dierschei* Subzone. *Fultacapsa sphaerica*, *Pseudoeucyrtis reticularis* and *Kilinora spiralis* are the subordinate marker species of this zone. Suzuki and Gawlick (2003a) and Gawlick *et al.* (2009) put it to the Subzone in the *Zhamoidellum ovum* Zone, because the faunal content of the Callovian-Oxfordian is very similar and no clear distinction was shown at that time. Because we can discriminate some early Oxfordian marker species among Callovian-Oxfordian-lasting species, we make this subzone ranked up as a zone apart from the *Zhamoidellum ovum* Zone of the Callovian, namely the *Williriedellum dierschei* Zone (Fig. 8). According as this, the overlying *Eucyrtidiellum unnumaense – Podocapsa amphitreptera* Interval Zone for the upper Oxfordian (Suzuki and Gawlick, 2003a) is also separated from the *Zhamoidellum ovum* Zone and it is here redefined as an independent zone (Fig. 8). And the upper limit of the *Williriedellum carpathicum* Subzone in the *Zhamoidellum ovum* Zone is also here emended as the first appearance horizon of *Protunuma japonicus.*

7. Conclusion

(1) 37 genera, 67 species and 2 subspecies of radiolarians are systematically described from the lower Oxfordian Fludergraben section that is calibrated by ammonites.
(2) Four radiolarian species have a potential to be marker for the base of Oxfordian. These are *Kilinora spiralis* Matsuoka, *Fultacapsa sphaerica* (Ozvoldova), *Protunuma japonicus* Matsuoka and Yao and *Pseudoeucyrtis reticularis* Matsuoka and Yao.
(3) The *Williriedellum dierschei* Zone is here redefined as the lower-middle Oxfordian radiolarian zone of the Northern Calcareous Alps.
(4) In the systematic part of radiolarians we have emended two genera and one species diagnoses, and redesignated of the type species of the genus *Loopus*.

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Plate 1 Scanning electron micrographs of radiolarians from the samples D1051 (1–2), D1023 (3–34) and D1024 (35–36), basal horizons of the Fludergraben section, Austria. A 50 μm scale bar applies to all photos.

1. *Williriedellum dierschei* Suzuki and Gawlick, 2004
2. *Archaeodictyomitra apiarium* (Rüst, 1885)
3. *Archaeospongoprunum* cf. *elegans* Wu, 1993
4. *Hsuum maxwelli* Pessagno, 1977a
5. *Loopus doliolum* Dumitrica, 1997
6. *Pseudodictyomitra primitiva* Matsuoka and Yao, 1985
7. *Parahsuum* sp. S sensu Matsuoka, 1986
8. *Tritrabs* cf. *exotica* (Pessagno, 1977a)
9. *Neorelumbra skenderbegi* Chiari *et al.*, 2002
10. *Archaeodictyomitra rigida* Pessagno 1977a
11. *Archaeodictyomitra apiarium* (Rüst, 1885)
12. *Hsuum brevicostatum* (Ozvoldova, 1975)
13. *Stichomitra annibill* Kocher, 1981
14. *Acanthocircus* cf. *suboblongus* (Yao, 1972)
15. *Cinguloturris carpatica* Dumitrica, 1982
16. *Takemuraella hungarica* (Kozur, 1985)
17. *Archaeodictyomitra mirabilis* Aita, 1987
18. *Takemuraella hexagonata* (Heitzer, 1930)
19. *Helvetocapsa matsuokai* (Sashida, 1999)
20. *Zhamoidellum ovum* Dumitrica, 1970
21. *Fultacapsa sphaerica* (Ozvoldova, 1988)
22. *Tricolocapsa undulata* (Heitzer, 1930)
23. *Stichocapsa robusta* Matsuoka, 1984
24. *Striatojaponocapsa synconexa* O'Dogherty *et al.*, 2006
25. *Zhamoidellum ventricosum* Dumitrica, 1970
26. *Gongylothorax favosus favosus* Dumitrica, 1970
27. *Williriedellum dierschei* Suzuki and Gawlick, 2004
28. *Stichocapsa cicciona* Chiari *et al.*, 2002
29. *Unuma gordus* Hull, 1997
30. *Protunuma japonicus* Matsuoka and Yao, 1985
31. *Kilinora* cf. *spiralis* (Matsuoka, 1982)
32. *Tricolocapsa tetragona* Matsuoka, 1983
33. *Eucyrtidiellum circumperforatum* Chiari *et al.*, 2002
34. *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo, 1974)
35–36. *Eucyrtidiellum unumaense* (Yao, 1979)

