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Reports

# Triassic to Middle Jurassic radiolarians from pelagic cherts in the Nanjō Mountains, Southwest Japan – Part 1. Imajō district

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**Abstract:** The Nanjō Mountains located in the central region of Fukui Prefecture, Southwest Japan, are chiefly underlain by a sedimentary complex consisting of various rock-types such as basalt, limestone, chert, mudstone and sandstone. Among these rocks within the mountains, 27 chert outcrops were explored for their radiolarian content. In the studied Imajō district, the 14 rock samples from 10 localities yielded moderately- to poorly-preserved radiolarian remains as a result. Most of the samples contained Triassic to Middle Jurassic species, with Spumellaria and Entactinaria dominant among the Triassic faunas and Nassellaria dominant among the Jurassic faunas. The description and faunal analysis of these radiolarians revealed that the cherts in the Imajō district indicate a long range in age from the Olenekian? stage to the Bajocian stage.

**Keywords:** radiolaria, Triassic, Middle Jurassic, Nanjō Mountains, Imajō district, Fukui Prefecture, Southwest Japan

## 1. Introduction

The Nanjō Mountains, which extend over an area of ca. 40 km x 20 km in the central region of Fukui Prefecture, are geotectonically divided into the Mino and Ultra-Tamba belts of the Inner Zone of Southwest Japan. The lithologic assemblages of each belt differ from one other; the accretionary complex of the Mino belt is regarded as one of the Jurassic accretionary complexes that formed along the eastern margin of the paleo-Asian continent (e.g., Wakita, 1988). The Mino belt consists of thrust-bounded units of basalt and limestone of oceanic island/seamount origin, cherts of pelagic origin and terrigenous clastic rocks (Wakita, 1988; Nakae *et al*., in press). Conversely, the accretionary complex of the Ultra-Tamba belt is dominated by pale or greenish gray sandstone with subordinate chert and phyllitic mudstone of Permian age (Umeda *et al*., 1996; Nakae, 2012). 1:50,000 scale maps of the "Imajō" and "Kanmuri Yama" districts almost cover the entire area of the Nanjō Mountains (Fig.1).

The age of the cherts in the Nanjō Mountains has so far been determined to be Triassic to Jurassic (e.g., Hattori and Yoshimura, 1982; Takamura and Hayami, 1985; Taga, 1997; Umeda and Taga, 2003). Through this work, additional extraction of radiolarians from the accretionary complex of the Mino belt in the Nanjō Mountains was therefore conducted for detailed age determination of its component rocks. Consequently, this first report documents all of the radiolarian species extracted from the cherts in the Imajō district; radiolarians from the Kanmuri Yama district will be described in a subsequent report.

## 2. Materials and Method

Through the course of this study, approximately 530 samples were collected from the Imajō and Kanmuri Yama districts in the Nanjō Mountains. The samples were undertaken using an usual technique for radiolarian extraction; briefly, the rock samples were individually soaked in dilute hydrofluoric acid (HF) solution (5%) for 10 to 15 hours, before being washed through a 62μm mesh sieve (235#). As a result, age-diagnostic radiolarians representative of Triassic to Middle Jurassic ages were recovered from 40 chert samples, 14 of which were from the Imajō district. The residues of each processed sample were then examined under a stereomicroscope, and radiolarian remains were selected for examination by scanning electronic microscope (SEM). All figured specimens were deposited and registered with the Geological Museum, Geological Survey of Japan under catalogue numbers (GSJ F).

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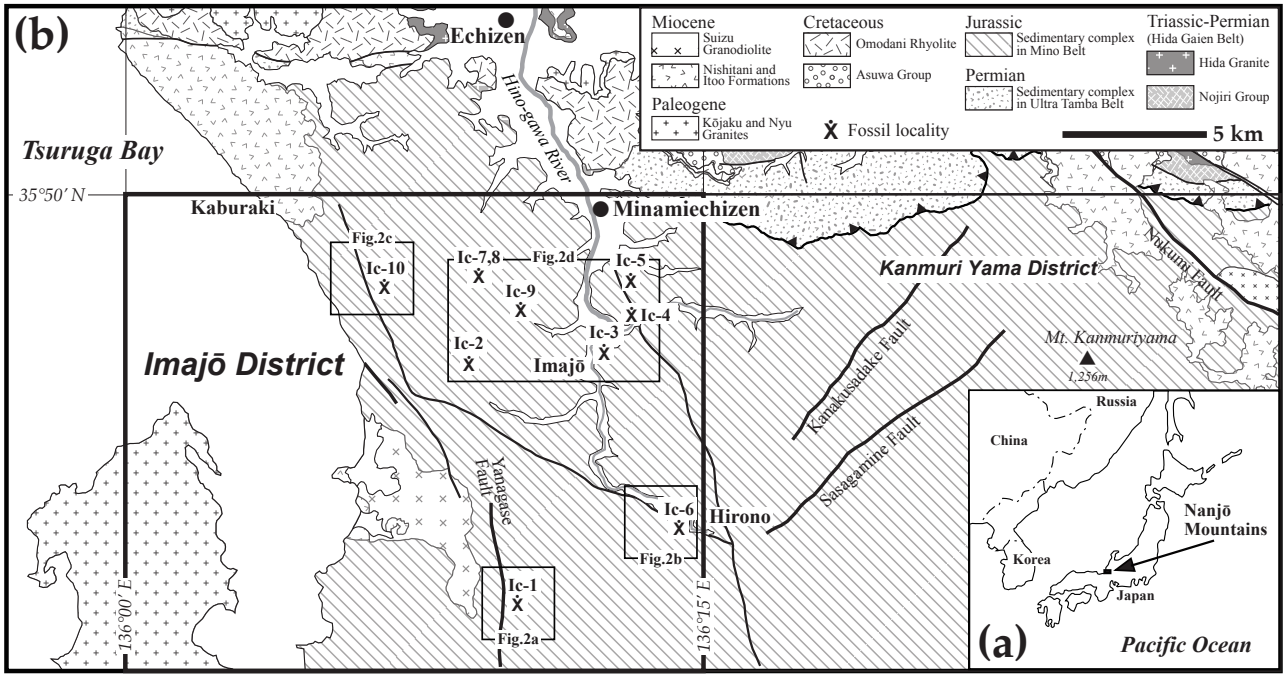


Fig. 1 Index map of the Imajō district in the Nanjō Mountains.
(a): The Nanjō Mountains are situated in a central region of Fukui Prefecture. (b): A simplified geological map of the mountains, most part of which geotectonically belongs to the Mino belt, Southwest Japan. The Imajō district contains the western part of the Nanjō Mountains and Tsuruga Bay. Detailed radiolarian localities with symbols are given in Fig. 2.

## 3. Radiolarian locality and fauna

Fourteen chert samples comprising part of a suite of 222 samples that were collected from the Imajō district in the Nanjō Mountains yielded moderately- to poorly-preserved radiolarian faunas. Most of the faunas consist of radiolarians, which are identifiable as Triassic to Middle Jurassic species. Radiolarian localities (Ic-1 – Ic10) are shown in Figs. 1 and 2, and the identified species are listed in Table 1. Below is a detailed description of the localities investigated and their faunal contents.

**(1) Locality Ic-1** (Fig. 2a)
**Location:** South of Tochinoki-tōge, Yogo, Nagahama City.
(lat. 35º41’34.6” N, long. 136º9’43.7” E)
**Sample number:** IJ 1502g.
**Lithology:** Thinly bedded gray chert.
**Fauna:** *Cryptostephanidium* spp., *Protopsium* spp. (Plate 1).
**Age:** Probably early Anisian – late Carnian.

**(2) Locality Ic-2** (Fig. 2d)
**Location:** North of Ōgiri, Minamiechizen Town.
(lat. 35º46’44.7” N, long. 136º8’36.1” E)
**Sample number:** IJ 2202.
**Lithology:** Thinly bedded light-gray chert. Slightly tuffaceous.
**Fauna:** *Archaeocenosphaera*? spp., *Entactinia*? spp. (Plate 1).
**Age:** Probably early Olenekian – middle Anisian.

**(3) Locality Ic-3** (Fig. 2d)
**Location:** Northeast of Imajō, Minamiechizen Town.
(lat. 35º46’54” N, long. 136º12’0.9” E)
**Sample number:** IJ 2703.
**Lithology:** Thinly bedded light-gray chert.
**Fauna:** *Pantanellium* sp., *Praewilliriedellum*? spp., *Praezhamoidellum*? sp., *Eucyrtidiellum unumaense* (Yao), *Parahsuum* spp., *Praeparvicingula*? sp., *Lantus* sp. cf. *L. sixi* Yeh, *Lantus*? sp. (Plate 1)
**Age:** Early Bajocian.

**(4) Locality Ic-4 (Fig. 2d)**
**Location:** Yashirodani, Minamiechizen Town.
(lat. 35º47’39.2” N, long. 136º12’59.7” E)
**Sample number:** IJ 2901.
**Lithology:** Thinly bedded gray chert.
**Fauna:** *Pantanellium*? spp., *Archaeocenosphaera* sp., *Plafkerium*? spp., *Plafkerium*? *antiquum* Sugiyama, *Protopsium* sp., *Eptingium*? sp., *Cryptostephanidium japonicum* (Nakaseko and Nishimura), *Cryptostephanidium* sp. cf. *C. longispinosum* (Sashida), *Pseudostylosphaera* sp. A sensu Sugiyama (1992), *Pseudostylosphaera* sp. (Plate 2).
**Age:** Early – middle Anisian.

