Pliensbachian, Early Jurassic radiolarians from Mount Rettenstein in the Northern Calcareous Alps, Austria

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One of the best preserved Early Pliensbachian radiolarian assemblages from the Western Tethys is described from the grey marly limestone exposed at Mount Rettenstein in the Northern Calcareous Alps, south of the Dachstein Massif. Fourty-five genera and 71 species are documented and illustrated here. Four species are newly described: *Tozerium filzmoosense* Cifer sp. nov., *Loupanus pliensbachicus* Cifer sp. nov., *Thurstonia*? *robusta* Cifer sp. nov., and *Ares rettensteinensis* Cifer sp. nov. Radiolarian age is in accordance with ammonoid data from the overlying red marly limestone, which was assigned to the upper part of the Lower Pliensbachian. The best equivalent for the radiolarian-bearing lithology is the Dürrnberg Formation, characteristic of the open-marine Hallstatt facies zone. Previously published radiolarian data from the Dürrnberg Formation were re-evaluated and the originally proposed age assignments revised. At two localities, the published Hettangian–Sinemurian age was emended to the early Early Pliensbachian that is in accordance with the age of radiolarians from Mount Rettenstein. We compared the studied fauna from Mount Rettenstein also with two other rich radiolarian assemblages, one from another locality in the Dürrnberg Formation and one from the Gümüslü Allochthon in Turkey, which were assigned to the late Early Pliensbachian and are somewhat younger than the assemblages studied herein.

Key words: Radiolaria, Polycystina, systematics, stratigraphy, Jurassic, Western Tethys, Eastern Alps, Austria.

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Introduction

Radiolarian dating is important for reconstruction and understanding of the tectono-stratigraphic evolution of the Western Tethys and the Northern Calcareous Alps as part of that paleogeographic realm (Fig. 1). In the Jurassic siliceous deep-water sediments (Fig. 2), other index fossils like ammonoids are very rare, therefore, Jurassic radiolarians were the focus of many studies in the Northern Calcareous Alps (Kozur and Mostler 1990; Gawlick and Suzuki 1999; Gawlick et al. 1999, 2001, 2003, 2004; Wegerer et al. 1999, 2001; Missoni et al. 2001a, b, 2005; Suzuki et al. 2001; Suzuki and Gawlick 2003a, b; O'Dogherty and Gawlick 2008; O'Dogherty et al. 2017), but only a few of these studies were concentrated on the Early Jurassic taxa (Kozur and Mostler 1990; Gawlick et al. 2001; O'Dogherty and Gawlick 2008). A precise radiolarian stratigraphy is needed for the facies reconstruction of the outer passive margin of the Neo-Tethys Ocean in the Jurassic; the relics of the outer margin are mainly preserved as blocks in Middle to lower Upper Jurassic mélanges along the Neotethyan Belt (Missoni and Gawlick 2011 for details).

Well-preserved Early Jurassic radiolarian assemblages are also rare on a global scale (e.g., Yeh 1987; Yao 1997; Carter et al. 1988, 1998; Matsuoka 1991, 2004; Yeh and Cheng 1998; Whalen and Carter 2002; Goričan et al. 2003; Yeh and Yang 2006; Bertinelli and Marcucci 2011) and in the Western Tethyan realm only two lithostratigraphic units with diverse and well-preserved Pliensbachian assemblages have been described so far: the Dürrnberg Formation in Austria (O'Dogherty and Gawlick 2008) and the grey bedded limestone of the Gümüşlü Allochthon in Turkey (De Wever 1981a, b, 1982a, b; Pessagno and Poisson 1981). Pliensbachian and Toarcian radiolarians were revised in a catalogue (Goričan et al. 2006) that served as a taxonomic basis to construct a global radiolarian zonation for this time period (Carter et al. 2010). Radiolarian-bearing successions with ammonite calibration are very rare on a global scale; of all Pliensbachian successions studied by Carter et al. (2010)

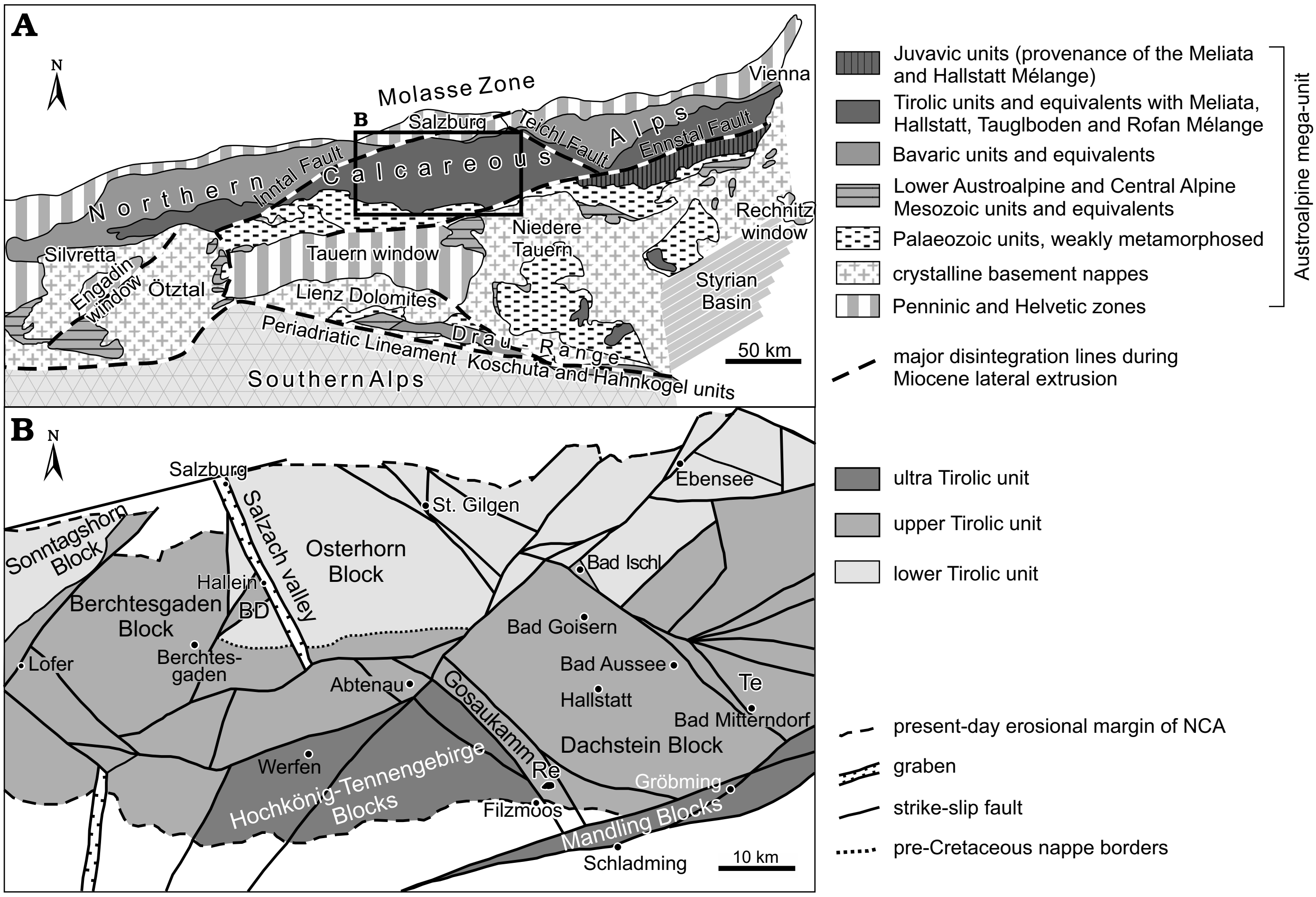


Fig. 1. **A**. Structural overview maps of the Alpine orogen, showing the situation of the central Northern Calcareous Alps. **B**. The middle sector of the central Northern Calcareous Alps with locations mentioned in the text indicated (modified from Frisch and Gawlick 2003). Abbreviations: Re, Mount Rettenstein; BD, Bad Dürrnberg; Te, Teltschengraben.

only those in western North America were dated with ammonites. Therefore, the studied succession in the Northern Calcareous Alps provides unique opportunity to test the age ranges of radiolarian species with ammonite dating.

The tectono-stratigraphy of Mount Rettenstein (Fig. 3) has been intensively studied for nearly 100 years with various attempts to explain the stratigraphy and its tectonic framework (Trauth 1926, 1928; Spengler 1943; Ganss et al. 1954; Tollmann 1960; Auer et al. 2009). The radiolarian-bearing limestone form the lower part of the Rettenstein succession sensu stricto (Auer et al. 2009; Fig. 3C) occur above the Hallstatt Mélange (in the sense of Gawlick and Frisch 2003), which is underlain by rocks of the Werfen imbricated Zone. The Rettenstein succession sensu stricto (Fig. 4) consists of Lower Jurassic grey, partly siliceous marly limestone at the bottom, followed by red limestone often attributed to the Adnet Formation (Tollmann 1960; Hirschberg and Jacobshagen 1965). In contrast, Meister and Böhm (1993) pointed out that there is no difference in the microfacies between the grey marly limestone and the red marl. The Middle Jurassic Klaus Formation follows above a hiatus. Upsection, the Rettenstein Debris Flow cuts erosionally through the higher part of the Middle Jurassic Klaus Formation (Auer et al. 2009). The latter is overlain by Oxfordian radiolarites of the Ruhpolding Radiolarite Group (Auer et al. 2009) and the Kimmeridgian–Tithonian Plassen Formation (Schlagintweit et al. 2007) that represents the youngest part of the succession on Mount Rettenstein (Auer et al. 2006, 2009). Well-preserved Early Jurassic radiolarians from the basal grey marly limestone were attributed to the Early Pliensbachian (Goričan et al. 2009; Cifer et al. 2017) but not studied in detail.

The aim of this study is a precise age assignment and a systematic description of radiolarian assemblages from Mount Rettenstein. These rich assemblages may augment significantly the known radiolarian diversity in the Pliensbachian of the Western Tethys and improve the published stratigraphic ranges of taxa. A comparison with previously known Pliensbachian assemblages of this realm is also presented.

The type material of the new species, described herein, is deposited in the palaeontological collection of the Slovenian Museum of Natural History under numbers PMS 2393–2399. These collection numbers refer to SEM stubs with several specimens; each specimen/photograph has an additional number indicated under the heading *Type material*. Other illustrated specimens are stored at ZRC SAZU, PIIR.

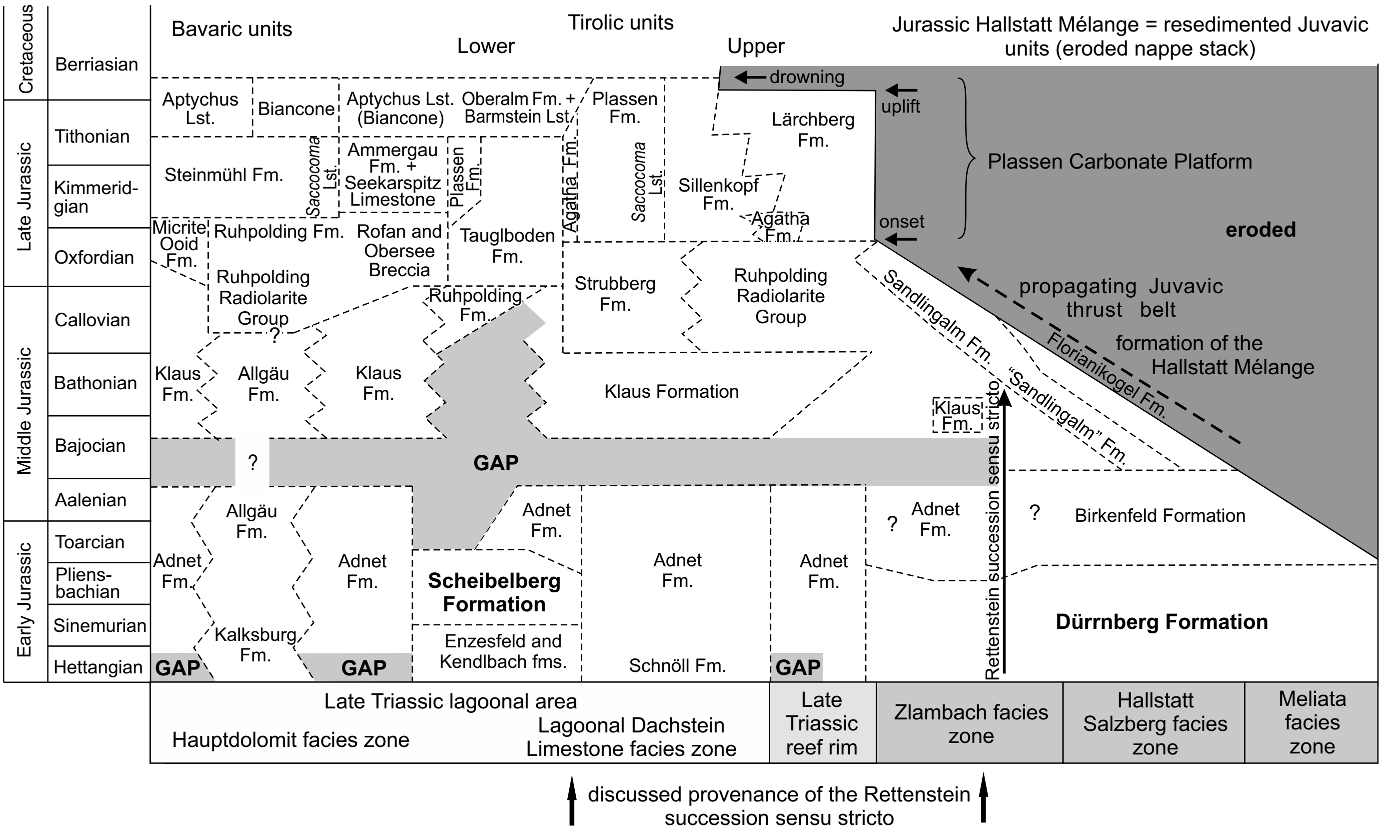


Fig. 2. Stratigraphic table with lithostratigraphic names and main tectonic events of the Jurassic of the Northern Calcareous Alps with their variations depending on the palaeogeographic position (after Gawlick et al. 2009). The different facies belts and therefore also the formations belong to depositional realms, which roughly correspond to the later formed tectonic units. The outer shelf region can only be reconstructed from blocks in Middle to Upper Jurassic mélanges and is, therefore, not completely understood in all details. The grey limestone succession from Mount Rettenstein shows characteristics of both the Scheibelberg and the Dürrnberg formations (in bold). Estimated palaeogeographic positions of the studied section are indicated. Abbreviations: Cret., Cretaceous; Fm., Formation; Lst., Limestone.

Institutional abbreviations.—PMS, Slovenian Museum of Natural History, Ljubljana, Slovenia; ZRC SAZU, PIIR, Research Centre of the Slovenian Academy of Sciences and Arts, Ivan Rakovec Institute of Palaeontology, Ljubljana, Slovenia.

Other abbreviations.—FAD, first appearance datum; LAD, last appearance datum.

Nomenclatural acts.—This published work and the nomenclatural acts it contains, have been registered in ZooBank: urn:lsid:zoobank.org:pub:50CB5818-049F-46C1-A90C-D2780E258FF3

Geological setting

Mount Rettenstein is a conspicuous, 2246 m high peak situated southwest of the Dachstein plateau near the small town Filzmoos (Salzburg, Austria; Fig. 1B). The limestone massif rises steeply from the morphologically far smoother Werfen imbricated Zone constituting the trailing edge of the Northern Calcareous Alps above their Greywacke Zone basement. The tectonic affiliation of the Mount Rettenstein succession is controversial (Kober 1938; Spengler 1956; Auer et al. 2009) as well as the paleogeographic provenance of the Rettenstein succession sensu stricto. In the most recent regional tectonic approach, the "block model" of Frisch and Gawlick (2003; Fig. 1B), Mount Rettenstein is part of the Upper Tirolic mega-unit. However, there are a variety of different opinions about Mount Rettenstein's internal build, its tectonic affiliation and the pre-contractional regional palaeogeographic constellation (see Schäffer 1976 and Tollmann 1981 for brief overviews of the most important models), with many questions about Mount Rettenstein's geological evolution (Fig. 3) not yet answered satisfactorily.

Age, litho- and microfacies of the Lower Jurassic grey sedimentary rocks and their overlying succession is crucial to unravel the palaeogeographic provenance of the Jurassic sequence. Lower Jurassic grey, often siliceous marly limestone topped by Pliensbachian–Toarcian mass transport deposits consisting of red nodular limestone (resemblance to Adnet Formation) were widely deposited in the Northern Calcareous Alps. In contrast, grey marly limestone with a relative high sedimentation rate (Fig. 4) overlain by red condensed limestone as on Mount Rettenstein are practically unkown. Deposition of grey siliceous limestone or red nodular limestone is generally related to the latest Triassic

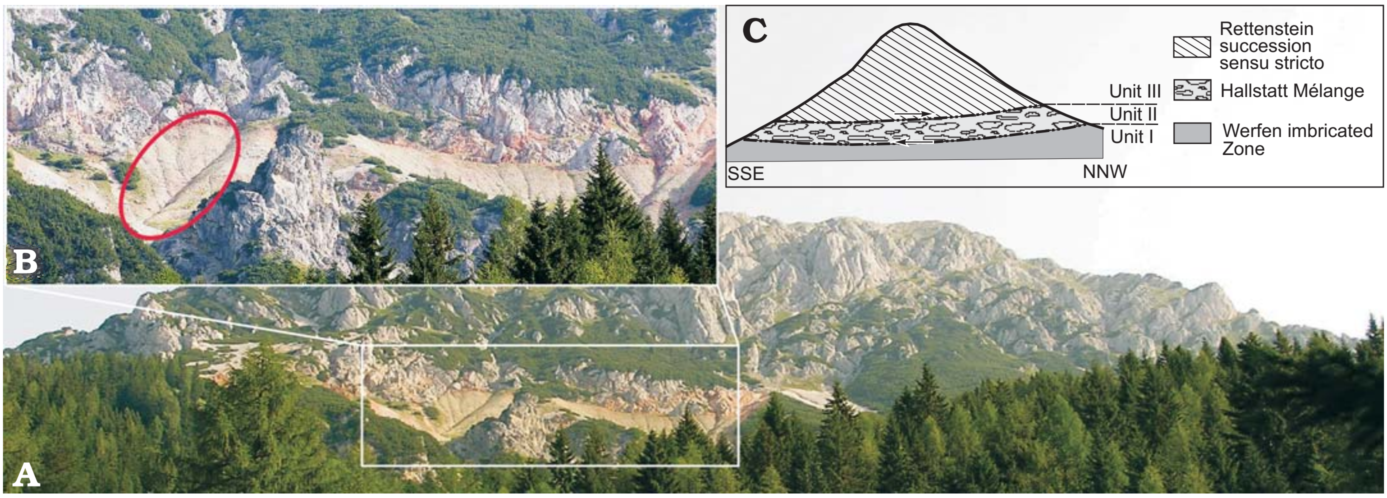


Fig. 3. **A**. View of the complete Mount Rettenstein complex from the southwest. **B**. Position of the studied section in the Weitenhaus cirque, the oval indicates the location where the studied samples were collected. **C**. Schematic sketch of the structural build of Mount Rettenstein with the three main tectonic units (from Auer et al. 2006). Structural Unit I: The primary part of the Tirolic mega-unit which, in contrast to the higher structural units, stayed (more or less) in place relative to the basis of the Upper Tirolic thrust sheet. In the Mount Rettenstein region, Permian to early Middle Triassic strata make up the succession above the Greywacke Zone basement (Ganss et al. 1954). Structural Unit II: This intermediate, rather thin sheet is mainly made up of a laterally variable mega-slide succession of the Middle Jurassic Hallstatt Mélange. It is thought to have achieved its present position in the hangingwall of a normal fault (Auer et al. 2006). Structural Unit III: The topmost Mount Rettenstein unit corresponds to the Lower to Upper Jurassic Mount Rettenstein succession sensu stricto in the sense of Auer et al. (2009). It is suggested to have been emplaced along a thrust fault (Auer et al. 2006).

topography (Fig. 2): in basinal areas like the Rhaetian (Late Triassic) Kössen Basin in the lagoonal area of the Dachstein Carbonate Platform or on the open-marine Hallstatt shelf, grey siliceous limestone was deposited in the Early Jurassic (Fig. 2). On morphological highs of the drowned Late Triassic Dachstein Carbonate Platform, red nodular limestone was formed after a stratigraphic gap (Fig. 2; for details see Gawlick et al. 2009).

The succession of Mount Rettenstein is made up of three individual tectonic units with both thrust and normal fault movements being important for their juxtaposition (Auer et al. 2006); between the Werfen imbricated Zone substratum (Fig. 3C; Structural Unit I) and the thick Rettenstein succession sensu stricto making up the Mount Rettenstein massif (Fig. 3C; Structural Unit III) exists a thin, laterally discontinuous sheet consisting of Hallstatt Mélange rocks (Fig. 3C; Structural Unit II; Auer et al. 2006, 2009). Our studied samples derive from the Lower Jurassic (part of Structural Unit III). The provenance of this unit is, until now, not clear. On the basis of the stratigraphic evolution of the succession and the present situation of the structural unit, an original position in the outer shelf region (Zlambach Facies Zone) is most likely, even though the lithofacies shows similarities to successions of more proximal parts of the shelf (see Fig. 2). Despite its resemblance to the Scheibelberg Formation, the studied grey marly limestone of Mount Rettenstein belongs most probably to the Dürrnberg Formation. The total age range of the Lower Jurassic grey marly limestone succession will allow a more substantiated evaluation of the original palaeogeographic position. That is, however, a future target and not the topic of this paper.

Material and methods

Six samples of grey bedded limestone were collected from Mount Rettenstein. Samples were collected from two parallel sections from the Weitenhausgraben cirque on the southern flank of Mount Rettenstein (Fig. 3B): (i) samples Rö416 and Rö417; (ii) samples Rö37, Rö38, and Rö40. Rö97 is from the western flank of the mountain. The succession is in normal stratigraphic position and was sampled with ascending order of sample numbers; in the same section the higher numbers are stratigraphically above. The radiolarian samples were processed in acetic acid (8–10%) for several days, washed and sieved. From all samples thin sections were prepared for microfacies analyses.

Radiolarian dating was chiefly based on the global Pliensbachian to Aalenian zonation by Carter et al. (2010). We also used the range chart of Jurassic and Cretaceous genera as compiled by O'Dogherty et al. (2009). For the taxa, which were not included in the zonation of Carter et al. (2010) or have not been described up to now in the Pliensbachian, we considered the Hettangian to Sinemurian zonation by Carter et al. (1998) and other publications on well-dated Early Jurassic radiolarian assemblages (e.g., Yeh and Yang 2006; Bertinelli and Marcucci 2011).

The Hettangian to Pliensbachian part of the section (Tolmann 1960; Fig. 4) is constituted by an up to 100 m thick grey marly siliceous limestone succession. The microfacies (Fig. 5) of the bioturbated basin sediment is identical to that of the Scheibelberg Formation (Gawlick et al. 2009), which occurs widespread in the more northern parts of the Tirolic realm (Fig. 1), even though mostly with significantly

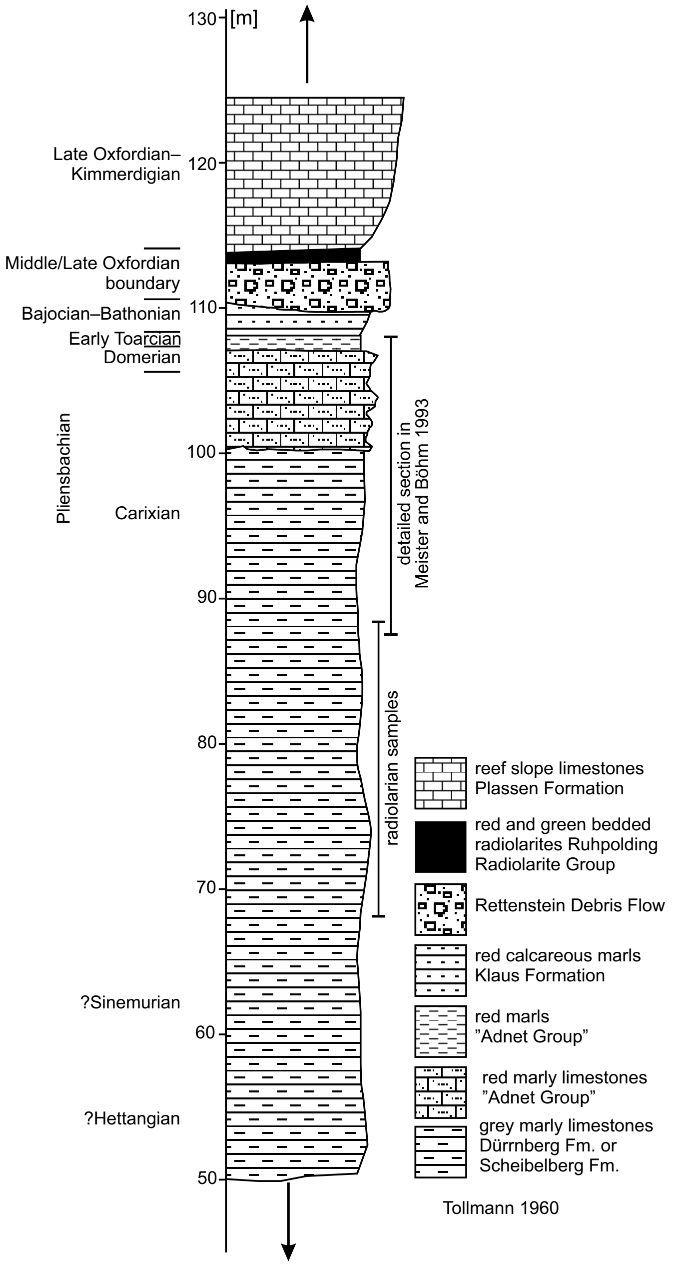


Fig. 4. Stratigraphy and lithology of the Mount Rettenstein succession sensu stricto.

lower thicknesses. On the other hand, the microfacies characteristics also resemble the microfacies of the Dürrnberg Formation (Gawlick et al. 2009), which is far better in line with the present-day geographic and structural situation.

In contrast to earlier interpretations (Spengler 1943; Ganss et al. 1954), the subordinate reddish limestone intercalations in the grey part of the succession are unlikely the result of tectonic stacking processes. Instead they seem to be stratigraphic-facies phenomena reflecting periods of condensed sedimentation (Tollmann 1960) or changing diagenetic conditions. The overlying condensed (Hirschberg and Jacobshagen 1965) nodular marly red limestone succession is maximally 8 m thick and contains a rich and well-studied ammonite fauna of Late Pliensbachian to Early Toarcian age (Meister and Böhm 1993; Fig. 4). The observed condensation throughout the Lower Jurassic is most prominent in the uppermost parts of the red marly limestone (Hirschberg and Jacobshagen 1965). Above follows a < 2 m thick Callovian to Oxfordian Klaus Formation with *Bositra* and protoglobigerinids, which is then overlain by the < 3.5 m thick Rettenstein Debris Flow above a slightly undulating, erosional surface (see Auer et al. 2009 for a more detailed description). The strata removal below the discontinuity seems to be only minor. The Rettenstein Debris Flow is almost exclusively made up of Upper Jurassic shallow-water carbonate detritus. The transition from the component-supported breccia to the < 1.5 m thick pure radiolarite of the Ruhpolding Radiolarite Group is sharp but still gradual over an approximately 10 cm wide zone. On top of the radiolarite, the Plassen Formation starts with a basal siliceous shallowing-upward sequence. By means of foraminifera and radiolarian stratigraphy, an early to middle late Oxfordian age has been proven for the Rettenstein Debris Flow, the Ruhpolding Formation, and the basal Plassen Formation (Auer et al. 2009).

Systematic palaeontology

The studied fauna is well-preserved and diverse. The family assignment follows De Wever et al. (2001) and O’Dogherty et al. (2009); the arrangement of families in the text is the same as that in O’Dogherty et al. (2009). The occurrence of genera and species in the samples studied is shown in Tables 5 and 6, the taxa are illustrated in Figs. 6–10. In total, 71 species belonging to 45 genera have been identified. For all species, stratigraphic and geographic ranges are given in the text. Of the 71 species, five are determined in open nomenclature and 4 species are newly described.

Subclass Radiolaria Müller, 1858

Superorder Polycystina Ehrenberg, 1838, emend. Riedel, 1967

Order Entactinaria Kozur and Mostler, 1982

Family Eptingiidae Dumitrica, 1978

Genus *Tozerium* Whalen and Carter in Carter et al., 1998

Type species: *Tozerium nascens* Whalen and Carter in Carter et al., 1998; Haida Gwaii, British Columbia, Canada, Sandilands Formation, lower Hettangian to lower Sinemurian.

Tozerium filzmoosense Cifer sp. nov.

Fig. 6G–J.

ZooBank LCID: urn:lsid:zoobank.org:act:D07845CD-7397-456F-A9E5-9C0075F0C3CD

Etymology: Named after the town Filzmoos, which is located near Mount Rettenstein, Austria.

Type material: Holotype, PMS 2398, sample Rö416: 170717 (Fig. 6G). Paratypes: PMS 2397, sample Rö416: 170503; PMS 2398, sample Rö416: 170739; PMS 2393, sample Rö37: 171105; all from type locality.

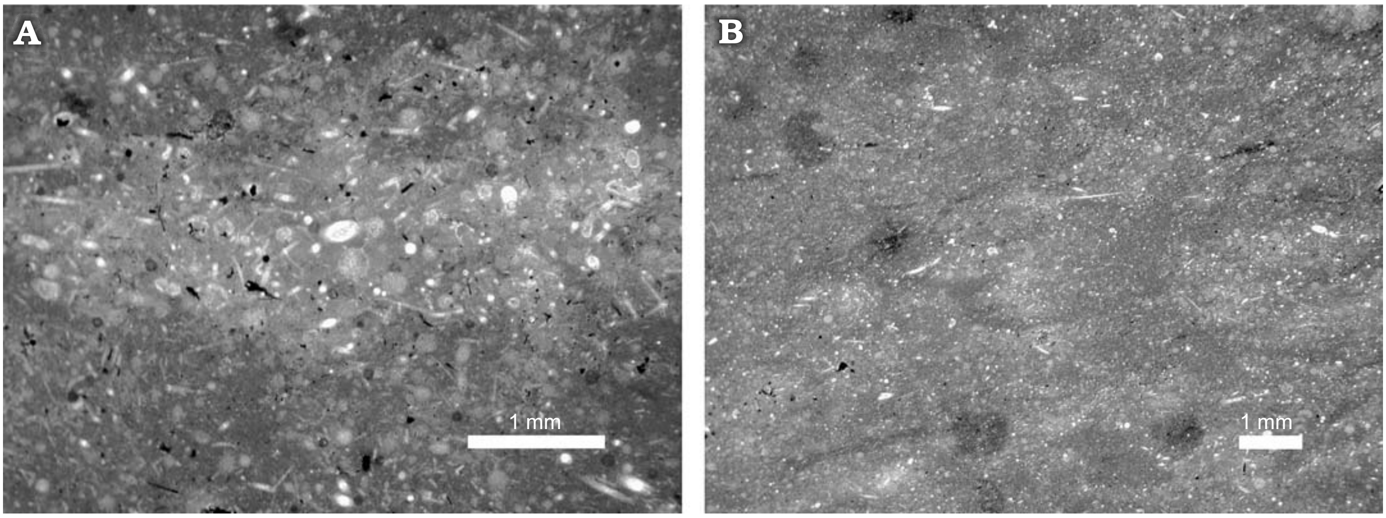


Fig. 5. Microfacies of grey marly limestone with high abundance of radiolarians and sponge spicules in micritic matrix. Bioturbation is indicated by brighter and darker areas. **A**. Sample Rö416. **B**. Sample Rö417.