Plate 1

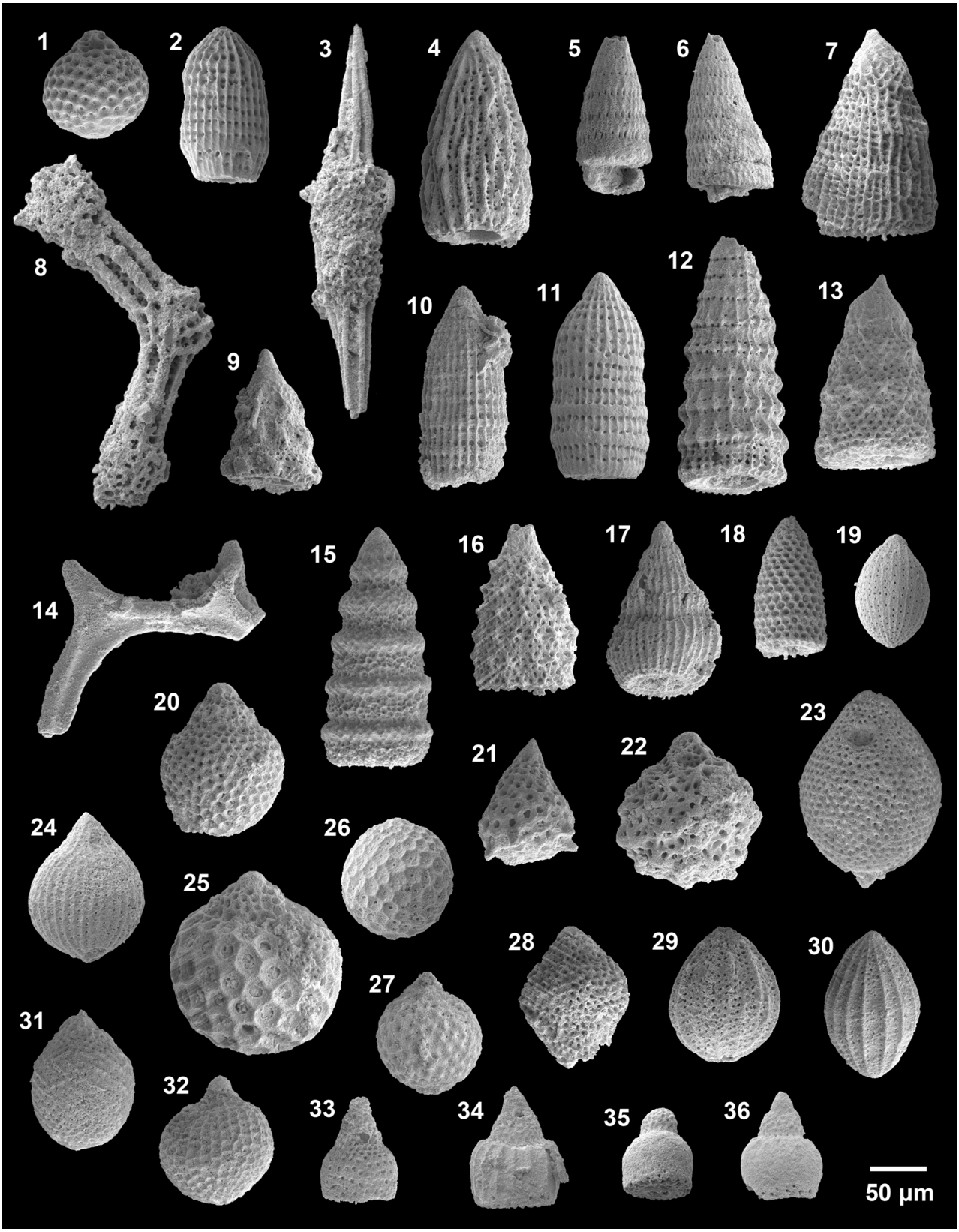
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Plate 2 Scanning electron micrographs of radiolarians from the samples D1024 (1–16) and D1052 (17–41), basal horizons of the Fludergraben section, Austria. A 50 μm scale bar applies to all photos.