**(5) Locality Ic-5 (Fig. 2d)**
**Location:** Northwest of Somayama, Minamiechizen Town.

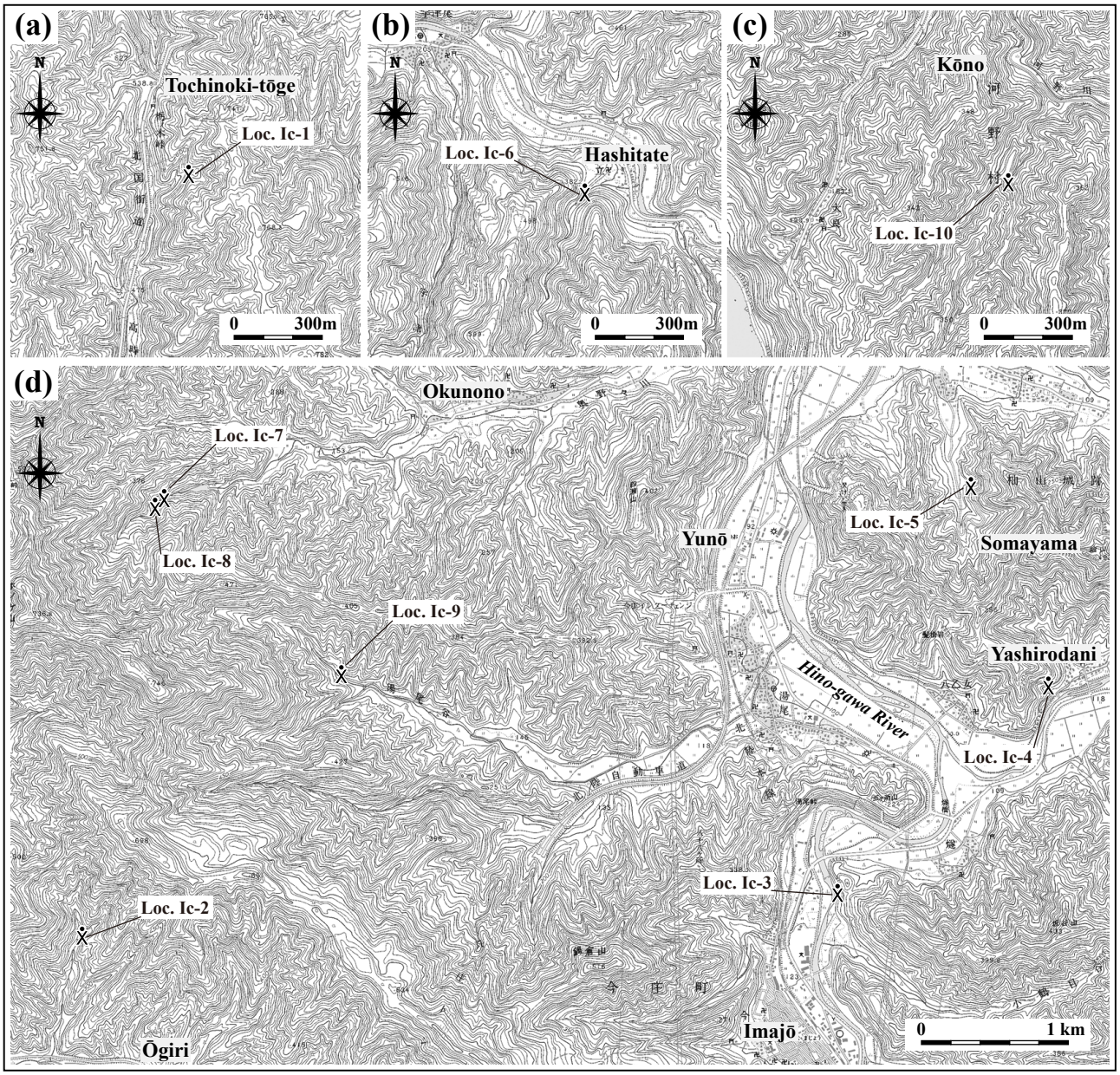


Fig. 2 Localities of chert samples yielding Triassic to Middle Jurassic radiolarians.
Parts of topographic maps of "Itadori" for figures (a) and (b), "Kōno" for figure (c) and "Imajō" for figure (d), published from the Geospatial Information Authority of Japan, are used.

(lat. 35º48'22.9" N, long. 136º12'41.7" E)
**Sample number:** IJ 3205.
**Lithology:** Thinly bedded light-gray chert.
**Fauna:** *Plafkerium*? sp., *Protopsium* spp. (Plate 2).
**Age:** Probably middle Anisian – late Rhaetian.

**(6) Locality Ic-6 (Fig. 2b)**
**Location:** Hashitate, Minamiechizen Town.
(lat. 35º43'17.3" N, long. 136º14'13" E)
**Sample number:** IJ 4001.
**Lithology:** Thinly bedded light-gray chert.
**Fauna:** Spumellaria gen. et sp. indet (Plate 2).
**Age:** Probably late Anisian – late Rhaetian.

**(7) Locality Ic-7 (Fig. 2d)**
**Location:** West of Okunono, Minamiechizen Town.
(lat. 35º48'21.5" N, Long. 136º8'59.9" E)
**Sample number:** IJ 5502.
**Lithology:** Thinly bedded light-gray chert.
**Fauna:** *Eptingium* sp. cf. *E. manfredi* Dumitrică, *Cryptostephanidium* spp., *Pseudostylosphaera japonica* (Nakaseko and Nishinura), *Pseudostylosphaera* spp., *Bulbocyrtium* sp. A sensu Sugiyama (1997), *Triassocampe deweveri* (Nakaseko and Nishimura), *Triassocampe* sp. aff. *T. diordinis* Bragin sensu Sugiyama (1992) (Plate 3).
**Age:** Late Anisian.

Table. 1 List of radiolarian species detected from the Imajō district in the Nanjō Mountains.