Type locality: Mount Rettenstein, Northern Calcareous Alps, Austria.

Type horizon: Sample Rö416, grey marly limestone, Lower Pliensbachian.

Material.—Sample Rö37: stubs Rö37_3 (one specimen), Rö37_6 (two specimens); sample Rö416: stubs Rö416_5 (three specimens), Rö416_7 (14 specimens); sample Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Diagnosis.—*Tozerium* with thick, three-bladed spines, throughout the whole length of the spine.

Description.—Cortical shell subspherical. Four spines in tetrahedral position. Pore frames irregularly shaped. Weak to relatively strong nodes are formed at pore frame vertices. Spines are three-bladed, tapering distally. Larger pores apparent at the base of the spines.

Dimensions.—See Table 1.

Table 1. Dimensions (in µm) of *Tozerium filzmoosense* Cifer sp. nov. N, number of specimens measured.

	Diameter of cortical shell	Length of longest spine
N	13	10
Holotype	102	93
Maximum	115	93
Minimum	75	70
Mean	99	80

Remarks.—*Tozerium filzmoosense* sp. nov. differs from *Tozerium nascens* Whalen and Carter in Carter et al., 1998 by having three-bladed spines. A similar species was described from the Hettangian (*Tozerium*? sp. B in Bertinelli and Marcucci 2011: 411, pl. 2: 16), but it differs from *Tozerium filzmoosense* sp. nov., by having the distal part of the spines circular in cross section. *Tozerium filzmoosense* sp. nov. may represent the advanced stage in the *Tozerium* lineage and is the youngest formally described species of the *Tozerium* which was considered to last appear at the end of the Sinemurian (O'Dogherty et al. 2009). More recently, a *Tozerium* species with three-bladed but much thinner spines was reported from the Bajocian of east-central Oregon (*Tozerium* sp. A in Yeh 2011: 6, pl. 12: 5, 16).

Stratigraphic and geographic range.—Lower Pliensbachian. Northern Calcareous Alps (Austria).

Family Quinquecapsulariidae Dumitrica, 1995

Genus *Empirea* Whalen and Carter in Carter et al., 1998

Type species: *Empirea hasta* Whalen and Carter in Carter et al., 1998; Haida Gwaii, British Columbia, Canada, Sandilands Formation, lower Hettangian to lower Sinemurian.

Empirea sp. 1

Fig. 6A.

Material.—Sample Rö37: stubs Rö37_2 (one specimen), Rö37_3 (two specimens); sample Rö416: stub Rö416_6 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Description.—Relatively large spherical cortical shell composed of numerous irregularly shaped pore frames. Medullary shell present but not observed in detail. Ten peripheral spines extend from the cortical shell. The three-bladed spines have about the same length as the diameter of the cortical shell.

Remarks.—*Empirea* sp. 1 has much longer spines and smaller and more numerous pore frames of the cortical shell than *Empirea hasta* Whalen and Carter in Carter et al., 1998. *Empirea* sp. A of Whalen and Carter in Carter et al. (1998) has a similar cortical shell as *Empirea* sp. 1, but lacks the long, well-developed spines.

Order Spumellaria Ehrenberg, 1875

Family Pantanelliidae Pessagno, 1977b

Genus *Pantanellium* Pessagno, 1977a

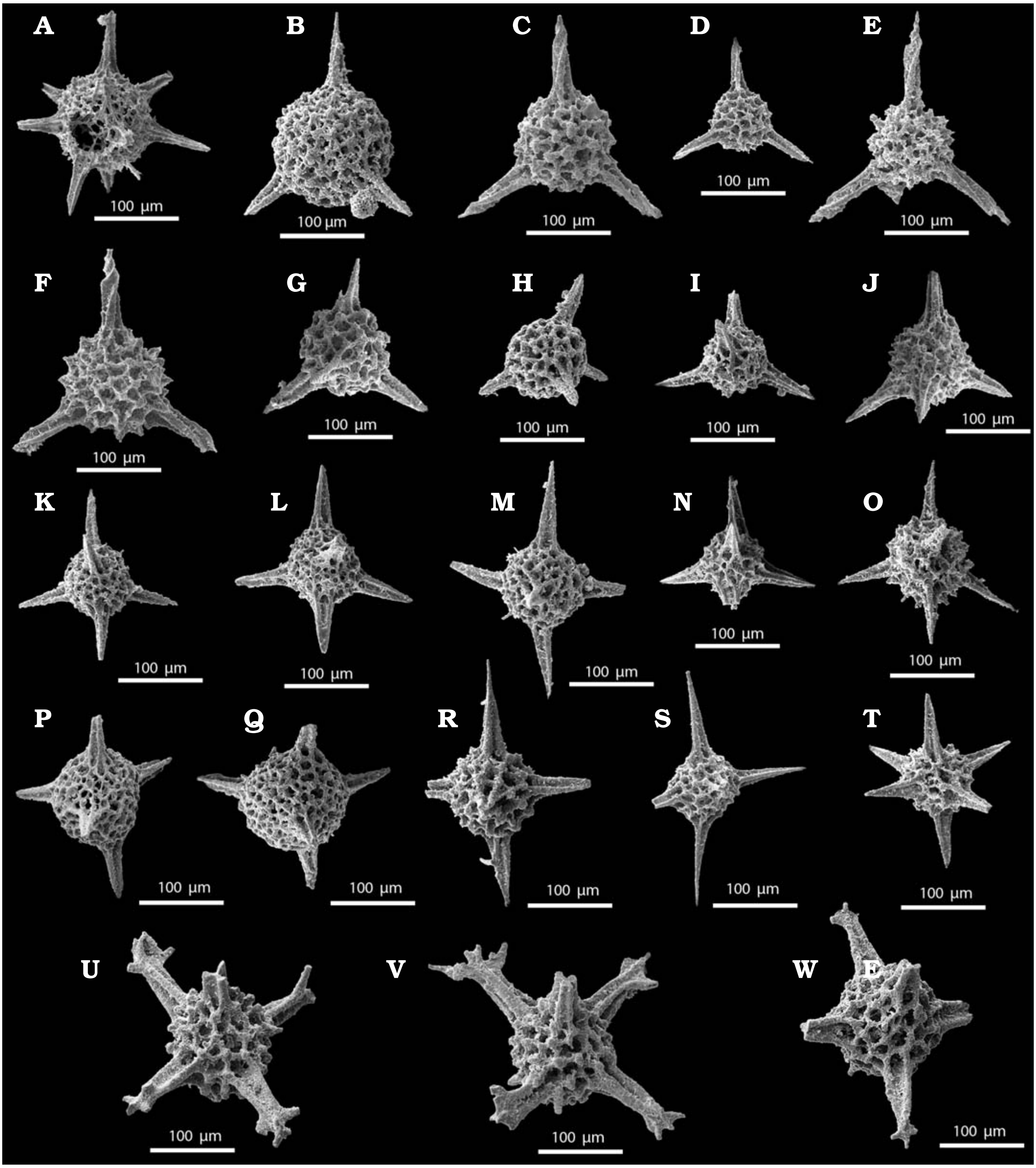


Fig. 6. Radiolarians from Mount Rettenstein, Austria, Pliensbachian, Early Jurassic. **A**. *Empirea* sp. 1, sample Rö416. **B**. *Acaeniotylopsis ghostensis* (Carter in Carter et al., 1988); sample Rö416. **C**, **D**. *Liassobetraccium bavaricum* (Kozur and Mostler, 1990); sample Rö37. **E**, **F**. *Liassobetraccium verticispinosum* (Kozur and Mostler, 1990); sample Rö37. **G–J**. *Tozerium filzmoosense* Cifer sp. nov. **G**. Holotype, sample Rö416: 170717. **H**. Paratype, sample Rö416: 170503. **I**. Paratype, sample Rö416: 170739. **J**. Paratype, sample Rö37: 171105. **K–O**. *Loupanus pliensbachicus* Cifer sp. nov. **K**. Holotype, sample Rö416: 170562. **L**. Paratype, sample Rö416: 170559. **M**. Paratype, sample Rö416: 170757. **N**. Paratype, sample Rö416: 170704. **O**. Paratype, sample Rö416: 170560. **P**, **Q**. *Loupanus* sp. 1; **s**ample Rö417. **R**, **S**. *Thurstonia*? *timberensis* Whalen and Carter in Carter et al., 1998; **s**ample Rö416. **T**. *Thurstonia*? *minutaglobus* Whalen and Carter in Carter et al., 1998; sample Rö416. **U–W**. *Thurstonia*? *robusta* Cifer sp. nov. **U**. Holotype, sample Rö417: Rö417_093.**V**. Paratype, sample Rö417: Rö417_090. **W**. Paratype, sample Rö417: Rö417_098.

Type species: *Pantanellium riedeli* Pessagno, 1977a; California Coast Ranges, USA, Upper Kimmeridgian–Lower Tithonian to Berriassian.

Pantanellium browni Pessagno and Blome, 1980

Fig. 8A–G.

1980 *Pantanellium browni* sp. nov.; Pessagno and Blome 1980: 239, pl. 4: 5–7, 12, 14, 16, 19, 20.
1990 *Ellipsoxiphus browni* (Pessagno and Blome, 1980); Kozur and Mostler 1990: 214, pl. 14: 14; pl. 15: 11, 14.
1991 *Pantanellium browni* Pessagno and Blome, 1980; Tipper et al. 1991: pl. 8: 13.
1998 *Pantanellium browni* Pessagno and Blome, 1980; Whalen and Carter in Carter et al. 1998: 47, pl. 1: 6, 16.
1998 *Pantanellium* sp. cf. *P. browni* Pessagno and Blome, 1980; Whalen and Carter in Carter et al. 1998: 47, pl. 2: 3.
2001 *Sphaerostylus kluensis* (Pessagno and Blome, 1980); Gawlick et al. 2001: 43, fig. 2: 14.
2002 *Pantanellium browni* Pessago and Blome, 1980; Tekin 2002: 180, pl. 1: 5.
2009 *Sphaerostylus kluensis* (Pessagno and Blome, 1980); Gawlick et al. 2009: 117, fig. 62: 3.
2011 *Pantanellium browni* Pessagno and Blome, 1980; Bertinelli and Marcucci 2011: 408, pl. 2: 2, 3, 4.

Material.—Sample Rö37: stubs Rö37_2 (one specimen), Rö37_3 (12 specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—In this species we include specimens with a nearly spherical shell, a relatively large number of pores and two stout spines. The length of spines is variable, ranging from one to 1.5 times the diameter of the cortical shell. The specimens can be without nodes on the pore-frame vertices (Fig. 8A) or with strong nodes (Fig. 8F).

Stratigraphic and geographic range.—Hettangian to Sinemurian (Carter et al. 1998), Lower Pliensbachian (this study). Haida Gwaii (British Columbia), Italy, Northern Calcareous Alps (Germany and Austria), Turkey.

Pantanellium haidaense Pessagno and Blome, 1980

Fig. 8K.

1980 *Pantanellium haidaense* sp. nov.; Pessagno and Blome 1980: 242, pl. 5: 5, 18, 19, 21.

Material.—14 specimens. Sample Rö37: stub Rö37_3 (two specimens); sample Rö38: stub Rö38_1 (12 specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Upper Sinemurian (Pessagno and Blome 1980), Lower Pliensbachian (this study). Haida Gwaii (British Columbia, Canada), Northern Calcareous Alps (Austria).

Pantanellium skedansense Pessagno and Blome, 1980

Fig. 8H–J.

1980 *Pantanellium skedansense* sp. nov.; Pessagno and Blome: 246, pl. 5: 8, 9, 15, 20, 23.
1990 *Ellipsoxiphus suessi* (Dunikowski, 1882); Kozur and Mostler 1990: 214, pl. 14: 12; pl. 15: 12, 13.
1998 *Pantanellium skedansense* Pessagno and Blome, 1980; Whalen and Carter in Carter et al. 1998: 49, pl. 1: 12.
2002 *Pantanellium skedansense* Pessagno and Blome, 1980; Whalen and Carter 2002: 105, pl. 6: 7, 8, 13, 14.
2006 *Pantanellium skedansense* Pessagno and Blome, 1980; Goričan et al. 2006: 280, pl. PAN16: 1–3.
2006 *Pantanellium skedansense* Pessagno and Blome, 1980; Yeh and Yang 2006: 326, pl. 8: 1.

Material.—Sample Rö37: stubs Rö37_2 (five specimens), Rö37_3 (three specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—This species is characterized by an elongated cortical shell and long polar spines with wide grooves. *Ellipsoxiphus suessi* (Dunikowski, 1882) is considered nomen dubium due its poor illustration (Dunikowski 1882: pl. 5: 50); *E. suessi* illustrated by Kozur and Mostler (1990) is assigned to *Pantanellium skedansense*.

Stratigraphic and geographic range.—Hettangian (Kozur and Mostler 1990), upper Sinemurian (Pessagno and Blome 1980; Carter et al. 1998), Pliensbachian (Whalen and Carter 2002; this study). Haida Gwaii (British Columbia, Canada), Baja California Sur, Nadanhada Terrane (China), Northern Calcareous Alps (Germany and Austria).

Genus *Gorgansium* Pessagno and Blome, 1980

Type species: *Gorgansium silviesense* Pessagno and Blome, 1980; Snowshoe Formation, Oregon, USA, upper Middle Bajocian to Lower Callovian.

Gorgansium alpinum Kozur and Mostler, 1990

Fig. 8L–M.

1984 *Gorgansium* sp. A; Igo and Nishimura 1984: pl. 3: 18, ? 20, ? 21, ? 23; pl. 4: 8.
1990 *Gorgansium alpinum* sp. nov.; Kozur and Mostler 1990: 216, pl. 16: 12.
2002 *Gorganisum alpinum* Kozur and Mostler, 1990; Tekin 2002: 179, pl. 1: 1, 2.
2006 *Gorgansium* sp. B; Yeh and Yang 2006: 326, pl. 6: 4.

Material.—Sample Rö37: stubs Rö37_1 (one specimen), Rö37_2 (four specimens), Rö37_3 (one specimen); sample Rö416: stubs Rö416_1 (two specimens), Rö416_7 (five specimens); sample Rö417: stub Rö417 (seven specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—See remarks under *Gorgansium gongyloideum* Kishida and Hisada, 1985.

Stratigraphic and geographic range.—Hettangian to Sinemurian (as published, see synonymy list); Lower Pliensbachian (this study). Northern Calcareous Alps (Germany and Austria), Turkey, Nadanhada Terrane (China), Japan.

Gorgansium blomei Kozur and Mostler, 1990

Fig. 8N.

1980 *Gorgansium* sp. C; Pessagno and Blome 1980: 236, pl. 4: 8.
1990 *Gorgansium blomei* sp. nov.; Kozur and Mostler 1990: 216 (species name misspelled as *blomi* in the description), pl. 16: 13.

2002 *Gorgansium blomei* Kozur and Mostler, 1990; Tekin 2002: 179, pl. 1: 3.
2011 *Gorgansium blomei* Kozur and Mostler, 1990; Bertinelli and Marcucci 2011: 408, pl. 2: 1.

Material.—Sample Rö37: stub Rö37_2 (one specimen); sample Rö416: stub Rö416_1 (three specimens); sample Rö417: stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Hettangian to Sinemurian (as published, see synonymy list), Lower Pliensbachian (this study). Northern Calcareous Alps (Germany and Austria), Italy, Turkey.

Gorgansium gongyloideum Kishida and Hisada, 1985

Fig. 9O–S.

1982 *Gorgansium* sp. A.; Kishida and Sugano 1982: pl. 4: 8.
1985 *Gorgansium gongyloideum* sp. nov.; Kishida and Hisada 1985: 116, pl. 1: 21–22.
1986 *Gorgansium gongyloideum* Kishida and Hisada, 1985; Kishida and Hisada 1986: fig. 4.4.
1990 *Gorgansium gongyloideum* Kishida and Hisada, 1985; Hori 1990: fig. 8.6.
1994 *Gorgansium gongyloideum* Kishida and Hisada, 1985; Goričan 1994: 70, pl. 1: 6.
1998 *Gorgansium gongyloideum* Kishida and Hisada, 1985; Yeh and Cheng 1998: 12, pl. 1: 1.
2002 *Gorgansium gongyloideum* Kishida and Hisada, 1985; Tekin 2002: 179, pl. 1: 4.
2003 *Gorgansium* spp.; Goričan et al. 2003: 291, pl. 1: 7.
2006 *Gorgansium gongyloideum* Kishida and Hisada, 1985; Goričan et al. 2006: 170, pl. GOR02: 1–5.
2006 *Gorgansium gongyloideum* Kishida and Hisada, 1985; Yeh and Yang 2006: 325, pl. 3: 25.
2009 *Gorgansium alpinum* Kozur and Mostler, 1990; Gawlick et al. 2009: 117, fig. 62: 1.

Material.—Sample Rö37: stubs Rö37_1 (one specimen), Rö37_3 (eight specimens); sample Rö38: stub Rö38_1 (seven specimens); sample Rö416: stubs Rö416_1 (15 specimens), Rö416_7 (seven specimens); sample Rö417: stub Rö417 (15 specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—In *Gorgansium gongyloideum* we group morphotypes with a spherical cortical shell, a relatively large number of small pores and three spines that are approximately as long as the diameter of the shell. One spine is somewhat longer than the other two. Species with the longer spine almost twice the length of the shorter spines are assigned to *Gorgansium alpinum* Kozur and Mostler, 1990.

Stratigraphic and geographic range.—Hettangian to Toarcian (as published, see synonymy list). Worldwide.

Family Parvivaccidae Pessagno and Yang in Pessagno et al., 1989, emend. De Wever et al. 2001

Subfamily Acaeniotylinae Yang, 1993

Genus *Acaeniotylopsis* Kito and De Wever, 1994

Type species: *Acaeniotylopsis triacanthus* Kito and De Wever, 1994; Contrada La Ferta, Sicily, Italy, Middle Jurassic.

Acaeniotylopsis ghostensis (Carter in Carter et al., 1988)

Fig. 6B.

1988 *Acaeniotyle* (?) *ghostensis* Carter sp. nov.; Carter et al. 1988: 33, pl. 9: 6.
1994 *Acaeniotylopsis ghostensis* (Carter, 1988); Kito and De Wever 1994: 132, pl. 1: 7, 8.
1995 *Acaeniotylopsis ghostensis* (Carter, 1988); Baumgartner et al. 1995: 56, pl. 2001: 1, 2.
1997 *Acaeniotylopsis ghostensis* (Carter, 1988); Yao 1997: pl. 3: 102.
2006 *Acaeniotylopsis ghostensis* (Carter, 1988), Goričan et al. 2006: 16, pl. 2001: 1, 2.

Material.—Sample Rö416: stub Rö416_7 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Lower Pliensbachian to Upper Bajocian (Carter et al. 2010; Baumgartner et al. 1995). Haida Gwaii (British Columbia, Canada), Northern Calcareous Alps (Austria), Italy, Japan.

Family Xiphostylidae Haeckel, 1881

Genus *Archaeocenosphaera* Pessagno and Yang in Pessagno et al., 1989

Type species: *Archaeocenosphaera ruesti* Pessagno and Yang in Pessagno et al., 1989; East Central Mexico, Upper Tithonian.

Archaeocenosphaera laseekensis Pessagno and Yang in Pessagno et al., 1989

Fig. 8T, U.

1989 *Archaeocenosphaera laseekensis* Pessagno and Yang sp. nov.; Pessagno et al. 1989: 203, pl. 2: 18, 21, 22, 25.
1998 *Archaeocenosphaera laseekensis* Pessagno and Yang in Pessagno et al., 1989; Carter et al. 1998: 57: pl. 11: 1, 5, 9, 21.
2001 *Cenosphaera laseekensis* (Pessagno and Yang in Pessagno et al., 1989); Gawlick et al. 2001: fig. 2: 1; fig. 5: 2.
2005 *Archaeocenosphaera laseekensis* Pessagno and Yang in Pessagno et al., 1989; Carter and Hori 2005: pl. 1A: 5.
2007 *Archaeocenosphaera laseekensis* Pessagno and Yang in Pessagno et al., 1989; Longridge et al. 2007: 161, pl. 2: 15.
2011 *Archaeocenosphaera laseekensis* Pessagno and Yang in Pessagno et al., 1989; Bertinelli and Marcucci 2011: 410, pl. 2: 7.
2011 *Archaeocenosphaera laseekensis* Pessagno and Yang in Pessagno et al., 1989; Yeh 2011: 34, pl. 18: 15, 21.

Material.—Sample Rö37: stubs Rö37_1 (two specimens), Rö37_2 (two specimens), Rö37_4 (31 specimens), Rö37_5 (one specimen); sample Rö38: stub Rö38_1 (three specimens); sample Rö40: stub Rö40_1 (36 specimens); sample Rö97: stubs Rö97_1 (two specimens), Rö97_2 (28 specimens), Rö97_3 (35 specimens); sample Rö416: stub Rö416_5 (seven specimens); sample Rö417: stub Rö417 (ten specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—We follow Carter et al. (1998) who included

Archaeocenosphaera of considerably variable size in this species.

Stratigraphic and geographic range.—Lowermost Hettangian to lower Sinemurian (Carter et al. 1998), Bajocian (Yeh 2011), Lower Pliensbachian (this study). British Columbia (Canada), east-central Oregon (USA), Italy, Northern Calcareous Alps (Austria).

Genus *Novamuria* Özdikmen, 2009

Type species: *Amuria impensa* Whalen and Carter in Carter et al., 1998; Haida Gwaii, British Columbia, Canada, Hettangian to Sinemurian.

Novamuria macfarlanei (Whalen and Carter in Carter et al., 1998)

Fig. 8V.

1998 *Amuria macfarlanei* Whalen and Carter sp. nov.; Carter et al. 1998: 56, pl. 11: 7.
2001 *Amuria macfarlanei* Whalen and Carter in Carter et al., 1998; Gawlick et al. 2001: fig. 5: 3.
2011 *Amuria macfarlanei* Whalen and Carter in Carter et al., 1998; Bertinelli and Marcucci 2011: 410, pl. 2: 6.

Material.—Sample Rö37: stubs Rö37_1 (one specimen), Rö37_4 (one specimen), Rö37_5 (one specimen); sample Rö416: stub Rö416_7 (two specimens); sample Rö417: stub Rö417 (six specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Lower Hettangian to lower Sinemurian (Carter et al. 1998), Lower Pliensbachian (this study). Haida Gwaii (British Columbia, Canada), Italy, Northern Calcareous Alps (Austria).

Genus *Xiphostylus* Haeckel, 1881, emend. Pessagno and Yang in Pessagno et al., 1989

Type species: *Xiphostylus attenuatus* Rüst, 1885 (subsequent designation by Campbell 1954), Ilsede, Germany, Jurassic.

Xiphostylus simplus Yeh, 1987

Fig. 8W–X.

1987 *Xiphostylus simplus* sp. nov.; Yeh 1987: 52, pl. 10: 7; pl. 22: 4.
1987 *Xiphostylus* sp. A; Yeh 1987: 53, pl. 3: 15; pl. 10: 10.
1987 *Xiphostylus* sp. B; Yeh 1987: 53, pl. 26: 7, 11.
1987 *Xiphosphaera* spp.; Hattori 1987: pl. 22: 9–14, not 15.
1989 *Xiphostylus* sp.; Hattori and Sakamoto 1989: pl. 1: K.
1989 *Xiphostylus* spp.; Hattori 1989: pl. 4: B, C, D.
1990 *Xiphostylus* sp.; Nagai 1990: pl. 5: 5.
1997 *Xiphostylus simplus* Yeh, 1987; Yao 1997: pl. 1: 15.
1997 *Xiphostylus* sp. P2; Yao 1997: pl. 1: 16.
2003 *Xiphostylus* spp.; Goričan et al. 2003: 291, pl. 1: 1.
2006 *Xiphostylus simplus* Yeh, 1987; Goričan et al. 2006: 406, pl. XTL01: 1–3.

Material.—Sample Rö37: stubs Rö37_2 (three specimens), Rö37_3 (four specimens), Rö37_4 (one specimen); sample Rö97: stub Rö97_2 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—*Xiphostylus simplus* was originally defined as having one extremely short polar spine (Yeh 1987). Later, species with both spines strong and relatively long were also included (Goričan et al. 2006). All our specimens have two long spines; in some specimens they are slightly torsioned (Fig. 8W).

Stratigraphic and geographic range.—Lower Pliensbachian (this study), Upper Pliensbachian to Aalenian (Carter et al. 2010). Worldwide.

Triactoma aff. *rosespitensis* (Carter in Carter et al., 1988)

Fig. 8Y.

Material.—Sample Rö37: stub Rö37_3 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—*Triactoma* aff. *rosespitensis* differs from typical *Triactoma rosespitensis* (Carter in Carter et al. 1988: 27, pl. 10: 1; Goričan et al. 2006: 384, pl. TCA01: 1–4; O'Dogherty and Gawlick 2008: 75, pl. 1:22) by the spines being shorter and more pyramidal. *Triactoma* aff. *rosespitensis* is identical to the specimen of Gawlick et al. (2001: fig. 2: 7). *Triactoma rosespitensis* is known from the Lower Pliensbachian to the Middle–Upper Toarcian (Carter et al. 2010) in Haida Gwaii (British Columbia, Canada), Oregon (USA), Baja California Sur, Northern Calcareous Alps (Austria), Philippines, and Japan.

Family Conocaryommidae Lipman, 1969

Genus *Praeconocaryomma* Pessagno, 1976

Type species: *Praeconocaryomma universa* Pessagno, 1976; California, USA, Yolo Formation, Coniacian.

Praeconocaryomma bajaensis Whalen in Goričan et al., 2006

Fig. 7J–N.

1989 *Praeconocaryomma* spp.; Hattori 1989: pl. 9: M.
1996 *Praeconosphaera sphaeroconus* (Yang, 1993); Pujana 1996: 136, pl. 1: 21.
1997 *Praeconocaryomma* sp. A; Yao 1997: pl. 1: 32.
2002 *Praeconocaryomma* sp. A; Whalen and Carter 2002: 108, pl. 8: 8.
2003 *Praeconocaryomma* spp.; Goričan et al. 2003: 291, pl. 1: 14 (only).
2006 *Praeconocaryomma bajaensis* Whalen sp. nov.; Goričan et al. 2006: 322, pl. PRY05: 1–9.
2011 *Praeconocaryomma bajaensis* Whalen in Goričan et al., 2006; Bandini et al. 2011: pl. 9: 19.

Material.—Sample Rö40: stub Rö40_1 (ten specimens); sample Rö97: stub Rö97_4 (six specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—*Praeconocaryomma bajaensis* as defined by Whalen in Goričan et al. (2006) shows a considerable variability in the size and arrangement of pores. The same variability is also obvious in our material (note that the illustrated specimens in Fig. 7J–N are from the same sample). In all specimens the mammae are larger than in a closely similar *Praeconocaryomma whiteavesi* Carterin in Carter et al., 1988.

Stratigraphic and geographic range.—Pliensbachian to Aalenian (Carter et al. 2010). Worldwide.

Praeconocaryomma decora gr. Yeh, 1987

Fig. 7O–R.

1987 *Praeconocaryomma decora* sp. nov.; Yeh 1987: 39, pl. 6: 15; pl. 20:1, 2, 9, 16, 19.
1987 *Praeconocaryomma* sp. A; Yeh 1987: 40, pl. 2: 17, 22; pl. 20: 4.
1987 *Praeconocaryomma* sp. C; Yeh 1987: 40, pl. 2: 28; pl. 20: 5.
1990 *Praeconocaryomma decora* Yeh, 1987; Nagai 1990: pl. 6: 6.
1998 *Praeconocaryomma decora* Yeh, 1987; Yeh and Cheng 1998: 15, pl. 11: 1, 5.
2002 *Praeconocaryomma* sp. A Yeh, 1987: Whalen and Carter 2002: 108, pl. 8: 5.
2003 *Praeconocaryomma* spp.; Goričan et al. 2003: 291, pl. 1: 10 (only).
2006 *Praeconocaryomma decora* gr. Yeh, 1987; Goričan et al. 2006: 324, pl. PRY01: 1, 2.
2008 *Praeconocaryomma decora* gr. Yeh, 1987; Črne and Goričan 2008: fig. 8a.
2011 *Praeconocaryomma decora* gr. Yeh, 1987; Bertinelli and Marcucci 2011: 406, pl. 1: 6, 7, 8.

Material.—Sample Rö40: stub Rö40_1 (five specimens); sample Rö97: stub Rö97_4 (25 specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—Similarly as Goričan et al. (2006) we consider *Praeconocaryomma decora* as a group of morphotypes with imperforate mammae and a variable interlocking meshwork of relatively large intermammary pore frames. We, therefore, agree with Bertinelli and Marcucci (2011) who assigned to *P. decora* Hettangian morphotypes with a considerably less complex intermammary structure than that of the type material illustrated by Yeh (1987).

Stratigraphic and geographic range.—Upper Lower Pliensbachian to Aalenian (Carter et al. 2010); Hettangian (Bertinelli and Marcucci 2011). Oregon (USA), Baja California Sur, Italy, Northern Calcareous Alps (Austria), Oman, and Philippines.

Praeconocaryomma parvimamma Pessagno and Poisson, 1981

Fig. 7S, T.

1981 *Praeconocaryomma parvimamma* sp. nov.; Pessagno and Poisson 1981: 58, pl. 8: 5–8; pl. 9: 2.
1987 *Praeconocaryomma parvimamma* Pessagno and Poisson, 1981; Yeh 1987: 39, pl. 2: 16; pl. 20:8, 13–15, 20, 21; pl. 23: 19.
1987 *Praeconocaryomma* sp. cf. *P. parvivamma* Pessagno and Poisson, 1981; Yeh 1987: 39, pl. 23: 18, 23.
1998 *Praeconocaryomma parvimamma* Pessagno and Poisson, 1981; Cordey 1998: 89, pl. 22: 3, 6.
2002 *Praeconocaryomma parvimamma* Pessagno and Poisson, 1981; Suzuki et al. 2002: 172, fig. 4B.
2006 *Praeconocaryomma parvimamma* Pessagno and Poisson, 1981; Goričan et al. 2006: 326, pl. PRY03: 1–5.

