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 radiaria-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/lowest 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
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., *Holocophylloceras 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
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.
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 Sproul, 2004, Striatojaponocapsa sp.

**D1023**: Acanthocircus cf. suboblongus (Yao, 1972), Archaeospengoprunum cf. elegans Wu, 1993, Trirhabd cf. exotica (Pessagno, 1977a), Archaeodictyomitra apiarium (Rüst, 1885), Archaeodictyomitra mirabilis Aita, 1987, Archaeodictyomitra rigida Pessagno, 1977a, Cinguloturris carpathica Dumitrica, 1982, Eucyrtidiellum circumperforatum Chiari, Marcucci and Prela, 2002, Eucyrtidiellum ptyctum (Riedel and Sanfilippo, 1974), Fultacapsa sphaerica (Ozvoldova, 1988), Gongylolithorax favosus favosus Dumitrica, 1970, Helvetocapsa matsukai (Sashida, 1999), Hsuum brevicostatum (Ozvoldova, 1975), Hsuum maxwelli Pessagno, 1977a, Loopus doliolium Dumitrica, 1997, Neorelumbra skenderbegi Chiari, Marcucci and Prela, 2002, Parahsuum sp. sensu Matsuoka, 1986, Prototumum japonicum Matsuoka and Yao, 1985, Pseudodictyomitra primitiva Matsuoka and Yao, 1985, Stichocapsa cicciana Chiari, Marcucci and Prela, 2002, Stichocapsa robusta Matsuoka, 1984, Stichomitra annibilli Kocher, 1981, Striatotjonoprocapsa synconexa O'Dogherty et al., 2006, Klinorora cf. spiralis (Matsuoka, 1982), Trilocapsga tetragona Matsuoka, 1983, Trilocapsga undulata (Heitzer, 1930), Takemuraelia hexagonata (Heitzer, 1930), Takemurala hungarica (Kozur, 1985), Unuma gordsus Hull, 1997, Williriedellum dierschei Suzuki and Gawlick, 2004, Zhamoidellum ovum Dumitric, 1970, Zhamoidellum ventricosum Dumitrica, 1970.

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

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**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 Tailigboden Basin was generated in front of the propagating thrust belt (indicated by a star symbol).
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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, Protrunuma 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, Eucrytidellum circumperforatum Chiarucci and Prella, 2002, Eucrytidellium nodosum Wákita, 1988, Eucrytidellium 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 (Chiarucci and Prella, 2002), Pseudodictyomittra primitiva Matsuoka and Yao, 1985, Pseudoeucyrtis reticularis Matsuoka and Yao, 1985, Ristola altissima (Rüst, 1885), Stichocapsa robusta Matsuoka, 1984, Stichocapsa annibill Kocher, 1981, Stichomittra 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 Wizd and De Weever, 1993, Zhamoidellum ovum Dumitrica, 1970.

EW146: Archaeospongoprunum cf. inlayi Pessagno, 1977a, Archaeodictyomittra minoensis (Mizutani, 1981), Cinguloturris carpatica Dumitrica, 1982, Cinguloturris
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. *A*starisk: 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

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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 radiolian wackestone to radiolian packstone. In the basal radiolian wackestone the radiolarians are well-preserved, in the upper radiolian 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.
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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; Plate 3, 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? casmalliaensis 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 carpathica Dumitrica, 1982

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

Genus *Neorelumbra* Kiessling, 1995

Type species: *Neorelumbra tipitiae* Kiessling, 1995

*Neorelumbra skenderbegi* Chiari, Marcucci and Prela, 2002

(Plate 1, fig. 9)

*2002 *Neorelumbra skenderbegi* – Chiari et al., pl. 68, 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 Parvingula? spinata (Vinassa) – Baumgartner *et al.*, p. 412, pl. 3187, figs. 1–3.
2003b **Parvingula 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: 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 smooth.