| | Locality Number (Ic-) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | | 10 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Number | IJ 1502g | IJ 2202 | IJ 2703 | IJ 2901 | IJ 3205 | IJ 4001 | IJ 5502 | IJ 5503 | IJ 5702a | IJ 5702b | IJ 5702i | IJ 6901a | IJ 6901b | IJ 6901c |
| SPUMELLARIA | *Gorgansium* sp. cf. *G. gongyloideum* Kishida and Hisada | | | | | | | | | | | + | | | |
| | *Pantanellium* sp. cf. *P. foveatum* Mizutani and Kido | | | | | | | | | | + | | | | |
| | *Pantanellium* sp. cf. *P. tanuense* Pessagno and Blome | | | | | | | | | | | + | | | |
| | *Pantanellium* spp. | | | + | | | | | | | | + | + | + | |
| | *Pantanellium* ? spp. | | | | + | | | | | | | | | | |
| | *Archaeocenosphaera* sp. | | | | + | | | | | | | | | | |
| | *Archaeocenosphaera* ? spp. | | + | | | | | | | | | | | | |
| | *Emiluvia* sp. | | | | | | | | | | | | | + | |
| | *Plafkerium* ? *antiquum* Sugiyama | | | | + | | | | | | | | | | |
| | *Plafkerium* ? spp. | | | | + | + | | | | + | | | | | |
| | *Paronaella* sp. cf. *P. notabilis* Whalen and Carter | | | | | | | | | | | | | + | |
| | *Protopsium* spp. | + | | | + | + | | | | | | | | | |
| | Pantanelliidae gen. et sp. indet. | | | + | | | | | | | | | | | |
| | Spumellaria gen. et sp. indet. | + | + | | + | + | + | | | + | | + | | | |
| ENTACTINARIA | *Thurstonia* sp. | | | | | | | | | | | + | | | |
| | *Entactinia* ? spp. | | + | | | | | | | | | | | | |
| | *Eptingium* sp. cf. *E. manfredi* Dumitriča | | | | | | | + | | | | | | | |
| | *Eptingium* ? sp. | | | | + | | | | | | | | | | |
| | *Cryptostephanidium japonicum* (Nakaseko and Nishinura) | | | | + | | | | | | | | | | |
| | *Cryptostephanidium* sp. cf. *C. longispinosum* (Sashida) | | | | + | | | | | | | | | | |
| | *Cryptostephanidium* spp. | + | | | | | | + | | + | | | | | |
| | *Hindeosphaera* sp. cf. *H. spinulosa* (Nakaseko and Nishimura) | | | | | | | | + | | | | | | |
| | *Pseudostylosphaera japonica* (Nakaseko and Nishimura) | | | | | | | + | | | | | | | |
| | *Pseudostylosphaera* sp. A sensu Sugiyama (1992) | | | | + | | | | | | | | | | |
| | *Pseudostylosphaera* spp. | | | | + | | | + | | + | | | | | |
| | *Mesosaturnalis* spp. | | | | | | | | | | | + | | | |
| | Entactinaria gen. et sp. indet. | + | | | | | | | | | | | | | |
| NASSELLARIA | *Hozmadia rotunda* (Nakaseko and Nishimura) | | | | | | | | | + | | | | | |
| | *Hozmadia* sp. cf. *H. gifuensis* Sugiyama | | | | | | | | | + | | | | | |
| | *Diceratigalea* sp. | | | | | | | | | | | + | | | |
| | *Napora* spp. | | | | | | | | | | + | | | | |
| | *Bulbocyrtium* sp. A sensu Sugiyama (1997) | | | | | | | + | | | | | | | |
| | *Williriedellum* ? sp. | | | | | | | | | | | | + | | |
| | *Praewilliriedellum* ? spp. | | | + | | | | | | | | | | | |
| | *Praezhamoidellum yaoi* Kozur | | | | | | | | | | + | | | | |
| | *Praezhamoidellum* sp. cf. *P. yaoi* Kozur | | | | | | | | | | | | | | + |
| | *Praezhamoidellum* sp. cf. *P. convexa* (Yao) | | | | | | | | | | | | | + | |
| | *Praezhamoidellum* ? spp. | | | + | | | | | | | | | + | | |
| | *Eucyrtidiellum unumaense* (Yao) | | | + | | | | | | | | | | | |
| | *Eucyrtidiellum gunense* Cordey | | | | | | | | | | | | | + | |
| | *Eucyrtidiellum* spp. | | | | | | | | | | | + | | + | |
| | *Triassocampe deweveri* (Nakaseko and Nishimura) | | | | | | | + | | | | | | | |
| | *Triassocampe* sp. aff. *T. diordinisi* Bragin sensu Sugiyama (1992) | | | | | | | + | | | | | | | |
| | *Triassocampe* sp. | | | | | | | | + | | | | | | |
| | *Bagotum maudense* Pessagno and Whalen | | | | | | | | | | | | | + | |
| | *Bagotum modestum* Pessagno and Whalen | | | | | | | | | | | | | | + |
| | *Bagotum* sp. | | | | | | | | | | | | + | | |
| | *Broctus ruesti* Yeh | | | | | | | | | | | | | + | |
| | *Hsuum* spp. | | | | | | | | | | | + | | | + |
| | *Parahsuum* spp. | | | + | | | | | | | | + | + | + | |
| | *Praeparvicingula* ? sp. | | | + | | | | | | | | | | | |
| | *Elodium* sp. cf. *E. pessagnoi* Yeh and Cheng | | | | | | | | | | | + | | | |
| | *Katroma angusta* Yeh | | | | | | | | | | | + | | | |
| | *Katroma brevitubus* Dumitrica and Goričan | | | | | | | | | | | | | + | |
| | *Katroma* spp. | | | | | | | | | | | + | | | |
| | *Teesium* ? sp. | | | | | | | | | | | + | | | |
| | *Striatojaponocapsa plicarum* (Yao) | | | | | | | | | | + | | | | |
| | *Corum* ? sp. | | | | | | | | | | | | + | | |
| | *Stichomitra* spp. | | | | | | | | | | | | + | | |
| | *Dictyomitrella* sp. | | | | | | | | | | + | | | | |
| | *Lantus* sp. cf. *L. sixi* Yeh | | | + | | | | | | | | | | | |
| | *Lantus* ? sp. | | | + | | | | | | | | | | | |
| | Poulpidae gen. et sp. indet | | | | | | | | + | | | + | | | |
| | Multisegmented Nassellaria gen. et sp. indet. | | | | | | | | + | | + | | + | | + |
| | Nassellaria gen. et sp. indet. | | | + | | | | + | | | | | | | |

**(8) Locality Ic-8 (Fig. 2d)**
**Location:** West of Okunono, Minamiechizen Town.
(lat. 35º48'19.4" N, long. 136º8'58.1" E)
**Sample number:** IJ 5503.
**Lithology:** Thinly bedded pale-gray chert.
**Fauna:** *Hindeosphaera* sp. cf. *H. spinulosa* (Nakaseko and Nishimura), *Triassocampe* sp. (Plate 3).
**Age:** Probably early – late Anisian.

**(9) Locality Ic-9 (Fig. 2d)**
**Location:** West of Yunō, Minamiechizen Town.
(lat. 35º47'41.7" N, long. 136º9'48.2" E)
Sample number: IJ 5702a.
**Lithology:** Thinly bedded pale-gray chert.
**Fauna:** *Plafkerium*? spp., *Cryptostephanidium* spp., *Pseudostylosphaera* spp., *Hozmadia rotunda* (Nakaseko and Nishimura), *Hozmadia* sp. cf. *H. gifuensis* Sugiyama (Plate 3).
**Age:** Late Anisian.

**Sample number:** IJ 5702b.
**Lithology:** Thinly bedded pale-gray chert.
**Fauna:** *Pantanellium* sp. cf. *P. foveatum* Mizutani and Kido, *Napora* spp., *Praezhamoidellum yaoi* Kozur, *Striatojaponocapsa plicarum* (Yao), *Dictyomitrella* sp. (Plate 4).
**Age:** Bajocian.

**Sample number:** IJ 5702i.
**Lithology:** Thinly bedded light-gray chert.
**Fauna:** *Gorgansium* sp. cf. *G. gongyloideum* Kishida and Hisada, *Pantanellium* sp. cf. *P. tanuense* Pessagno and Blome, *Pantanellium* spp., *Thurstonia* sp., *Mesosaturnalis* spp., *Diceratigalea* sp., *Eucyrtidiellum* sp., *Hsuum* sp., *Parahsuum* sp., *Elodium* sp. cf. *E. pessagnoi* Yeh and Cheng, *Katroma angusta* Yeh, *Katroma* spp., *Teesium*? sp. (Plate 4)
**Age:** Late Pliensbachian – early Toarcian.

**Locality Ic-10 (Fig. 2c)**
**Location:** South of Kōno, Minamiechizen Town.
(lat. 35º48'15.4" N, long. 136º6'28.5" E)
**Sample number:** IJ 6901a.
**Lithology:** Thinly bedded reddish-brown chert.
**Fauna:** *Pantanellium* sp., *Williriedellum*? sp., *Praezhamoidellum*? sp., *Bagotum* sp., *Parahsuum* spp., *Corum*? sp., *Stichomitra* spp. (Plate 5).
**Age:** Probably early Sinemurian – early Toarcian.

**Sample number:** IJ 6901b.
**Lithology:** Thinly bedded reddish-brown chert.
**Fauna:** *Pantanellium* sp., *Emiluvia* sp., *Paronaella* sp. cf. *P. notabilis* Whalen and Carter, *Praezhamoidellum* sp. cf. *P. convexa* (Yao), *Eucyrtidiellum gunense* Cordey, *Eucyrtidiellum* sp., *Bagotum maudense* Pessagno and Whalen, *Broctus ruesti* Yeh, *Parahsuum* sp., *Katroma brevitubus* Dumitrica and Goričan (Plate 5).
**Age:** Early Pliensbachian – earliest Toarcian.

Table. 2 List of radiolarian genera and their biostratigraphic ranges from O'Dogherty *et al*. (2009).

| Genus | Range |
|---|---|
| *Gorgansium* | upper Norian — upper Valanginian |
| *Pantanellium* | upper Carnian — lower Aptian |
| *Archaeocenosphaera* | middle Anisian — upper Campanian |
| *Emiluvia* | lower Sinemurian — upper Valanginian |
| *Plafkerium* | middle Anisian — upper Rhaetian |
| *Paronaella* | lower Rhaetian — upper Coniacian |
| *Protopsium* | upper Hettangian — lower Toarcian |
| *Thurstonia* | low Hettangian — lower Toarcian |
| *Entactinia* | upper Devonian — lower Olenekian |
| *Eptingium* | lower Anisian — upper Rhaetian |
| *Cryptostephanidium* | lower Anisian — upper Carnian |
| *Hindeosphaera* | middle Anisian — middle Norian |
| *Pseudostylosphaera* | upper Olenekian — lower Carnian |
| *Mesosaturnalis* | middle Norian — upper Coniacian |
| *Hozmadia* | upper Olenekian — upper Carnian |
| *Diceratigalea* | lower Pliensbachian — upper Aalenian |
| *Napora* | upper Sinemurian — lower Turonian |
| *Bulbocrytium* | upper Carnian — middle Norian |
| *Williriedellum* | upper Aalenian — lower Aptian |
| *Praewilliriedellum* | upper Aalenian — upper Barremian |
| *Praezhamoidellum* | upper Aalenian — upper Barremian |
| *Eucyrtidiellum* | lower Pliensbachian — upper Tithonian |
| *Triassocampe* | lower Anisian — lower Norian |
| *Bagotum* | lower Sinemurian — lower Toarcian |
| *Broctus* | upper Sinemurian — lower Toarcian |
| *Hsuum* | lower Pliensbachian — lower Cenomanian |
| *Parahsuum* | lower Hettangian — upper Kimmeridgian |
| *Praeparvicingula* | middle Toarcian — upper Barremian |
| *Elodium* | middle Toarcian — upper Aalenian |
| *Katroma* | lower Sinemurian — lower Toarcian |
| *Teesium* | upper Sinemurian |
| *Corum* | Ladinian — middle Norian |
| *Striatojaponocapsa* | lower Bajocian — upper Callovian |
| *Lantus* | lower Pliensbachian — lower Kimmeridgian |

**Sample number:** IJ 6901c.
**Lithology:** Thinly bedded reddish-brown chert.
**Fauna:** *Praezhamoidellum* sp. cf. *P. yaoi* Kozur, *Bagotum modestum* Pessagno and Whalen, *Hsuum* sp. (Plate 5).
**Age:** Early Pliensbachian – early Toarcian.