Material.—Sample Rö97: stubs Rö97_3 (one specimen), Rö97_4 (12 specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Sinemurian to Pliensbachian (as published, see synonymy list). California, Oregon (USA), British Columbia (Canada), Peru, Northern Calcareous Alps (Austria), Turkey, and Oman.

Family Veghicycliidae Kozur and Mostler, 1972

Genus *Orbiculiformella* Kozur and Mostler, 1978

Type species: *Orbiculiforma railensis* Pessagno, 1977b; California Coast Ranges, USA, Albian.

Orbiculiformella sp. 1

Fig. 7U.

Material.—Sample Rö37: stub Rö37_3 (two specimens); sample Rö417: stub Rö417 (four specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Description.—Test thin, circular, spongy, with short peripheral spines, circular in cross section. Central cavity shallow, with the central part of the cavity slightly raised and having smaller pores than the rest of the shell.

Remarks.—This species differs from *Orbiculiformella callosa* (Yeh, 1987) by being thinner and having a much shallower cavity.

Family Hagiastridae Riedel, 1971

Genus *Crucella* Pessagno, 1971

Type species: *Crucella messinae* Pessagno, 1971; Yolo County, California, USA, Cenomanian.

Crucella angulosa sensu lato Carter in Carter et al., 1988

Fig. 7X.

1988 *Crucella angulosa* Carter sp. nov.; Carter et al. 1988: 43, pl. 4: 11, 12.
1998 *Crucella carpenterensis* sp. nov.; Cordey 1998: 69, pl. 19: 3, 4.
2006 *Crucella angulosa angulosa* Carter in Carter et al., 1988; Goričan et al. 2006: 118, pl. CRU11: 1–5.
2006 *Crucella angulosa longibrachiata* Carter ssp. nov.; Goričan et al. 2006: 118, pl. CRU12: 1, 2.
2017 *Crucella* sp. cf. *C. angulosa angulosa* Carter in Carter et al., 1988; Bragin and Bragina 2017: 8, pl. 3: 9.

Material.—Sample Rö416: stub Rö416_3 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Pliensbachian to Toarcian (Carter et al. 2010). Haida Gwaii, Williston Lake and coastal Canadian Cordillera (British Columbia, Canada), Northern Calcareous Alps (Austria), Sikhote-Alin (eastern Russia).

Crucella jadeae Carter and Dumitrica in Goričan et al., 2006

Fig. 7V.

1987 *Pseudocrucella* sp. E; Yeh 1987: 30, pl. 2: 18; pl. 3: 14.
2006 *Crucella jadeae* Carter and Dumitrica sp. nov.; Goričan et al. 2006: 124, pl. PDC05: 1–5.

Material.—Sample Rö417: stub Rö417 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Pliensbachian, as far as known. Haida Gwaii (British Columbia, Canada), Oregon (USA), Northern Calcareous Alps (Austria), Oman.

Crucella squama (Kozlova, 1971)

Fig. 7W.

1971 *Hagiastrum squama* sp. nov.; Kozlova 1971: 1175, pl. 1: 10.
1973 *Hagiastrum squama* sp. nov.; Kozlova 1973: 59, pl. 18: 8.
1981b *Crucella squama* (Kozlova, 1971); De Wever 1981b: 38, pl. 5: 7.
1982b *Crucella squama* (Kozlova, 1971); De Wever 1982b: 255, pl. 29: 4.
1988 *Crucella* sp. aff. *C. squama* (Kozlova, 1971); Carter et al. 1988: 43, pl. 12: 11, 12.
2002 *Crucella squama* (Kozlova, 1971); Whalen and Carter 2002: 106, pl. 2: 2, 5.
2002 *Crucella squama* (Kozlova, 1971); Suzuki et al. 2002: 176, fig. 7D.
2006 *Crucella squama* (Kozlova, 1971); Goričan et al. 2006: 128, pl. CRU 16: 1–3.

Material.—Sample Rö38: stub Rö38_1 (one specimen); sample Rö416: stub Rö416_3 (five specimens); sample Rö417: stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Pliensbachian to Kimmeridgian (as published, see synonymy list). Baja California Sur, Haida Gwaii (British Columbia, Canada), Peru, Ural (Russia), Northern Calcareous Alps (Austria), Turkey.

Family Emiluviidae Dumitrica, 1995

Genus *Beatricea* Whalen and Carter in Carter et al., 1998

Type species: *Beatricea christovalensis* Whalen and Carter in Carter et al., 1998; Haida Gwaii, British Columbia, Canada, Sandilands Formation, upper Hettangian to upper Sinemurian.

Beatricea? *argescens* (Cordey, 1998)

Fig. 7AB, AC.

1988 *Orbiculiforma* sp. A; Carter et al. 1988: 45, pl. 1: fig. 9.
1989 *Emiluvia*? spp.; Hattori 1989: pl. 2: J.
1996 *Orbiculiforma* sp. A of Carter in Carter et al. 1988; Hori et al. 1996: pl. 1: 19.
1998 *Orbiculiforma argescens* sp. nov.; Cordey 1998: 94, pl. 21: 6, 9, 11.
2006 *Beatricea* ? *argescens* (Cordey, 1998); Goričan et al. 2006: 60, pl. ORB04: 1–6.

Material.—Sample Rö37: stubs Rö37_2 (one specimen), Rö37_3 (three specimens); sample Rö38: stub Rö38_1 (three specimens); sample Rö416: stub Rö416_7 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Hettangian–Sinemurian to Pliensbachian, as far as known. Bridge River Complex and Haida Gwaii (British Columbia, Canada), Northern Calcareous Alps (Austria), New Zealand, Japan.

Genus *Thurstonia* Whalen and Carter in Carter et al., 1998

Type species: *Thurstonia minutaglobus* Whalen and Carter in Carter et al., 1998; Haida Gwaii, British Columbia, Canada, Sandilands Formation, Hettangian to Pliensbachian.

Remarks.—The family assignment to Emiluviidae Dumitrica, 1995 is questionable (O'Dogherty et al. 2009). The generic assignment of all species is marked with a question mark because *Thurstonia* is a homonym that has not been corrected yet.

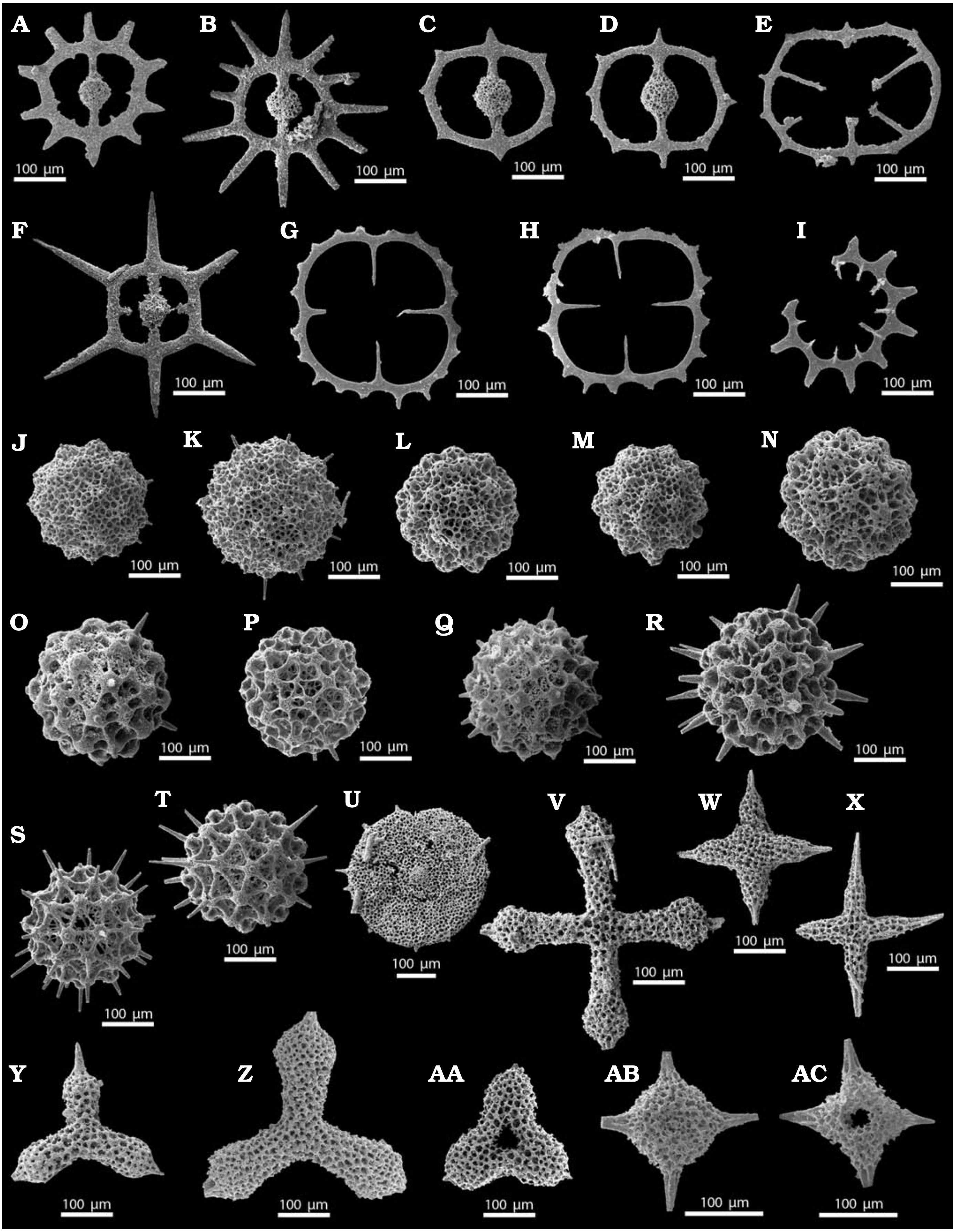
Thurstonia? *timberensis* Whalen and Carter in Carter et al., 1998

Fig. 6R, S.

1989 Genus 4 spp.; Hattori 1989: pl. 17: B, C.
1990 *Beturiella*? sp.; Nagai 1990: pl. 6: 1, 2.
1998 *Thurstonia timberensis* Whalen and Carter sp. nov.; Carter et al. 1998: 43, pl. 6: 3–5, 10.
1998 *Thurstonia* sp. B; Yeh and Cheng 1998: 11, pl. 8: 8.
2006 *Thurstonia timberensis* Whalen and Carter in Carter et al., 1998; Goričan et al. 2006: 380, pl. THU04: 1–8.
2006 *Thurstonia timberensis* Whalen and Carter in Carter et al., 1998; Yeh and Yang 2006: 323, pl. 2: 17, 18.
2011 *Thurstonia timberensis* Whalen and Carter in Carter et al., 1998; Bertinelli and Marcucci 2011: 407, pl. 1: 13, 14.

Material.—Sample Rö416: stubs Rö416_6 (seven specimens), Rö416_7 (two specimens); sample Rö417: stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Fig. **7**. Radiolarians from Mount Rettenstein, Austria, Pliensbachian, Early Jurassic. **A**. *Pseudoheliodiscus robustospinosus* Kozur and Mostler, 1990, sample Rö37. **B**. *Palaeosaturnalis liassicus* Kozur and Mostler, 1990, sample Rö417. **C**, **D**. *Palaeosaturnalis subovalis* Kozur and Mostler, 1990, sample Rö416. **E**. *Stauracanthocircus asymmetricus* Kozur and Mostler, 1990, sample Rö37. **F**. *Palaeosaturnalis tetraradiatus* (Kozur and Mostler, 1990), sample Rö417. **G**, **H**. *Stauromesosaturnalis deweveri* Kozur and Mostler, 1990, sample Rö97. **I**. *Pseudoheliodiscus radiosus* De Wever, 1981; sample Rö97. **J–N**. *Praeconocaryomma bajaensis* Whalen in Goričan et al., 2006, sample Rö97. **O–R**. *Praeconocaryomma decora* gr. Yeh, 1987, **s**ample Rö97. **S**, **T**. *Praeconocaryomma parvimamma* Pessagno and Poisson, 1981, sample Rö97. **U**. *Orbiculiformella* sp. 1, sample Rö417. **V**. *Crucella jadeae* Carter and Dumitrica in Goričan et al., 2006, sample Rö417. **W**. *Crucella squama* (Kozlova, 1971), sample Rö416. **X**. *Crucella angulosa* Carter in Carter et al., 1988, sample Rö416. **Y**, **Z**. *Paronaella grahamensis* Carter in Carter et al., 1988. **Y**. Sample Rö416. **Z**. Sample Rö37. **AA**. *Paronaella corpulenta* De Wever, 1981b, sample Rö38. **AB**, **AC**. *Beatricea*? *argescens* (Cordey, 1998), sample Rö37. →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Stratigraphic and geographic range.—Hettangian to Lower Toarcian (Carter et al. 1998, 2010). Haida Gwaii and Williston Lake (British Columbia, Canada), Oregon (USA), Northern Calcareous Alps (Austria), Italy, Oman, Nadanhada Terrane (China), Philippines, Japan.

Thurstonia? *minutaglobus* Whalen and Carter in Carter et al., 1998

Fig. 6T.

1998 *Thurstonia minutaglobus* Whalen and Carter sp. nov.; Carter et al. 1998: 43, pl. 6: 7, 9; pl. 8: 2, 5–7, 9, 10, 13.
2001 *Thurstonia minutaglobus* Whalen and Carter in Carter et al., 1998; Gawlick et al. 2001: 46, fig. 5: 5.
2009 *Thurstonia minutaglobus* Whalen and Carter in Carter et al., 1998; Gawlick et al. 2009: 118, fig. 64: 8.

Material.—Sample Rö37: stub Rö37_3 (one specimen); sample Rö416: stub Rö416_6 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Hettangian to Sinemurian (Carter et al. 1998), lower Pliensbachian (this study). Haida Gwaii (British Columbia, Canada), Northern Calcareous Alps (Austria).

Thurstonia? *robusta* Cifer sp. nov.

Fig. 6U, W.

1987 *Beturiella* (?) spp.; Hattori 1987: pl. 23: 2 (only).

ZooBank LCID: urn:lsid:zoobank.org:act:4C67029D-237C-4508-B720-BF5E90092585

Etymology: From the Latin *robustus*, strong, though. In reference to its strong and big spines.

Type material: Holotype, PMS 2399, sample Rö417: stub Rö417_093 (Fig. 6U). Paratypes: PMS 2399, sample Rö417: stub Rö417_090; PMS 2399, sample Rö417: stub Rö417_098, all from type locality and age.

Type locality: Mount Rettenstein, Northern Calcareous Alps, Austria.

Type horizon: Sample Rö417, grey marly limestone, Lower Pliensbachian.

Material.— Sample Rö37: stub Rö37_2 (one specimen); sample Rö38: stub Rö38_1 (one specimen); sample Rö416: stub Rö416_6 (four specimens); sample Rö417: stub Rö417 (two specimens), all from type locality and age.

Diagnosis.—*Thurstonia* with branched spines.

Description.—Test with large spherical cortical shell with six spines. Pore frames small- to medium-sized and irregularly shaped. Pore frame vertices have prominent, rounded nodes. All spines are approximately equal in length, usually longer than diameter of cortical shell. Spines are three-bladed with rounded longitudinal ridges; secondary grooves present in some specimens (Fig. 6V). Spines are branched distally.

Dimensions.—See Table 2.

Remarks.—*Thurstonia*? *robusta* sp. nov. differs from *Thurstonia timberensis* Whalen and Carter and all other species of *Thurstonia* by having branched and larger spines. The generic assignment of *Thurstonia*? *robusta* sp. nov. is under question, because the genus *Thurstonia* is a homonym.

Table 2. Dimensions (in µm) of *Thurstonia*? *robusta* Cifer sp. nov. N, number of specimens measured.

	Diameter of cortical shell	Length of longest spine
N	6	6
Holotype	106	113
Maximum	121	127
Minimum	103	107
Mean	115	113

Stratigraphic and geographic range.—Northern Calcareous Alps (Austria), Japan. Lower Pliensbachian (this study).

Family Angulobracchiidae Baumgartner, 1980

Genus *Liassobetraccium* Kozur, 1996

Type species: *Betraccium bavaricum* Kozur and Mostler, 1990; Northern Calcareous Alps, Germany, Kirchstein Limestone, Hettangian.

Remarks.—*Liassobetraccium* from Mount Rettenstein is the first record of this genus in the Pliensbachian. Until now, the genus was known from the Hettangian to the lower Sinemurian (O'Dogherty et al. 2009).

Liassobetraccium bavaricum (Kozur and Mostler, 1990)

Fig. 6C, D.

1990 *Betraccium bavaricum* sp. nov.; Kozur and Mostler 1990: 215, pl. 14: 4, 9.

Material.—Sample Rö37: stub Rö37_6 (three specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—*Liassobetraccium bavaricum* varies in the size of the specimens (compare Fig. 6C and D) and torsion of spines. Some specimens show stronger torsion throughout the whole length of spines (Fig. 6C), whereas others have a weak torsion (Fig. 6D). The specimen in Fig. 6C resembles *Liassobetraccium hettangicum* (Kozur and Mostler 1990: pl. 14: 4) but has distinct nodes on the pore-frame vertices of the cortical shell.

Stratigraphic and geographic range.—Hettangian (Kozur and Mostler 1990) and Lower Pliensbachian (this study). Northern Calcareous Alps (Austria, Germany).

Liassobetraccium verticispinosum (Kozur and Mostler, 1990)

Fig. 6E, F.

1990 *Betraccium verticispinosum* sp. nov.; Kozur and Mostler 1990: 216, pl. 14: 7, 8.

Material.—Sample Rö37: stubs Rö37_1 (one specimen), Rö37_6 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—In this species, the torsion of spines is strong and, according to the original definition, limited to the distal third of spines. In our material, the degree of torsion varies among spines of the same specimen (Fig. 6F) and the differentiation from *Liassobetraccium bavaricum* is not sharp (compare Fig. 6C). It is possible that in future studies, when more material is available, different *Liassobetraccium* with torsioned spines will be merged in one species.

Stratigraphic and geographic range.—Hettangian (Kozur and Mostler 1990) and Lower Pliensbachian (this study). Northern Calcareous Alps (Austria, Germany).

Genus *Loupanus* Carter, 1993

Type species: *Loupanus thompsoni* Carter, 1993, Haida Gwaii, British Columbia, Canada, Sandiland Formation, Rhaetian.

Remarks.—The *Loupanus* has been so far described only in the Rhaetian (Carter 1993) and in the Bathonian (Yeh and Pessagno 2013) but a Rhaetian to Tithonian stratigraphic range has been proposed (O'Dogherty et al. 2009). The lower Pliensbachian species (*Loupanus pliensbachicus* sp. nov. and *Loupanus* sp. 1) described below represent the first record of *Loupanus* in the Lower Jurassic.

Loupanus pliensbachicus Cifer sp. nov.

Fig. 6K–O.

ZooBank LCID: urn:lsid:zoobank.org:act:61C753C2-739E-464D-BBC2-AF835FB78963

Etymology: Named for the Pliensbachian stage. It is the first species of *Loupanus* found in the Pliensbachian.

Type material: Holotype, PMS 2397, sample Rö416: 170562 (Fig. 6K). Paratypes, PMS 2397, sample Rö416: 170559; PMS 2398, Rö416: 170757; PMS 2398, 170704; PMS 2398, 170560.

Type locality: Mount Rettenstein, Northern Calcareous Alps, Austria.

Type horizon: Sample Rö416, grey marly limestone, Lower Pliensbachian.

Material.—Sample Rö38: stub Rö38_1 (one specimen); sample Rö416: stubs Rö416_5 (four specimens), Rö416_7 (seven specimens); sample Rö417: stub Rö417 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Diagnosis.—Round cortical shell with five three-bladed spines, forming the edges of two tetrahedrons.

Description.—Three spines are in the equatorial plane, forming a 120° angle between them. Perpendicularly to this plane are two bipolar spines. All spines three-bladed, massive, tapering distally. Spines in equatorial plane equal in length, approximately as long as the diameter of the cortical shell. One polar spine as long as the equatorial spines, the other polar spine slightly longer. The cortical shell is spherical. Outer layer of small pore frames irregularly polygonal in shape, composed of thick bars with small nodes at vertices. The nodes can be faint (Fig. 6K–M) or rather strong and can bear small spines (Fig. 6O).

Dimensions.—See Table 3.

Table 3. Dimensions (in μm) of *Loupanus pliensbachicus* Cifer sp. nov. N, number of specimens measured.

	Diameter of cortical shell	Length of longest spine
N	13	13
Holotype	89	83
Maximum	147	123
Minimum	88	58
Mean	101	88

Remarks.—*Loupanus pliensbachicus* Cifer sp. nov. differs from the Triassic *Loupanus thompsoni* Carter, 1993 (Carter 1993: 86, pl. 3: 4, 5) by having a spherical rather than five-sided cortical shell. The spines are shorter and the bipolar spines are unequal in length. The structure of the cortical shell and spines resembles *Thurstonia*? *timberensis* Whalen and Carter, 1998, but the number of spines is different; *Loupanus* has 5 spines (3 in equatorial plane) whereas *Thurstonia* has 6 spines (4 in equatorial plane).

Stratigraphic and geographic range.—Lower Pliensbachian. Northern Calcareous Alps (Austria).

Loupanus sp. 1

Fig. 6P, Q.

Material.—Sample Rö417: stub Rö417 (five specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Description.—Cortical shell is slightly ellipsoidal with five spines. Three spines are in equatorial plane, with a 120° angle between them. Two spines are bipolar. Spines are equal in length, shorter than diameter of the cortical shell.

Remarks.—*Loupanus* sp. 1 differs from *Loupanus pliensbachicus* sp. nov. by having a larger, ellipsoidal cortical shell and spines shorter than the diameter of the cortical shell.

Genus *Paronaella* Pessagno, 1971, emend. Baumgartner 1980

Type species: *Paronaella solanoensis* Pessagno, 1971; California, USA, Yolo Formation, Turonian to Coniacian.

Paronaella corpulenta De Wever, 1981b

Fig. 7AA.

1981b *Paronaella corpulenta* sp. nov.; De Wever 1981b: 33, pl. 2: 7–9.
1982b *Paronaella corpulenta* De Wever, 1981b; De Wever 1982b: 245, pl. 22: 7; pl. 23: 1–3.
1988 *Paronaella* sp. C; Carter in Carter et al. 1988: 42, pl. 11: 7.
2002 *Paronaella corpulenta* De Wever, 1981b; Whalen and Carter 2002: 107, pl. 2: 6, 12.
2003 *Paronaella* spp.; Goričan et al. 2003: 295, pl. 2: 4 (only).
?2004 *Paronaella corpulenta* De Wever, 1981b; Matsuoka 2004: fig. 32.
2006 *Paronaella corpulenta* De Wever, 1981b; Goričan et al. 2006: 298, pl. PAR13: 1–9.

Material.—Sample Rö38: stub Rö38_1 (one specimen); sample Rö417: stub Rö417 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Pliensbachian to Lower Toarcian (Carter et al. 2010). Worldwide.

Paronaella grahamensis Carter in Carter et al., 1988

Fig. 7Y, Z.

1987 *Paronaella* (?) sp.; Hattori 1987: pl. 4: 12.
1988 *Paronaella grahamensis* Carter sp. nov.; Carter et al. 1988: 40, pl. 11: 11, 12, not 10.
1998 *Paronaella jamesi* Whalen and Carter sp. nov.; Carter et al. 1998: 51, pl. 13: 18, 22, 24, not 19, 23.
2001 *Paronaella grahamensis* Carter in Carter et al., 1988; Gawlick et al. 2001: fig. 2: 17.
2001 *Paronaella* cf. *grahamensis* Carter in Carter et al., 1988; Gawlick et al. 2001: fig. 5: 21.
2002 *Paronaella grahamensis* Carter in Carter et al., 1988; Whalen and Carter 2002: 107, pl. 2: 3, 4, 9, 11, 13.
2004 *Paronaella* sp.; Matsuoka 2004: fig. 30.
2006 *Paronaella grahamensis* Carter in Carter et al., 1988; Goričan et al. 2006, pl. PAR16: 1–7.
2009 *Paronaella grahamensis* Carter in Carter et al., 1988; Yeh 2009: 56, pl. 14: 1, 5, 9, 22.
2013 *Paronaella grahamensis* Carter in Carter et al., 1988; Yeh and Pessagno 2013: 89, pl. 16: 3.
2013 *Paronaella grahamensis* Carter in Carter et al., 1988; Chiari et al. 2013: fig. 11d.
2013 *Paronaella* sp. cf. *P. grahamensis* Carter in Carter et al., 1988; Chiari et al. 2013: fig. 11e.
2017 *Paronaella grahamensis* Carter in Carter et al., 1988; Bragin and Bragina 2017: pl. 3: 3, 4.

Material.—Sample Rö37: stubs Rö37_4 (three specimens), Rö37_5 (one specimen); sample Rö38: stub Rö38_1 (one specimen); sample Rö416: stub Rö416_1 (one specimen); sample Rö417: stub Rö417 (eight specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Pliensbachian to lower Aalenian (Carter et al. 2010); Bathonian (Yeh and Pessagno 2013). Worldwide.

Genus *Cyclastrum* Rüst, 1898

Type species: *Cyclastrum infundibuliforme* Rüst, 1898; siliceous limestone of Cittiglio, Italy, Upper Jurassic.

Cyclastrum scammonense Whalen and Carter, 2002

Fig. 8Z.

?1998 *Orbiculiforma silicatilis* sp. nov.; Cordey 1998: 93, pl. 21: 7, not 5, 8.
2002 *Cyclastrum scammonense* sp. nov.; Whalen and Carter 2002: 111, pl. 4: 3–5, 11–13, 15; pl. 5: 1, 2, 9.
2006 *Cyclastrum scammonense* Whalen and Carter, 2002; Goričan et al. 2006: 130, pl. CYC02: 1–4.
2006 *Gelasinus scammonensis* (Whalen and Carter, 2002); Yeh and Yang 2006: 335, pl. 4: 1, 21.

Material.—Sample Rö416: stub Rö416_7 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Lower Pliensbachian (Carter et al. 2010). Baja California Sur, Northern Calcareous Alps (Austria), Oman.

Family Saturnalidae Deflandre, 1953
Subfamily Heliosaturnalinae Kozur and Mostler, 1972

Genus *Palaeosaturnalis* Donofrio and Mostler, 1978, emend. Kozur and Mostler 1981

Type species: *Spongosaturnalis triassicus* Kozur and Mostler, 1972; Göstling limestone, Steinbach brook, Austria, Carnian.

Palaeosaturnalis subovalis Kozur and Mostler, 1990

Fig. 7C, D.

? 1972 *Spongosaturnalis* ? sp. c; Yao 1972: 35, pl. 8: 3.
1987 *Acanthocircus* sp. B; Yeh 1987: 49, pl. 5: 13.
1990 *Palaeosaturnalis subovalis* sp. nov.; Kozur and Mostler 1990: 193, pl. 1: 7; pl. 13: 4, 9.
1991 *Palaeosaturnalis* sp. aff. *P. liassicus* Kozur and Mostler, 1990; Yang and Mizutani 1991: 65, pl. 2: 4, 11, 13; not pl. 3: 2, 12, 13.
2002 *Palaeosaturnalis lenggriesensis* Kozur and Mostler, 1990; Tekin 2002: 182, pl. 2: 2.
2002 *Palaeosaturnalis subovalis* Kozur and Mostler, 1990; Tekin 2002: 182, pl. 2: 5.
2006 *Palaeosaturnalis subovalis* Kozur and Mostler, 1990; Goričan et al. 2006: 270, pl. SAT12: 1–4.
2006 *Palaeosaturnalis subovalis* Kozur and Mostler, 1990; Yeh and Yang 2006: 330, pl. 2: 1.

Material.—Sample Rö416: stub Rö416_3 (six specimens); sample Rö417: stub Rö417 (five specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—Our specimens have shorter peripheral spines than the type material.

Stratigraphic and geographic range.—Hettangian to Pliensbachian (as published, see synonymy list). Worldwide.

Palaeosaturnalis liassicus Kozur and Mostler, 1990

Fig. 7B.

1990 *Palaeosaturnalis liassicus* sp. nov.; Kozur and Mostler 1990: 192, pl. 1: 2, 3; pl. 12: 1, 3, 4, 5, 8–10; pl. 13: 1, 2, 6, 7.
1998 *Palaeosaturnalis liassicus* Kozur and Mostler, 1990; Carter et al. 1998: 53, pl. 14: 11, 12, 15–17.
1998 *Palaeosaturnalis liassicus* Kozur and Mostler, 1990; Yeh and Cheng 1998: 16, pl. 2: 7, pl. 11: 7.
2001 *Palaeosaturnalis liassicus* Kozur and Mostler, 1990; Gawlick et al. 2001: 43, fig. 2: 15.
2002 *Palaeosaturnalis liassicus* Kozur and Mostler, 1990; Tekin 2002: 182, pl. 2: 3.
2006 *Palaeosaturnalis liassicus* Kozur and Mostler, 1990; Yeh and Yang 2006: 329, pl. 5: 2, 5.
2009 *Palaeosaturnalis liassicus* Kozur and Mostler, 1990; Gawlick et al. 2009: 117, fig. 63: 7.

Material.—Sample Rö37: stub Rö37_4 (two specimens); sample Rö417: stub Rö417 (three specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Hettangian to Sinemurian (as published, see synonymy list), Lower Pliensbachian (this study). Worldwide.

Palaeosaturnalis tetraradiatus (Kozur and Mostler, 1990)

Fig. 7F.

1990 *Praehexasaturnalis tetraradiatus* sp. nov.; Kozur and Mostler 1990: 195, pl. 6: 8, 9, 11, 12.
1994 *Praehexasaturnalis tetraradiatus* Kozur and Mostler, 1990; Carter 1994: pl. 1: 19.
1998 *Praehexasaturnalis tetraradiatus* Kozur and Mostler, 1990; Carter et al. 1998: 54, pl. 14: 1, 2, 5, 6, 9, 10.
2001 *Praehexasaturnalis* cf. *tetraradiatus* Kozur and Mostler, 1990; Gawlick et al. 2001: 43, fig. 2: 16.
2002 *Praehexasaturnalis tetraradiatus* Kozur and Mostler, 1990; Whalen and Carter 2002: 108, pl. 5: 7, 11, 12.
2002 *Praehexasaturnalis tetraradiatus* Kozur and Mostler, 1990; Tekin 2002: 184, pl. 2: 10.
2006 *Praehexasaturnalis tetraradiatus* Kozur and Mostler, 1990; Goričan et al. 2006: 332, pl. SAT01: 1–3.
2011 *Palaeosaturnalis tetraradiatus* (Kozur and Mostler, 1990); Bandini et al. 2011: pl. 10: 23.

Material.—Sample Rö417: stub Rö417 (five specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Rhaetian?, Hettangian to Lower Pliensbachian (as published, see synonymy list). Worldwide.