1. *Archaeospongoprunum* cf. *elegans* Wu, 1993
2. *Parahsuum* sp. S sensu Matsuoka, 1986
3. *Cinguloturris carpatica* Dumitrica, 1982
4. *Dictyomitrella kamoensis* Mizutani and Kido, 1983
5. *Eucyrtidiellum nodosum* Wakita, 1988
6. *Unuma typicus* Ichikawa and Yao, 1976
7. *Gongylothorax favosus favosus* Dumitrica, 1970
8. *Protunuma lanosus* Ozvoldova, 1996
9. *Tricolocapsa tetragona* Matsuoka, 1983
10. *Williriedellum marcucciae* Cortese, 1993
11. *Striatojaponocapsa riri* O'Dogherty *et al.*, 2006
12. *Williriedellum dierschei* Suzuki and Gawlick, 2004
13. *Zhamoidellum ovum* Dumitrica, 1970
14. *Cyrtocapsa* sp. B
15. *Hsuum maxwelli* Pessagno, 1977a
16. *Williriedellum crystallinum* Dumitrica, 1970
17. *Ristola altissima* (Rüst, 1885)
18. *Pseudoeucyrtis reticularis* Matsuoka and Yao, 1985
19. *Stichomitra annibill* Kocher, 1981
20. *Williriedellum carpathicum* Dumitrica, 1970
21. *Striatojaponocapsa naradaniensis* (Matsuoka, 1984)
22. *Tritrabs exotica* (Pessagno, 1977a)
23. *Gongylothorax favosus oviformis* Suzuki and Gawlick, 2009
24. *Parahsuum* sp. S sensu Matsuoka, 1986
25. *Stichomitra annibill* Kocher, 1981
26. *Stichocapsa robusta* Matsuoka, 1984
27. *Tricolocapsa undulata* (Heitzer, 1930)
28. *Gongylothorax favosus favosus* Dumitrica, 1970
29. *Loopus doliolum* Dumitrica, 1997
30. *Williriedellum dierschei* Suzuki and Gawlick, 2004
31. *Podobursa nodosa* (Chiari *et al.*, 2002)
32. *Williriedellum sujkowskii* Widz and De Wever, 1993
33. *Striatojaponocapsa synconexa* O'Dogherty *et al.*, 2006
34. *Stichomitra* sp. A sensu Baumgartner *et al.*, 1995a
35. *Zhamoidellum ovum* Dumitrica, 1970
36. *Williriedellum crystallinum* Dumitrica, 1970
37. *Hsuum brevicostatum* (Ozvoldova, 1975)
38. *Pseudodictyomitra primitiva* Matsuoka and Yao, 1985
39. *Striatojaponocapsa conexa* (Matsuoka, 1983)
40. *Striatojaponocapsa riri* O'Dogherty *et al.*, 2006
41. *Unuma gordus* Hull, 1997