## 4. Age determination

In order to determine the age of the radiolarian faunas extracted from the chert samples and described in this report, the zonation schemes proposed by Sugiyama (1992, 1997) for the Triassic, by Hori (1990) and Carter *et al*. (1998, 2010) for the Lower Jurassic, and by Baumgartner *et al*. (1995) and Matsuoka (1995) for the Middle Jurassic periods, are primarily applicable. The biostratigraphic ranges that were recently extensively analyzed by O'Dogherty *et al* (2009) are used for the radiolarian genera listed in Table 2. In addition, the biostratigraphic ranges of the radiolarian species discussed below are mainly based on Yao (1984), Kozur (1984) and Yeh (1987), together with the above literatures.

Samples IJ1502g, IJ2202, IJ3205, IJ4001 and IJ5503 contain radiolarian faunas with very low diversity. Sample IJ2202 yields poorly-preserved *Archaeocenosphaera*? spp. and *Entactinia*? spp. The biostratigraphic ranges of each genus are middle Anisian – upper Campanian and upper Devonian – lower Olenekian, therefore probably implying that the age of this fauna is estimated to be an early Olenekian? – middle Anisian interval. Sample IJ5503 includes poorly-preserved specimens belonging to genera *Triassocampe*, which existed in a interval from the lower Anisian to the lower Norian. A comparable specimen with *Hindeosphaera spinulosa* (Nakaseko and Nishimura) indicating the lower – upper Anisian is also obtained. Therefore, the age of this sample probably coincides with an early – late Anisian interval. Radiolarian faunas from Samples IJ1502g, IJ3205 and IJ4001 are characterized by genera ranging from Anisian to Carnian or to Rhaetian; *Plafkerium*? spp., *Protopsium* spp. and *Cryptostephanidium* spp.

Sample IJ2901 contains *Plafkerium*? *antiquum* Sugiyama, *Cryptostephanidium japonicum* (Nakaseko and Nishimura) and *Pseudostylosphaera* sp. A sensu Sugiyama (1992), together with some species belonging to Triassic genera. Coexistence of the first three species is restricted to the interval from early to middle Anisian age (Sugiyama, 1992, 1997).

Samples IJ5502 and IJ5702a are estimated to be late Anisian age, based on the co-occurrence of *Pseudostylosphaera japonica* (Nakaseko and Nishimura), *Bulbocyrtium* sp. A sensu Sugiyama (1997), *Triassocampe deweveri* (Nakaseko and Nishimura) and *Triassocampe* sp. aff. *T. diordinis* Bragin sensu Sugiyama (1992) recognized in the former sample, and the occurrence of *Hozmadia rotunda* (Nakaseko and Nishimura) in the latter sample.

*Bagotum* sp. is the only a diagnostic radiolarian specimen in Sample IJ6901a, indicating that it is from an early Sinemurian – early Toarcian interval. *Bagotum modestum* Pessagno and Whalen in Sample IJ6901c and *Katroma angusta* Yeh in Sample IJ5702i are also diagnostic species, with their ages assigned to an early Pliensbachian – early Toarcian interval and a late Pliensbachian – early Toarcian interval, respectively.

Sample IJ6901b yielded *Eucyrtidiellum gunense* Cordey, *Bagotum maudense* Pessagno and Whalen, *Broctus ruesti* Yeh and *Katroma brevitubus* Dumitrica and Goričan, therefore indicating that age of this sample is constrained with these species which co-exist in an interval from early Pliensbachian to earliest Toarcian.

Sample IJ2703 contains *Eucyrtidiellum unumaense* (Yao) and numerous species belonging to Jurassic genera. *Eucyrtidiellum unumaense* (Yao) has a relatively longer age range extending from the lower Bajocian to the lower Oxfordian. Among the other Jurassic species, *Parahsuum* spp. are poorly-preserved but the presence of short and inflated spindle-shaped test with simple square pore frames. These morphologic features indicate that they are probably correlated with *Parahsuum izeense* (Pessagno and Whalen), which ranges from before the

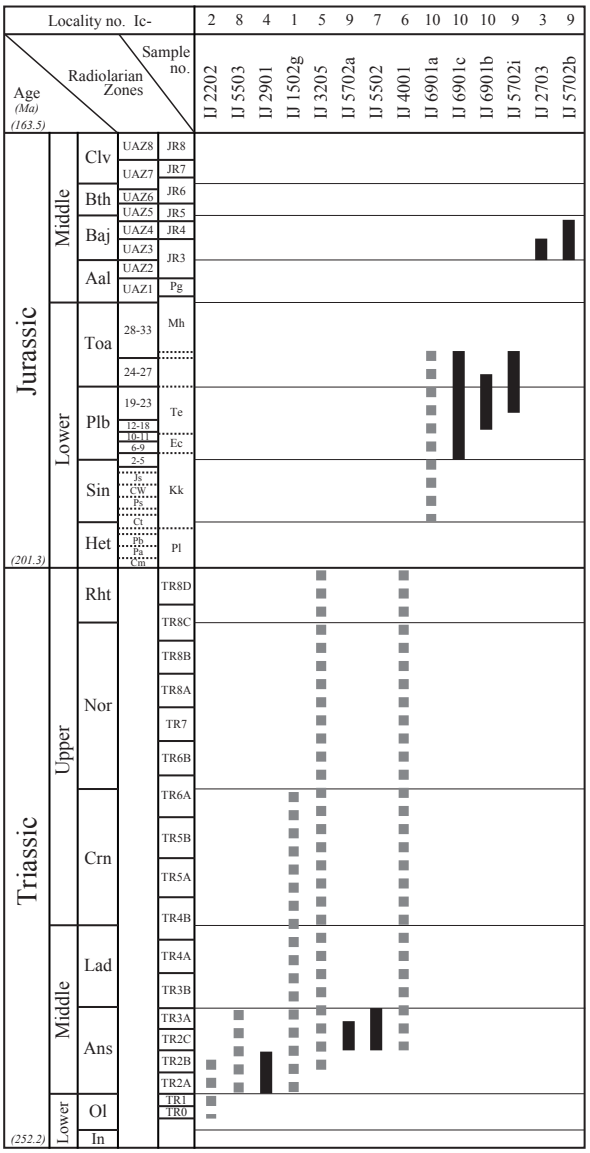


Fig. 3 Geologic age of each chert sample based on the detected radiolarians.
Radiolarian zonation schemes proposed by aftermentioned literatures are primarily adapted in this figure. These zones are arranged in ascending order: TR0 – TR8 for Triassic (Sugiyama, 1997); Pl, Kk, Ec, Te, Mh and Pg for Hettangian – lower Aalenian (Hori, 1990); Cm, Pa, Pb, Ct, Ps, CW, Js for Hettangian – Sinemurian (Carter *et al*., 1998); 2 – 33 for uppermost Sinemurian – Toarcian (Carter *et al*., 2010); JR3 – JR8 for Middle Jurassic (Matsuoka, 1995); UAZ1 – UAZ8 for Middle Jurassic (Baumgartner *et al*., 1995). Abbreviations are as follows. Pl: *Parahsuum* aff. *longiconicum*, Kk: *Katroma kurusuensis*, Ec: *Eucyrtidieum*? sp. C, Te: *Trillus elkhornensis*, Mh: *Mesosaturnalis hexagonus*, Pg: *Parahsuum*? *grande*, Cm: *Canoptum merum*, Pa: *Protokatroma aquila*, Pb: *Pantanellium browni*, Ct: *Crucella hettangica*, Ps: *Parahsuum simplum*, CW: *Canutus rockfishensis* and *Wrangellium thurstonense*, Js: *Jacus*? *sandspitensis*, UAZ: Unitary Association Zone.

middle Bajocian. On the basis of coexistence of the above two species, the age of this sample is estimated to be an interval of between early and late Bajocian.

*Praezhamoidellum yaoi* Kozur and *Striatojaponocapsa plicarum* (Yao) detected from Sample IJ5702b are diagnostic species of the Middle Jurassic period. *Praezhamoidellum yaoi* Kozur has a range that probably extends from the Aalenian to Bajocian ages. *Striatojaponocapsa plicarum* s.l. (Yao) has a slightly long range from the lower Bajocian to lower Oxfordian ages, and is divided into different morphological types with slightly different age ranges (Baumgartner, 1984; Baumgartner *et al*., 1995). The examined specimens are included in a broad type (Baumgartner, 1984) or they may belong to *Striatojaponocapsa plicarum* ssp. A (Baumgartner *et al*., 1995), in which case the age range of these specimens would extend from the upper Bajocian to lower Bathonian. Nevertheless, due to their poorly-preserved state, these specimens are treated as *Striatojaponocapsa plicarum* s.l. This consideration may suggest a Bajocian age.