Genus *Pseudoheliodiscus* Kozur and Mostler, 1972

Type species: *Pseudoheliodiscus riedeli* Kozur and Mostler, 1972; Groß Reifling, Austria, Triassic to Cretaceous.

Pseudoheliodiscus radiosus De Wever, 1981b

Fig. 7I.

1981b *Pseudoheliodiscus radiosus* sp. nov.; De Wever 1981b: 143, pl. 4, 2–4, 6.

Material.—Sample Rö97: stub Rö97_3 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Lower Pliensbachian, as far as known. Northern Calcareous Alps (Austria), Turkey.

Pseudoheliodiscus robustospinosus Kozur and Mostler, 1990

Fig. 7A.

1990 *Pseudoheliodiscus robustospinosus* sp. nov.; Kozur and Mostler 1990: pl. 2: 3, 8; pl. 4: 8–11; pl. 5: 10.
2006 *Pseudoheliodiscus robustospinosus* Kozur and Mostler, 1990; Yeh and Yang 2006: 330, pl. 5: 9.

Material.—Sample Rö37: stub Rö37_4 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Hettangian to Sinemurian (Kozur and Mostler 1990; Yeh and Yang 2006), Lower Pliensbachian (this study). Northern Calcareous Alps (Germany and Austria), Hungary, Nadanhada Terrane (China).

Genus *Stauracanthocircus* Kozur and Mostler, 1983, emend. Kozur and Mostler 1990

Type species: *Pseudoheliodiscus concordis* De Wever, 1981b; Gümuslu Allochthon, Turkey, Pliensbachian.

Stauracanthocircus asymmetricus Kozur and Mostler, 1990

Fig. 7E.

1990 *Stauracanthocircus asymmetricus* sp. nov.; Kozur and Mostler 1990: 197, pl. 2: 9; pl. 8: 7–10; pl. 9: 1–5, 7, 10, 12.

Material.—Sample Rö37: stub Rö37_4 (two specimens); sample Rö417: stub Rö417 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Hettangian (Kozur and Mostler 1990), Lower Pliensbachian (this study). Northern Calcareous Alps, Germany and Austria.

Subfamily Parasaturnalinae Kozur and Mostler, 1972

Genus *Stauromesosaturnalis* Kozur and Mostler, 1990

Type species: *Stauromesosaturnalis schizospinosus* Kozur and Mostler, 1990; Northern Calcareous Alps, Bavaria, Hettangian.

Stauromesosaturnalis deweveri Kozur and Mostler, 1990

Fig. 7G, H.

1981b *Pseudoheliodiscus*? sp. aff. *P. concordis* sp. nov.; De Wever 1981b: 142, pl. 2: 4.
1990 *Stauromesosaturnalis deweveri* sp. nov.; Kozur and Mostler 1990: 202.
1997 *Kozurastrum* sp. A; Yao 1997: pl. 5: 205.
2002 *Stauracanthocircus sanrafaelensis* sp. nov.; Whalen and Carter 2002: 108, pl. 6: 1, 2; pl. 17: 3.
2004 *Stauromesosaturnalis deweveri* Kozur and Mostler, 1990; Matsuoka 2004: fig. 11.
2006 *Stauromesosaturnalis deweveri* Kozur and Mostler, 1990; Goričan et al. 2006: 372, pl. SAT19: 1–4.

Material.—Sample Rö97: stub Rö97_3 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Pliensbachian to Aalenian (Carter et al. 2010). Worldwide in low latitudes.

Order Nassellaria Ehrenberg, 1875

Family Poulpidae De Wever, 1981a

Genus *Saitoum* Pessagno, 1977a

Type species: *Saitoum pagei* Pessagno, 1977a; Santa Barbara County, California, USA, Upper Kimmeridgian to Lower Tithonian.

Saitoum keki De Wever, 1982a

Fig. 8A–H.

1982a *Saitoum keki* sp. nov.; De Wever 1982a: 192, pl. 2: 4–6.
1995 *Saitoum keki* De Wever, 1982a; Suzuki 1995: fig. 8: 6.
2001 *Saitoum keki* De Wever, 1982a; Gawlick et al. 2001: fig. 5: 15, fig. 6: 10.
2003 *Saitoum keki* De Wever, 1982a; Goričan et al. 2003: 296, pl. 4: 3.
2013 *Saitoum* sp. cf. *S. keki* De Wever, 1982a; Chiari et al. 2013: fig. 11n.

Material.—Sample Rö38: stub Rö38_1 (four specimens); sample Rö416: stub Rö416_4 (five specimens); sample Rö417: stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—Our specimens have shorter spines than the type material of *Saitoum keki*.

Stratigraphic and geographic range.—Pliensbachian to Lower Toarcian (as published, see synonymy list). Northern Calcareous Alps (Austria), Slovenia, Greece, Turkey, Japan.

Family Ultranaporidae Pessagno, 1977b

Genus *Bipedis* De Wever, 1982a

Type species: *Bipedis calvabovis* De Wever, 1982a; Turkey, Lower Pliensbachian.

Bipedis douglasi Whalen and Carter in Carter et al., 1998

Fig. 8AI, AJ.

1998 *Bipedis douglasi* Whalen and Carter sp. nov.; Carter et al. 1998: 76, pl. 23: 1, 5, 9–12; pl. 27: 15, 19.
2002 *Bipedis douglasi* Whalen and Carter in Carter et al., 1998; Tekin 2002: 192, pl. 5: 11.

Material.—Sample Rö37: stub Rö37_2 (one specimen); sample Rö38: stub Rö38_1 (one specimen); sample Rö416: stub Rö416_4 (one specimen); sample Rö417: stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—*Bipedis douglasi* from Mount Rettenstein has the feet less widely extended and a little shorter than *Bipedis douglasi* of Carter et al. (1998).

Stratigraphic and geographic range.—Upper Sinemurian of Haida Gwaii, British Columbia, Canada (Carter et al. 1998) and Turkey (Tekin 2002). Lower Pliensbachian of the Northern Calcareous Alps, Austria (this study).

Bipedis fannini Carter in Carter et al., 1988

Fig. 8AK.

1988 *Bipedis fannini* Carter sp. nov.; Carter et al. 1988: 61, pl. 2: 7, 8.
2006 *Bipedis fannini* Carter in Carter et al., 1988; Goričan et al. 2006: 68, pl. BPD14: 1a–6b.
2009 *Bipedis fannini* Carter in Carter et al., 1998; Gawlick et al. 2009: 117, fig. 63: 6.
2011 *Bipedis fannini* Carter in Carter et al., 1988; Bandini et al. 2011: pl. 10: 4.

Material.—Sample Rö38: stub Rö38_1 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Lower to Upper Pliensbachian (Carter et al. 2010); Haida Gwaii and Williston Lake (British Columbia, Canada), Costa Rica, Northern Calcareous Alps (Austria).

Genus *Anaticapitula* Dumitrica and Zügel, 2003

Type species: *Anaticapitula clauda* Dumitrica and Zügel, 2003; Solnhofen, Germany, Lower Tithonian.

Anaticapitula anatiformis (De Wever, 1982a)

Fig. 9A–D.

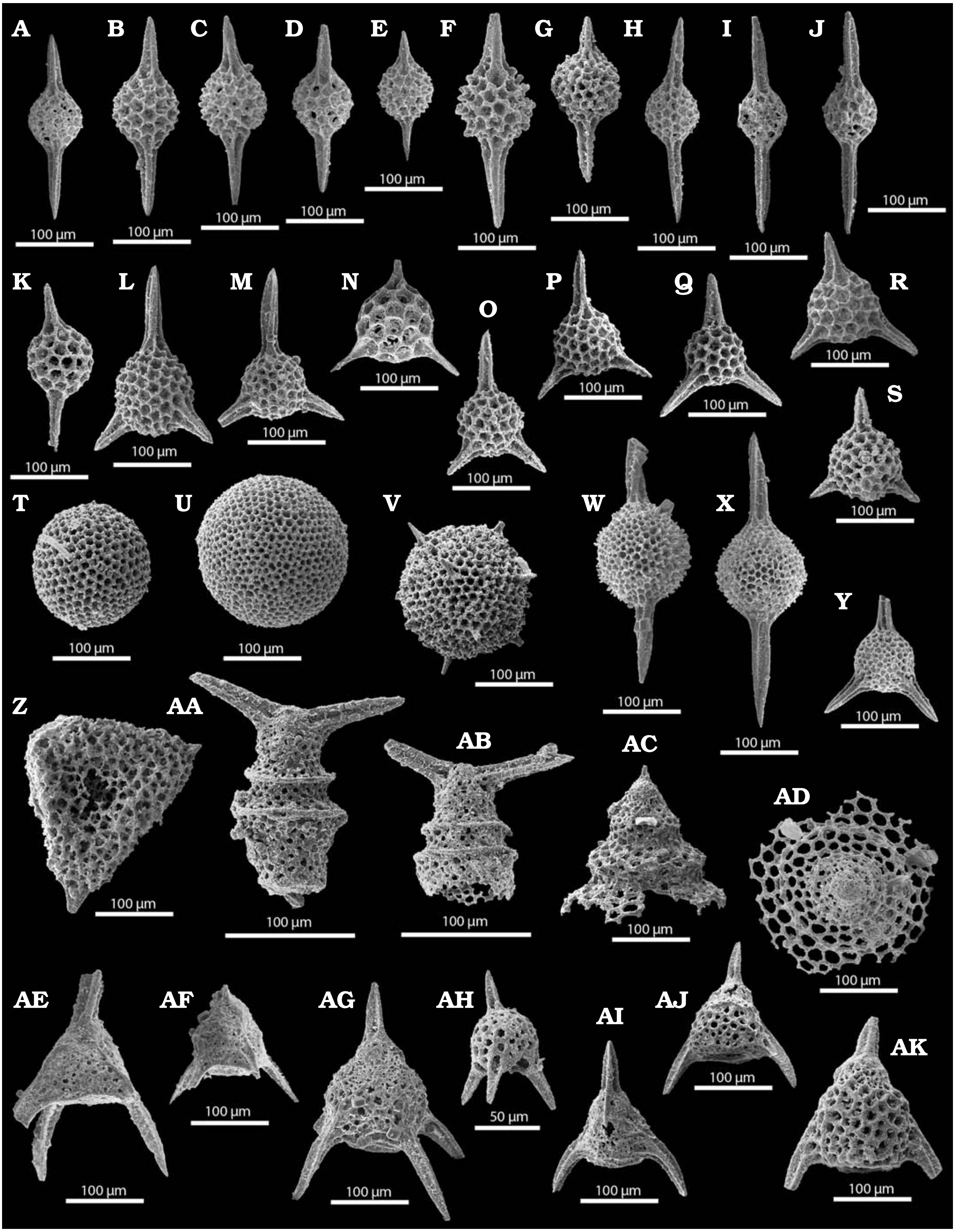
1982 *Bisphaerocephalina* (?) sp.; Imoto et al. 1982: pl. 1: 10.
1982a *Jacus*? *anatiformis* sp. nov.; De Wever 1982a: 205, pl. 11: 10–15.
1982b *Jacus*? *anatiformis* De Wever, 1982a; De Wever 1982b: 343, pl. 54: 1–5; pl. 58: 1, 2, 6.
1990 *Jacus anatiformis* De Wever, 1982a; De Wever et al. 1990: pl. 3: 10.
2001 *Jacus* cf. *anatiformis* De Wever, 1982a; Gawlick et al. 2001: 43, fig. 2: 19.
2001 *Jacus anatiformis* De Wever, 1982a; Gawlick et al. 2001: 46, fig. 5: 16.
2004 *Anaticapitula* (?) *anatiformis* (De Wever, 1982a); Matsuoka 2004: fig. 145.
2006 *Anaticapitula anatiformis* (De Wever, 1982a); Goričan et al. 2006: 18, pl. JAC02: 1–11 (and synonymy therein).
2006 *Jacus*? *anatiformis* De Wever, 1982a; Yeh and Yang 2006: 343, pl. 7: 14.
2009 *Jacus anatiformis* De Wever, 1982a; Gawlick et al. 2009: 118, fig. 64: 2.
2011 *Anaticapitula anatiformis* (De Wever, 1982a); Bandini et al. 2011: pl. 8: 26.

Material.—Sample Rö37: stub Rö37_6 (seven specimens); sample Rö38: stub Rö38_1 (one specimen); sample Rö416: stub Rö416_4 (nine specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—A huge variety of forms differing in overall size and structure of the thorax have been included in *Anaticapitula anatiformis* (Goričan et al. 2006). The samples of the present study only contain specimens with a two-layered thorax. The morphotype with a simple thoracic wall of large polygonal pore frames (e.g., Goričan et al. 2006: pl. JAC02: 6–11) has not been found.

Stratigraphic and geographic range.—Hettangian to Middle –Upper Toarcian (Carter et al. 1998, 2010). Worldwide.

Fig. 8. Radiolarians from Mount Rettenstein, Austria, Pliensbachian, Early Jurassic. **A**–**G**. *Pantanellium browni* Pessagno and Blome, 1980. **A**–**F**. Sample Rö37. **G**. *S*ample Rö416. **H**–**J**. *Pantanellium skedansense* Pessagno and Blome, 1980, sample Rö37. **K**. *Pantanellium haidaense* Pessagno and Blome, 1980; sample Rö37. **L**, **M**. *Gorgansium alpinum* Kozur and Mostler, 1990, sample Rö37. **N**. *Gorgansium blomei* Kozur and Mostler, 1990, sample Rö417. **O**–**S**. *Gorgansium gongyloideum* Kishida and Hisada, 1985. **O**–**Q**, **S**. Sample Rö416. **R**. Sample Rö37. **T**, **U**. *Archaeocenosphaera laseekensis* Pessagno and Yang in Pessagno et al., 1989. **T**. Sample Rö416. **U**. **S**ample Rö37. **V**. *Novamuria macfarlanei* (Whalen and Carter in Carter et al., 1998), sample Rö417. **W**–**X**. *Xiphostylus simplus* Yeh, 1987, sample Rö37. **Y**. *Triactoma* aff. *rosespitensis* (Carter in Carter et al., 1988), sample Rö37. **Z**. *Cyclastrum scammonense* Whalen and Carter, 2002; sample Rö416. **AA**, **AB**. *Cuniculiformis plinius* De Wever, 1982a, sample Rö416. **AC**–**AD**. *Haeckelicyrtium* sp. 1. **AC**. Sample Rö416. **AD**. Sample Rö37. **AE**, **AF**. *Farcus* cf. *kozuri* Yeh, 1987, sample Rö37. **AG**. *Farcus graylockensis* Pessagno, Whalen and Yeh, 1986, sample Rö37. **AH**. *Saitoum keki* De Wever, 1982a, sample Rö416. **AI**, **AJ**. *Bipedis douglasi* Whalen and Carter in Carter et al., 1998. **AI**. Sample Rö416. **AJ**. Sample Rö417. **AK**. *Bipedis fannini* Carter in Carter et al., 1988, sample Rö38. →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AC
AD
AE
AF
AG
AH
AI
AJ
AK
100 µm
50 µm

Anaticapitula parvireticulata Bertinelli and Marcucci, 2011

Fig. 9E.

2011 *Anaticapitula parvireticulata* sp. nov.; Bertinelli and Marcucci 2011: 416, pl. 3: 10a, b, 11a, b.

Material.—Sample Rö38: stub Rö38_1 (one specimen); sample Rö417: stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—*Anaticapitula parvireticulata* has been known from the Hettangian and now we found one specimen in the lower Pliensbachian. Considering its rarity in the Pliensbachian and the discontinuous stratigraphic record it is possible that the illustrated specimen (Fig. 9E) represents an early ontogenetic stage of *A. anatiformis* (De Wever, 1982a) and not an independent species.

Stratigraphic and geographic range.—Middle and upper Hettangian of Italy (Bertinelli and Marcucci 2011). Lower Pliensbachian of the Northern Calcareous Alps (Austria; this study).

Genus *Napora* Pessagno, 1977a

Type species: *Napora bukryi* Pessagno, 1977a; Santa Barbara County, California, USA, Upper Kimmeridgian to Lower Tithonian.

Napora sp. B sensu Whalen and Carter in Carter et al., 1998

Fig. 9G.

Material.—Sample Rö37: stub Rö37_5 (one specimen); sample Rö416: stub Rö416_4 (three specimens); sample Rö417: stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Upper Sinemurian of Haida Gwaii, British Columbia, Canada (Carter et al. 1998). Lower Pliensbachian of the Northern Calcareous Alps, Austria (this study).

Genus *Dumitricaella* De Wever, 1982a

Type species: *Dumitricaella pauliani* De Wever, 1982a; Turkey, Lower Pliensbachian.

Dumitricaella? *cucurbitina* De Wever, 1982a

Fig. 9F.

1982a *Dumitricaella*? *cucurbitina* sp. nov.; De Wever 1982a: 198, pl. 6: 8, 9.

Material.—Sample Rö416: stub Rö416_4 (two specimens).

Stratigraphic and geographic range.—Lower Pliensbachian. Turkey, Northern Calcareous Alps, Austria.

Family Foremanellinidae Dumitrica, 1982
Genus *Farcus* Pessagno, Whalen, and Yeh, 1986

Type species: *Farcus graylockensis* Pessagno, Whalen, and Yeh, 1986; Oregon, USA, Lower Jurassic.

Farcus graylockensis Pessagno, Whalen, and Yeh, 1986

Fig. 8AG.

1986 *Farcus graylockensis* sp. nov.; Pessagno et al. 1986: 24, pl. 2: 4, 6–8, 12, 15.
1987 *Farcus graylockensis* Pessagno, Whalen, and Yeh, 1986; Yeh 1987: 76, pl. 1: 7.
1996 *Farcus graylockensis* Pessagno, Whalen, and Yeh, 1986; Pujana 1996: 139, pl. 1: 7.
1997 *Farcus graylockensis* Pessagno, Whalen, and Yeh, 1986; Yao 1997: pl. 8: 395.
1997 *Farcus* aff. *kozuri* Yeh, 1987; Yao 1997: pl. 8: 396.
2002 *Farcus graylockensis* Pessagno, Whalen, and Yeh, 1986; Tekin 2002: 189, pl. 4: 2.
2006 *Farcus graylockensis* Pessagno, Whalen, and Yeh, 1986; Goričan et al. 2006: 162, pl. FAR04: 1, 2.
2009 *Farcus graylockensis* Pessagno, Whalen, and Yeh, 1986; Gawlick et al. 2009: 117, fig. 62: 4.

Material.—Sample Rö37: stub Rö37_5 (one specimen); sample Rö38: stub Rö38_1 (three specimens); sample Rö417: stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Lower Sinemurian to Lower Toarcian (as published, see synonymy list). Oregon (USA), Argentina, Northern Calcareous Alps (Austria), Turkey, Oman, Japan.

Farcus cf. *kozuri* Yeh, 1987

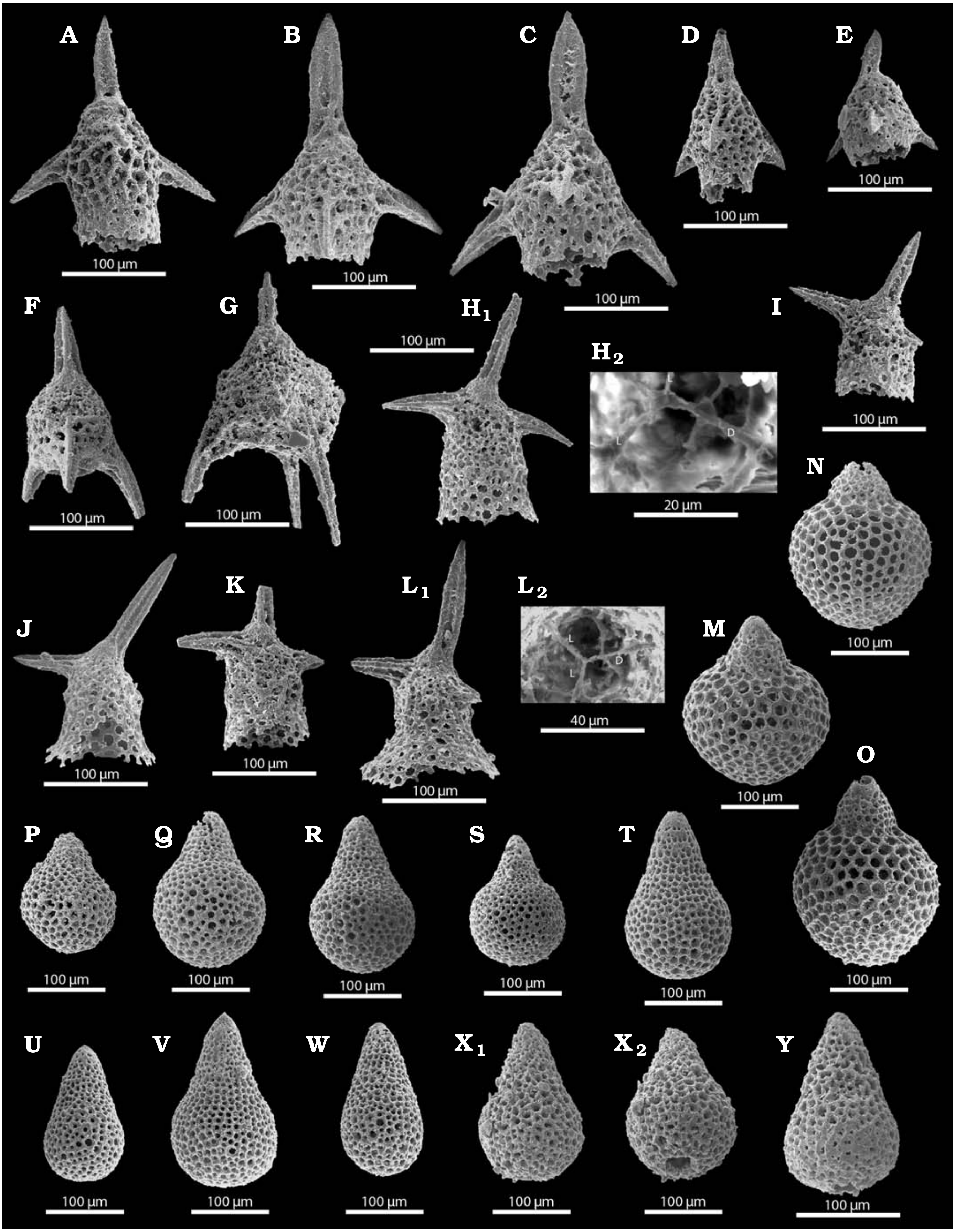
Fig. 8AE, AF.

Material.—Sample Rö37: stubs Rö37_3 (one specimen), Rö37_5 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—Our specimens have a test with smaller pores and a smoother thorax than typical *Farcus kozuri* Yeh, 1987. Typical *Farcus kozuri* is known from the Upper Pliensbachian of Oregon, USA (Yeh 1987).

Family Deflandrecyrtiidae Kozur and Mostler, 1979
Genus *Haeckelicyrtium* Kozur and Mostler, 1979, emend. Carter, 1993

Fig. 9. SEM images of radiolarians, Mount Rettenstein, Austria, Pliensbachian, Early Jurassic. **A**–**D**. *Anaticapitula anatiformis* (De Wever, 1982a). → **A**. Sample Rö416. **B**, **C**. Sample Rö37. **D**. Sample Rö38. **E**. *Anaticapitula parvireticulata* Bertinelli and Marcucci, 2011, sample Rö417. **F**. *Dumitricaella*? *cucurbitina* De Wever, 1982a, sample Rö416. **G**. *Napora* sp. B sensu Whalen and Carter in Carter et al., 1998, sample Rö416. **H**–**L**. *Ares rettensteinensis* Cifer sp. nov. **H**. Holotype and its inner structure (H_2), sample Rö37: 182455. **I**. Paratype, sample Rö416: 170431. **J**. Paratype, sample Rö37: 171137. **K**. Paratype, sample Rö38: 182323. **L**. Paratype and its inner structure (L_2), sample Rö37: 182462. **M**–**O**. *Zhamoidellum sutnal* (O'Dogherty and Gawlick, 2008), sample Rö97. **P**–**S**. *Lantus obesus* (Yeh, 1987). **P**. Sample Rö416. **Q**–**S**. Sample Rö97. **T**–**W**. *Lantus praeobesus* Carter in Goričan et al., 2006; sample Rö97. **X**, **Y**. *Doliocapsa* sp. 1, sample Rö37.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I
J
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L1
L2
M
N
O
P
Q
R
S
T
U
V
W
X1
X2
Y
100 μm
20 μm
40 μm
L
D

Type species: *Haeckelicyrtium austriacum* Kozur and Mostler, 1979; Northern Calcareous Alps, Austria, Carnian.

Haeckelicyrtium sp. 1

Fig. 8AC, AD.

Material.—Sample Rö37: stubs Rö37_3 (one specimen), Rö37_5 (three specimens); sample Rö38: stub Rö38_1 (one specimen); sample Rö416: stub Rö416_5 (two specimens); sample Rö417: stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Description.—Test composed of tricyrtid conical part and a flaring skirt. Cephalis smooth, covered with small pores; a short three-bladed apical horn present. Pores on the rest of the test much larger; the size of pore frames increases from thorax to abdomen and the skirt. The skirt is separated from the abdomen by a pronounced constriction.

Remarks.—*Haeckelicyrtium* sp. 1 differs from *Haeckelicyrtium crickmayi* Carter (in Goričan et al. 2006) by having a higher conical part and a pronounced constriction between the abdomen and the flaring skirt. It differs from *Haeckelicyrtium* sp. A sensu Carter et al. (1998, pl. 16: 14, 15, 19–22) by its conical instead of dome-shaped outline.

Family Cuniculiformidae De Wever, 1982a

Genus *Cuniculiformis* De Wever, 1982a

Type species: *Cuniculiformis plinius* De Wever, 1982a; Turkey, Lower Pliensbachian.

Cuniculiformis plinius De Wever, 1982a

Fig. 8AA, AB.

1982a *Cuniculiformis plinius* sp. nov.; De Wever 1982a: 199, pl. 6: 17–20.
1989 *Cuniculiformis plinius* De Wever, 1982a; Spörli et al. 1989: fig. 5: 7.
1992 *Cuniculiformis plinius* De Wever, 1982a; Aita and Spörli 1992: fig. 5: 5.
1998 *Cuniculiformis plinius* De Wever, 1982a; Carter et al. 1998: 66.

Material.—Sample Rö416: stub Rö416_4 (five specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Sinemurian to Pliensbachian (Carter et al. 1998). Northern Calcareous Alps (Austria), Turkey, New Zealand.

Family Acropyramididae Haeckel, 1881

Genus *Cornutella* Ehrenberg, 1838

Type species: *Cornutella clathrata* Ehrenberg, 1838; Sicily, Italy, Miocene.

Cornutella riedeli Yao, 1979

Fig. 10P.

1979 *Cornutella*? *riedeli* sp. nov.; Yao 1979: 41, 42, pl. 11: 5–9.
1979 *Cornutella* sp. cf. *C. californica* Campbell and Clark; Yao 1979: 41, pl. 11: 1–4.
1986 *Cornutella riedeli* Yao, 1979; Takemura 1986: 68, pl. 12: 20–22.
1997 *Cornutella riedeli* Yao, 1979; Yao 1997: fig. 389.
2004 *Cornutella* sp.; Matsuoka 2004: fig. 250.

Material.—Sample Rö37: stub Rö37_6 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Toarcian to Bajocian in Japan (as published, see synonymy list). Lower Pliensbachian in the Northern Calcareous Alps, Austria (this study).

Family Williriedellidae Dumitrica, 1970

Genus *Zhamoidellum* Dumitrica, 1970

Type species: *Zhamoidellum ventricosum* Dumitrica 1970; Romania, Upper Callovian to Oxfordian.

Zhamoidellum sutnal (O'Dogherty and Gawlick, 2008)

Fig. 9M–O.

2001 *Dicolocapsa* sp.; Gawlick et al. 2001: fig. 6: 4.
2008 *Lantus sutnal* sp. nov.; O'Dogherty and Gawlick 2008: 74, pl. 1: 15, 17.

Material.—Sample Rö97: stubs Rö97_1 (three specimens), Rö97_3 (three specimens), Rö97_4 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—O'Dogherty and Gawlick (2008) assigned this species to *Lantus* because they assumed that it has four segments. Our specimens apparently have three segments but are otherwise practically identical. They only differ from the type material by being somewhat larger and by having more numerous and proportionally smaller pores on the abdomen. This species differs from *Zhamoidellum yehae* Dumitrica in Goričan et al., 2006) by the cephalothorax not being encased in the abdomen. *Zhamoidellum sutnal* closely resembles the Middle–Upper Jurassic species *Zhamoidellum ventricosum* Dumitrica, 1970 but stratigrapic ranges of these two species are disconnected.

Stratigraphic and geographic range.—Lower Pliensbachian. Northern Calcareous Alps, Austria.

Family Minocapsidae O'Dogherty, Goričan, and Gawlick, 2017

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

Type species: *Stichomitra* (?) *stecki* O'Dogherty, Goričan, and Dumitrica in O'Dogherty et al., 2006. Gets Nappe, Swiss-French Alps, Bathonian.

Remarks.—The Lower Pliensbachian occurrence on Mount Rettenstein is the oldest record of this genus. Previously, *Doliocapsa* was known from the Lower Toarcian to the Tithonian (O'Dogherty et al. 2017).

Doliocapsa sp. 1

Fig. 9X, Y.

Material.—Sample Rö37: stubs Rö37_1 (two specimens), Rö37_2 (three specimens), Rö37_4 (two specimens), Rö37_5 (six specimens); sample Rö416: stub Rö416_7 (two specimens); sample Rö417, stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—This species differs from *Doliocapsa matsuokai* (Yeh, 2009) by having a less pronounced stricture between the conical proximal conical part and the inflated last segment (Yeh 2009: 67, pl. 21: 1, 8, 20, 22). *Doliocapsa* sp. 1 is very similar to *Lantus obesus* (Yeh, 1987) but differs from the latter in having an aperture.

Family Bagotidae Pessagno and Whalen, 1982

Genus *Droltus* Pessagno and Whalen, 1982

Type species: *Droltus lyellensis* Pessagno and Whalen, 1982; Haida Gwaii, British Columbia, Canada, upper Sinemurian.

Droltus eurasiaticus Kozur and Mostler, 1990

Fig. 10A–D.

1982 *Parahsuum* (?) sp. A; Yao 1982: pl. 3: 6.
1990 *Droltus eurasiaticus* sp. nov.; Kozur and Mostler 1990: 223, pl. 17: 3, 4.
1998 *Droltus eurasiaticus* Kozur and Mostler, 1990; Yeh and Cheng 1998: 20, pl. 12: 1.
2002 *Droltus eurasiaticus* Kozur and Mostler, 1990; Whalen and Carter 2002: 116, pl. 16: 5, 6.
2006 *Droltus eurasiaticus* Kozur and Mostler, 1990; Goričan et al. 2006: 136, pl. DRO07: 1–3.