Plate 2

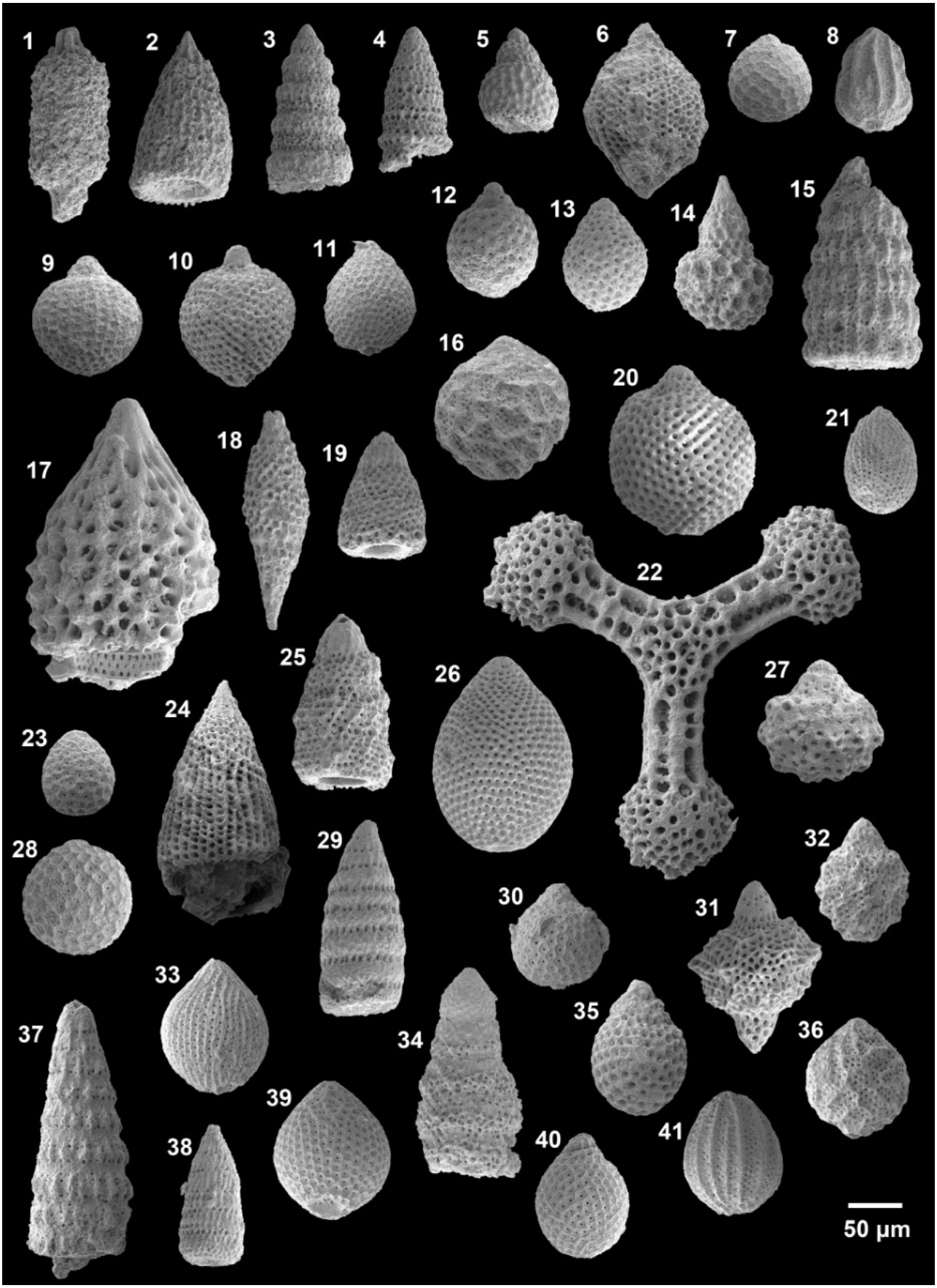
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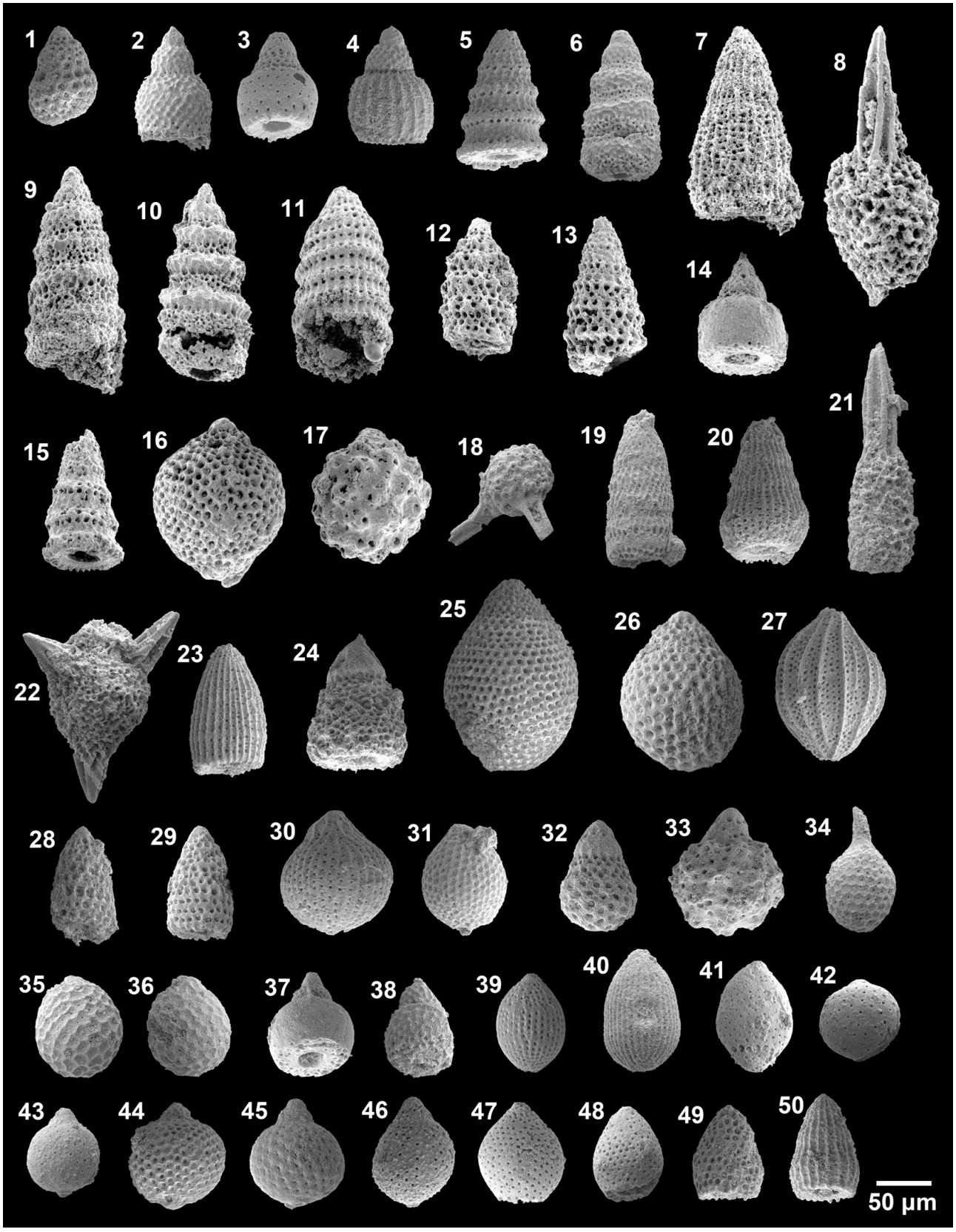
Plate 3 Scanning electron micrographs of radiolarians from the samples D1052 (1–6), EW146 (7–17) and D1025 (18–45), basal horizons of the Fludergraben section, Austria. A 50 μm scale bar applies to all photos.