## 5. Conclusion

Moderately- to poorly-preserved radiolarian faunas were extracted from 14 chert samples of 10 localities in the Imajō district, the Nanjō Mountains, Southwest Japan, and were examined to constrain the ages of the cherts. Based on the recent biostratigraphic data of the Triassic to Middle Jurassic radiolarians, the studied faunas contain a long range in age from the Olenekian? stage to the Bajocian stage (Fig. 3).

## 6. Systematic Paleontology

Descriptions of the radiolarian species examined in this report, mainly employed the taxonomic classification of De Wever *et al*. (2001) and O'Dogherty *et al*. (2009).

Subclass **RADIOLARIA** Müller 1858
Order **SPUMELLARIA** Ehrenberg 1875, *emend*. De Wever, Dumitrica, Caulet, Nigrini and Caridroit 2001

Family **Pantanelliidae** Pessagno 1977b

Genus ***Gorgansium*** Pessagno and Blome 1980
Type species *Gorgansium siviesense* Pessagno and Blome 1980

***Gorgansium* sp. cf. *G. gongyloideum*** Kishida and Hisada 1985
(Plate 4, fig. 13)
*Remarks*: The specimen is characterized by having a spherical cortical shell with hexagonal pore frames and lacking well-developed nodes at vertices. Two spines are nearly equal in length, whereas the third spine is slightly longer. It may be assignable to *Gorgansium gongyloideum* Kishida and Hisada, but is partly broken due to poor preservation.

Genus ***Pantanellium*** Pessagno 1977a
Type species *Pantanellium riedeli* Pessagno 1977a

***Pantanellium* sp. cf. *P. foveatum*** Mizutani and Kido 1983
(Plate 4, figs. 1-2)
*Remarks*: The specimen is similar to *Pantanellium foveatum* Mizutani and Kido, but differs slightly from it by having an elongated cortical shell.

***Pantanellium* sp. cf. *P. tanuense*** Pessagno and Blome 1980
(Plate 4, fig. 10)
*Remarks*: The specimen is poorly preserved but is morphologically similar to *Pantanellium tanuense* Pessagno and Blome by having a spherical cortical shell with small nodes at vertices.

***Pantanellium* spp.**
(Plate 1, fig. 21; Plate 4, figs. 11-12; Plate 5, figs. 1, 11)
*Remarks*: Four of the obtained specimens lack one of the bipolar spines, and cortical shell of the remaining specimen is partially broken. However, they are identical with species of *Pantanellium* on the basis of the spherical cortical shell that is composed of massive polygonal pore frames having nodes at vertices.

***Pantanellium*? spp.**
(Plate 2, figs. 3-4)
*Remarks*: The obtained specimens are similar to genus *Pantanellium* in general shape, but their surface structures are indistinct.

Family **Xiphostylidae** Haeckel 1881, *emend*. De Wever, Dumitrica, Caulet, Nigrini and Caridroit 2001

Genus ***Archaeocenosphaera*** Pessagno and Yang *in* Pessagno, Six and Yang 1989
Type species *Archaeocenosphaera ruesti* Pessagno and Yang *in* Pessagno, Six and Yang 1989

***Archaeocenosphaera* sp.**
(Plate 2, fig. 1)
*Remarks*: Spherical cortical shell of the figured specimen consists of two fused latticed layers with symmetrical polygonal pore frames.

***Archaeocenosphaera*? spp.**
(Plate 1, figs. 7-8)
*Remarks*: The obtained specimens are similar to genus *Archaeocenosphaera* in general shape, but their surface structure is indistinct.

Family **Emiluviidae** Dumitrica 1995

Genus ***Emiluvia*** Foreman 1973
Type species *Emiluvia chica* Foreman 1973
***Emiluvia* sp.**

(Plate 5, fig. 12)
*Remarks*: A poorly-preserved specimen was obtained. It is similar to genus *Emiluvia* in possessing a modified rectangular shell with four spines, two of which are broken.

Genus ***Plafkerium*** Pessagno *in* Pessagno, Finch and Abbott 1979
Type species *Plafkerium abbotti* Pessagno *in* Pessagno, Finch and Abbott 1979

***Plafkerium*? *antiquum*** Sugiyama 1992
(Plate 2, fig. 12)
1980 *Staurosphaera*? sp. B – Yao, Matsuda and Isozaki, plate 1, fig. 6.
1982 *Staurodoras*? sp. – Mizutani and Koike, plate 4, fig. 5.
1992 *Plafkerium*? *antiquum* Sugiyama – Sugiyama, p.1219, figs. 18-4, 18-5, 18-6.
*Remarks*: The specimen resembles *Plafkerium*? *antiquum* Sugiyama in having the four long coplanar spines which are three-bladed proximally, but needle-like distally. It differs from other species of *Plafkerium* by having non-twisted spines.
*Range*: Upper Spathian – middle Anisian (Sugiyama, 1992).

***Plafkerium*? spp.**
(Plate 2, figs. 10-11, 27; Plate 3, figs. 26-27)
*Remarks*: Cortical shell of the obtained specimens is slightly spherical rather than square in shape. Four triradiate spines, some of which are broken, extend from each corner of the shell.

Family **Angulobracchiidae** Baumgartner 1980, *emend*. De Wever, Dumitrica, Caulet, Nigrini and Caridroit 2001

Genus ***Paronaella*** Pessagno 1971
Type species *Paronaella solanoensis* Pessagno 1971

***Paronaella* sp. cf. *P. notabilis*** Whalen and Carter 2002
(Plate 5, fig. 13)
*Remarks*: This specimen is closely related to *Paronaella notabilis* Whalen and Carter by having three stout rays with irregularly shaped tetragonal or pentagonal pore frames, although the tips of its rays are broken.

Family **Archaeospongoprunidae** Pessagno 1973

Genus ***Protopsium*** Pessagno and Poisson 1981
Type species *Protopsium ehrenbergi* Pessagno and Poisson 1981

***Protopsium* spp.**
(Plate 1, figs. 5-6; Plate 2, figs. 7, 23-25)
*Remarks*: Although lacking patagium-like mass, the examined specimens are similar to genus *Protopsium* in general shape.

Order **ENTACTINARIA** Kozur and Mostler 1982

Family **Entactiniidae** Riedel 1967

Genus ***Thurstonia*** Whalen and Carter 1998
Type species *Thurstonia minutaglobus* Whalen and Carter 1998

***Thurstonia* sp.**
(Plate 4, fig. 15)
*Remarks*: The figured specimen possesses a spherical shell and six spines; two spines are bipolar, and four spines are arranged at right angles in radial plane. The cortical shell consists of polygonal pore frames with nodes at the vertices. These appearances are similar to those of genus *Thurstonia*.

Genus ***Entactinia*** Foreman 1963
Type species *Entactinia herculea* Foreman 1963

***Entactinia*? spp.**
(Plate 1, figs. 10-20)
*Remarks*: Some poorly-preserved specimens were examined. They have a subspherical shell in lateral view and main spines.

Family **Eptingiidae** Dumitrică 1978

Genus ***Eptingium*** Dumitrică 1978
Type species *Eptingium manfredi* Dumitrică 1978

***Eptingium* sp. cf. *E. manfredi*** Dumitrică 1978
(Plate 3, fig. 4)
*Remarks*: This specimen, damaged and broken, is similar to *Eptingium manfredi* Dumitrică in overall shape, but different slightly by having stout and twisted rays.

***Eptingium*? sp.**
(Plate 2, fig. 15)
*Remarks*: This specimen is intensely damaged and one of the horns lacks due to poor preservation.

Genus ***Cryptostephanidium*** Dumitrică 1978
Type species *Cryptostephanidium cornigerum* Dumitrică 1978

***Cryptostephanidium japonicum*** (Nakaseko and Nishimura) 1979
(Plate 2, fig. 9)
1979 *Trilonche japonica*, n. sp. – Nakaseko and Nishimura, p.72, plate 4, figs. 8, 10.
1990 *Cryptostephanidium japonicum* (Nakaseko and Nishimura) – Yeh, p.22, plate 4, fig. 10; plate 5, figs.1, 2, 7; plate 10, fig. 11; plate 11, fig. 18.
1995 *Cryptostephanidium japonicum* (Nakaseko and Nishimura) – Ramovš and Goričan, p.184, plate 5, fig. 1.
1996 *Cryptostephanidium japonicum* (Nakaseko and

Nishimura) – Kozur, Krainer and Mostler, p.207-208, plate 6, figs. 1-3.

*Remarks*: This specimen is characterized by having a spherical shell with high and strong nodes on the vertices of pore frames and by spines, one of which is broken, that are cylindrical in cross section.

*Range*: Upper Spathian – lowermost Ladinian (Sugiyama, 1997).

***Cryptostephanidium* sp. cf. *C. longispinosum*** (Sashida) 1991
(Plate 2, fig. 8)

*Remarks*: This specimen is characterized by having a spherical shell with short and irregular nodes at the vertices of pore frames. But it differs from *Cryptostephanidium longispinosum* (Sashida) by having slightly longer rod-like spines.

***Cryptostephanidium* spp.**
(Plate 1, figs. 1-2; Plate 3, figs. 5-8, figs. 23-25)

*Remarks*: The illustrated specimens are similar to species of genus *Cryptostephanidium* in having a globular cephalis with three horns, one of which lacks due to poor preservation.