Material.—Sample Rö37: stubs Rö37_1 (two specimens), Rö37_2 (four specimens), Rö37_3 (four specimens); sample Rö416: stub Rö416_2 (three specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—*Droltus eurasiaticus* is differentiated from the closely similar *Droltus hecatensis* by its pointed proximal part and distinct apical horn.

Stratigraphic and geographic range.—Upper Rhaetian, Hettangian (Kozur and Mostler 1990), lower Sinemurian (Yeh and Cheng 1998), Lower Pliensbachian (Whalen and Carter 2002; this study). Baja California Sur, Northern Calcareous Alps (Germany, Austria), Philippines.

Droltus hecatensis Pessagno and Whalen, 1982

Fig. 10I.

1982 *Droltus hecatensis* sp. nov.; Pessagno and Whalen 1982: 121, pl. 1: 12, 13, 18, 22; pl. 4: 1, 2, 6, 10; pl. 12: 18, 19.
1988 *Droltus* sp.; Sashida 1988: 24, pl. 3: 7, 16, 17.
1989 *Droltus hecatensis* Pessagno and Whalen, 1982; Hattori 1989: pl. 12: F.
1996 *Bagotidae* gen. et sp. indet.; Pujana 1996: 138, pl. 1: 10.
1998 *Droltus hecatensis* Pessagno and Whalen, 1982; Carter et al. 1998: 63, pl. 15: 14.
2001 *Droltus hecatensis* Pessagno and Whalen, 1982; Gawlick et al. 2001: fig. 5: 13.
2002 *Droltus hecatensis* Pessagno and Whalen, 1982; Suzuki et al. 2002: 181, figs. 8 G, L, M, not H.
2002 *Droltus hecatensis* Pessagno and Whalen, 1982; Tekin 2002: 186, pl. 3: 9.
2006 *Droltus hecatensis* Pessagno and Whalen, 1982; Goričan et al. 2006: 136, pl. DRO02: 1–7.
2007 *Droltus hecatensis* Pessagno and Whalen, 1982; Longridge et al. 2007: 162, pl. 2: 20.
2009 *Droltus hecatensis* Pessagno and Whalen, 1982; Gawlick et al. 2009: 117, fig. 63: 5.

Material.—Sample Rö37: stubs Rö37_2 (one specimen), Rö37_3 (two specimens); sample Rö38: stub Rö38_1 (two specimens); sample Rö416: stub Rö416_2 (six specimens); sample Rö417: stub Rö417 (four specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—See remarks under *Droltus eurasiaticus*.

Stratigraphic and geographic range.—Rhaetian (?), Hettangian to Lower Toarcian (as published, see synonymy list). Worldwide.

Droltus laseekensis Pessagno and Whalen, 1982

Fig. 10E, F.

1982 *Droltus laseekensis* sp. nov.; Pessagno and Whalen 1982: 122, pl. 2: 5, 6, 11, 16; pl. 12: 8, 15.
1998 *Droltus laseekensis* Pessagno and Whalen, 1982; Carter et al. 1998: 63, pl. 15: 8; pl. 26: 4.
2004 *Droltus laseekensis* Pessagno and Whalen, 1982; Matsuoka 2004: fig. 199.
2006 *Droltus laseekensis* Pessagno and Whalen, 1982; Goričan et al. 2006: 138, pl. DRO03: 1–5.
2011 *Droltus laseekensis* Pessagno and Whalen, 1982; Bertinelli and Marcucci 2011: 412, pl. 2: 20.

Material.—Sample Rö38: stub Rö38_1 (one specimen); sample Rö416: stubs Rö416_2 (ten specimens), Rö416_7 (one specimen); sample Rö417: stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Hettangian to Toarcian (as published, see synonymy list). Haida Gwaii (British Columbia, Canada), Italy, Northern Calcareous Alps (Austria), Japan.

Droltus sanignacioensis Whalen and Carter, 2002

Fig. 10G, H.

1990 *Droltus* (?) sp.; De Wever et al. 1990: pl. 4: 6.
1998 *Droltus* sp.; Kashiwagi 1998: pl. 1: 12; pl. 2: 2, 3.
2001 *Droltus galerus* Suzuki, 1995; Gawlick et al. 2001: fig. 5: 14.
2002 *Droltus sanignacioensis* sp. nov.; Whalen and Carter 2002: 116, pl. 10: 7, 8. 15.
2003 *Parahsuum* sp.; Kashiwagi and Kurimoto 2003: pl. 3: 5.
2006 *Droltus sanignacioensis* Whalen and Carter, 2002; Goričan et al. 2006: 140, pl. DRO08: 1–7.
2011 *Droltus sanignacioensis* Whalen and Carter, 2002; Yeh 2011: 8, pl. 2: 7–13.

Material.—Sample Rö37: stub Rö37_3 (two specimens); sample Rö416: stub Rö416_2 (two specimens); sample

Rö417: stub Rö417 (three specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—*Droltus galerus* Suzuki, 1995 illustrated in Gawlick et al. (2001) is here assigned to *Droltus sanignacioensis* Whalen and Carter. *Droltus galerus* as defined by Suzuki (1995) has a shorter test and the pore frames on the distal half of the test are not aligned in rows.

Stratigraphic and geographic range.—Lower Pliensbachian (Carter et al. 2010). Haida Gwaii (British Columbia, Canada), Baja California Sur, Northern Calcareous Alps (Austria), Oman, Japan. Bajocian of east-central Oregon, USA (Yeh 2011).

Genus *Bagotum* Pessagno and Whalen, 1982

Type species: *Bagotum maudense* Pessagno and Whalen, 1982; California Coast Ranges, USA, Upper Pliensbachian.

Bagotum modestum Pessagno and Whalen, 1982

Fig. 10Q.

1982 *Bagotum modestum* sp. nov.; Pessagno and Whalen 1982: 120, pl. 3: 7, 16, 17.
1990 *Bagotum modestum* Pessagno and Whalen, 1982; Hori 1990: fig. 8.29.
1993 *Bagotum modestum* Pessagno and Whalen, 1982; Kashiwagi and Yao 1993: pl. 1: 8.
1998 *Bagotum modestum* Pessagno and Whalen, 1982; Kashiwagi 1998: pl. 1: 13.
2002 *Bagotum modestum* Pessagno and Whalen, 1982; Whalen and Carter 2002: 116, pl. 10: 9, 11, 12.
2003 *Bagotum modestum* Pessagno and Whalen, 1982; Goričan et al. 2003: 296, pl. 5: 22.
2004 *Lantus*? sp.; Hori 2004: pl. 1: 62 (only).
2004 *Bagotum modestum* Pessagno and Whalen, 1982; Matsuoka 2004: fig. 193.
2006 *Bagotum modestum* Pessagno and Whalen, 1982; Goričan et al. 2006: 56, pl. BAG06: 1–9.

Material.—Sample Rö40: stub Rö40_1 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Lower Pliensbachian to Lower Toarcian (Carter et al. 2010). California (USA), Baja California Sur, Northern Calcareous Alps (Austria), Slovenia, Oman, Japan.

Genus *Broctus* Pessagno and Whalen, 1982

Type species: *Broctus selwynensis* Pessagno and Whalen, 1982; Haida Gwaii, British Columbia, Canada, upper Sinemurian.

Broctus kuensis Pessagno and Whalen, 1982

Fig. 10R, S.

1982 *Broctus kuensis* sp. nov.; Pessagno and Whalen 1982: 120, pl. 1: 7; pl. 2: 17, 21.
2002 *Broctus kuensis* Pessagno and Whalen, 1982; Tekin 2002: 186, pl. 3: 7.
2006 *Broctus kuensis* Pessagno and Whalen, 1982; Goričan et al. 2006: 78, pl. BRO02: 1, 2.

Material.—Sample Rö37, stub Rö37_5 (one specimen); sample Rö416, stub Rö416_4 (four specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Sinemurian to Lower Pliensbachian (as published, see synonymy list). Haida Gwaii (British Columbia, Canada), Northern Calcareous Alps (Austria), Turkey.

Genus *Noritus* Pessagno and Whalen, 1982

Type species: *Noritus lillihornensis* Pessagno and Whalen, 1982; Haida Gwaii, British Columbia, Canada, Lower Pliensbachian.

Noritus lillihornensis Pessagno and Whalen, 1982

Fig. 10J.

1982 *Noritus lillihornensis* sp. nov.; Pessagno and Whalen: 123, pl. 5: 3, 4, 10, 15, 19; pl. 12: 1.
1987 *Noritus* sp. cf. *N. lillihornensis* Pessagno and Whalen, 1982; Yeh 1987: 55, pl 4: 11, 14.
1992 *Noritus lillihornensis* Pessagno and Whalen, 1982; Pessagno and Mizutani 1992: pl. 99: 1, 2, 9.
2004 *Noritus* sp.; Matsuoka 2004: fig. 229.
2006 *Noritus lillihornensis* Pessagno and Whalen, 1982; Goričan et al. 2006: 258, pl. NTS01: 1–3.

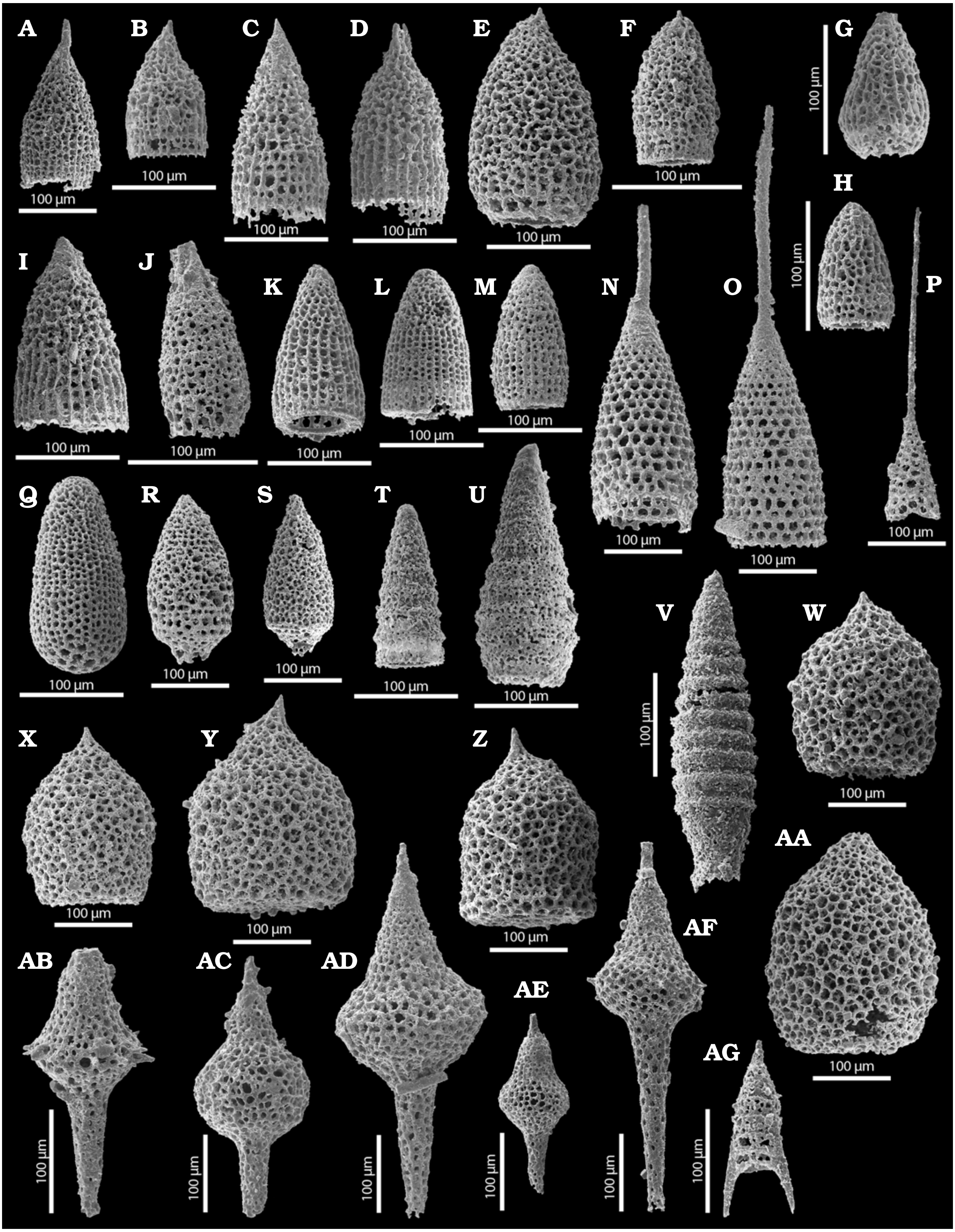
Material.—Sample Rö38: stub Rö38_1 (four specimens); sample Rö416: stub Rö416_2 (three specimens); sample Rö417: stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Lower Pliensbachian to Lower Toarcian (Carter et al. 2010). Haida Gwaii (British Columbia, Canada), Oregon (USA), Northern Calcareous Alps (Austria), Japan.

Genus *Trexus* Whalen and Carter in Carter et al., 1998

Type species: *Trexus dodgensis* Whalen and Carter in Carter et al., 1998; Haida Gwaii, British Columbia, Canada, Rhaetian to Upper Pliensbachian.

Fig. 10. Radiolarians from Mount Rettenstein, Austria, Pliensbachian, Early Jurassic. **A–D**. *Droltus eurasiaticus* Kozur and Mostler, 1990. **A**. Sample Rö416. **B–D**. Sample Rö37. **E**, **F**. *Droltus laseekensis* Pessagno and Whalen, 1982, sample Rö416. **G**, **H**. *Droltus sanignacioensis* Whalen and Carter, 2002. **G**. Sample Rö37. **H**. Sample Rö416. **I**. *Droltus hecatensis* Pessagno and Whalen, 1982, sample Rö416. **J**. *Noritus lillihornensis* Pessagno and Whalen, 1982, sample Rö416. **K**, **L**. *Parahsuum simplum* Yao, 1982. **K**. Sample Rö97. **L**. Sample Rö40. **M**. *Parahsuum ovale* Hori and Yao, 1988, sample Rö416. **N**, **O**. *Atalantria emmela* (Cordey and Carter, 1996), sample Rö37. **P**. *Cornutella riedeli* Yao, 1979, sample Rö37. **Q**. *Bagotum modestum* Pessagno and Whalen, 1982, sample Rö40. **R**, **S**. *Broctus kuensis* Pessagno and Whalen, 1982, sample Rö416. **T**. *Canoptum rugosum* Pessagno and Poisson, 1981, sample Rö37. **U**, **V**. *Canoptum reefense* (Pessagno and Whalen, 1982). **U**. Sample Rö37. **V**. Sample Rö416. **W–AA**. *Trexus dodgensis* Whalen and Carter in Carter et al., 1998. **W**. Sample Rö38. **X**, **Z**. Sample Rö416. **Y**, **AA**. Sample Rö37. **AB**. *Katroma* cf. *clara* Yeh, 1987, sample Rö37. **AC–AF**. *Katroma ninstintsi* Carter in Carter et al., 1988, sample Rö37. **AG**. *Turritus venturii* Bertinelli and Marcucci, 2011, sample Rö416. →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Trexus dodgensis Whalen and Carter in Carter et al., 1998

Fig. 10W–AA.

1998 *Trexus dodgensis* Whalen and Carter sp. nov.; Carter et al. 1998: 82, pl. 24: 11, 12, 16, 22, 23.
2001 *Trexus dodgensis* Whalen and Carter in Carter et al., 1998; Gawlick et al. 2001: fig. 2: 26; fig. 6: 5.
2002 *Trexus dodgensis* Whalen and Carter in Carter et al., 1998; Suzuki et al. 2002: 184, fig. 9D.
2002 *Trexus dodgensis* Whalen and Carter in Carter et al., 1998; Tekin 2002: 196, pl. 5: 17.
2004 *Canutus* sp.; Matsuoka 2004: fig. 213.
2006 *Trexus dodgensis* Whalen and Carter in Carter et al., 1998; Goričan et al. 2006: 382, pl. TRX01: 1, 2.
2006 *Trexus dodgensis* Whalen and Carter in Carter et al., 1998; Yeh and Yang 2006: 345, pl. 5: 28; pl. 6: 17.
2009 *Trexus dodgensis* Whalen and Carter in Carter et al., 1998; Gawlick et al. 2009: 117, fig. 63: 4.

Material.—Sample Rö37: stubs Rö37_4 (six specimens), Rö37_5 (three specimens); sample Rö38: stub Rö38_1 (three specimens); sample Rö416: stubs Rö416_2 (five specimens), Rö416_5 (one specimen); sample Rö417: stub Rö417 (nine specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Upper Hettangian to Toarcian (as published, see synonymy list). Worldwide.

Family Hsuidae Pessagno and Whalen, 1982

Genus *Parahsuum* Yao, 1982

Type species: *Parahsuum simplum* Yao, 1982; Japan, Lower Jurassic.

Parahsuum simplum Yao, 1982

Fig. 10K, L.

1982 *Parahsuum simplum* sp. nov.; Yao 1982: 61, pl. 4: 1–8.
1982 *Parahsuum simplum* Yao, 1982; Yao et al. 1982: pl. 2: 9.
2006 *Parahsuum simplum* Yao, 1982; Goričan et al. 2006: 290, pl. PHS01: 1–10 (and synonymy therein).
2006 *Parahsuum simplum* Yao, 1982; Yeh and Yang 2006: 340, pl. 8: 19, 21, 24.
2008 *Parahsuum simplum* Yao, 1982; O'Dogherty and Gawlick 2008: 73, pl. 1: 9.
2013 *Parahsuum simplum* Yao, 1982; Chiari et al. 2013: fig. 10s.

Material.—Sample Rö40: stub Rö40_1 (two specimens); sample Rö97: stub Rö97_2 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Hettangian to Aalenian (as published, see synonymy list herein and in Goričan et al. 2006). Worldwide.

Parahsuum ovale Hori and Yao, 1988

Fig. 10M.

1988 *Parahsuum ovale* sp. nov.; Hori and Yao 1988: 51, pl. 1: 3a–3e, 4a–c, 6–8, 9a, b.
2006 *Parahsuum ovale* Hori and Yao, 1988; Goričan et al. 2006: 288, pl. PHS05: 1–6 (and synonymy therein).
2011 *Parahsuum ovale* Hori and Yao, 1988; Bandini et al. 2011: pl. 8: 2; pl. 9: 6, 7.

Material.—Sample Rö416: stub Rö416_2 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Sinemurian to Toarcian (as published, see synonymy list herein and in Goričan et al. 2006). Northern Calcareous Alps (Austria), Montenegro, Oman, Tibet, Japan.

Family Canoptidae Pessagno in Pessagno et al., 1979

Genus *Canoptum* Pessagno in Pessagno et al., 1979

Type species: *Canoptum poissoni* Pessagno in Pessagno et al., 1979; Turkey, Lower Jurassic.

Remarks.—We follow O'Dogherty et al. (2009), who synonymized *Relanus* Pessagno and Whalen, 1982 with *Canoptum* Pessagno in Pessagno et al., 1979. *Relanus* was originally distinguished from *Canoptum* by having a horn and a less extensive veneer of microgranular silica (Pessagno and Whalen 1982). The horn is always very small or even lacking, and the degree of coverage with microgranular silica is not an appropriate character to distinguish different genera in fossil material. Representatives of the genus *Canoptum* are very rare in our samples.

Canoptum reefense (Pessagno and Whalen, 1982)

Fig. 10U, V.

1982 *Relanus reefensis* sp. nov.; Pessagno and Whalen 1982: 125, pl. 1: 2–4; pl. 12: 3.
1990 *Relanus hettangicus* sp. nov.; Kozur and Mostler 1990: 220, pl. 16: 1, 4, 5, 7, 10, 11, 14; pl. 17: 8, 14–16.
1990 *Relanus multiperforatus* sp. nov; Kozur and Mostler 1990: 221, pl. 16: 2, 3.
1998 *Relanus reefensis* Pessagno and Poisson, 1981; Carter et al. 1998: 65, pl. 16: 4, 5, 10, 11; pl. 26: 6.
2001 *Canoptum reefense* (Pessagno and Whalen, 1982); Gawlick et al. 2001: 43, fig. 2: 24.
2002 *Relanus reefensis* Pessagno and Whalen, 1982; Tekin 2000: 189, pl. 4: 9.

Material.—Sample Rö37: stub Rö37_1 (one specimen); sample Rö38: stub Rö38_1 (two specimens); sample Rö416: stub Rö416_5 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—In *Canoptum reefense* we group spindle-shaped distally constricted morphotypes with hoop-like segments. Postabdominal segments are covered with irregularly distributed small pores but lack a more distinct ornamentation.

Stratigraphic and geographic range.—Hettangian to lower Sinemurian (Carter et al. 1998), Lower Pliensbachian (this study). Haida Gwaii (British Columbia, Canada), Northern Calcareous Alps (Austria, Germany), Turkey.

Canoptum rugosum Pessagno and Poisson, 1981

Fig. 10T.

1981 *Canoptum rugosum* sp. nov.; Pessagno and Poisson 1981: 61, pl. 11: 5–9; pl. 13: 3; pl. 14: 1, 2.
1982 *Canoptum rugosum* Pessagno and Poisson, 1981; Pessagno and Whalen 1982: 125, pl. 6: 7.

1987 *Canoptum rugosum* Pessagno and Poisson, 1981; Hattori 1987: pl. 18: 10–12.
1988 *Canoptum rugosum* Pessagno and Poisson, 1981; Sashida 1988: 23, pl. 2: 13,14, 22, 23.
1988 *Canoptum rugosum* Pessagno and Poisson, 1981; Li 1988: pl. 1: 1.
1989 *Canoptum rugosum* Pessagno and Poisson, 1981; Hattori 1989: pl. 13: F–I.
1995 *Canoptum rugosum* Pessagno and Poisson, 1981; Suzuki 1995: pl. 8: 2.
1998 *Canoptum rugosum* Pessagno and Poisson, 1981; Kashiwagi 1998: pl. 1: 16, pl. 2: 11.
2003 *Canoptum rugosum* Pessagno and Poisson, 1981; Goričan et al. 2003: 297, pl. 5: 11.
2003 *Canoptum* cf. *rugosum* Pessagno and Poisson, 1981; Kashiwagi and Kurimoto 2003: pl. 3: 14.
2004 *Canoptum rugosum* Pessagno and Poisson, 1981; Matsuoka 2004: fig. 244.
2005 *Canoptum* sp. cf. *C. rugosum* Pessagno and Poisson, 1981; Kashiwagi et al. 2005: pl. 5: 1.
2006 *Canoptum rugosum* Pessagno and Poisson, 1981; Goričan et al. 2006: 88, pl. CAN14: 1–6.

Material.—Sample Rö37: stub Rö37_1 (one specimen); sample Rö417: stub Rö417 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Lower Pliensbachian to Lower Toarcian (Carter et al. 2010). Haida Gwaii (British Columbia, Canada), Northern Calcareous Alps (Austria), Slovenia, Turkey, Oman, Tibet, Japan.

Family Parvicingulidae Pessagno, 1977a

Genus *Atalantria* Cordey and Carter, 2007

Type species: *Atalanta emmela* Cordey and Carter, 1996; Haida Gwaii, British Columbia, Canada, lower Sinemurian to Pliensbachian.

Atalantria emmela (Cordey and Carter, 1996)

Fig. 10N, O.

1991 Gen. indet. Z sp. A; Tipper et al. 1991: pl. 8: 8.
1996 *Atalanta emmela* n. gen., sp. nov.; Cordey and Carter 1996: 447, pl. 1: 1–3.
1998 *Atalanta emmela* Cordey and Carter, 1996; Cordey 1998: 126, pl. 25: 1.
1998 *Atalanta emmela* Cordey and Carter, 1996; Carter et al. 1998: 67, pl. 24: 13.
2001 *Atalanta emmela* Cordey and Carter, 1996; Gawlick et al. 2001: fig. 2: 22.
2002 *Atalanta emmela* Cordey and Carter, 1996; Whalen and Carter 2002: 128, pl. 16: 1, 8.
2002 *Atalanta emmela* Cordey and Carter, 1996; Tekin 2002: 190, pl. 4: 10, 11.
2002 *Atalanta* sp. A; Tekin 2002: 190, pl. 4: 12.
2006 *Atalanta emmela* Cordey and Carter, 1996; Goričan et al. 2006: 48, pl. ATA02: 1, 2.
2008 *Atalanta emmela* Cordey and Carter, 1996; O'Dogherty and Gawlick 2008: 73, pl. 1: 7.
2009 *Atalanta emmela* Cordey and Carter, 1996; Gawlick et al. 2009: 117, fig. 63: 1.

Material.—Sample Rö37: stub Rö37_6 (five specimens); sample Rö417: stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—Our specimens have a much longer horn than typical *Atalantria emmela* (Cordey and Carter, 1996). Transverse ridges are less raised. These characters are considered as intraspecific variability; *Atalanta* sp. A of Tekin (2002) is therefore included in the synonymy.

Stratigraphic and geographic range.—Sinemurian to Lower Pliensbachian (Carter et al. 1998, 2010). Haida Gwaii and coastal Canadian Cordillera (British Columbia, Canada), Baja California Sur, Northern Calcareous Alps (Austria), Turkey.

Family Eucyrtidiidae Ehrenberg, 1847

Subfamiliy Favosyringiinae Steiger, 1992

Genus *Katroma* Pessagno and Poisson, 1981, emend. Whalen and Carter in Carter et al. 1998

Type species: *Katroma neagui* Pessagno and Poisson, 1981; Turkey, Lower Pliensbachian.

Katroma cf. *clara* Yeh, 1987

Fig. 10AB.

Material.—Sample Rö37: stub Rö37_5 (one specimen); sample Rö38: stub Rö38_1 (two specimens); sample Rö40: stub Rö40_1 (one specimen); sample Rö97: stub Rö97_2 (one specimen); sample Rö416: stub Rö416_4 (one specimen); sample Rö417: stub Rö417 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Remarks.—Due to the broken horn, the species assignment is uncertain. Typical *Katroma clara* is known from the Lower Pliensbachian to the Lower Toarcian (Carter et al. 2010). It was found in Oregon (USA), Baja California Sur, Northern Calcareous Alps (Austria), Montenegro, Greece, Turkey, Oman, Japan, and Sikhote-Alin (eastern Russia).

Katroma ninstintsi Carter in Carter et al., 1988

Fig. 10AC–AF.

1987 *Katroma* sp. A; Yeh 1987: 81, pl. 3: 1; pl. 6: 4, 14.
1988 *Katroma ninstintsi* Carter sp. nov.; Carter et al. 1988: 60, pl. 2: 4, 9.
1992 *Katroma* sp.; Pessagno and Mizutani 1992: pl. 99: 6, 10, 11, 15.
1996 *Katroma* sp. A; Tumanda Maater et al. 1996: 181, fig. 4.15.
1998 *Katroma* sp. A; Yeh and Cheng 1998: 30, pl. 7: 7, 10, 11, 15.
2001 *Syringocapsa inflata* (Yeh 1987); Gawlick et al. 2001: fig. 5: 9.
2006 *Katroma ninstintsi* Carter in Carter et al., 1988; Goričan et al. 2006: 228, pl. KAT14: 1–10.
2009 *Syringocapsa inflata* (Yeh 1987); Gawlick et al. 2009: 118, fig. 64: 7.
2011 *Katroma* cf. *ninstintsi* Carter in Carter et al., 1988; Bandini et al. 2011: pl. 8: 19; pl. 10: 6.
2017 *Katroma* sp. cf. *K. ninstintsi* Carter in Carter et al., 1988; Bragin and Bragina 2017: 10, pl. 2: 1.

Material.—Sample Rö37: stubs Rö37_1 (two specimens), Rö37_2 (one specimen), Rö37_3 (four specimens), Rö37_5 (five specimens); sample Rö38: stub Rö38_1 (11 specimens); sample Rö416,: stub Rö416 (five specimens); sample Rö417: stub Rö417 (three specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Pliensbachian (Carter et al. 2010). Haida Gwaii (British Columbia, Canada), Oregon (USA), Costa Rica, Northern Calcareous Alps (Austria), Philippines, Japan, Sikhote-Alin (eastern Russia).

Unnamed family pro Eucyrtidiidae Ehrenberg, 1847

Remarks.—*Lantus* is included in the unnamed family pro Eucyrtidiidae as used by O'Dogherty et al. (2009).

Genus *Lantus* Yeh, 1987

Type species: *Lantus sixi* Yeh, 1987; East-Central Oregon, USA, Upper Pliensbachian to Lower Toarcian.

Lantus obesus (Yeh, 1987)

Fig. 9P–S.

1987 *Pseudoristola obesa* sp. nov.; Yeh 1987: 96, pl. 14: 11, 12.
1997 *Pseudoristola obesa* Yeh, 1987; Yao 1997: pl. 15: 724.
2001 *Stichocapsa obesa* (Yeh, 1987); Gawlick et al. 2001: fig. 2: 13; fig. 5: 6.
2003 *Stichocapsa convexa* Yao, 2003; Kashiwagi and Kurimoto 2003: pl. 4: 1, 2.
2005 *Sethocapsa* sp.; Hori 2005: pl. 8: 29, 30, 50.
2006 *Lantus obesus* (Yeh, 1987); Goričan et al. 2006: 234, LAN01: 1–10.
2008 *Lantus obesus* (Yeh, 1987); O'Dogherty and Gawlick 2008: 74, pl. 1: 14.
2009 *Stichocapsa obesa* (Yeh, 1987); Gawlick et al. 2009: 118, fig. 64: 9.
2013 *Lantus obesus* (Yeh, 1987); Chiari et al. 2013: fig. 10l.

Material.—Sample Rö37: stubs Rö37_1 (five specimens), Rö37_3 (nine specimens), Rö37_5 (one specimen); sample Rö40: stub Rö40_1 (three specimens); sample Rö97: stubs Rö97_1 (four specimens), Rö97_2 (seven specimens), Rö97_3 (seven specimens), Rö97_4 (two specimens); sample Rö416: stubs Rö416_4 (four specimens), Rö416_5 (two specimens); sample Rö417: stub Rö417 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Lower Pliensbachian to Middle–Upper Toarcian (Carter et al. 2010). Haida Gwaii (British Columbia, Canada), Oregon (USA), Northern Calcareous Alps (Austria), Greece, Oman.

Lantus praeobesus Carter in Goričan et al., 2006

Fig. 9T–W.

1988 *Hemicryptocephalis dengqensis* sp. nov.; Li 1988: 330, pl. 1: ?4, ?10, not 5, 6.
1993 *Stichocapsa* sp.; Kashiwagi and Yao 1993, pl. 1: 5.
1998 *Lantus* sp. A; Yeh and Cheng 1998: 34, pl. 12: 9.
? 2001 *Stichocapsa* sp.; Kashiwagi 2001: fig. 6.5.
2006 *Lantus praeobesus* sp. nov. Carter in Goričan et al. 2006: 236, pl. LAN04: 1–13.