Remarks: After the original generic definition of Pessagno (1977b) *Pseudodictyomitra* has two transverse rows of primary pores. But many species which can be attributed to the genus *Pseudodictyomitra* 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...
Early Oxfordian radiolarians from the Fludergraben section (Suzuki and Gawlick)

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? zhainoidai* Foreman, 1973

*Pseudoeucyrtis reticularis* Matsuoka and Yao, 1985
(Plate 2, fig. 18)
*1985* *Pseudoeucyrtis reticularis* – Matsuoka and Yao, p. 132, pl. 1, figs. 16–17; 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 AMHPYNDACIDAEE 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, Id, le.
1986 *Triversus spinifer* – Takemura, p. 63, pl. 10, figs. 21–23; pl. 11, figs. 1, 2.
1995a *Parvicingula dhimenaensis* spp. 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* *Cytropicalis 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 bertrandii* 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,
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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 annibil* Kocher – Missoni et al., fig. 13.4.
2006 *Stichomitra annibil* Kocher – Gawlick et al., fig. 8b.30.
2006 *Stichomitra annibil* Kocher – Auer et al., fig. 6.37.
2009 *Stichomitra annibil* Kocher – Suzuki and Gawlick, p. 176, fig. 5.16; fig. 6.16A, 6.16B.
2011 *Stichomitra annibil* Kocher – Gawlick et al., fig. 3.32.
2014 *Stichomitra annibil* Kocher – Suzuki et al., p. 15, pl. 5, figs. 5, 9.
2015 *Stichomitra annibil* 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 gordus – 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 – Ozvoldová 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)
on 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.
on 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.

Early Oxfordian radiolarians from the Fludergraben section (SUZUKI and GAWLICK)

Genus **Podobursa** (Chiari, Marcucci and Prela, 2002)

(Plate 2, fig. 31)

1997 *Podobursa?* sp. – Hull, p. 108, pl. 43, figs. 5, 18, 19.

*2002* *Podobursa nodosa* – 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).

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)

1993 *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 common, 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;
Early Oxfordian radiolarians from the Fludergraben section (SUZUKI and GAWLICK)

2009 Zhamoide
dellum ovum Dumitrica – Missoni et al., fig. 7.28; fig. 13.7.
2006 Zhamoide
dellum ovum Dumitrica – Auer et al., fig. 6.56.
2006 Zhamoide
dellum ovum Dumitrica – Gawlick et al., fig. 8c.45.

2009 Zhamoide
dellum 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 Zhamoide
dellum ovum Dumitrica – Gawlick et al., fig. 1.28; fig. 2.39; fig. 3.45.

2014 Zhamoide
dellum ovum Dumitrica – Suzuki et al., p. 16, pl. 4, fig. 2; pl. 5, fig. 16.
2015 Zhamoide
dellum ovum Dumitrica – Ishida, pl. 1, fig. 62; pl. 6, figs. 59, 60.

Family ARCANICAPSIDAE Takemura, 1986

Genus Styl
capsa Principi, 1909; emend. Tan, 1927

Type species: Styl
capsa exagonata Principi, 1909

Styl
capsa oblongula Kocher, 1980
(Plate 3, fig. 34)

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

Genus Kilinora Hull, 1997

Type species: Styl
capsa? 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 Styl
capsa? 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 Gong
ylothorax Foreman, 1968; emend. Dumitrica, 1970

Type species: Dico
capsa 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. 105, 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 – Gorican, 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.
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, 1979

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. 1, 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 Dumitrlic, 2006

(Plate 2, figs. 11, 40)

1994 *Tricolocapsa riri* – Goričan, p. 9, pl. 11, figs. 11–13.

*2006 Striatojaponocapsa riri* – O’Dogherty, Goričan and Dumitrlic, p. 447, pl. 8, figs. 14, 15.

2007 *Striatojaponocapsa riri* O’Dogherty, Goričan and Dumitrlic – 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 Dumitrlic – Ishida, pl. 1, figs. 20–24; pl. 6, figs. 26–32.

*Striatojaponocapsa synconexa* O’Dogherty, Goričan and Dumitrlic, 2006

(Plate 1, fig. 24; Plate 2, fig. 33; Plate 3, fig. 30)

*2006 Striatojaponocapsa synconexa* – O’Dogherty, Goričan and Dumitrlic, p. 447, pl. 10, figs. 9–17. (Detailed synonymy)

2007 *Striatojaponocapsa synconexa* O’Dogherty, Goričan and Dumitrlic – Hatakeda et al., p. 54, pl. 1, figs. 11–20.