Family **Hindeosphaeridae** Kozur and Mostler 1981

Genus ***Hindeosphaera*** Kozur and Mostler 1979
Type species *Hindeosphaera foremanae* Kozur and Mostler 1979

***Hindeosphaera* sp. cf. *H. spinulosa*** (Nakaseko and Nishimura) 1979
(Plate 3, fig. 18)

*Remarks*: The examined specimen is characterized by having a slightly ellipsoidal shell and polar spines which are quite different in length. The irregularly spongy meshwork which is characteristic of *Hindeosphaera spinulosa* (Nakaseko and Nishimura) and is constructed by polygonal pore frames, is obscure in this specimen, due to poor preservation.

Genus ***Pseudostylosphaera*** Kozur and Mostler 1981
Type species *Pseudostylosphaera gracilis* Kozur and Mock *in* Kozur and Mostler 1981

***Pseudostylosphaera japonica*** (Nakaseko and Nishinura) 1979
(Plate 3, fig. 1)

1979 *Archaeospongoprunum japonica* n. sp. – Nakaseko and Nishimura, p.67-68, plate 1, figs. 2, 4, 9.
1986 *Pseudostylosphaera japonica* (Nakaseko and Nishimura) – Blome, Jones, Murchey and Liniecki, plate 8, figs. 1, 2.
1990 *Pseudostylosphaera japonica* (Nakaseko and Nishimura) – Yeh, p.15, plate 4, figs. 5-7.

*Remarks*: The illustrated specimen is characterized by having an ellipsoidal shell with two polar spines which are equal in length. The spines are moderately long, massive and three-bladed in axial section.

*Range*: Middle Anisian – lower Carnian (Sugiyama, 1997).

***Pseudostylosphaera* sp. A** sensu Sugiyama 1992
(Plate 2, fig. 6)

1992 *Pseudostylosphaera* sp. A – Sugiyama, p.1209, figs. 14-1, 14-2.
1997 *Pseudostylosphaera* sp. A – Sugiyama, p.168, fig. 46–8.

*Remarks*: Although poorly preserved, the illustrated specimen is characterized by having three-bladed polar spines which are obliquely directed.

*Range*: Lower Anisian – Middle Anisian (Sugiyama, 1997).

***Pseudostylosphaera* spp.**
(Plate 2, fig. 5; Plate 3, figs. 2-3, 19-22)

*Remarks*: The obtained specimens, some of which are poorly-preserved, resemble *Pseudostylosphaera* in general shape.

Family **Saturnalidae** Deflandre 1953, *emend*. Kozur and Mostler, 1972

Genus ***Mesosaturnalis*** Kozur and Mostler 1981
Type species *Palaeosaturnalis levis* Donofrio and Mostler 1978

***Mesosaturnalis* spp.**
(Plate 4, figs. 20-23)

*Remarks*: On the basis of their general characters, the illustrated specimens are identical with genus *Mesosaturnalis*.

Order **NASSELLARIA** Ehrenberg 1875

Family **Poulpidae** De Wever 1981

Genus ***Hozmadia*** Dumitrică, Kozur and Mostler 1980
Type species *Hozmadia reticulata* Dumitrică, Kozur and Mostler 1980

***Hozmadia rotunda*** (Nakaseko and Nishimura) 1979
(Plate 3, fig. 31)

1979 *Tripilidium rotundum* n. sp. – Nakaseko and Nishimura, p.81-82, plate 8, figs. 1-3.
1994 *Hozmadia rotunda* (Nakaseko and Nishimura) – Kozur and Mostler, p.116, plate 29, figs. 3, 4, 7.

*Remarks*: The shell of this specimen is spherical with large hexagonal or pentagonal pore frames. Its apical horn is slightly shorter. Although the three feet are broken, this specimen belongs to *Hozmadia rotunda* (Nakaseko and Nishimura).

*Range*: Upper Anisian (Sugiyama, 1997).

***Hozmadia* sp. cf. *H. gifuensis*** Sugiyama 1992
(Plate 3, figs. 29-30)
*Remarks*: The cephalic shell of the illustrated specimen is constricted at its base as with *Hozmadia gifuensis* Sugiyama, but its apical spine is not stout.

Family **Foremanellinidae** Dumitrica 1982

Genus ***Diceratigalea*** Takemura and Nakaseko 1982
Type species *Diceratigalea hemisphaera* Takemura and Nakaseko 1982

***Diceratigalea* sp.**
(Plate 4, fig. 19)
*Remarks*: The poorly-preserved specimen possesses two apical spines and four feet, one of which is broken. This appearance is coincides with the diagnostic features of genus *Diceratigalea*.

Family **Ultranaporidae** Pessagno 1977b

Genus ***Napora*** Pessagno 1977a
Type species *Napora bukryi* Pessagno 1977a

***Napora* spp.**
(Plate 4, figs. 3-4)
*Remarks*: The poorly-preserved specimens are composed of a two-segmented test with a conical cephalis and a large thorax, and are similar to genus *Nopora* in possessing a massive apical horn and three slightly curved feet, one of which is broken, at the base.

Family **Bulbocyrtiidae** Kozur and Mostler 1981

Genus ***Bulbocyrtium*** Kozur and Mostler 1981
Type species *Bulbocyrtium reticulatum* Kozur and Mostler 1981

***Bulbocyrtium* sp. A** sensu Sugiyama 1997
(Plate 3, fig. 10)
1990 *Yeharaia*? sp. A – Yeh, p.30, plate 7, fig.13; plate 9, figs.13,18.
1997 *Bulbocyrtium* sp. A – Sugiyama, p.147, fig.37-11.
*Remarks*: This specimen is characterized by having a large balloon-like cephalis with a stout apical horn, thus indicating that it can be correlated with *Bulbocyrtium* sp. A sensu Sugiyama.
*Range*: Middle Anisian – lower Ladinian (Sugiyama, 1997).

Family **Williriedellidae** Dumitrică 1970

Genus ***Williriedellum*** Dumitrică 1970
Type species *Williriedellum crystallinum* Dumitrică 1970

***Williriedellum*? sp.**
(Plate 5, fig. 2)
*Remarks*: The obtained specimen is similar to genus *Williriedellum* in general form, but its constricted aperture does not appear clearly.

Genus ***Praewilliriedellum*** Kozur 1984
Type species *Praewilliriedellum cephalospinosum* Kozur 1984

***Praewilliriedellum*? spp.**
(Plate 1, figs. 24-25)
*Remarks*: The specimens are similar to genus *Praewilliriedellum* in general form, but internal structures of their cephalothorax are indistinct.

Genus ***Praezhamoidellum*** Kozur 1984
Type species *Praezhamoidellum yaoi* Kozur 1984
*Remarks*: O'Dogherty *et al*. (2009) have considered that *Praezhamoidellum* Kozur is a synonym of *Hemicryptocapsa* Tan. However, they differ from each other by the thoracic structure; thorax of the former genus is not depressed into the abdominal cavity (Kozur, 1984), whereas that of the latter is partly to almost completely depressed (Dumitrică, 1970).

***Praezhamoidellum yaoi*** Kozur 1984
(Plate 4, fig. 5)
1973 "*Hemicryptocapsa*" sp. – Ichikawa and Yao, plate 4, fig. 7.
1979 *Tricolocapsa* sp. cf. *T. rüsti* Tan – Yao, p.30-31, plate 3, figs. 8-20.
1984 *Praezhamoidellum yaoi* n. sp. – Kozur, p.53-54, plate 3, fig. 3.
*Remarks*: This specimen is composed of a spherical cephalis, truncated conical thorax and globose abdomen. The entire shell surface has a large hexagonal frame with narrow ridges, in the center of which there is a small circular pore.
*Range*: Upper Aalenian? – lower Bajocian? (Yao, 1984).

***Praezhamoidellum* sp. cf. *P. yaoi*** Kozur 1984
(Plate 5, fig. 23)
*Remarks*: The examined specimen is poorly-preserved, but similar to *Praewilliriedellum yaoi* Kozur in general form and in having hexagonal pore frames on the surface of abdomen.

***Praezhamoidellum* sp. cf. *P. convexa*** (Yao) 1979
(Plate 5, fig. 22)
*Remarks*: The illustrated specimen is similar to *Praezhamoidellum convexa* (Yao) by having a test consisting of four segments, especially by having a poreless cephalis. It, however, differs from the latter by possessing larger pores on the surface of its fourth segment.

***Praezhamoidellum*? spp.**
(Plate 1, fig. 26; Plate 5, fig. 3)
*Remarks*: It is difficult to identify the examined specimens due to their poor preservation. However, they are slightly

similar to genus *Praezhamoidellum* in general form and in having a cephalothorax that is weakly depressed into the abdominal cavity.