1. *Tetracapsa* sp. A sensu Suzuki and Gawlick, 2003b
2. *Eucyrtidiellum nodosum* Wakita, 1988
3. *Eucyrtidiellum circumperforatum* Chiari *et al.*, 2002
4. *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo, 1974)
5. *Dictyomitrella kamoensis* Mizutani and Kido, 1983
6. *Cinguloturris carpatica* Dumitrica, 1982
7. *Hsuum baloghi* Grill and Kozur, 1986
8. *Archaeospongoprunum* cf. *imlayi* Pessagno, 1977a
9. *Cinguloturris carpatica* Dumitrica, 1982
10. *Cinguloturris primorika* Kemkin and Taketani, 2004
11. *Archaeodictyomitra minoensis* (Mizutani, 1981)
12. *Takemuraella hungarica* (Kozur, 1985)
13. *Parvicingula spinata* (Vinassa, 1899)
14. *Eucyrtidiellum unumaense* (Yao, 1979)
15. *Dictyomitrella* cf. *kamoensis* Mizutani and Kido, 1983
16. *Williriedellum carpathicum* Dumitrica, 1970
17. *Tricolocapsa undulata* (Heitzer, 1930)
18. *Saitoum pagei* Pessagno, 1977a
19. *Pseudodictyomitra primitiva* Matsuoka and Yao, 1985
20. *Archaeodictyomitra mirabilis* Aita, 1987
21. *Archaeospongoprunum* cf. *elegans* Wu, 1993
22. *Spongotripus* sp. D sensu Suzuki and Gawlick, 2003b
23. *Archaeodictyomitra patricki* Kocher, 1981
24. *Stichomitra annibill* Kocher, 1981
25. *Stichocapsa robusta* Matsuoka, 1984
26. *Zhamoidellum ovum* Dumitrica, 1970
27. *Protunuma fusiformis* Ichikawa and Yao, 1976
28–29. *Takemuraella hexagonata* (Heitzer, 1930)
30. *Striatojaponocapsa synconexa* O'Dogherty *et al.*, 2006
31. *Striatojaponocapsa conexa* (Matsuoka, 1983)
32. *Tetracapsa* sp. A sensu Suzuki and Gawlick, 2003b
33. *Tricolocapsa undulata* (Heitzer 1930)
34. *Stylocapsa oblongula* Kocher, 1981
35. *Gongylothorax favosus favosus* Dumitrica, 1970
36. *Gongylothorax favosus oviformis* Suzuki and Gawlick, 2009
37. *Eucyrtidiellum unumaense* (Yao, 1979)
38. *Eucyrtidiellum nodosum* Wakita, 1988
39. *Helvetocapsa matsuokai* (Sashida, 1999)
40. *Striatojaponocapsa naradaniensis* (Matsuoka, 1984)
41. *Japonocapsa tegiminis* (Yao, 1979)
42. *Gongylothorax* sp. C sensu Suzuki and Gawlick, 2003b
43. *Williriedellum* sp. C sensu Gawlick *et al.*, 2018
44. *Williriedellum marcucciae* Cortese, 1993
45. *Williriedellum dierschei* Suzuki and Gawlick, 2004
46. *Praewilliriedellum* aff. *spinosum* Kozur, 1984
47–48. *Japonocapsa fusiformis* (Yao, 1979)
49. *Droltus galerus* Suzuki, 1995b
50. *Archaeodictyomitra sixi* Yang, 1993

Plate 3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Appendix 1

Updated inventory of radiolarian species from the sample BT1 of the middle Callovian Brielgraben section.