2015 *Striatojaponocapsa synconexa* O’Dogherty, Goričan and Dumitrlic – Ishida, pl. 1, figs. 13–15; pl. 6, figs.
Early Oxfordian radiolarians from the Fludergraben section (SUZUKI and GAWLICK)

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)
*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)
*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.
*1884 Tetracapsa – Haeckel, p. 1515.
pt. 1881 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 Stichocapsa 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 Arcanica caps 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 – 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 cicciana Chiari, Marcucci and Prela, 2002 (Plate 1, fig. 28)
*2002 Stichocapsa cicciana – Chiari et al., p. 76, pl. 3, figs. 8–12.
2007 Stichocapsa cicciana Chiari, Marcucci and Prela – Auer et al., fig. 6.78.
2011 Stichocapsa cicciana 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.
five segments. Suzuki and Gawlick (2009) described this species for the first time under the genus Tricolocapsa, a three-chambered 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 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-chambered 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.

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. 9b.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 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.

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.
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 radiolite 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 *Williriellidellum carpathicum* from the samples MR149 and MR175. Gawlick *et al.* (2009) invented a new subzone of the *Zhamoidellum ovum* Zone, i.e. the *Williriellidellum carpathicum* Subzone, based on the lower part of the Knallalm-Neualm section that is situated below the *Kilinora spiralis*-bearing radiolite.

If the first appearance horizon of *Kilinora spiralis* can be placed in the lowermost Oxfordian, the *Williriellidellum 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
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 Matsuoaka
(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, Meld (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 spiralis
occurs in the horizon just below the first appearance
horizon of the ammonite Ataxisoceras (Ataxisoceras)
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 Carpathians (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

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).
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 carpathica. 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 apiartum, Archaeodictyomitra minoensis, Cinguloturris carpathica, 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).

Dictyomitrellaria 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)
Stickocapsa cicciana (U. A. Zone 5–7: Chiari et al., 2002)
Stickocapsa 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 Willriedellium dierscheli 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 Willriedellium dierscheli Zone

In the Jurassic radiolarian zonation of the Northern Calcareous Alps the Willriedellium dierscheli Subzone of the Zhamoidellum ovum Zone was first established by Suzuki and Gawlick (2003a) as the partial-range zone of the species Willriedellium dierscheli 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 unmaense 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 Willriedellium dierscheli 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
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* – *Podacapsa 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. *Tritubs* 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. *Zhamaoidellum 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. *Zhamaoidellum ventricosum* Dumitrica, 1970
26. *Gongylothorax favosus favosus* Dumitrica, 1970
27. *Williriedellum dierschei* Suzuki and Gawlick, 2004
28. *Stichocapsa ciccionea* 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

Early Oxfordian radiolarians from the Fludergraben section (SUZUKI and GAWLICK)
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. *Eucyrtidellium 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 marucciae* 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. *Pseudoecyrtis reticularis* Matsuoka and Yao, 1985
19. *Stichomitra annibill* Kocher, 1981
20. *Williriedellum carpathicum* Dumitrica, 1970
21. *Striatojaponocapsa naradaniensis* (Matsuoka, 1984)
22. *Tritrab 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 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. *Archeospongoprunum cf. imlayi* Pessagno, 1977a
9. *Cinguloturris carpatica* Dumitrica, 1982
10. *Cinguloturris primorika* Kemkin and Taketani, 2004
11. *Archeodictyomitra 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. *Archaeodictyomitra primitiva* Matsuoka and Yao, 1985
20. *Archaeodictyomitra mirabilis* Aita, 1987
21. *Archeospongoprunum cf. elegans* Wu, 1993
22. *Spongotripus* sp. D sensu Suzuki and Gawlick, 2003b
23. *Archeodictyomitra 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. *Archeodictyomitra sixed* Yang, 1993
Early Oxfordian radiolarians from the Fludergraben section (SUZUKI and GAWLICK)

Plate 3

1  2  3  4  5  6  7  8
9 10 11 12 13 14 15 16
17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32
33 34 35 36 37 38 39 40
41 42 43 44 45 46 47 48
49 50