Family **Eucyrtidiellidae** Takemura 1986

Genus ***Eucyrtidiellum*** Baumgartner 1984
Type species *Eucyrtidium*? *unumaensis* Yao 1979

***Eucyrtidiellum unumaense*** (Yao) 1979
(Plate 1, fig. 27)
1979 *Eucyrtidium*? *unumaensis* n. sp. – Yao, p.39, plate 9, figs. 1-11.
1984 *Eucyrtidiellum unumaensis* (Yao) – Baumgartner, p.765, plate 4, fig. 6.
1987 *Eucyrtidiellum unumaense* (Yao) – Nagai, plate 2, figs. 1a, 1b, 1c.
1990a *Eucyrtidiellum unumaense* (Yao) – Nagai, p.597, figs. 4-6, 4-7.
*Remarks*: The cephalis is somewhat broken and an apical horn is lacked. Hexagonal meshwork is preserved on the surface of the thorax. The abdomen is relatively large and inflated-hemispherical in shape with poreless and smooth surface. Circular pores are arranged in transverse row at the base of the abdomen.
*Range*: Lower Bajocian – lower Oxfordian (Baumgartner *et al*., 1995).

***Eucyrtidiellum gunense*** Cordey 1998
(Plate 5, fig. 14)
1986 *Eucyrtidiellum* sp. C group – Nagai, p.12, plate 2, fig. 10.
1990b *Eucyrtidiellum* sp. $C_3$ – Nagai, plate 4, figs. 2-3.
1998 *Eucyrtidiellum gunense* n. sp. – Cordey, p.109, plate 25, figs. 8-9.
*Remarks*: This specimen is characterized by having a cylindrical cephalis with a stout and longer apical horn. The wide abdomen possesses pores with thick hexagonal pore frames. The fourth segment is lacked.
*Range*: Lower Pliensbachian – middle Toarcian (Carter *et al*., 2010).

***Eucyrtidiellum* spp.**
(Plate 4, fig. 24; Plate 5, fig. 15)
*Remarks*: The examined specimens are poorly-preserved, but similar to genus *Eucyrtidiellum* in general form and in having a very inflated abdomen.

Family **Ruesticyrtiidae** Kozur and Mostler 1979

Genus ***Triassocampe*** Dumitrică, Kozur and Mostler 1980
Type species *Triassocampe scalaris* Dumitrică, Kozur and Mostler 1980

***Triassocampe deweveri*** (Nakaseko and Nishimura) 1979
(Plate 3, figs. 12-13)
1979 *Dictyomitrella deweveri* n. sp. – Nakaseko and Nishimura, p.77, plate 10, figs. 8-9.
1982 *Triassocampe deweveri* (Nakaseko and Nishimura) – Yao, plate 1, figs. 1-3.
1994 *Triassocampe deweveri* (Nakaseko and Nishimura) – Kozur and Mostler, p.140-141, plate 45, fig. 6.
*Remarks*: The illustrated specimens are not well preserved, but have characteristic features of *Triassocampe deweveri* (Nakaseko and Nishimura); the cephalis is dome-shaped and imperforate, and post-cephalic segments increase slightly in width toward the distal end. On the surface of the segments, a single row of small knob-like protrusions is circumferentially arranged between well-developed circumferential ridges.
*Range*: Upper Anisian – upper Ladinian (Sugiyama, 1997).

***Triassocampe* sp. aff. *T. diordinis*** Bragin 1991 sensu Sugiyama 1992
(Plate 3, fig. 11)
*Remarks*: The illustrated specimen resembles *Triassocampe* sp. aff. *T. diordinis* Bragin of Sugiyama (1992) in overall form, which is characterized by poorly developed circumferential ridges.
*Range*: Middle Anisian (Sugiyama1992).

***Triassocampe* sp.**
(Plate 3, fig. 14)
*Remarks*: The obtained specimen belongs to genus *Triassocampe* on the basis of its well-developed circumferential ridges on the long subcylindrical test.

Family **Bagotidae** Pessagno and Whalen 1982

Genus ***Bagotum*** Pessagno and Whalen 1982
Type species *Bagotum maudense* Pessagno and Whalen 1982

***Bagotum maudense*** Pessagno and Whalen 1982
(Plate 5, figs. 16-17)
1982 *Bagotum maudense* n. sp. – Pessagno and Whalen, p.118-120, plate 3, figs. 6, 11, 20.
1997 *Bagotum maudense* Pessagno and Whalen – Yao, plate 13, fig. 637.
2001 *Bagotum maudense* Pessagno and Whalen – Gawlick, Suzuki and Missoni, plate 5, fig. 8.
*Remarks*: The illustrated specimens resemble *Bagotum maudense* Pessagno and Whalen in possessing an elongated, slender and less inflated test. Cephalis and thorax with irregular tetragonal or pentagonal pore frames, and remaining segments with linearly arranged square to rectangular pore frames.
*Range*: Lower Pliensbachian – lower Toarcian (Carter *et al*., 2010).

***Bagotum modestum*** Pessagno and Whalen 1982
(Plate 5, fig. 24)
1982 *Bagotum modestum* n. sp. – Pessagno and Whalen, p.120, plate 3, figs. 7, 16, 17.

2002 *Bagotum modestum* Pessagno and Whalen – Whalen and Carter, p.116, plate 10, figs. 9, 11, 12.
2003 *Bagotum modestum* Pessagno and Whalen – Goričan, Šmuca and Baumgartner, p.296, plate 5, fig. 22.
2004 *Bagotum modestum* Pessagno and Whalen – Matsuoka, fig. 193.

*Remarks*: This specimen resembles *Bagotum modestum* Pessagno and Whalen in overall shape, possessing a broader test. Square to rectangular pore frames on the post-abdominal segments are linearly arranged.
*Range*: Lower Pliensbachian – lower Toarcian (Carter *et al*., 2010).

***Bagotum* sp.**
(Plate 5, fig. 4)
*Remarks*: The obtained specimen consists of an ellipsoidal test possessing a final post-abdominal segment terminating in a dome-shaped cap. Then, it belongs to genus *Bagotum*.

Genus ***Broctus*** Pessagno and Whalen 1982
Type species *Broctus selwynensis* Pessagno and Whalen 1982

***Broctus ruesti*** Yeh 1987
(Plate 5, figs. 18-19)
1987 *Broctus ruesti* n. sp. – Yeh, p.54, plate 4, figs. 1-3, 7, 21.
2004 *Broctus ruesti* Yeh – Ziabrev, Aitchison, Abrajevitch, Badengzhu, Davis and Luo, figs. 5-9.

*Remarks*: This specimen is characterized by possessing a spindle-like test. Massive costae and thin transverse bars on the thorax and subsequent segments form rectangular pore frames.
*Range*: Lower Pliensbachian – lowermost Toarcian (Carter *et al*., 2010).

Family **Hsuidae** Pessagno and Whalen 1982

Genus ***Hsuum*** Pessagno 1977a, *emend*. Takemura 1986
Type species *Hsuum cuestaensis* Pessagno 1977a

***Hsuum* spp.**
(Plate 4, fig. 27; Plate 5, fig. 26)
*Remarks*: The obtained specimens consist of a long conical and multi-segmented test that is covered by weakly developed longitudinal costae.

Genus ***Parahsuum*** Yao 1982
Type species *Parahsuum simplum* Yao 1982

***Parahsuum* spp.**
(Plate 1, figs. 30-34; Plate 4, fig. 25; Plate 5, figs. 8-9, 20)
*Remarks*: Some morphotypes are recognized among the obtained specimens, but they are characterized by pores on the test that are arranged in both longitudinal and lateral lines.

Family **Parvicingulidae** Pessagno 1977a

Genus ***Praeparvicingula*** Pessagno, Blome and Hull *in* Pessagno, Blome, Hull and Six 1993
Type species *Parvicingula profunda* Pessagno and Whalen 1982

***Praeparvicingula*? sp.**
(Plate 1, fig. 36)
*Remarks*: The obtained specimen is characterized by two or three rows of pores that are laterally arranged between thick circumferential ridges. However, it is unclear that this specimen belongs to genus *Praeparvicingula*.

Genus ***Elodium*** Carter *in* Carter, Whalen and Guex 1998
Type species *Elodium cameroni* Carter *in* Carter, Whalen and Guex 1998

***Elodium* sp. cf. *E. pessagnoi*** Yeh and Cheng 1996
(Plate 4, fig. 26)
*Remarks*: This specimen is broken and poorly preserved, but is similar to *Elodium pessagnoi* Yeh and Cheng in general form and in having a conical test with a massive apical horn.

Family **Syringocapsidae** Foreman 1973

Genus ***Katroma*** Pessagno and Poinsson 1981, *emend*. De Wever 1982, *emend*. Whalen and Carter 1998
Type species *Katroma neagui* Pessagno and Poinsson 1981

***Katroma angusta*** Yeh 1987
(Plate 4, fig. 28)
1987 *Katroma angusta* n. sp. – Yeh, p.79, plate 23, fig. 8; plate 30, fig. 10.
2002 *Katroma angusta* Yeh – Whalen and Carter, p.134, plate 14, figs. 1-3, 9-10; plate 18, figs. 7-8.

*Remarks*: Although the apical horn and tubular extension are partly broken, this specimen resembles *Katroma angusta* Yeh in having an inflated post-abdominal chamber.
*Range*: Upper Pliensbachian – lower Toarcian (Yeh, 1987).