Material.—Sample Rö37: stub Rö37_5 (one specimen); sample Rö38: stub Rö38_1 (one specimen); sample Rö40; stub Rö40_1 (four specimens); sample Rö97: stubs Rö97_1 (two specimens), Rö97_2 (16 specimens), Rö97_3 (four specimens), Rö97_4 (seven specimens); sample Rö417: stub Rö417 (two specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Pliensbachian (Carter et al. 2010). Haida Gwaii (British Columbia, Canada), Northern Calcareous Alps (Austria), Oman, Philippines, Japan.

Nassellaria incertae sedis

Genus *Ares* De Wever, 1982a

Type species: *Ares armatus* De Wever, 1982a; Turkey, Lower Pliensbachian.

Ares rettensteinensis Cifer sp. nov.

Fig. 9H–L.

2002 *Ares* sp. A; Whalen and Carter 2002: 142, pl. 15: 6, 13.
? 2002 *Cuniculiformis* sp. A; Tekin 2002: 186, pl. 3: 11.
? 2002 *Ares* sp. cf. A. *moresbyensis* Whalen and Carter in Carter et al. 1998; Tekin 2002: 192, pl. 5: 9.
2006 *Ares sutherlandi* Whalen and Carter in Carter et al. 1998; Goričan et al. 2006: 44, pl. ARS02: 2, not 1.
2009 *Ares armatus* De Wever, 1982a; Gawlick et al. 2009: 117, fig. 62: 6.

ZooBank LCID: urn:lsid:zoobank.org:act:E32A34DF-6847-4C8F-9679-B2540E6C969D

Etymology: Named after Mount Rettenstein, where the holotype was found.

Type material: Holotype, PMS 2394, sample Rö37: 182455 (Fig. 9H). Paratypes, PMS 2396, sample Rö416: 170431; PMS 2393, sample Rö37: 171137; PMS 2394, sample Rö37: 182462; PMS 2395, sample Rö38: 182323, all from type locality.

Type locality: Mount Rettenstein, Northern Calcareous Alps, Austria.

Type horizon: Sample Rö37, grey marly limestone, Lower Pliensbachian.

Material.—Sample Rö37: stubs Rö37_3 (two specimens), Rö37_6 (11 specimens); sample Rö38: stub Rö38_1 (three specimens); sample Rö416: stub Rö416_4 (three specimens), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Diagnosis.—*Ares* with rectilinear or upward directed straight ventral spine.

Description.—Test with small, dome-shaped cephalis with prominent broad, tapering horn; horn approximately two-thirds length of cephalis and thorax combined, three-bladed with rounded longitudinal ridges and grooves of similar width. Thorax is increasing in width distally and expanded in a skirt in some specimens (Fig. $9L_1$). Pore frames are irregularly arranged, small- to medium in size, polygonal. Ventral spine rectilinear or directed slightly upward and having a slight downward curving trend in some specimens. Dorsal spine directed slightly downward and may have a slight downward curving trend. Dorsal spine less robust than the ventral spine and often not preserved. Apical horn is directed slightly towards the dorsal spine, and forms an approximate 90° angle with both the dorsal and the ventral spine.

Dimensions.—See Table 4.

Table 4. Dimensions (in µm) of *Ares rettensteinensis* Cifer sp. nov. N, number of specimens measured.

	Length (excluding horn)	Width of thorax	Maximum length of short arm
N	12	12	5
Holotype	140	102	75
Maximum	163	146	75
Minimum	98	77	25
Mean	129	107	50

Remarks.—*Ares rettensteinensis* Cifer sp. nov. differs from *Ares mexicoensis* Whalen and Carter, 2002, *Ares moresbyensis* Whalen and Carter, 1998, and *Ares sutherlandi* Whalen and Carter, 1998, by having the ventral spine rectilinear or directed upwards. *Ares armatus* De Wever, 1982 has the ventral spine also slightly upward directed in some cases, but the spines of *Ares armatus* are longer and more curved.

Stratigraphic and geographic range.—Lower Pliensbachian. Northern Calcareous Alps (Austria), Baja California Sur, ?Turkey.

Genus *Turritus* Bertinelli and Marcucci, 2011

Type species: *Turritus venturii* Bertinelli and Marcucci, 2011; Italy, upper Hettangian–Sinemurian to Toarcian–Aalenian (?).

Turritus venturii Bertinelli and Marcucci, 2011

Fig. 10AG.

1987 Gen. 2 sp. B; Hattori 1987: pl. 21: 7.
1988 Gn. 10 sp.; Hattori 1988: pl. 9: G.
1989 Gen. 1 sp. A; Hattori 1989: pl. 16: G.
1989 Gen. 1 spp.; Hattori 1989: pl. 16: H, I, pl. 21: L, pl. 22: A.
1989 Gen. sp. indet.; Hattori 1989: pl. 36: E, F.
1996 *Bipedis* (?) sp. A; Hori et al. 1996: pl. 2: 17.
2004 *Bipedis* (?) sp.; Matsuoka 2004: fig. 134.
2011 *Turritus venturii* sp. nov.; Bertinelli and Marcucci 2011: 418, pl. 3: 21–24.

Material.—Sample Rö416: stub Rö416_5 (one specimen), Mount Rettenstein, Northern Calcareous Alps, Austria, Lower Pliensbachian.

Stratigraphic and geographic range.—Hettangian to Toarcian (as published, see synonymy list). Italy, Northern Calcareous Alps (Austria), Philippines, Japan, New Zealand.

Radiolarian biostratigraphy

The age of the radiolarian assemblages was determined first with stratigraphic ranges of genera (according to O’Dogherty et al. 2009), that allow for a substage precision, and second with stratigraphic ranges of species according to Carter et al. (2010) who divided the Lower Pliensbachian into four radiolarian zones (Fig. 11).

The most precise age determination with genera (Table 5) was possible in samples Rö37 and Rö417. With first appearance datums (FADs) of *Lantus*, *Noritus*, and *Triactoma* and last appearance datum (LAD) of *Atalantria* we assigned the sample Rö417 to the Early Pliensbachian. Sample Rö37 was also assigned to the Early Pliensbachian, based on FADs of *Cyclastrum*, *Lantus*, and *Triactoma* and LADs of *Atalantria* and *Stauracanthocircus*. A similar fauna was found in samples Rö38 and Rö416. Based on FADs of *Acaeniotylopsis*, *Cyclastrum*, *Lantus*, *Noritus*, and *Triactoma* and LADs of *Beatricea*, *Bipedis*, *Haeckelicyrtium*, and *Palaeosaturnalis*, the age of sample Rö416 could be constrained to the Pliensbachian. The sample Rö38 was assigned to the Pliensbachian, based on FADs of *Lantus* and *Noritus* and on LADs of *Beatricea*, *Bipedis*, and *Haeckelicyrtium*. Samples Rö40 and Rö97 have the lowest generic diversity, and consequently the most imprecise age determination. Based on FAD of *Lantus* and LADs of *Katroma* and *Bagotum*, the age of sample Rö40 was determined as Early Pliensbachian to Early Toarcian. The sample Rö97 was assigned to the same age, based on FADs of *Lantus* and *Zhamoidellum* and on LAD of *Katroma*.

A more precise age determination is enabled on species level (Table 6). Among nominal taxa of the Pliensbachian zones established by Carter et al. (2010), only *Katroma clara* Yeh, 1987 is possibly present but it is rare and poorly preserved (here identified as *K.* cf. *clara*; Fig. 10AB).

Sample Rö416 contains *Noritus lillihornensis* Pessagno and Whalen, 1982, which first appears in the *Zartus mostleri–Pseudoristola megaglobosa* Zone. The sample further contains *Cyclastrum scammonense* Whalen and Carter, 2002, which disappears in the *Zartus mostleri–Pseudoristola megaglobosa* Zone. Based on these FAD and LADs, the sample Rö416 could be assigned to the *Zartus mostleri–Pseudoristola megaglobosa* Zone. However, the sample also contains *Bipedis douglasi* Whalen and Carter in Carter et al., 1998, which last appears at the Sinemurian–Pliensbachian boundary (Carter et al. 2010), and *Thurstonia minutaglobus* Whalen and Carter in Carter et al., 1998, known to disappear in the uppermost Sinemurian (Carter et al. 1998). It is likely that these two species extend at least to the lowermost Pliensbachian *Canutus tipperi–Katroma clara* Zone.

Noritus lillihornensis Pessagno and Whalen, 1982, and *Bipedis douglasi* Whalen and Carter in Carter et al., 1998, co-occur also in sample Rö417, in which we also identified *Atalantria emmela* (Cordey and Carter, 1996) and *Droltus sanignacioensis* Whalen and Carter, 2002, which appear in the *Canutus tipperi–Katroma clara* Zone and disappear in the *Gigi fustis–Lantus sixi* Zone. Another important species is *Palaeosaturnalis tetraradiatus* (Kozur and Mostler, 1990) which makes its last appearance in the *Canutus tipperi–Katroma clara* Zone. Based on these taxa the assignment to the *Canutus tipperi–Katroma clara* Zone is the most probable, but the discrepancy between *Noritus lillihornensis* Pessagno and Whalen, 1982, and the older *Bipedis douglasi* Whalen and Carter in Carter et al., 1998, and *Palaeosaturnalis tetraradiatus* (Kozur and Mostler, 1990) should be kept in mind. This zonal assignment reinforces the inference that sample Rö416 collected stratigraphically below Rö417 cannot be younger than the *Canutus tipperi–Katroma clara* Zone.

Table 5. Occurrence of genera in the samples studied. Stratigraphic ranges based on O’Dogherty et al. 2009; genera with blank ranges were described after 2009. Sample age: Rö417, Rö37, Early Pliensbachian; Rö416, Rö38, Pliensbachian; Rö40, Rö97, Early Pliensbachian–Early Toarcian.

Genus	Stratigraphic range	Rö416	Rö417	Rö37	Rö38	Rö40	Rö97
Acaeniotylopsis	Lower Pliensbachian–Lower Oxfordian	●					
Anaticapitula	Middle Hettangian–Upper Barremian	●	●		●		
Archaeocenosphaera	Middle Anisian–Upper Campanian	●	●	●	●	●	●
Ares	Lower Sinemurian–Upper Bajocian	●	●	●	●		
Atalantria	Lower Hettangian–Lower Pliensbachian		●	●			
Bagotum	Lower Sinemurian–Lower Toarcian					●	
Beatricea	Upper Hettangian–Upper Pliensbachian	●		●	●		
Bipedis	Upper Norian–Upper Pliensbachian	●	●	●	●		
Broctus	Upper Sinemurian–Lower Toarcian	●		●			
Canoptum	Ladinian–Upper Bajocian	●	●	●	●		
Cornutella	Late Anisian–Recent			●			
Crucella	Lower Carnian–Upper Campanian	●	●		●		
Cuniculiformis	Upper Sinemurian–Lower Toarcian	●					
Cyclastrum	Lower Pliensbachian–Lower Albian	●		●			
Doliocapsa	–	●	●	●			
Droltus	Lower Hettangian–Lower Bajocian	●	●	●	●		
Dumitricaella	Lower Pliensbachian–Upper Aalenian	●					
Empirea	Lower Carnian–Lower Tithonian	●	●				
Farcus	Upper Hettangian–Upper Aalenian		●	●	●		
Gorgansium	Upper Norian–Upper Valanginian	●	●	●	●		
Haeckelicyrtium	Lower Carnian–Upper Pliensbachian	●	●	●	●		
Katroma	Lower Sinemurian–Lower Toarcian	●	●	●	●	●	●
Lantus	Lower Pliensbachian–Lower Kimmeridgian	●	●	●	●	●	●
Liassobetraccium	Middle Hettangian–Lower Sinemurian			●			
Loupanus	Lower Rhaetian–Lower Tithonian	●	●		●		
Napora	Upper Sinemurian–Lower Turonian	●	●	●	●		●
Noritus	Lower Pliensbachian–Lower Toarcian	●	●		●		
Novamuria	Upper Anisian–Lower Hauterivian	●	●	●			
Orbiculiformella	Lower Rhaetian–Lower Cenomanian		●	●			
Palaeosaturnalis	Lower Carnian–Upper Pliensbachian	●	●	●			
Pantanellium	Upper Carnian–Upper Aptian	●		●	●		
Parahsuum	Lower Hettangian–Upper Kimmeridgian			●		●	●
Paronaella	Lower Rhaetian–Upper Coniacian	●	●	●	●		
Praeconocaryomma	Middle Hettangian–Upper Campanian	●	●			●	●
Pseudoheliodiscus	Lower Carnian–Upper Bajocian			●			●
Saitoum	Upper Hettangian–Upper Barremian	●	●	●	●		
Stauracanthocircus	Upper Hettangian–Lower Pliensbachian			●			
Stauromesosaturnalis	Upper Hettangian–Lower Callovian						●
Thurstonia	Lower Hettangian–Lower Toarcian	●	●	●			
Tozerium	Lower Hettangian–Lower Sinemurian	●	●	●	●		
Trexus	Upper Hettangian–Lower Toarcian	●	●	●	●		
Triactoma	Lower Pliensbachian–Upper Turonian	●	●	●			
Turritus	–	●					
Xiphostylus	Upper Pliensbachian–Upper Bathonian			●			
Zhamoidellum	?Lower Pliensbachian–Upper Tithonian						●

Sample Rö37 contains *Canoptum rugosum* Pessagno and Poisson, 1981, *Paronaella grahamensis* Carter in Carter et al., 1988, *Katroma* cf. *clara* and *Lantus obesus* (Yeh, 1987). All appear in the *Canutus tipperi–Katroma clara* Zone, whereas *Atalantria emmela* (Cordey and Carter, 1996) and *Droltus sanignacioensis* Whalen and Carter, 2002, disappear in the *Gigi fustis–Lantus sixi* Zone. Supposedly older species *Bipedis douglasi* Whalen and Carter in Carter et al., 1998, and *Thurstonia minutaglobus* Whalen and Carter in Carter et al., 1998, are also present similarly as in samples Rö416 and Rö417; an assignment to the *Canutus tipperi–Katroma clara* Zone and *Zartus mostleri–Pseudoristola megaglobosa* Zone is thus the most probable. We also identified *Liassobetraccium* so far known up to the lower Sinemurian and *Xiphostylus* so far recorded in Upper Pliensbachian and younger strata (O’Dogherty et al. 2009).

Rö38 contains *Noritus lillihornensis* Pessagno and Whalen, 1982, and *Bipedis fannini* Carter, 1988, which first ap-

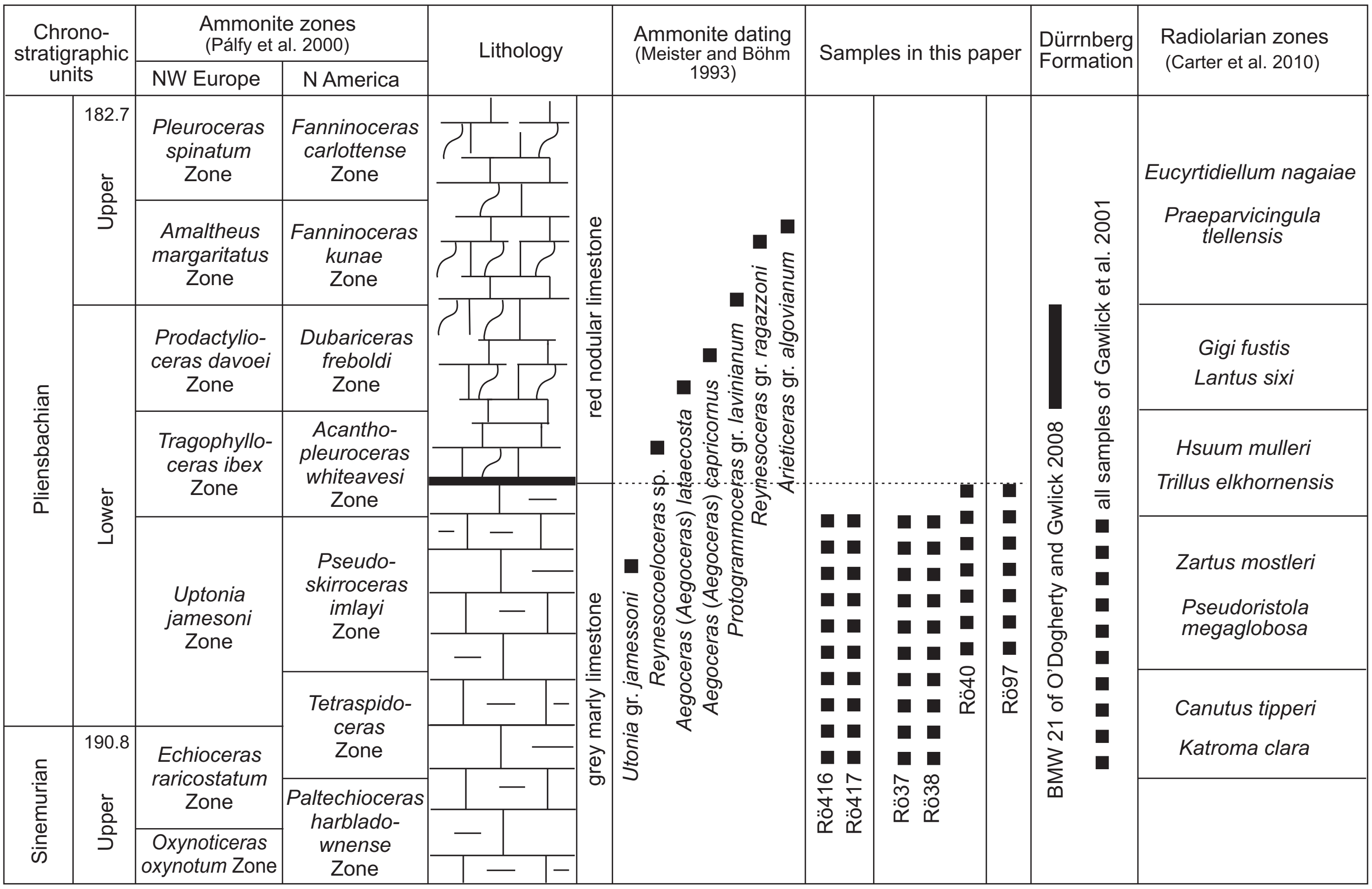

Fig. 11. Combined radiolarian and ammonite dating of Lower Jurassic deposits on Mount Rettenstein. The upper age limit of the grey marly limestone is constrained with ammonites, determined in the overlying red nodular limestone, numerical age after Gradstein et al. (2012). Revised radiolarian dating of samples from the Dürrnberg Formation is shown for comparison.

pear in the *Zartus mostleri–Pseudoristola megaglobosa* Zone. *Bipedis fannini* Carter, 1988, and *Lantus praeobesus* Carter in Goričan et al., 2006, extend to the *Eucyrtidiellum nagaiae–Praeparvicingula tlellensis* Zone. Similar to samples Rö416, Rö417, and Rö37, *Bipedis douglasi* Whalen and Carter in Carter et al., 1998, is present, which suggests the lowermost Pliensbachian *Canutus tipperi–Katroma clara* Zone. Therefore an age between the *Canutus tipperi–Katroma clara* and *Zartus mostleri–Pseudoristola megaglobosa* Zone is the most probable.

In samples Rö40 and Rö97 we were able to identify only eight and 12 species, respectively. Specimens in both samples are well-preserved but the diversity is lower than in the other samples. We also note that *Praeconocaryomma* is abundant in these two samples but absent in the others. The co-occurrence of *Praeconocaryomma bajaensis* Whalen in Goričan et al., 2006, with *Lantus praeobesus* Carter in Goričan et al., 2006, in samples Rö40 and Rö97 assigns an age from the *Zartus mostleri–Pseudoristola megaglobosa* Zone to the *Eucyrtidiellum nagaiae–Praeparvicingula tlellensis* Zone, that is, to an interval that covers practically the entire Pliensbachian except its base. In sample Rö97, *Stauromesosaturnalis deweveri* Kozur and Mostler, 1990 with FAD in the *Zartus mostleri–Pseudoristola megaglobosa* Zone is also stratigraphically important.

If we consider the ammonite dating of the upper part of the grey marly limestone and the overlying red nodular limestone, we can narrow the age of radiolarian samples (Fig. 11). The lithological boundary between the grey marly limestone and the red nodular limestone is placed in the Ibex Ammonite Zone (Meister and Böhm 1993), which is equivalent to the *Hsuum mulleri–Trillus elkhornensis* Radiolarian Zone (Carter et al. 2010). Ammonite dating and the normal stratigraphic evolution from the grey marly limestone to the red nodular limestone suggest that the radiolarian samples, all collected in the grey limestone, cannot be younger than the Lower Pliensbachian *Hsuum mulleri–Trillus elkhornensis* Zone.

Discussion

Taxa with extended ranges.—Five genera were found for the first time in the Lower Pliensbachian. *Tozerium* was supposed to have disappeared in the early Sinemurian (Carter et al. 1998; O'Dogherty et al. 2009) and only a rare isolated occurrence has been recorded in the Bajocian (Yeh 2011).

Table 6. Occurrence of species in the samples studied. Stratigraphic ranges are given according to Carter et al. 2010 (UA Uppermost Sinemurian–Aalenian), unless otherwise indicated: [1] after Carter et al. 1998; [2] after Bertinelli and Marcucci 2011; [3] Tekin 2002; [4] Kozur and Mostler 1990; [5] Pessagno and Blome 1980; [6] Yeh and Yang 2006. Species with blank ranges are either long ranging or have a sparse record. Sample age: Rö416, Rö417, Rö37, Rö38, *Canutus tipperi–Katroma clara* (UA 02–05) to *Zartus mostleri–Pseudoristola megaglobosa* (UA 06–09); Rö40, Rö97, *Zartus mostleri–Pseudoristola megaglobosa* (UA 06–09) to *Eucyrtidiellum nagaiae–Praeparvicingula tlellensis* (UA 19–23).

Species	Stratigraphic range	Rö416	Rö417	Rö37	Rö38	Rö40	Rö97
Acaeniotylopsis ghostensis (Carter in Carter et al., 1988)	Lower Pliensbachian–Aalenian, UA 11–40	●					
Anaticapitula anatiformis (De Wever, 1982)	Middle Hettangian[1]–middle Upper Toarcian, UA 01–29	●		●	●		
Anaticapitula parvireticulata Bertinelli and Marcucci, 2011	Middle and Upper Hettangian[2]		●		●		
Archaeocenosphaera laseekensis Pessagno and Yang in Pessagno et al., 1989	Lower Hettangian–Lower Sinemurian[1]	●	●	●	●	●	●
Ares rettensteinensis Cifer sp. nov.	–	●		●	●		
Atalantria emmela (Cordey and Carter, 1996)	Upper Sinemurian–Lower Pliensbachian, UA 01–14		●	●			
Bagotum modestum Pessagno and Whalen, 1982	Lower Pliensbachian–Lower Toarcian, UA 02–27					●	
Beatricea? *argescens* (Cordey, 1998)	–	●		●	●		
Bipedis fannini Carter in Carter et al., 1988	Pliensbachian, UA 06–22				●		
Bipedis douglasi Whalen and Carter in Carter et al., 1988	Sinemurian, UA 01–01	●	●	●	●		
Broctus kuensis Pessagno and Whalen, 1982	–	●		●			
Canoptum reefense (Pessagno and Whalen, 1982)	Hettangian–Lower Sinemurian[1]	●		●	●		
Canoptum rugosum Pessagno and Poisson, 1981	Pliensbachian–Lower Toarcian, UA 02–27		●	●			
Cornutella riedeli Yao, 1979	–			●			
Crucella angulosa Carter in Carter et al., 1988	Pliensbachian–Toarcian, UA 06–32	●					
Crucella jadeae Carter and Dumitrica in Goričan et al., 2006	–		●				
Crucella squama (Kozlova, 1971)	–	●	●		●		
Cuniculiformis plinius De Wever, 1982	–	●					
Cyclastrum scammonense Whalen and Carter, 2002	Lower Pliensbachian, UA 02–09	●					
Doliocapsa sp. 1	–	●	●	●			
Droltus eurasiaticus Kozur and Mostler, 1990	–	●		●			
Droltus hecatensis Pessagno and Whalen, 1982	–	●	●	●	●		
Droltus laseekensis Pessagno and Whalen, 1982	–	●	●		●		
Droltus sanignacioensis Whalen and Carter, 2002	Lower Pliensbachian, UA 02–16	●	●	●			
Dumitricaella? *cucurbitina* De Wever, 1982	–	●					
Empirea sp. 1	–	●	●				
Farcus cf. *kozuri please* Yeh, 1987	–			●			
Farcus graylockensis Pessagno, Whalen, and Yeh, 1986	–		●	●	●		
Gorgansium alpinum Kozur and Mostler, 1990	Hettangian and Sinemurian[3]	●	●	●			
Gongarsium blomei Kozur and Mostler, 1990	Hettangian and Sinemurian[3]	●	●	●			
Gorgansium gongyloideum Kishida and Hisada, 1985	–	●	●	●	●		
Haeckelicyrtium sp. 1	–	●	●	●	●		
Katroma cf. *clara* Yeh, 1987	Lower Pliensbachian–Lower Toarcian, UA 03–26	●	●	●	●	●	●
Katroma ninstintsi Carter in Carter et al., 1988	Pliensbachian, UA 02–23	●	●	●	●		
Lantus obesus (Yeh, 1987)	Pliensbachian–Toarcian, UA 02–30	●	●	●		●	●
Lantus praeobesus Carter in Goričan et al., 2006	Pliensbachian, UA 02–20		●	●	●	●	●
Liassobetraccium bavaricum (Kozur and Mostler, 1990)	Hettangian[4]			●			
Liassobetraccium verticispinosum (Kozur and Mostler, 1990)	Hettangian[4]			●			
Loupanus pliensbachicus Cifer sp. nov.	–	●	●		●		
Loupanus sp. 1	–		●				
Napora sp. B sensu Whalen and Carter in Carter et al., 1998	–	●	●	●			
Noritus lillihornensis Pessagno and Whalen, 1982	Lower Pliensbachian–Lower Toarcian, UA 06–26	●	●		●		
Novamuria macfarlanei (Whalen and Carter in Carter et al., 1998)	Lower Hettangian–Lower Sinemurian[1]	●	●	●			
Orbiculiformella sp. 1	–		●	●			
Palaeosaturnalis liassicus Kozur and Mostler, 1990	Middle Hetangian–Lower Sinemurian[1]		●	●			
Palaeosaturnalis tetraradiatus (Kozur and Mostler, 1990)	Lower Pliensbachian, UA 01–04		●				
Palaeosaturnalis subovalis Kozur and Mostler, 1990	–	●	●				

Pantanellium browni Pessagno and Blome, 1980	–			●			
Pantanellium haidaense Pessagno and Blome, 1980	Upper Sinemurian[5]			●	●		
Pantanellium skedansense Pessagno and Blome, 1980	–			●			
Parahsuum ovale Hori and Yao, 1988	Upper Sinemurian–Upper Toarcian, UA 01–33	●					
Parahsuum simplum Yao, 1982	Upper Sinemurian–Aalenian, UA 01–36					●	●
Paronaella corpulenta De Wever, 1981	Lower Pliensbachian–Lower Toarcian, UA 01–27		●		●		
Paronaella grahamensis Carter in Carter et al., 1988	Lower Pliensbachian–Aalenian, UA 03–34	●	●	●	●		
Praeconocaryomma bajaensis Whalen in Goričan et al., 2006	Lower Pliensbachian–Aalenian, UA 06-38					●	●
Praeconocaryomma decora gr. Yeh, 1987	Upper Lower Pliensbachian–Aalenian, UA 17–35					●	●
Praeconocaryomma parvimamma Pessagno and Poisson, 1981	–						●
Pseudoheliodiscus radiosus De Wever, 1981	–						●
Pseudoheliodiscus robustospinosus Kozur and Mostler, 1990	Hettangian–Sinemurian [4, 6]			●			
Saitoum keki De Wever, 1982	–	●	●		●		
Stauracanthocircus asymmetricus Kozur and Mostler, 1990	Hettangian [4]		●	●			
Stauromesosaturnalis deweveri Kozur and Mostler, 1990	Lower Pliensbachian–Aalenian, UA 09–40						●
Thurstonia robusta Cifer sp. nov.	–	●	●	●	●		
Thurstonia minutaglobus Whalen and Carter in Carter et al., 1998	Hettangian–Sinemurian[1]	●		●			
Thurstonia timberensis Whalen and Carter in Carter et al., 1998	Upper Sinemurian–Lower Toarcian, UA 01–26	●	●				
Tozerium filzmoosense Cifer sp. nov.	–	●	●	●			
Trexus dodgensis Whalen and Carter in Carter et al., 1998	–	●	●	●	●		
Triactoma aff. *rosespitensis* (Carter in Carter et al., 1998)	Lower Pliensbachian–middle Upper Toarcian, UA 10–32			●			
Turritus venturii Bertinelli and Marcucci, 2011	Upper Hettangian [2]	●					
Xiphostylus simplus Yeh, 1987	Upper Pliensbachian–Aalenian, UA 19–39			●			●
Zhamoidellum sutnal (O'Dogherty and Gawlick, 2008)	–						●

Liassobetraccium was also known to have disappeared in the early Sinemurian (O'Dogherty et al. 2009). On the other hand, *Doliocapsa* was known to first appear in the Early Toarcian (O'Dogherty et al. 2017) and *Xiphostylus* in the Late Pliensbachian (O'Dogherty et al. 2009). The postulated range of *Loupanus* was from the Early Rhaetian to the Early Tithonian (O'Dogherty et al. 2009) but the only species described so far, *Loupanus thompsoni* Carter, 1993, comes from the Rhaetian (Carter 1993) and rare undescribed specimens were illustrated from the Middle Jurassic (Yeh and Pessagno 2013: pl. 25:12, 22; also see De Wever et al. 2001: fig. 81: 11).

Several species were also identified, which have not been found in samples of this age up until now. The species that supposedly became extinct before the Early Pliensbachian are *Bipedis douglasi* Whalen and Carter in Carter et al. 1998, *Canoptum reefense* (Pessagno and Whalen, 1982), *Liassobetraccium bavaricum* (Kozur and Mostler, 1990), *Liassobetraccium verticispinosum* (Kozur and Mostler, 1990), *Palaeosaturnalis liassicus* Kozur and Mostler, 1990, *Pantanellium browni* Pessagno and Blome, 1980, *Pseudoheliodiscus robustospinosus* Kozur and Mostler, 1990, *Stauracanthocircus asymmetricus* Kozur and Mostler, 1990, and *Thurstonia minutaglobus* Whalen and Carter in Carter et al. 1998. The species that were thought to first appear after the Early Pliensbachian are *Cornutella riedeli* Yao, 1979, and *Xiphostylus simplus* Yeh, 1987 (for previously stated stratigraphic ranges see the section on systematic paleontology and Table 6). All samples also contained specimens of either *Archaeocenosphaera,* some species of *Gorgansium*, or *Novamuria*, which were occasionally used as index fossils for the Hettangian and Sinemurian. Species of these genera are not suitable for age determination due to their simple structure, which does not change significantly from the Triassic to the Cretaceous.