50 μm
Appendix 1

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

**BT1**: Gorgansium xigazeense Wu, 1993, Stylophaera cf. lanceola Parona, 1890, Archaeodictyomitra amabilis Aita, 1987, Archaeodictyomitra cf. minoensis (Mizutani, 1981), Archaeodictyomitra mitra Dumitrica, 1997, Archaeodictyomitra rigidum Pessagno, 1977a, Cinguloturris carpathica Dumitrica, 1982, Dictymitrella kamoensis Mizutani and Kido, 1983, Droltus galerus Suzuki, 1995b, Eucyrtidiellum ptyctum (Riedel and Sanfilippo, 1974), Eucyrtidiellum semifactum Nagai and Mizutani, 1990, Eucyrtidiellum unumaense dentatum Baumgartner, 1995 in Baumgartner et al. (1995a), Eucyrtidiellum unumaense unumaense (Yao, 1979), Gorgansium xigazeense Wu, 1993, Gyrocapsula favosus Dumitrica, 1970, Gorgansium favosus sp. C sensu Suzuki and Gawlick (2003b), Guexella nudata (Kocher, 1980) in Baumgartner et al. (1980), Helvetocapsa matsukai (Sashida, 1999), Hiscocapsa magnipora (Chiarie t 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 bukkense Kozur, 1984, Praezhamoidellum cf. parvipora (Tan, 1927), Protunumana lansus Ozvoldova, 1996, Quarticularia ovalis Takemura, 1986, Ristiola procrera (Pessagno, 1977a), Stictocapsa 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 oblonga Kocher, 1981, Syringocapsa levis (Hori, 1999), Tetracapsa hinedaruma (Aita, 1987), Tetracapsa sp. A sensu Suzuki and Gawlick (2003b), Theocapsomma cf. costata Chiarie t al., 2002, Theocapsomma cucurbiiformis Baumgartner, 1995 in Baumgartner et al. (1995a), Trilococapsa tetragona Matsuoka, 1983, Trilococapsa undulata (Heitzer, 1930), Trilococapsa sp. C sensu Auer et al. (1997), Trilococapsa sp. M sensu Baumgartner et al. (1995a), Takemuraella hexagonata (Heitzer, 1930), Takemuraella hungarica (Kozur, 1985), Umuna gordinist Hull, 1997, Williriedellum cristallinum Dumitrica, 1970, Williriedellum dierschii 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 apicarium (Rüst, 1885), Archaeodictyomitra cf. minoensis (Mizutani, 1981), Archaeodictyomitra mitra Dumitrica, 1997, Archaeodictyomitra rigidum Pessagno, 1977a, Archaeospongoprannum sp. (this specimen is reidentified here as Archaeospongoprannum cf. elegans Wu, 1993), Cinguloturris carpathica Dumitrica, 1982, Dictymitrella kamoensis Mizutani and Kido, 1983, Emiliaeva cf. bixellea Danelian, 1995, Eucyrtidiellum cf. circumperforatum Chiarie t al., 2002, Eucyrtidiellum nodosum Wakitaka, 1988, Eucyrtidiellum ptyctum (Riedel and Sanfilippo, 1974), Eucyrtidiellum unumaense postulatum 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 Chiarie t al., 2002, Naporan 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 Yoo, 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), *Tetradiotryma* sp., *Theocapsomma bicornis* Baumgartner, 1995 in Baumgartner et al. (1995a) *Theocapsomma cordis* Kocher, 1981, *Theocapsomma costata* Chiari et al., 2002, *Trilocapsa leiostra* (Foreman, 1973), *Trilocapsa undulata* (Heitzer, 1930), *Trilocapsium* sp. A sensu Auer et al. (2007), *Trilocapsium* sp. B sensu Auer et al. (2007), *Tritrabs* cf. *casmaliensis* (Pessagno, 1977a), *Tritrabs rhododactylus* Baumgartner, 1980, *Takemuraela hexagonata* (Heitzer, 1930), *Takemuraela hungarica* (Kozur, 1985), *Unuma gordus* Hull, 1997, *Williriedellum carpathicum* Dumitrica, 1970, *Williriedellum