BT1: *Gorgansium xigazeense* Wu, 1993, *Stylosphaera* cf. *lanceola* Parona, 1890, *Archaeodictyomitra amabilis* Aita, 1987, *Archaeodictyomitra* cf. *minoensis* (Mizutani, 1981), *Archaeodictyomitra mitra* Dumitrica, 1997, *Archaeodictyomitra rigida* Pessagno, 1977a, *Cinguloturris carpatica* Dumitrica, 1982, *Dictyomitrella kamoensis* Mizutani and Kido, 1983, *Droltus galerus* Suzuki, 1995b, *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo, 1974), *Eucyrtidiellum semifactum* Nagai and Mizutani, 1990, *Eucyrtidiellum takemurai* Hull, 1997, *Eucyrtidiellum unumaense dentatum* Baumgartner, 1995 in Baumgartner *et al.* (1995a), *Eucyrtidiellum unumaense unumaense* (Yao, 1979), *Gongylothorax favosus* Dumitrica, 1970, *Gongylothorax* sp. C sensu Suzuki and Gawlick (2003b), *Guexella nudata* (Kocher, 1980) in Baumgartner *et al.* (1980), *Helvetocapsa matsuokai* (Sashida, 1999), *Hiscocapsa magnipora* (Chiari *et al.*, 2002), *Hiscocapsa* cf. *acuta* Hull, 1997, *Hsuum brevicostatum* (Ozvoldova, 1975), *Hsuum maxwelli* Pessagno, 1977a, *Japonocapsa* aff. *fusiformis* (Yao, 1979), *Loopus doliolum* Dumitrica, 1997, *Parvifavus* sp. A, *Praezhamoidellum buekkense* Kozur, 1984, *Praezhamoidellum* cf. *parvipora* (Tan, 1927), *Protunuma lanosus* Ozvoldova, 1996, *Quarticella ovalis* Takemura, 1986, *Ristola procera* (Pessagno, 1977a), *Saitoum levium* De Wever, 1981, *Spongocapsula krahsteinensis* Suzuki and Gawlick, 2004, *Stichocapsa convexa* Yao, 1979, *Stichocapsa robusta* Matsuoka, 1984, *Striatojaponocapsa conexa* (Matsuoka, 1983), *Striatojaponocapsa naradaniensis* (Matsuoka, 1984), *Stylocapsa oblongula* Kocher, 1981, *Syringocapsa levis* (Hori, 1999), *Tetracapsa himedaruma* (Aita, 1987), *Tetracapsa* sp. A sensu Suzuki and Gawlick (2003b), *Theocapsomma* cf. *costata* Chiari *et al.*, 2002, *Theocapsomma cucurbiformis* Baumgartner, 1995 in Baumgartner *et al.* (1995a), *Tricolocapsa tetragona* Matsuoka, 1983, *Tricolocapsa undulata* (Heitzer, 1930), *Tricolocapsa* sp. C sensu Auer *et al.* (2007), *Tricolocapsa* sp. M sensu Baumgartner *et al.* (1995a), *Takemuraella hexagonata* (Heitzer, 1930), *Takemuraella hungarica* (Kozur, 1985), *Unuma gordus* Hull, 1997, *Williriedellum crystallinum* Dumitrica, 1970, *Williriedellum dierschei* Suzuki and Gawlick, 2004, *Williriedellum marcucciae* Cortese, 1993, *Zhamoidellum ovum* Dumitrica, 1970.

Appendix 2

The inventory of radiolarian species from the samples MR149 and MR175 of the lower part of the Knallalm-Neualm section, described by Auer *et al*. (2007). The lower part of the Knallalm-Neualm section is the stratum typicum of the *Williriedellum carpathicum* Subzone in the *Zhamoidellum ovum* Zone.

MR149: *Acanthocircus* cf. *suboblongus* (Yao, 1972), *Alievium* sp., *Archaeodictyomitra amabilis* Aita, 1987, *Archaeodictyomitra apiarium* (Rüst, 1885), *Archaeodictyomitra* cf. *minoensis* (Mizutani, 1981), *Archaeodictyomitra mitra* Dumitrica, 1997, *Archaeodictyomitra rigida* Pessagno, 1977a, *Archaeospongoprunum* sp. (this specimen is reidentified here as *Archaeospongoprunum* cf. *elegans* Wu, 1993), *Cinguloturris carpatica* Dumitrica, 1982, *Dictyomitrella kamoensis* Mizutani and Kido, 1983, *Emiluvia* cf. *bisellea* Danelian, 1995, *Eucyrtidiellum* cf. *circumperforatum* Chiari *et al.*, 2002, *Eucyrtidiellum nodosum* Wakita, 1988, *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo, 1974), *Eucyrtidiellum unumaense pustulatum* Baumgartner, 1984, *Eucyrtidiellum unumaense* ssp. (Yao, 1979), *Gongylothorax favosus favosus* Dumitrica, 1970, *Gongylothorax favosus oviformis* Suzuki and Gawlick, 2009, *Gorgansium* sp., *Homoeoparonaella* sp., *Hsuum brevicostatum* (Ozvoldova, 1975), *Hsuum hisuikyoense* Isozaki and Matsuda, 1985, *Hsuum maxwelli* Pessagno, 1977a, *Lithocampium* sp. C sensu Auer *et al.* (2007), *Loopus doliolum* Dumitrica, 1997, *Neorelumbra skenderbegi* Chiari *et al.*, 2002, *Napora* sp., *Paronaella* sp., *Parvicingula cappa* Cortese, 1993, *Parvifavus* sp., *Podobursa triacantha* (Fischli, 1916), *Praewilliriedellum spinosum*