Comparison with assemblages of the Dürrnberg Formation (Austria).—The Dürrnberg Formation was studied in shorter sections, preserved as blocks in the Hallstatt Mélange (Sandlingalm Formation in Fig. 2), which were then combined to a possible lithostratigraphic evolution (e.g., O'Dogherty and Gawlick 2008; Gawlick et al. 2009). The lower part of the formation (Hettangian) is represented by dark grey, partly siliceous marl. The upper Hettangian to the Sinemurian is represented by bioturbated grey siliceous limestone with marl intercalations, followed by Pliensbachian dark-grey siliceous marly limestone. During the Pliensbachian the marl content increased towards the top. The overlying Lower Jurassic Birkenfeld Formation consists of siliceous marl (Gawlick et al. 2009).

Radiolarian faunas from the Dürrnberg Formation were studied at the Hallein–Berchtesgaden Hallstatt Zone (Gawlick et al. 2001) as well as at the Teltschengraben (O'Dogherty and Gawlick 2008). The fauna studied in Gawlick et al. (2001) was assigned to the Hettangian to Sinemurian, based on the range charts available at that time (Carter et al. 1998). Since Carter et al. (2010) updated the ranges of many Early Jurassic taxa and integrated them in a global radiolarian zonation for the Pliensbachian to Aalenian, a re-evaluation of these samples is discussed below. We compare the fauna studied

Table 7. Comparison of faunas from Mount Rettenstein and from the Dürrnberg Formation (data from Gawlick et al. 2001; O'Dogherty and Gawlick 2008). Stratigraphic ranges are given according to Carter et al. 2010 (UA Uppermost Sinemurian–Aalenian). All taxa from the Dürrnberg Formation and all age-diagnostic taxa from Mount Rettenstein samples are included. Sample BER 30/1/D is placed in the last column of the table, because it is stratigraphically higher than BER 30/1/F (Gawlick et al. 2001). Sample age: Rö416, Rö37, KB 2/98, BER 30/1/A–D, BER 30/1/F, *Canutus tipperi–Katroma clara* (UA 02–05) to *Zartus mostleri–Pseudoristola megaglobosa* (UA 06–09); BMW-21, *Gigi fusti–Lantus sixi* (UA 12–18; UA 14, according to Carter et al. 2010).

Species	Strati-graphic range	This study						O'Dogherty and Gawlick 2009	Gawlick et al. 2001					
		Rö416	Rö417	Rö37	Rö38	Rö40	Rö97	BMW-21	KB 2/98	BER 30/1/A	BER 30/1/B	BER 30/1/C	BER 30/1/F	BER 30/1/D
Acaeniotylopsis ghostensis (Carter in Carter et al., 1998)	UA 11–40	●												
Anaticapitula anatiformis (De Wever, 1982)	UA 01–29	●	●		●				●	●				
Archaeocenosphaera laseekensis Pessagno and Yang in Pessagno et al., 1989	–	●	●	●	●	●	●		●	●		●	●	
Archaeohagiastrum longipes Baumgartner in Baumgartner et al., 1995	UA 14–41							●						
Archaeotriastrum hirsutum De Wever, 1981	–							●						
Atalantria emmela Cordey and Carter, 1996	UA 01–14		●	●				●	●					
Bagotum erraticum Pessagno and Whalen, 1982	–										●			
Bagotum maudense Pessagno and Whalen, 1982	UA 02–26										●			
Bagotum modestum Pessagno and Whalen, 1982	UA 02–27					●		●						
Beatricea c*hristovalensis* Whalen and Carter in Carter et al., 1998	UA 01–20								cf.					
Bipedis douglasi Whalen and Carter in Carter et al., 1998	UA 01–01	●	●	●	●									
Bipedis yaoi Hori in Goričan et al., 2006	UA 04–12													●
Broctus kuensis Pessagno and Whalen, 1982	–	●		●										
Canoptum dixoni Pessagno and Whalen, 1982	UA 01–21							●						
Canoptum reefense (Pessagno and Whalen, 1982)	–	●		●	●				●					
Canoptum rugosum Pessagno and Poisson, 1981	UA 02–27		●	●										
Canoptum triassicum Yao, 1982	–								●					
Charlottea amurensis Whalen and Carter in Carter et al., 1998	UA 01–02								●					
Crucella angulosa Carter in Carter et al., 1998	UA 06–32	●												
Crucella spongase De Wever, 1981	UA 14–18							●						
Cuniculiformis plinius De Wever, 1982	–	●												
Cyclastrum scammonense Whalen and Carter, 2002	UA 02–09	●												
Doliocapsa sp. 1	–	●		●				●						
Droltus hecatensis Pessagno and Whalen, 1982	–	●	●	●	●					●	●			
Droltus laseekensis Pessagno and Whalen, 1982	–	●	●		●									
Droltus sanignacioensis Whalen and Carter, 2002	UA 02–16	●	●	●							●			
Empirea hasta Whalen and Carter in Carter et al., 1998	–								●					
Foremania sandilandsensis Whalen and Carter in Carter et al., 1998	UA 01–18							●						
Gorgansium gongyloideum Kishida and Hisada, 1985	–	●	●	●	●									●
Hagiastrum majusculum Whalen and Carter in Carter et al., 1998	UA 01–40							●						
Homoeoparonaella lowryensis Whalen and Carter, 2002	UA 03–20							●						
Katroma angusta Yeh, 1987	UA 02–24							●						
Katroma bicornus De Wever, 1982	UA 05–26							●						
Katroma brevitubus Dumitrica and Goričan in Goričan et al., 2006	UA 08–26							●						
Katroma cf. *clara* Yeh, 1987	UA 03–26	●	●	●	●	●	●							
Katroma elongata Carter in Goričan et al., 2006	UA 01–20									●	●	●	●	●
Katroma ninstintsi Carter in Carter et al., 1988	UA 02–23	●	●	●	●					●	●			
Lantus obesus (Yeh, 1987)	UA 02–30	●	●	●				●	●		●			

Lantus praeobesus Carter in Goričan et al., 2006	UA 02–20		●	●	●	●	●							
Noritus lillihornensis Pessagno and Whalen, 1982	UA 06–26	●	●		●									
Novamuria macfarlanei (Whalen and Carter in Carter et al., 1998)	–	●	●	●						●	●	●	●	●
Novamuria impensa (Whalen and Carter in Carter et al., 1998)	–								●		●			
Orbiculiformella callosa Yeh, 1987	–							●						
Orbiculiformela radiata De Wever, 1981	–							cf.						
Palaeosaturnalis liassicus Kozur and Mostler, 1990	–		●	●					●					
Palaeosaturnalis tetraradiatus Kozur and Mostler, 1990	UA 01–04		●						cf.					
Palaeosaturnalis schaafi Kozur and Mostler, 1990	–											●		
Pantanellium browni Pessagno and Blome, 1980	–			●					●					
Pantanellium inornatum Pessagno and Poisson, 1981	UA 03–22			●				●					●	
Pantanellium kluense Pessagno and Blome, 1980	–								●					
Pantanellium skedansense Pessagno and Blome, 1980	–			●										
Paradroltus mitterndorfensis O'Dogherty and Gawlick, 2008	–							●						
Parahsuum edenshawi (Carter in Carter et al., 1988)	UA 06–26							●						
Parahsuum levicostatum Takemura, 1986	–											●		●
Parahsuum longiconicum Sashida, 1988	UA 10–35							●						
Parahsuum mostleri (Yeh, 1987)	UA 06–27							●						
Parahsuum ovale Hori and Yao, 1988	UA 01–33	●									●			
Parahsuum simplum Yao, 1982	UA 01–36					●	●	●						
Paronaella bona (Yeh, 1987)	–							●						
Paronaella corpulenta De Wever, 1981	UA 01–27		●	●										
Paronaella grahamensis Carter in Carter et al., 1988	UA 03–34	●	●	●	●				●	cf.				
Paronaella gemmata De Wever, 1982	–								●					
Paronaella tripla De Wever, 1981	–							●						
Pobum infinitum (Pessagno and Poisson, 1981)	–							●						
*Praeconocaryomma bajaensis*Whalen in Goričan et al., 2006	UA 06–38					●	●							
Praeconocaryomma decora gr. Yeh, 1987	UA 17–35					●	●							
Praeconocaryomma magnimamma (Rüst, 1989)	–									aff.		aff.	aff.	aff.
Praeconocaryomma sarahae Carter in Goričan et al., 2006	UA 02–20							●			●	●		●
Saitoum keki De Wever, 1982	–	●	●		●					●				●
Saitoum levium De Wever, 1981	–										●			
Thurstonia minutaglobus Whalen and Carter in Carter et al., 1998	–	●		●							●			
Thurstonia timberensis Whalen and Carter in Carter et al., 1998	UA 01–26	●	●											
Trexus dodgensis Whalen and Carter in Carter et al., 1998	–	●	●	●	●				●					●
Triactoma rosespitensis (Carter in Carter et al., 1988)	UA 10–32			aff.				●						
Xiphostylus simplus Yeh, 1987	UA 19–39			●			●							
Zhamoidellum sutnal (O'Dogherty and Gawlick, 2008)	–						●	●				●	●	

herein with the described radiolarian species of Gawlick et al. (2001) and O'Dogherty and Gawlick (2008; Table 7).

Radiolarian faunas from other siliceous Lower Jurassic sedimentary rocks in the Northern Calcareous Alps have been described only seldom. Hettangian radiolarians were described by Kozur and Mostler (1990) from the Kirchstein Limestone of the Bavaric units and from the Kendlbach Formation of the Tirolic units by Gawlick et al. (2009) (Fig. 2). In these younger Sinemurian to Pliensbachian siliceous grey bedded limestone radiolarians are poorly preserved. Instead spicules occur in large quantities (e.g., Mostler 1989a, b).

The following re-evaluation of the samples from Gawlick et al. (2001) was conducted according to the global radiolarian zonation of Carter et al. (2010) and according to the results of this study. Sample KB2/98 contains *Archaeocenosphaera laseekensis* Pessagno and Yang in Pessagno et al., 1989 (= *Cenosphaera laseekensis* in Gawlick et al. 2001), *Novamuria impensa* (Whalen and Carter in Carter et al., 1998) (= *Amuria impensa* in Gawlick et al. 2001), *Pantanellium browni* Pessagno and Blome, 1980 (= *Sphaerostylus kluensis* in Gawlick et al. 2001), *Palaeosaturnalis liassicus* Kozur and Mostler, 1990, and *Trexus dodgensis* Whalen and Carter in Carter et al., 1998. The fauna also includes *Anaticapitula anatiformis* (De Wever 1982a) (= *Jacus* cf. *anatiformis* in Gawlick et al. 2001), *Atalantria emmela* (Cordey and Carter, 1996) (= *Atalanta emmela* in Gawlick et al. 2001), and *Palaeosaturnalis tetraradiatus* (Kozur and Mostler, 1990) (= *Praehexasaturnalis* cf. *tetraradiatus* in Gawlick et al. 2001), as well as the aforementioned *Palaeosaturnalis liassicus* Kozur and Mostler and *Trexus dodgensis* Whalen and

Carter in Carter et al., 1998, which all continue at least into the lower Pliensbachian (Goričan et al. 2006). Additionally, the sample also contains *Lantus obesus* (Yeh, 1987) (= *Stichocapsa* sp. in Gawlick et al. 2001) and *Paronaella grahamensis* Carter in Carter et al., 1988, which first appear in the Pliensbachian (Carter et al. 2010). The fauna of Gawlick et al. (2001) is very similar to the fauna studied at Mount Rettenstein and can be assigned to the uppermost Sinemurian to Lower Pliensbachian. Based on the assemblage, the age of the sample KB2/98 is *Canutus tipperi–Katroma clara* to *Zartus mostleri–Pseudoristola megaglobosa* Zone. The sample also contains two supposedly older species, *Archaeocenosphaera laseekensis* Pessagno and Yang in Pessagno et al., 1989, and *Empirea hasta* Whalen and Carter in Carter et al., 1998, which were also identified in the samples studied herein. The former age determination was also based on *Canoptum reefense* (Pessagno and Whalen, 1982) and *Sphaerostylus kluensis* (in Gawlick et al. 2001), which we determined as *Pantanellium browni*), but these taxa were also identified in our samples from Mount Rettenstein. KB2/98 furthermore contains *Beatricea* cf. *christovalensis* Whalen and Carter in Carter et al., 1998, which was interpreted by Gawlick et al. (2001) to be an index taxon for the lower Sinemurian. However, this species also occurs in the Pliensbachian (Carter et al. 2010).

Re-evaluation of samples BER 30/1/A, 30/1/B, 30/1/C, 30/1/D, and 30/1/F (Gawlick et al. 2001) from a continuous section in the Hallein–Berchtesgaden Hallstatt Zone according to Carter et al. (2010) and this study suggests a similar age assignment. Sample BER 30/1A contains *Katroma ninstintsi* Carter, 1988 (= *Syringocapsa inflata* in Gawlick et al. 2001) and *Paronaella* cf. *grahamensis* Carter in Carter et al., 1988, which first appear in the lowermost Pliensbachian. Furthermore, the sample contains *Katroma elongata* Carter in Goričan et al., 2006 (= *Syringocapsa angusta*, *Syringocapsa coliformis*, and *Gigi* aff. *fustis* in Gawlick et al. 2001), *Praeconocaryomma* aff. *magnimamma* (Rüst, 1898), and *Anaticapitula anatiformis* (De Wever, 1982) (= *Jacus anatiformis* in Gawlick et al. 2001).

Sample 30/1/B contains *Bagotum maudense* Pessagno and Whalen, 1982, *Droltus sanignacioensis* Whalen and Carter, 2002 (= *Droltus galerus* in Gawlick et al. 2001), *Katroma ninstintsi* Carter in Carter et al., 1988 (= *Syringocapsa inflata* in Gawlick et al. 2001), and *Lantus obesus* (Yeh, 1987) (= *Stichocapsa obesa* in Gawlick et al. 2001), which first appear in the lowermost Pliensbachian. The sample also contains *Katroma elongata* Carter in Goričan et al., 2006 (= *Syringocapsa angusta*, *Syringocapsa coliformis*, and *Gigi* aff. *fustis* in Gawlick et al. 2001) and *Parahsuum ovale* Hori and Yao, 1988.

Sample 30/1/C contains common Pliensbachian taxa: *Zhamoidellum* sutnal (O'Dogherty and Gawlick, 2008) (= *Dicolocapsa* sp. in Gawlick et al. 2001), *Praeconocaryomma sarahae* Carter in Goričan et al., 2006 (= *Praeconocaryomma media* in Gawlick et al. 2001), *Praeconocaryomma* aff. *magnimamma* (Rüst, 1898), and *Katroma elongata* Carter in Goričan et al., 2006 (= *Syringocapsa coliformis* and *Syringocapsa inflata* in Gawlick et al. 2001). This sample also contains the genera *Novamuria* and *Archaeocenosphaera*.

Sample 30/1/F contains *Pantanellium inornatum* Pessagno and Poisson, 1981 (= *Sphaerostylus inornatum* in Gawlick et al. 2001). This species appears in the lowermost Pliensbachian. The sample furthermore contains the genus *Zhamoidellum*, which appears in the lower Pliensbachian. *Praeconocaryomma* aff. *magnimamma* (Rüst, 1898) was also identified in this sample.

Sample 30/1/D contains *Bipedis yaoi* Hori in Goričan et al., 2006 (= *Bipedis* sp. in Gawlick et al. 2001) which appears in the Lower Pliensbachian. It furthermore contains *Praeconocaryomma media* Pessagno and Poisson, 1981, *Trexus dodgensis* Whalen and Carter in Carter et al., 1998, *Praeconocaryomma* aff. *magnimamma* (Rüst, 1898), and *Katroma elongata* Carter in Goričan et al., 2006 (= *Syringocapsa coliformis* and *Syringocapsa inflata* in Gawlick et al. 2001).

Based on these faunas we can assign the samples from the Hallein–Berchtesgaden Hallstatt Zone to two Lower Pliensbachian radiolarian zones: *Canutus tipperi–Katroma clara* Zone and *Zartus mostleri–Pseudoristola megaglobosa* Zone. Formerly Gawlick et al. (2001) assigned all these samples to the upper Hettangian to Sinemurian, based on the presence of Hettangian–Sinemurian taxa *Archaeocenosphaera laseekensis* Pessagno and Yang in Pessagno et al., 1989, *Novamuria impensa* (Whalen and Carter in Carter et al., 1998), and *Novamuria macfarlanei* (Whalen and Carter in Carter et al., 1998), which we consider as unreliable taxa for age determination.

Another locality for the Dürrnberg Formation is the Teltschengraben slide (O'Dogherty and Gawlick 2008). The studied sample BMW-21 was originally assigned to the lowermost Upper Pliensbachian (O'Dogherty and Gawlick, 2008) but later corrected to the upper Lower Pliensbachian (Carter et al. 2010). The sample was included to construct the zonation of Carter et al. (2010) and assigned to the *Gigi fustis–Lantus sixi* Zone (UA 14, see Carter et al. 2010: fig. 5). The assemblage from BMW-21, compared to the assemblage from Mount Rettenstein, lacks *Cyclastrum scammonense* Whalen and Carter, 2002, *Palaeosaturnalis tetraradiatus* (Kozur and Mostler, 1990), and *Bipedis douglasi* Whalen and Carter in Carter et al., 1998, which only appear in the lower Lower Pliensbachian. On the other hand, BMW-21 contains *Crucella spongase* De Wever, 1981, and *Archaeohagiastrum longipes* Baumgartner in Baumgartner et al., 1995 that first appear in the upper Lower Pliensbachian and are missing in the samples from Mount Rettenstein. The comparison supports the assignment of the samples from Mount Rettenstein in the lower Lower Pliensbachian and, thus, a somewhat older age than that of the assemblage from BMW-21.

Comparison with the assemblage of the Gümüşlü Allochthon (Turkey).—The radiolarian assemblage of sample 1662D collected in light grey bedded limestone of the

Gümüşlü allochthonous unit was extensively studied in the 1980s by De Wever (1981a, b, 1982a, b), Pessagno and Poisson (1981), and later by Dumitrica (in Goričan et al. 2006) and is one of the best preserved Pliensbachian radiolarian assemblages of the Tethyan realm. The sample was recently assigned to the *Gigi fustis–Lantus sixi* Zone (UA18) by Carter et al. (2010). The sample 1662D contains some taxa that were also found in our studied samples, such as *Anaticapitula anatiformis* (De Wever, 1982), *Canoptum rugosum* Pessagno and Poisson, 1981, *Cuniculiformis plinius* De Wever, 1982, and *Katroma clara* Yeh, 1987. Several taxa were identified in 1662D, but were not identified in our samples, like *Ares armatus* De Wever, 1982, *Ares cuniculiformis* Dumitrica and Whalen in Goričan et al., 2006, *Bipedis calvabovis* De Wever, 1982, *Crucella mijo* De Wever, 1981, *Crucella spongase* De Wever, 1981, *Foremania sandilandsensis* gr. Whalen and Carter in Carter et al., 1998, *Gigi fustis* De Wever, 1982, *Katroma bicornus* De Wever, 1982, *Pseudoheliodiscus yaoi* gr. Pessagno, 1981, and *Thetis oblonga* De Wever, 1982. These differences are in accordance with a slightly older age of our samples. However, the absence of some taxa in our samples is not necessarily related to an age difference but may be due to the fact that the assemblages are less well-preserved and less complete than that of sample 1662D.

Conclusions

The Rettenstein succession sensu stricto consists of Lower Jurassic grey marly limestone, upper Lower Pliensbachian to Upper Pliensbachian red nodular limestone, Lower Toarcian red marl, Middle Jurassic red calcareous *Bositra* marl, Upper Oxfordian debris-flow deposits and radiolarite, and the Upper Oxfordian–Tithonian shallowing-upward carbonate sequence of the Plassen Formation. Six samples from three localities in the Lower Jurassic grey marly limestone were examined for radiolarian taxonomy and biostratigraphy.

Radiolarian assemblages are well-preserved and diverse. Seventy-one species belonging to 45 genera are described. Four species are new: *Tozerium filzmoosense* Cifer sp. nov., *Loupanus pliensbachicus* Cifer sp. nov., *Thurstonia*? *robusta* Cifer sp. nov., and *Ares rettensteinensis* Cifer sp. nov. Based on radiolarian fauna, the oldest samples are assigned to the *Canutus tipperi–Katroma clara* Zone which is the lowest radiolarian zone in the Pliensbachian. Radiolarians in the upper part of the sampled unit indicate an interval from the *Zartus mostleri–Pseudoristola megaglobosa* Zone to the *Eucyrtidiellum nagaiae–Praeparvicingula tlellensis* Zone, which covers the rest of the Pliensbachian. Based on previous ammonite data, indicating that the lithological boundary with the overlying red marly limestone lies in the *Tragophylloceras ibex* Ammonite Zone (Meister and Böhm 1993), we narrowed the age of the studied radiolarian samples to the early Early Pliensbachian. Some genera have yet not been found in samples of this age. These are: *Doliocapsa*, *Liassobetraccium*, *Loupanus*, *Tozerium*, and *Xiphostylus*.

Correlative assemblages were previously found in the Dürrnberg Formation and assigned to the Hettangian–Sinemurian (Gawlick et al. 2001); their age is here revised to the early early Pliensbachian. The assemblages from Mount Rettenstein are somewhat older than the late Early Pliensbachian assemblages of the Dürrnberg Formation (O'Dogherty and Gawlick 2008) and of the famous radiolarian sample 1662D from Turkey (De Wever 1982b with references).

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References

Aita, Y. and Spörli, K.B. 1992. Tectonic and paleobiogeographic significance of radiolarian microfaunas in the Permian to Mesozoic basement rocks of the North Island, New Zealand. *Paleogeography, Palaeoclimatology, Palaeoecology* 96: 103–125.

Auer, M., Gawlick, H.-J., and Schlagintweit, F. 2006. Mount Rettenstein southwest of the Dachstein Massif—a structurally controlled, isolated occurrence of Jurassic strata at the southern rim of the Northern Calcareous Alps. *In*: M. Tessadri-Wackerle (ed.), *PANGEO Austria 2006, Conference Series*, 7–8. Innsbruck University Press, Insbruck.

Auer, M., Gawlick, H.-J., Suzuki, H., and Schlagintweit, F. 2009. Spatial and temporal development of siliceous basin and shallow-water carbonate sedimentation in Oxfordian Northern Calcareous Alps. *Facies* 55: 63–87.

Baumgartner, P.O. 1980. Late Jurassic Hagiastridae and Patulibracchiidae (Radiolaria) from the Argolis Peninsula (Peloponnesus, Greece). *Micropaleontology* 26: 274–322.

Baumgartner, P.O., O'Dogherty, L., Goričan, Š., Dumitrica-Jud, R., Dumitrica, P., Pillevuit, A., Urquhart, E., Matsuoka, A., Danelian, T., Bartolini, A., Carter, E.S., De Wever, P., Kito, N., Marcucci, M., and Steiger, T. 1995. Radiolarian catalogue and systematics of Middle Jurassic to Early Cretaceous Tethyan genera and speciesn. *In*: P.O. Baumgartner, L. O'Dogherty, Š. Goričan, E. Urquhart, A. Pillevuit, and P. De Wever (eds.), *Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: Occurrences, Systematics, Biochronology*, 37–688. Mémoires de Géologie, Lausanne.

Bandini, A.N., Baumgartner, P.O., Flores, K., Dumitrica, P., and Jackett, S.-J. 2011. Early Jurassic to early Late Cretaceous radiolarians from Santa Rosa accretionary complex (Northwestern Costa Rica). *Ofioliti* 36: 1–35.

Bertinelli, A. and Marcucci, M. 2011. Middle and Late Hettangian radiolarians from Mt. Camicia succession (Gran Sasso, Central Apennines, Italy). *Rivista Italiana di Paleontologia e Stratigrafia* 117: 399–421.

Bragin, N. and Bragina, L. 2017. Early and Middle Jurassic (Pliensbachian to Bajocian) Radiolaria from cherts of Kiselevka-Manoma accretionary complex (Amur River, Eastern Russia). *Ofioliti* 42: 1–19.

Campbell, A.S. 1954. Radiolaria. *In*: R.C. Moore (ed.), *Treatise on Invertebrate Paleontology*, 11–195. Geological Society of America Special Paper and University of Kansas Press, Lawrence.

Carter, E.S. 1993. Biochronology and paleontology of uppermost Triassic (Rhaetian) radiolarians, Queen Charlotte Islands, British Columbia, Canada. *Mémoires de Géologie (Lausanne)* 11: 1–175.

Carter, E.S. 1994. Evolutionary Trends in latest Norian through Hettangian radiolarians from the Queen Charlotte Islands, British Columbia. *Geobios* 17: 111–119.

Carter, E.S. and Hori, R.S. 2005. Global correlation of the radiolarian faunal change across the Triassic–Jurassic boundary. *Canadian Journal of Earth Sciences* 42: 777–790.

Carter, E.S., Cameron, B.E.B., and Smith, P.L. 1988. Lower and Middle Jurassic radiolarian biostratigraphy and systematic paleontology, Queen Charlotte Islands, British Columbia. *Geological Survey of Canada, Bulletin* 386: 1–109.

Carter, E.S., Goričan, Š., Guex, J., O'Dogherty, De Wever, P., Dumitrica, P., Hori, R.S., Matsuoka, A., and Whalen, P. A. 2010. Global radiolarian zonation for the Pliensbachian, Toarcian and Aalenian. *Palaeogeography, Palaeoclimatology, Palaeoecology* 297: 401–419.

Carter, E.S., Whalen, P.A., and Guex, J. 1998. Biochronology and paleontology of Lower Jurassic (Hettangian and Sinemurian) radiolarians, Queen Charlotte Islands, British Columbia. *Geological Survey of Canada, Bulletin* 496: 1–162.

Chiari, M., Baumgartner, P.O., Bernoulli, D., Bortolli, V., Marcucci, M., Photiades, A., and Principi, G. 2013. Late Triassic, Early and Middle Jurassic Radiolaria from ferromanganese-chert "nodules" (Angelokastron, Argolis, Greece): evidence for prolonged radiolarite sedimentation in the Maliac-Vardar Ocean. *Facies* 59: 391–424.

Cifer, T., Goričan, Š., Gawlick, H.-J., and Auer, M. 2017. Pliensbachian (Early Jurassic) radiolarians from Mount Rettenstein, Northern Calcareous Alps, Austria. *Radiolaria: newsletter of the International Association of Radiolarists* 40: 174–175.

Cordey, F. 1998. Radiolaires des complexes d'accrétion de la Cordillère Canadienne (Colombie-Britannique). *Commission Géologique du Canada, Bulletin* 509: 1–209.

Cordey, F. and Carter, E.S. 1996. New Nassellaria (Radiolaria) from the Lower Jurassic of the Canadian Cordillera. *Canadian Journal of Earth Sciences* 33: 444–451.

Cordey, F. and Carter, E.S. 2007. *Atalantria*, new name for *Atalanta* Cordey and Carter, 1996 (Nasselaria, Radiolaria). *Micropaleontology* 56: 430.

Črne, A.E. and Goričan, Š. 2008. The Dinaric Carbonate Platform margin in the Early Jurassic: a comparison between successions in Slovenia and Montenegro. *Bollettino della Società geologica italiana* 127: 389–405.

De Wever, P. 1981a. Hagiastridae, Patulibracchiidae et Spongodiscidae (radiolaires polycystines) du Lias de Turquie. *Revue de Micropaléontologie* 24: 27–50.

De Wever, P. 1981b. Parasaturnalidae, Pantanellidae et Sponguridae (radiolaires polycystynes) du Lias de Turquie. *Revue de Micropaléontologie* 24: 138–156.

De Wever, P. 1982a. Nassellaria (radiolaires polycystines) du Lias de Turquie. *Revue de Micropaléontologie* 24: 189–232.

De Wever, P. 1982b. Radiolaires du Trias et du Lias de la Tethys (Systématique, Stratigraphie). *Société Géologique du Nord, Publication* 7: 1–599.

De Wever, P., Bourdillon de Grissac, C., and Béchennec, F. 1990. Permian to Cretaceous radiolarian biostratigraphic data from Hawasina Complex, Oman Mountains. *In*: A.H.F. Robertson, M.P. Searle, and A.C. Ries (eds.), *The Geology and Tectonics of the Oman region, Special Publications of the Geological Society of London*, 225–238. Geological Society of London, London.

De Wever, P., Dumitrica, P., Caulet, J.P., Nigrini, C., and Caridroit, M. 2001. *Radiolarians in the Sedimentary Record*. 533 pp. Gordon and Breach Science Publishers, Amsterdam,

Deflandre, G. 1953. Radiolaires fossiles. *In*: P.P. Grassé (ed.), *Traite de Zoologie*, 389–436. Masson, Paris.

Donofrio, D.A. and Mostler, H. 1978. Zur Verbreitung der Saturnalidae (Radiolaria) im Mesozoikum der Nördlichen Kalkalpen und Südalpen. *Geologisch Paläontologische Mitteilungen Innsbruck* 7: 1–55.

Dumitrica, P. 1970. Cryptocephalic and cryptothoracic Nassellaria in some Mesozoic deposits of Romania. *Revue roumaine de Géologie, Géophysique et Géographie (série Géologie)* 14: 45–124.

Dumitrica, P. 1978. Triassic Palaeoscenidiidae and Entactiniidae from the Vicentinian Alps (Italy) and eastern Carpathians (Romania). *Dari de Seama ale sedintelor, Institutul de Geologie si Geofizica, Bucuresti* 64: 39–54.

Dumitrica, P. 1982. Foremanellinidae, a new family of Triassic Radiolaria. *Dari de Seama ale Sedintelor, Institutul de Geologie si Geofizica, Bucuresti* 67: 75–82.

Dumitrica, P. 1995. Systematic framework of Jurassic and Cretaceous Radiolaria. *In*: P.O. Baumgartner, L. O'Dogherty, Š. Goričan, E. Urquhart, A. Pillevuit, and P. De Wever (eds.), Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: Occurrences, Systematics, Biochronology. *Mémories de Géologie (Lausanne)* 1995: 19–35.

Dumitrica, P. and Zügel, P. 2003. Lower Tithonian mono- and dicrytid Nassellaria (Radiolaria) from the Solnhofen area (southern Germany). *Geodiversitas* 25: 5–72.

Dunikowski, E. 1882. Die Spongien, Radiolarien und Foraminiferen der unterliassischen Schichten vom Schafberg bei Salzburg. *Denkschriften der Akademie der Wissenschaften, Wien. Mathematisch-Naturwissenschaftlige Classe* 45: 163–194.

Ehrenberg, C.G. 1838. Über die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. *Abhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin* 1838: 59–147.

Ehrenberg, C.G. 1847. Über die mikroskopischen kieselschaligen Polycystinen als mächtige Gebirgsmasse von Barbados und über das Verhältniss deraus mehr als 300 neuen Arten bestehenden ganz eigenthümlichen Formengruppe jener Felsmasse zu den jetzt lebenden Thieren und zur Kreidebildung Eine neue Anregung zur Erforschung des Erdlebens. *Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin* 1847: 40–60.