dierschi* 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 minoenis* (Mizutani, 1981), *Archaeodictyomitra mira* Dumitrica, 1997, *Archaeodictyomitra rigida* Pessagno, 1977a, *Archaeodictyomitra szi Yang* 1993, *Cingulotortis carpathica* Dumitrica, 1982, *Crucella* sp., *Droltus galerus* Suzuki, 1995b, *Eucyrtidiellum nodosum* Wakita, 1988, *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo, 1974), *Eucyrtidiellum semifacatum* Nagei and Mizutani, 1990, *Eucyrtidiellum unumaense dentatum* Baumgartner, 1995 in Baumgartner et al. (1995a), *Eucyrtidiellum unumaense postulatum* Baumgartner, 1984, *Eucyrtidiellum unumaense unumaense* (Yao, 1979), *Gongylothorax favosus oviformis* Suzuki and Gawlick, 2009, *Gongylothorax aff. siphonoper-Dumitrica, 1970, Gorgansium cf. morganese* Pessagno and Blome, 1980, *Helvetocapsa matsuokai* (Sashida, 1999), *Hisocapsa* cf. *hexagona* (Hori, 1999), *Homoeoparonaella* cf. *elegans* (Pessagno, 1977a), *Hsuum brevicostatum* (Ozvoldova, 1975), *Hsuum cf. exigum* Yeh and Cheng, 1996, *Hsuum maxwelli* Pessagno, 1977a, *Lithocampium matsuokai* (Hull, 1997), *Loopus doliolum* Dumitrica, 1997, *Neocelidura skenderbegi* Chiari et al., 2002, *Parahsuum leviocostatum* Takemura, 1986, *Parahsuum aff. simplicium* Yao, 1982, *Parahsuum* sp. S sensu Matsuoka (1986), *Parvicingula cappa Cortese, 1993, Parvicingula spinata* (Vinassa, 1899), *Parvicingula dhimenaensis* Baumgartner, 1984, *Parvijaffa wallacheri* (Grill and Kozur, 1986), *Parvijaffa* sp. A sensu Auer et al. (2007), *Praewilliriedellyum spinosum* Kozur, 1984, *Protunuma lanosus* Ozvoldova, 1996, *Protunuma ochiensiss* Matsuoka, 1983, *Pseudodictyomitra venusta* (Chiari et al., 1997) [= *Pseudodictyomitra* sp. D sensu Matsuoka and Yao (1985)], *Pseudoeucyrtis* sp. J sensu Baumgartner et al. (1995a), *Pseudodictyomitrilla spinosi* Grill and Kozur, 1986, *Quarticella levis* Takemura, 1986, *Quarticella ovalis* Takemura, 1986, *Saitoum* cf. *pagei* Pessagno, 1977a, *Stylosphaera lanceola* Parona, 1890, *Spongipirrus* sp. E, *Stichocapsa aff. biconica* Matsuoka, 1991, *Stichomitra* cf. *annibill* Kocher, 1981, *Stichomitra takanoensis* Aita, 1987, *Stylocapsa convecta* Matsuoka, 1983, *Striatojaponocapsa* cf. *conexa* (Matsuoka, 1983), *Striatojaponocapsa naradaniensis* (Matsuoka, 1984), *Striatojaponocapsa riri* O’Dogherty et al., 2006 [= *Trilocapsa* sp. A sensu Goričan (1994)], *Takemuraela hexagonata* (Heitzer, 1930), *Takemuraela 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. *cucuriformis* Baumgartner, 1995, *Trilocapsa leiostra* (Foreman, 1973), *Trilocapsium undulata* (Heitzer, 1930), *Williriedellum* sp. C [= *Trilocapsia* sp. A sensu Ozvoldova (1992)], *Trilocapsia* sp. C sensu Auer et al. (2007), *Tritrabs* cf. *casmaliensis* (Pessagno, 1977a), *Tritrabs simplex* Kito and De Wever, 1992, *Unuma gordus* Hull, 1997, *Williriedellum carpathicum* Dumitrica, 1970, *Williriedellum dierschi* 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产出する種が
引き続き上部統からも產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带において, これ
まで Zhamosidellum ovum 帯中に含まれていた Williriedellum dierschei 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。古生物学的記載の新では 37 属 67 種 2 亜種を記載し, 2 属 (Loopus 属, Pseudodictyomitra 属) 1 種 (Protunuma
japonicus) の標微を改定するとともに, Loopus 属の模式種を再指定した。