Kozur, 1984, *Praezhamoidellum* cf. *parvipora* (Tan, 1927), *Protunuma lanosus* Ozvoldova, 1996, *Pseudodictyomitra primitiva* Matsuoka and Yao, 1985, *Stylosphaera lanceola* Parona, 1890, *Spongocapsula krahsteinensis* Suzuki and Gawlick, 2004, *Stichocapsa convexa* Yao, 1979, *Stichocapsa robusta* Matsuoka, 1984, *Stichomitra* sp., *Striatojaponocapsa conexa* (Matsuoka, 1983), *Striatojaponocapsa synconexa* O'Dogherty *et al.*, 2006, *Stylocapsa oblongula* Kocher, 1981, *Syringocapsa lata* Yang, 1993, *Syringocapsa suavis* Yang, 1993, *Tetracapsa* sp. A sensu Suzuki and Gawlick (2003b), *Tetraditryma* sp., *Theocapsomma bicornis* Baumgartner, 1995 in Baumgartner *et al.* (1995a) *Theocapsomma cordis* Kocher, 1981, *Theocapsomma costata* Chiari *et al.*, 2002, *Tricolocapsa leiostraca* (Foreman, 1973), *Tricolocapsa undulata* (Heitzer, 1930), *Tricolocapsium* sp. A sensu Auer *et al.* (2007), *Tricolocapsium* sp. B sensu Auer *et al.* (2007), *Tritrabs* cf. *casmaliaensis* (Pessagno, 1977a), *Tritrabs rhododactylus* Baumgartner, 1980, *Takemuraella hexagonata* (Heitzer, 1930), *Takemuraella hungarica* (Kozur, 1985), *Unuma gordus* Hull, 1997, *Williriedellum carpathicum* Dumitrica, 1970, *Williriedellum dierschei* Suzuki and Gawlick, 2004, *Williriedellum marcucciae* Cortese, 1993, *Xitus magnus* Baumgartner, 1995 in Baumgartner *et al.* (1995a), *Zhamoidellum ovum* Dumitrica, 1970.