Ehrenberg, C.G. 1875. Fortsetzung der mikrogeologischen Studien als Gesammt-Uebersicht der mikroskopischen Paläontologie gleichartig analysirter Gebirgsarten der Erde, mit specieller Rücksicht auf den Polycystinen-Mergel von Barbados. *Abhandlungen der Königlichen Preussichen Akademie der Wissenschaften zu Berlin* 1874: 1–225.

Frisch, W. and Gawlick, H.-J. 2003. The nappe structure of the central Northern Calcareous Alps and its disintegration during Miocene tectonic extrusion—a contribution to understanding the orogenic evolution of the Eastern Alps. *International Journal of Earth Sciences* 92: 712–727.

Ganss, O., Kümel, F., and Spengler, E. 1954. Erläuterungen zur geologischen Karte der Dachsteingruppe. *Wissenschaftliche Alpenvereinshefte* 15: 1–82.

Gawlick, H.-J. and Frisch, W. 2003. The Middle to Late Jurassic clastic radiolaritic flysch sediments in the Northern Calcareous Alps: sedimentology, basin evolution, and tectonics—an overview. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* 230: 163–213.

Gawlick, H.-J., and Suzuki, H. 1999. Zur stratigraphischen Stellung der Strubbergschichten in den Nördlichen Kalkalpen (Callovium–Oxfordium). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* 211: 233–262.

Gawlick, H.-J., Frisch, W., Vercsei, A., Steiger, T., and Böhm, F. 1999. The change from rifting to thrusting in the Northern Calcareous Alps as recorded in Jurassic sediments. *Geologische Rundschau* 87: 644–657.

Gawlick, H.-J., Janauschek, W., Missoni, S., Suzuki, H., Diersche, V., and Zankl, H. 2003. Fazies, Alter und Komponentenbestand der jurassichen Kieselsedimente mit polymikten Brekzien (Callovium–Oxfordium) des Büchsenkopfes im Nationalpark Berchtesgaden und deren Bedeutung für die tektonische und paläogeographische Interpretation der Berchtesgadener Kalkalpen (Deutschland). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* 228: 275–304.

Gawlick, H.J., Missoni, S., Schlagintweit, F., Suzuki, H., Frisch, W., Krystyn, L., Blau, J., and Lein, R. 2009. Jurassic Tectonostratigraphy of the Austroalpine Domain. *Journal of Alpine Geology* 50: 1–152.

Gawlick, H.-J., Schlagintweit, F., Ebli, O., and Suzuki, H. 2004. Die Plassen-Formation (Kimmeridgium) des Krahstein (Steirisches Salzkammergut, Österreich) und ihre Unterlagerung: neue Daten zur Fazies, Biostratigraphie und Sedimentologie. *Zentralblatt für Geologie und Paläontologie*, *Teil 1* 2003: 295–334.

Gawlick, H.-J., Suzuki, H., and Missoni, S. 2001. Nachweis von unterliassischen Beckensedimenten in Hallstätter Fazies (Dürrnberg-Formation) im Bereich der Hallein-Berchtesgadener Hallstätter Zone und des Lammer Beckens (Hettangium–Sinemurium). *Mitteilungen der Gesellschaft der Geologie- und Bergbaustudenten in Österreich* 45: 39–55.

Goričan, Š. 1994. Jurassic and Cretaceous radiolarian biostratigraphy and sedimentary evolution of the Budva Zone (Dinarides, Montenegro). *Mémoires de Géologie (Lausanne)* 18: 1–177.

Goričan, Š., Carter, E.S., Dumitrica, P., Whalen, P.A., Hori, R.S., De Wever, P., O'Dogherty, L., Matsuoka, A., and Guex, J. 2006. *Catalogue and Systematics of Pliensbachian, Toarcian and Aalenian Radiolarian Genera and Species*. 446 pp. ZRC Publishing, Scientific Research Centre of the Slovenian Academy of Sciences and Arts, Ljubljana.

Goričan, Š., O'Dogherty, L., De Wever, P., Auer, M., Gawlick, H.-J., and Missoni, S. 2009. Radiolarian dating with the new range chart of Mesozoic genera: An example from the Lower Jurassic of the Northern Calcareous Alps (Austria). *In*: H. Luo, J.C. Aitchinson, Q. Yang, Y.-J. Wang, H.-H. Chen, S.-W. Chen, B. Xu, and H. Yang (eds.), *Radiolarians Through Time. Interrad 12, Nanjing 2009, China, Programme and Abstracts*, 70–71. Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing.

Goričan, Š., Šmuc, A., and Baumgartner, P.O. 2003. Toarcian Radiolaria from Mt. Mangart (Slovenian-Italian border) and their paleoecological implications. *Marine Micropaleontology* 49: 275–301.

Gradstein, F.M., Ogg, J.G., Schmitz, M.D., and Ogg, G.M. 2012. *The Geological Time Scale 2012*. 1176 pp. Elsevier BV, Amsterdam.

Haeckel, E. 1881. Entwurf eines Radiolarien-Systems auf Grund von Studien der Challenger-Radiolarien. *Jenaische Zeitschrift für Naturwissenschaft* 15: 418–472.

Hattori, I. 1987. Jurassic Radiolarian Fossils from the Nanjo Massif, Fukui Prefecture, Central Japan. *Bulletin of the Fukui Municipal Museum of Natural History* 34: 29–101.

Hattori, I. 1988. Radiolarian fossils from manganese nodules at the upper reach of the Turamigawa in the Nanjo Massif, Fukui Prefecture, central Japan, and the tectonic significance of the northwestern Mino Terrane. *Bulletin of the Fukui Municipal Museum of Natural History* 35: 55–101.

Hattori, I. 1989. Jurassic radiolarians from manganese nodules at three sites in the western Nanjo Massif, Fukui Prefecture, Central Japan. *Journal of the Faculty of Education, Fukui University, Part II (Natural Sciences)* 39: 47–134.

Hattori, I. and Sakamoto, N. 1989. Geology and Jurassic Radiolarians from manganese nodules of the Kanmuriyama-Kanakusadake Area in the Nanjo Massif, Fukui Prefecture, Central Japan. *Bulletin of the Fukui Municipal Museum of Natural History* 36: 25–79.

Hirschberg, K. and Jacobshagen, V. 1965. Stratigraphische Kondensation in Adnether Kalken am Rötelstein bei Filzmoos (Salzburger Kalkalpen). *Verhandlungen der Geologischen Bundesanstalt* 1965: 33–42.

Hori, R. 1990. Lower Jurassic radiolarian zones of SW Japan. *Transactions and Proceedings of the Palaeontological Society of Japan, New Series* 159: 562–586.

Hori, N. 2004. Jurassic radiolarians from chert and clastic rocks of the Chichibu Belt in the Toyohashi district, Aichi Prefecture, Southwest Japan. *Bulletin of the Geological Survey of Japan* 55: 335–388.

Hori, N. 2005. Paleozoic and Mesozoic radiolarians from the Chichibu Belt in the Iragomisaki district, Atsumi Peninsula, Aichi Prefecture, Southwest Japan. *Bulletin of the Geological Survey of Japan* 56: 37–83.

Hori, R. and Yao. A. 1988. *Parahsuum* (Radiolaria) from the Lower Jurassic of the Inuyama Area, Central Japan. *Journal of Geosciences, Osaka City University* 31: 47–61.

Hori, R., Aita, Y., and Grant-Mackie, J.A. 1996. Preliminary report on Lower Jurassic Radiolaria of Gondwana origin from the Kawhia coast, New Zealand. *The Island Arc* 5: 104–113.

Igo, H. and Nishimura, H. 1984. The Late Triassic and Early Jurassic radiolarian biostratigraphy in the Karasawa, Kuzuu Town, Tochigi Prefecture (Preliminary report). *Bulletin of the Tokyo Gakugei University Section* 4: 173–193.

Imoto, N., Tamaki, A., Tanabe, T. and Ishiga, H. 1982. An age determination on the basis of radiolarian biostratigraphy of a bedded manganese deposit at the Yumiyama Mine in the Tamba District, southwest Japan. *News of Osaka Micropaleontologists, Special Volume* 5: 227–235.

Kashiwagi, K. 1998. Early Jurassic radiolarians from the Oura Complex of the Northern Chichibu Terrane in the western Kii Peninsula, southwest Japan. *News of Osaka Micropaleontologists, Special Volume* 11: 123–135.

Kashiwagi, K. 2001. The Inumodorikyo Complex of the Chichibu Terrane, eastern Kii Peninsula, Southwest Japan: Jurassic accretionary complex as characterized by chert-clastics sequence. *The Journal of the Geological Society of Japan* 107: 640–658.

Kashiwagi, K. and Kurimoto, C. 2003. Reexamination of radiolarian biochronology of the Shimizu Formation (Northern Chichibu Belt) in the Shimizu-Misato area, western Kii Peninsula, Southwest Japan. *Bulletin of the Geological Survey of Japan* 54: 279–293.

Kashiwagi, K. and Yao, A. 1993. Jurassic to Early Cretaceous radiolarians from Yuasa area in western Kii Peninsula, southwest Japan and its significance. *News of Osaka Micropaleontologists, Special Volume* 9: 177–189.

Kashiwagi, K., Niwa, M., and Tokiwa, T. 2005. Early Jurassic radiolarians from the Chichibu Composite Belt in the Sannokou area, central Kii Peninsula, Southwest Japan. *The Journal of the Geological Society of Japan* 111: 170–181.

Kito, N. and De Wever, P. 1994. New species of Middle Jurassic Actinommidae (Radiolaria) from Sicily (Italy). *Revue de Micropaléontologie* 35: 127–141.

Kishida, Y. and Hisada. K. 1985. Late Triassic to Early Jurassic Radiolarian Assemblages from the Ueno-mura area, Kanto Mountains, Central Japan. *Memoirs of Osaka Kyoiku University, Series III* 34: 103–129.

Kishida, Y. and Hisada. K. 1986. Radiolarian assemblages of the Sambosan Belt in the western part of the Kanto Mountains, central Japan. *News of Osaka Micropaleontologists, Special Volume* 7: 25–34.

Kishida, Y. and Sugano, K. 1982. Radiolarian zonation of Triassic and Jurassic in outer side of southwest Japan. *News of Osaka Micropaleontologists, Special Volume* 5: 271–300.

Kober, L. 1938. *Der Geologische Aufbau Österreichs*. 204 pp. Verlag Julius Springer, Wien.

Kozlova, G.E. 1971. Radiolaria in lower Kimmeridgian deposits of the Timan-Urals region. *Doklady Akademii Nauk SSSR* 201: 1175–1177.

Kozlova, G.E. 1973. Subclass Radiolaria. *In*: Y.V. Myatylyak, M.A. Simakova, and D.L. Stepanov (eds.), *New Species of Ancient Plants and Invertebrates in the USSR*, 57–62. Nedra, Leningrad.

Kozur, H.W. 1996. The systematic position of *Pseudoertlispongus* Lahm (Radiolaria) and description of some new Middle Triassic and Liassic radiolarian taxa. *Geologisch Paläontologische Mitteilungen Innsbruck, Sonderband* 4: 287–299.

Kozur, H. and Mostler, H. 1972. Beiträge zur Erforschung der mesozoischen Radiolarien. Teil I: Revision der Oberfamilie Coccodiscacea HAECKEL 1862 emend. und Beschreibung ihrer triassischen Vertreter. *Geologisch Paläontologische Mitteilungen Innsbruck* 2: 1–60.

Kozur, H. and Mostler, H. 1978 Beiträge zur Erforschung der mesozoischen Radiolarien. Teil II: Oberfamilie Trematodiscacea Haeckel 1962. emend. und Beschreibung ihrer triassischen Vertreter. *Geologisch Paläontologische Mitteilungen Innsbruck* 8 (Festschrift W. Heissel): 123–182.

Kozur, H. and Mostler, H. 1979. Beiträge zur Erforschung der mesozoischen Radiolarien. Teil III: Die Oberfamilien Actinommacea Haeckel 1862 emend., Artiscacea Haeckel 1882, Multiarcusellacea nov. der Spumellaria und triassische Nassellaria. *Geologisch Paläontologische Mitteilungen Innsbruck* 9: 1–132.

Kozur, H. and Mostler, H. 1981. Beiträge zur Erforschung der mesozoischen Radiolarien. Teil IV: Thalassosphaeracea Haeckel, 1862, Hexastylacea Haeckel, 1862 emend. Petruševskaja, 1979, Sponguracea Haeckel, 1862 emend. und weitere triassische Lithocycliacea, Trematodiscacea, Actinommacea und Nassellaria. *Geologisch Paläontologische Mitteilungen Innsbruck, Sonderband* 1: 1–208.

Kozur, H. and Mostler, H. 1982. Entactinaria subordo nov., a new radiolarian suborder. *Geologisch Paläontologische Mitteilungen Innsbruck* 11: 399–414.

Kozur, H. and Mostler, H. 1983. The polyphyletic origin and the classification of the Mesozoic saturnalids (Radiolaria). *Geologisch Paläontologische Mitteilungen Innsbruck* 13: 1–47.

Kozur, H. and Mostler, H. 1990. Saturnaliacea Deflandre and some other stratigraphically important Radiolaria from the Hettangian of Lenggries/Isar (Bavaria, Northern Calcareous Alps). *Geologisch Paläontologische Mitteilungen Innsbruck* 17: 179–248.

Li, H.S. 1988. Early Jurassic (Late Pliensbachian) Radiolaria from Denggen area, Xizang (Tibet). *Acta Micropaleontologica Sinica* 5: 323–330.

Lipman, R.K. 1969. A new genus and new species of Eocene radiolarians in the USSR [in Russian]. *Trudy Vsesoûznogo Naučno-Issledovatel'skogo Geologičeskogo Instituta* 130: 180–200.

Longridge, L.M., Carter, E.S., Smith, P.L., and Tipper, H.W. 2007. Early Hettangian ammonites and radiolarians from the Queen Charlotte Islands, British Columbia and their bearing on the definition of the Triassic–Jurassic boundary. *Palaeogeography, Palaeoclimatology, Palaeoecology* 244: 142–169.

Matsuoka, A. 1991. Early Jurassic radiolarians from the Nanjo Massif in the Mino Terrane, central Japan. Part 1. *Tricolocapsa*, *Stichocapsa* and *Minocapsa*, n. gen. *Transactions and Proceedings of the Palaeontological Society of Japan, New Series* 161: 720–738.

Matsuoka, A. 2004. Toarcian (Early Jurassic) radiolarian fauna from the Nanjo Massif in the Mino Terrane, central Japan. *News of Osaka Micropaleontologists, Special Volume* 13: 69–87.

Matsuoka, A. and Yao, A. 1986. A newly proposed radiolarian zonation for the Jurassic of Japan. *Marine Micropaleontology* 11: 91–106.

Meister, C. and Böhm, F. 1993. Austroalpine Liassic Ammonites from the Adnet Formation (Northern Calcareous Alps). *Jahrbuch der Geologischen Bundesanstalt* 136/1: 163–211.

Missoni, S. and Gawlick, H.-J. 2011. Jurassic mountain building and Mesozoic–Cenozoic geodynamic evolution of the Northern Calcareous Alps as proven in the Berchtesgaden Alps (Germany). *Facies* 57: 137–186.

Missoni, S., Gawlick, H.-J., Suzuki, H., and Diersche, V. 2005. Die paläogeographische Stellung des Watzmann Blockes in den Berchtesgadener Kalkalpen – Neuergebnisse auf der Basis der Analyse der Trias- und Jura-Entwicklung. *Journal of Alpine Geology* 47: 169–209.

Missoni, S., Schlagintweit, F., Suzuki, H., and Gawlick, H.-J. 2001a. Die oberjurassische Karbonatplattformentwicklung im Bereich der Berchtesgadener Kalkalpen (Deutschland) – eine Rekonstruktion auf der Basis von Untersuchungen polymikter Brekzienkörper in pelagischen Kieselsedimenten (Sillenkopf-Formation). *Zentralblatt für Geologie und Paläontologie, Teil 1* 2000: 117–143.

Missoni, S., Steiger, T., and Gawlick, H.-J. 2001b. Das Gschirrkopffenster in den Berchtesgadener Kalkalpen (Deutschland) und seine Interpretation: Neuergebnisse auf der Basis von stratigraphischen und faziellen Untersuchungen. *Mitteilungen der Gesellschaft der Geologie- und Bergbaustudenten in Österreich* 45: 89–110.

Mostler, H. 1989a. Mikroskleren hexactinellider Schwämme aus dem Lias der Nördlichen Kalkalpen. *Jahrbuch der Geologischen Bundesanstalt* 132: 687–700.

Mostler, H. 1989b. Mit „Zygomen" ausgestattete Dermalia von Kieselschwämmen (Demospongiae) aus pelagischen Sedimenten der Obertrias und des unteren Jura (Nördliche Kalkalpen). *Jahrbuch der Geologischen Bundesanstalt* 132: 701–726.

Müller, J. 1858. Über die Thalassicollen, Polycystinen und Acanthometren des Mittelmeeres. *Königliche Preussische Akademie der Wissenschaften zu Berlin*, *Abhandlungene* 1858: 1–62.

Nagai, H. 1990. Jurassic (Lower Toarcian) Radiolarians from the Hyde Formation, central Oregon, North America. *Bulletin of the Nagoya University, Furukawa Museum* 6: 1–19.

O'Dogherty, L. and Gawlick, H.-J. 2008. Pliensbachian radiolarians in Teltschengraben (Northern Calcareous Alps, Austria): a keystone in reconstructing the Early Jurassic evolution of the Tethys. *Stratigraphy* 5: 63–81.

O'Dogherty, L., Carter, E.S., Dumitrica, P., Goričan, Š., De Wever, P., Bandini, A.N., Baumgartner, P.O., and Matsuoka, A. 2009. Catalogue of Mesozoic radiolarian genera; Part 2, Jurassic–Cretaceous. *Geodiversitas* 31: 271– 356.

O'Dogherty, L., Goričan, Š., and Gawlick, H.-J. 2017. Middle and Late Jurassic radiolarians from the Neotethys suture in the Eastern Alps. *Journal of Paleontology* 91: 25–72.

Özdikmen, H. 2009. Substitute names for some unicellular animal taxa (Protozoa). *Munis Entomology and Zoology Journal* 4: 233–256.

Pálfy, J., Smith, P., and Mortensen, J. K. 2000. A U-Pb and ^{40}Ar/^{39}Ar time scale for the Jurassic. *Canadian Journal of Earth Sciences* 37: 923–944.

Pessagno, E.A. Jr. 1971. Jurassic and Cretaceous Hagiastridae from the Blake-Bahama Basin (Site 5A, JOIDES Leg 1) and the Great Valley Sequence, California Coast Ranges. *Bulletins of American Paleontology* 60: 5–83.

Pessagno, E.A. Jr. 1976. Radiolarian zonation and stratigraphy of the Upper Cretaceous portion of the Great Valley Sequence, California Coast Ranges. *Micropaleontology, Special Publication* 2: 1–95.

Pessagno, E.A. Jr. 1977a. Upper Jurassic Radiolaria and radiolarian biostratigraphy of the California Coast Ranges. *Micropaleontology* 23: 56–113.

Pessagno, E.A. Jr. 1977b. Lower Cretaceous radiolarian biostratigraphy of the Great Valley Sequence and Franciscan Complex. California Coast Ranges. *Cushman Foundation for Foraminiferal Research, Special Publication* 15: 1–95.

Pessagno, E.A. Jr. and Blome, C.D. 1980. Upper Triassic and Jurassic Pantanelliinae from California, Oregon and British Columbia. *Micropaleontology* 28: 289–318.

Pessago, E.A. Jr. and Mizutani, S. 1992. Radiolarian biozones of North America and Japan. *In*: G. E.G. Westerman (ed.), *The Jurassic of the Circum-Pacific*, 293–295, 578–585. Cambridge University Press, New York.

Pessagno, E.A. Jr. and Poisson, A. 1981. Lower Jurassic Radiolaria from the Gümüslü allochton of southwestern Turkey (Taurides occidentales). *Bulletin of the Mineral Research and Exploration Institute of Turkey* 92: 47–69.

Pessagno, E.A. Jr. and Whalen, P.A. 1982. Lower and Middle Jurassic Radiolaria (multicrytid Nassellariina) from California, east-central Oregon and the Queen Charlotte Islands, B.C. *Micropaleontology* 28: 111–169.

Pessagno, E.A. Jr., Finch, W., and Abbott, P.L. 1979. Upper Triassic Radiolaria from the San Hipolito Formation, Baja California. *Micropaleontology* 25: 160–197.

Pessagno, E.A. Jr., Six., W.M., and Yang, Q. 1989. The Xiphostylidae Haeckel and Parivaccidae, n. fam. (Radiolaria) from the North American Jurassic. *Micropaleontology* 35: 193–255.

Pessagno, E.A. Jr., Whalen, P.A, and Yeh, K.-Y. 1986. Jurassic Nassellariina (Radiolaria) from North American geologic terranes. *Bulletins of American Paleontology* 9: 1–75.

Pujana, I. 1996. A new Lower Jurassic radiolarian fauna from the Neuquén Basin, central west Argentina. *XIII Congreso Argentino de Geología, y II Congreso de Exploración de Hidrocarburos, Actas* V: 133–142.

Riedel, W.R. 1967. Sublass Radiolaria. In: W.B. Harland, C.H. Holland, M.R. House, N.F. Hughes, A.B. Reynolds, M.J.S. Rudwick, G.E. Satterthwaite, L.B.H. Tarlo, and E.C. Willey (eds.), *The Fossil Record. A Symposium with Documentation*, 291–298. Geological Society of London, London.

Riedel, W.R. 1971. Systematic classification of polycystine Radiolaria. *In*: B.M. Funnel and W.R. Riedel (eds.), *The Micropaleontology of the Oceans*, 649–661. Cambridge University Press, Cambridge.

Rüst, D. 1885. Beiträge zur Kenntniss der fossilen Radiolarien aus Gesteinen des Jura. *Palaeontographica* 31: 269–321.

Rüst, D. 1898. Neue Beiträge zur Kenntniss der Fossilen Radiolarien aus Gesteinen des Jura und der Kreide. *Paleontographica* 45: 1–67.

Sashida, K. 1988. Lower Jurassic multisegmented Nassellaria from the Itsukaichi area, western part of Tokyo Prefecture, central Japan. *Science Reports of the Institute of Geoscience, University of Tsukuba, Section B: Geological Sciences* 9: 1–27.

Schäffer, G. 1976. Einführung zur geologischen Karte der Republik Österreich, 1:50 000, Blatt 96, Bad Ischl. *Arbeitstagung der Geologischen Bundesanstalt* 1976: 6–26.

Schlagintweit, F., Auer, M., and Gawlick, H.-J. 2007. *Reophax*? *rhaxelloides* n. sp., a new benthic foraminifer from Late Jurassic reefal limestones of the Northern Calcareous Alps (Austria). *Journal of Alpine Geology* 48: 57–69.

Spengler, E. 1943. Über den geologischen Bau des Rettensteins (Dachsteingruppe). *Mitteilungen des Reichsamts für Bodenforschung, Zweigstelle Wien* 5: 55–66.

Spengler, E. 1956. Versuch einer Rekonstruktion des Ablagerungsraumes der Decken der Nördlichen Kalkalpen. II. Teil: Der Mittelabschnitt der Kalkalpen. *Jahrbuch der geologischen Bundesanstalt* 99: 1–74.

Spörli, K.B., Aita, Y., and Gibson, G.W. 1989. Juxtaposition of Tethyan and non-Tethyan Mesozoic radiolarian faunas in melanges, Waipapa terrane, North Island, New Zealand. *Geology* 17: 753–756.

Steiger, T. 1992. Systematik, Stratigraphie und Palökologie der Radiolarien des Oberjura-Unterkreide-Grenzbereiches im Osterhorn-Tirolikum (Nördliche Kalkalpen, Salzburg und Bayern). *Zitteliana* 19: 3–188.

Suzuki, H. 1995. Frühjurassische Radiolarienfauna aus dem mesozoischen akkretierten Komplex von Ost-Shikoku, Südwestjapan. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* 3: 275–296.

Suzuki, H. and Gawlick, H.-J. 2003a. Biostratigraphie und Taxonomie der Radiolarien aus den Kieselsedimenten der Blaa Alm und nördlich des Loser (Nördliche Kalkalpen, Callovium–Oxfordium). *Mitteilungen der Gesellschaft der Geologie- und Bergbaustudenten in Österreich* 46: 137–228.

Suzuki, H. and Gawlick, H.-J. 2003b. Die jurassischen Radiolarienzonen der Nördlichen Kalkalpen. *In*: J.T. Weidinger, H. Lobitzer, and I. Spitzbar (eds.), *Beiträge zur Geologie des Salzkammerguts*, 115–122. Geo-Studien 2, Gmundner.

Suzuki, H., Prinz-Grimm, P., and Schmidt-Effing, R. 2002. Radiolarien aus dem Grenzbereich Hettangium/Sinemurium von Nordperu. *Paläontologische Zeitschrift* 76: 163–187.

Suzuki, H., Wegerer, E., and Gawlick, H.-J. 2001. Zur Radiolarienstratigraphie im unteren Callovium in den Nördlichen Kalkalpen—das Klauskogelbachprofil westlich von Hallstatt. *Zentralblatt für Geologie und Paläontologie, Teil 1* 2000: 167–184.

Takemura, A. 1986. Classification of Jurassic Nassellarians (Radiolaria). *Palaeontographica. Abteilung A: Paläozoologie-Stratigraphie* 195: 29–74.

Tekin, U.K. 2002. Lower Jurassic (Hettangian–Sinemurian) radiolarians from the Antalya Nappes, Central Taurids, Southern Turkey. *Micropaleontology* 48: 177–205.

Tipper, H.W., Smith, P.L., Cameron, B.E.B., Carter, E.S., Jakobs, G.K., and Johns, M.J. 1991. Biostratigraphy of the Lower Jurassic formations of the Queen Charlotte Islands, British Columbia. *In*: Evolution and Hydrocarbon Potential of the Queen Charlotte Basin, British Columbia. *Geological Survey of Canada, Paper* 90-10: 203–235.

Trauth, F. 1926. Geologie der nördlichen Radstädter Tauern und ihres Vorlandes. I. Teil. *Denkschriften der Akademie der Wissenschaften* 100: 101–212.

Trauth, F. 1928. Geologie der nördlichen Raadstädter Tauern und ihres Vorlandes. 2. Teil. *Denkschriften der Akademie der Wissenschaften* 101: 29–65.

Tollmann, A. 1960. Die Hallstätter Zone des östlichen Salzkammergutes und ihr Rahmen. *Jahrbuch der geologischen Bundesanstalt Wien* 103: 37–131.

Tollmann, A. 1981. Oberjurassische Gleittektonik als Hauptformungsprozeß der Hallstätter Region und neue Daten zur Gesamttektonik der Nördlichen Kalkalpen in den Ostalpen. *Mitteilungen der Österreichischen Geologischen Gesellschaft* 74/75: 167–195.

Tumanda Mateer, F., Sashida, K., and Igo, H. 1996. Some Jurassic radiolarians from Busuanga Island, Calamian Island Group, Palawan, Philippines. *In*: H. Noda and K. Sashida (eds.), *Geology and Paleontology of Japan and Southeast Asia, Prof. H. Igo Commemorative Volume*, 165–192. University of Tsukuba, Tokyo.

Wegerer, E., Suzuki, H., and Gawlick, H.-J. 1999. Stratigraphische Einstufung von Radiolarienfaunen aus Kieselsedimenten im Bereich der Hallstätter Zone, westlich von Hallstatt (Callovium–Oxfordium, Nördliche Kalkalpen). *Mitteilungen der Gesellschaft der Geologie- und Bergbaustudenten in Österreich* 42: 93–108.

Wegerer, E., Suzuki, H., and Gawlick, H.-J. 2001. Zur stratigraphischen Einstufung von Kieselsedimenten im Bereich des Sandling (Nördliche Kalkalpen, Callovium–Oxfordium). *Mitteilungen der Gesellschaft der Geologie- und Bergbaustudenten in Österreich* 45: 67–85.

Whalen, P.A. and Carter, E.S. 2002. Pliensbachian (Lower Jurassic) Radiolaria from Baja California Sur, Mexico. *Micropaleontology* 48: 97–151.

Yang, Q. 1993. Taxonomic studies of Upper Jurassic (Tithonian) Radiolaria from the Taman Formation, east-central Mexico. *Palaeoworld* 3: 1–164.

Yang, Q. and Mizutani, S. 1991. Radiolaria from the Nadanhada Terrane, Northeast China. *Journal of Earth Sciences, Nagoya University* 38: 49–78.

Yao, A. 1972. Radiolarian fauna from the Mino Belt in the northern part of the Inuyama Area, Central Japan, Part I: Spongosaturnalids. *Journal of Geosciences, Osaka City University* 15: 21–65.

Yao, A. 1979. Radiolarian fauna from the Mino Belt in the northern part of the Inuyama Area, Central Japan, Part II: Nassellaria 1. *Journal of Geosciences, Osaka City University* 22: 21–72.

Yao, A. 1982. Middle Triassic to Early Jurassic radiolarians from the Inuyama area, central Japan. *Journal of Geosciences*, *Osaka City University* 25: 53–70.

Yao, A. 1997. Faunal change of Early–Middle Jurassic radiolarians. *News of Osaka Micropaleontologists, Special Volume* 10: 155–182.

Yao, A., Matsuoka, A., and Nakatani, T. 1982. Triassic and Jurassic radiolarian assemblages in southwest Japan. *News of Osaka Micropaleontologists, Special Volume* 5: 27–43.

Yeh, K.-Y. 1987. Taxonomic studies of Lower Jurassic Radiolaria from east-central Oregon. *National Museum of Natural Science, Special Publication* 2: 1–169.

Yeh, K.-Y. 2009. A Middle Jurassic radiolarian fauna from South Fork Member of Snowshoe Formation, east-central Oregon. *National Museum of Natural Science,Taiwan, Collection and Research* 22: 15–125.

Yeh, K.-Y. 2011. A Middle Jurassic (upper Bajocian) Radiolarian Assemblage from Snowshoe Formation, East-Central Oregon. *National Museum of Natural Science, Taiwan, Collection and Research* 24: 1–77.

Yeh, K.-Y. and Cheng, Y.-N. 1998. Radiolarians from the Lower Jurassic of the Busuanga Island. Philippines. *Bulletin of the National Museum of Natural Science, Taiwan* 11: 1–65.

Yeh, K.-Y. and Pessagno, E.A. Jr. 2013. Upper Bathonian (Middle Jurassic) Radiolarians from Snowshoe Formation, east-central Oregon, USA. *National Museum of Natural Science, Taiwan, Collection and Research* 26: 51–175.

Yeh, K.Y. and Yang, Q. 2006. Radiolarian assemblages from T–J boundary strata, Nadanhada Terrane, NE China. *Acta Micropalaeontologica Sinica* 23/4: 317–360.