MR175: *Amphipyndax* cf. *tsunoensis* Aita, 1987, *Archaeodictyomitra* cf. *apiarium* (Rüst, 1885), *Archaeodictyomitra minoensis* (Mizutani, 1981), *Archaeodictyomitra mitra* Dumitrica, 1997, *Archaeodictyomitra rigida* Pessagno, 1977a, *Archaeodictyomitra sixi* Yang, 1993, *Cinguloturris carpatica* Dumitrica, 1982, *Crucella* sp., *Droltus galerus* Suzuki, 1995b, *Eucyrtidiellum nodosum* Wakita, 1988, *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo, 1974), *Eucyrtidiellum semifactum* Nagai and Mizutani, 1990, *Eucyrtidiellum unumaense dentatum* Baumgartner, 1995 in Baumgartner *et al.* (1995a), *Eucyrtidiellum unumaense pustulatum* Baumgartner, 1984, *Eucyrtidiellum unumaense unumaense* (Yao, 1979), *Gongylothorax favosus oviformis* Suzuki and Gawlick, 2009, *Gongylothorax* aff. *siphonofer* Dumitrica, 1970, *Gorgansium* cf. *morganense* Pessagno and Blome, 1980, *Helvetocapsa matsuokai* (Sashida, 1999), *Hiscocapsa* cf. *hexagona* (Hori, 1999), *Homoeoparonaella* cf. *elegans* (Pessagno, 1977a), *Hsuum brevicostatum* (Ozvoldova, 1975), *Hsuum* cf. *exiguum* Yeh and Cheng, 1996, *Hsuum maxwelli* Pessagno, 1977a, *Lithocampium matsuokai* (Hull, 1997), *Loopus doliolum* Dumitrica, 1997, *Neorelumbra skenderbegi* Chiari *et al.*, 2002, *Parahsuum levicostatum* Takemura, 1986, *Parahsuum* aff. *simplum* Yao, 1982, *Parahsuum* sp. S sensu Matsuoka (1986), *Parvicingula cappa* Cortese, 1993, *Parvicingula spinata* (Vinassa, 1899), *Parvicingula dhimenaensis* Baumgartner, 1984, *Parvifavus wallacheri* (Grill and Kozur, 1986), *Parvifavus* sp. A sensu Auer *et al.* (2007), *Praewilliriedellum spinosum* Kozur, 1984, *Protunuma lanosus* Ozvoldova, 1996, *Protunuma ochiensis* Matsuoka, 1983, *Pseudodictyomitra venusta* (Chiari *et al.*, 1997) [= *Pseudodictyomitra* sp. D sensu Matsuoka and Yao (1985)], *Pseudoeucyrtis* sp. J sensu Baumgartner *et al.* (1995a), *Pseudodictyomitrella spinosa* Grill and Kozur, 1986, *Quarticella levis* Takemura, 1986, *Quarticella ovalis* Takemura, 1986, *Saitoum* cf. *pagei* Pessagno, 1977a, *Stylosphaera lanceola* Parona, 1890, *Spongotripus* sp. E, *Stichocapsa* aff. *biconica* Matsuoka, 1991, *Stichomitra* cf. *annibill* Kocher, 1981, *Stichomitra takanoensis* Aita, 1987, *Stylocapsa tecta* Matsuoka, 1983, *Striatojaponocapsa* cf. *conexa* (Matsuoka, 1983), *Striatojaponocapsa naradaniensis* (Matsuoka, 1984), *Striatojaponocapsa riri* O'Dogherty *et al.*, 2006 [= *Tricolocapsa* sp. A sensu Goričan (1994)], *Takemuraella hexagonata* (Heitzer, 1930), *Takemuraella hungarica* (Kozur, 1985), *Tetracapsa* sp. A sensu Suzuki and Gawlick (2003b), *Tetracapsa* sp. C sensu Auer *et al.* (2007), *Theocapsomma cordis* Kocher, 1981, *Theocapsomma* cf. *cucurbiformis* Baumgartner, 1995, *Tricolocapsa leiostraca* (Foreman, 1973), *Tricolocapsa undulata* (Heitzer, 1930), *Williriedellum* sp. C [= *Tricolocapsa* sp. A sensu Ozvoldova (1992)], *Tricolocapsa* sp. C sensu Auer *et al.* (2007), *Tritrabs* cf. *casmaliaensis* (Pessagno, 1977a), *Tritrabs simplex* Kito and De Wever, 1992, *Unuma gordus* Hull, 1997, *Williriedellum carpathicum* Dumitrica, 1970, *Williriedellum dierschei* Suzuki and Gawlick, 2004, *Williriedellum marcucciae* Cortese, 1993, *Xitus magnus* Baumgartner, 1995 in Baumgartner *et al.* (1995a), *Zhamoidellum kozuri* (Hull, 1997), *Zhamoidellum ovum* Dumitrica, 1970, *Zhamoidellum ventricosum* Dumitrica, 1970.

アンモナイト層準直上のジュラ系上部統基底フルダーグラーベン部層から産した放散虫化石（北部石灰アルプス，オーストリア）

鈴木　寿志・ハンス - ユルゲン　ガウリック

要　旨

北部石灰アルプスのフルダーグラーベン（オーストリア）において，アンモナイトで年代決定されたクラウス層石灰岩（ジュラ系中部統最上部）の直上に累重する放散虫岩から放散虫群集を記載した．この放散虫群集はジュラ系上部統最下部（Oxfordian）からのものであり，放散虫生層序を考える上で重要である．ジュラ系中部統から得られる長期間生存種が多い中で，上部統最下部から初めて出現する指標種 4 種（*Kilinora spiralis*，*Fultacapsa sphaerica*，*Protunuma japonicus*，*Pseudoeucyrtis reticularis*）を識別した．得られた放散虫種の生存期間について再検討し，ジュラ系中部統から産する種が引き続き上部統からも産する例を明らかにした．その結果，北部石灰アルプスのジュラ紀放散虫化石帯において，これまで *Zhamoidellum ovum* 帯中に含められていた *Williriedellum dierschei* 亜帯を，新たな指標種に基づき独立した帯として再定義した．古生物学的記載の章では 37 属 67 種 2 亜種を記載し，2 属（*Loopus* 属，*Pseudodictyomitra* 属）1 種（*Protunuma japonicus*）の標徴を改定するとともに，*Loopus* 属の模式種を再指定した．