***Katroma brevitubus*** Dumitrica and Goričan *in* Goričan *et al*. 2006
(Plate 5, fig. 21)
1982 *Syringocapsa* sp. B – Yao, plate 4, figs.14-15.
1990 *Syringocapsa* sp. B – Hori, plate 8, fig.11.
1998 *Katroma megasphaera* n. sp. – Yeh and Cheng, p.28-29, plate 7, figs. 9, 20.
2006 *Katroma brevitubus* n. sp. – Goričan *et al*., p.220, plate KAT12, figs. 1-9.

*Remarks*: This specimen resembles *Katroma brevitubus* Dumitrica and Goričan in having an inflated spherical abdomen and a short tubular extension.
*Range*: Lower Pliensbachian – lowermost Toarcian (Carter *et al*., 2010).

***Katroma* spp.**
(Plate 4, figs. 29-30)
*Remarks*: The examined specimens are comprised of four segmented test. Post-abdominal segment is subspherical in shape and terminates in cylindrical tubular extension. This appearance is characteristic features of genus *Katroma*.

Genus ***Teesium*** Whalen and Carter 1998
Type species *Teesium insignitum* Whalen and Carter 1998

***Teesium*? sp.**
(Plate 4, fig. 16)
*Remarks*: Genus *Teesium* consists of a test with cephalis, thorax and large inflated abdomen: one prominent cylindrical horn and two cylindrical arms are attached to top of cephalis and base of abdomen, respectively (Whalen and Carter, 1998). This form is similar to that of the obtained specimen, but pore frame structure of the specimen is unclear.

Genus ***Striatojaponocapsa*** Kozur 1984
Type species *Tricolocapsa plicarum* Yao 1979

***Striatojaponocapsa plicarum*** (Yao 1979)
(Plate 4, figs. 6-7)
1979 *Tricolocapsa plicarum* n. sp. – Yao, p.32-33, plate 4, figs. 1-11.
1983 *Tricolocapsa plicarum* (Yao) – Matsuoka, p.20, plate 3, figs. 1-2.
1984 *Tricolocapsa plicarum* (Yao) – Baumgartner, p.790, plate 10, figs. 6-7.
1984 *Striatojaponocapsa plicarum* (Yao) – Kozur, plate 7, fig. 3.
1997 *Striatojaponocapsa plicarum plicarum* (Yao) – Hull, p168. plate 37, figs. 6, 9.
*Remarks*: Two morphotypes, broadly spindle-shaped and slenderly spindle-shaped, are included in this species (Baumgartner, 1984). The obtained specimens are grouped into the broad type which has longitudinal plicae. 16-18 plicae are visible in lateral view. A dish-like basal appendage of each of the specimens is broken. Baumgartner *et al*. (1995) distinguished this type as *Striatojaponocapsa plicarum* ssp. A, which possesses a circular depression near aperture, but the depression is indistinct on the obtained specimen.
*Range*: Upper Bajocian – lower Bathonian (Baumgartner *et al*., 1995).

Family **Pseudodictyomitridae** Pessagno 1977b

Genus ***Corum*** Blome 1984
Type species *Corum speciosum* Blome 1984

***Corum*? sp.**
(Plate 5, fig. 5)
*Remarks*: A poorly-preserved specimen was obtained and resembles genus *Corum* in having discontinuous costae on the surface of abdomen and post-abdominal segments, but one row of primary pores at the end of the costae are indistinct.

Family **Eucyrtidiidae** Ehrenberg 1847

Genus ***Stichomitra*** Cayeux 1897
Type species *Stichomitra bertrandi* Cayeux 1897

***Stichomitra* spp.**
(Plate 5, figs. 6-7)
*Remarks*: The examined specimens consist of a multi-segmented test. Cephalis without apical horn distinctively tends to be knob-like. Polygonal pore frames cover almost all portion of test. This appearance is characteristic features of genus *Stichomitra*.

**NASSELLARIA** *Incertae sedis*

*Genus* ***Dictyomitrella*** Haeckel 1887
Type species *Eucyrtidium articulatum* Ehrenberg 1875

***Dictyomitrella* sp.**
(Plate 4, fig. 8)
*Remarks*: The illustrated specimen is composed of a conical multi-segmented test which has circumferential ridges with each one row of pores below and above. On the basis of this appearance, this specimen is assigned to genus *Dictyomitrella*.

Genus ***Lantus*** Yeh 1987
Type species *Lantus sixi* Yeh 1987

***Lantus* sp. cf. *L. sixi*** Yeh 1987
(Plate 1, fig. 28)
*Remarks*: Although poorly preserved, the obtained specimen is similar to *Lantus sixi* Yeh in overall shape. However, it differs slightly from the type species by having less developed strictures between post-abdominal chambers.

***Lantus*? sp.**
(Plate 1, fig. 29)
*Remarks*: The examined specimen is similar to genus *Lantus* in having a final post-abdominal segment which is closed with an ellipsoidal cap, but is slightly different from it in overall form.

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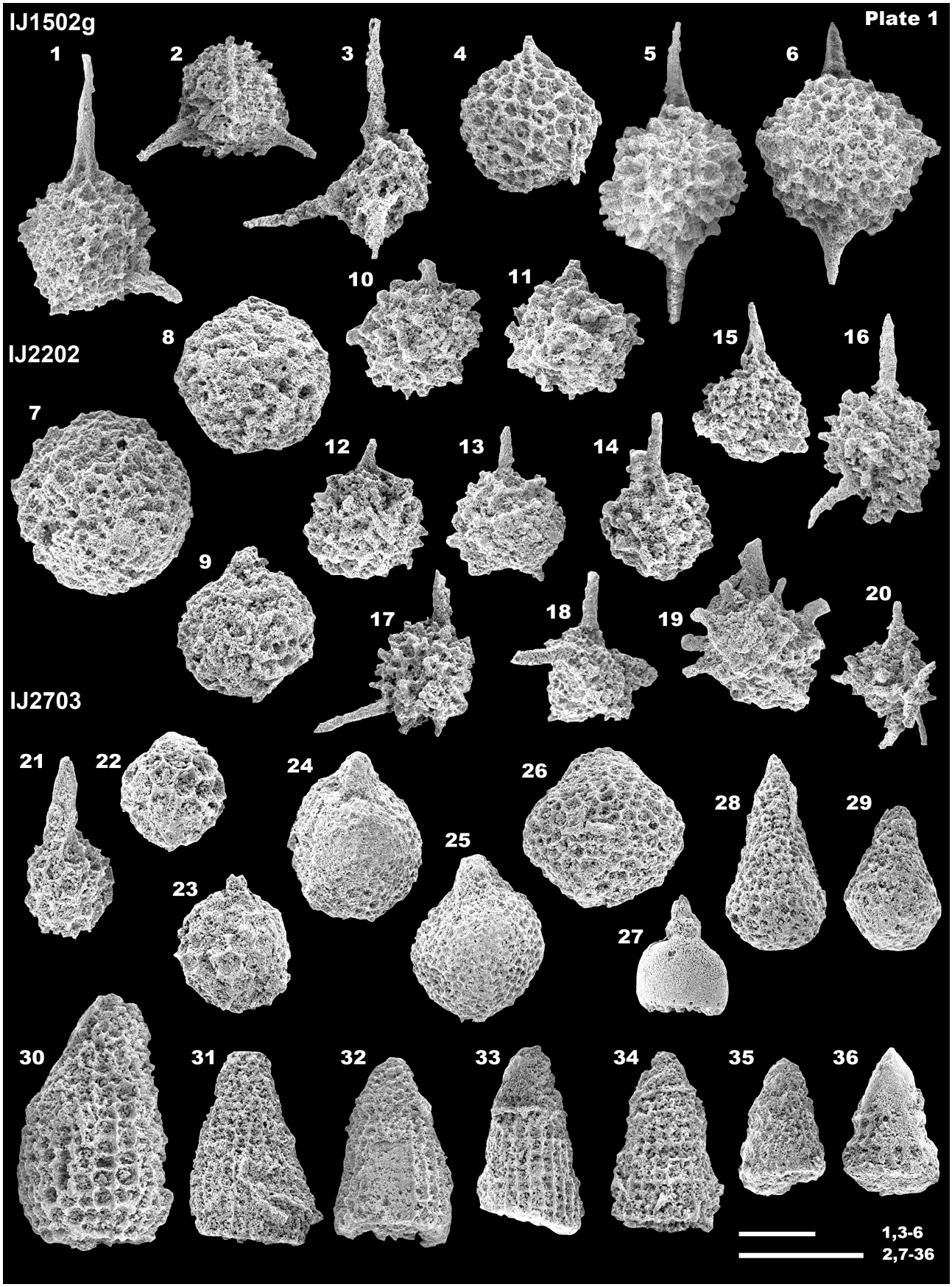
Plate 1 SEM images of Triassic to Middle Jurassic radiolarians from the Imajō district.

**IJ1502g** (Locality Ic-1: South of Tochinoki-tōge)
**1-2:** *Cryptostephanidium* spp. (1: GSJ F18100-000, 2: -004)
**3:** Entactinaria gen. et sp. indet. (GSJ F18100-003)
**4:** Spumellaria gen. et sp. indet. (GSJ F18100-007)
**5-6:** *Protopsium* spp. (5: GSJ F18100-006, 6: -005)

**IJ2202** (Locality Ic-2: North of Ōgiri)
**7-8:** *Archaeocenosphaera*? spp. (7: GSJ F18101-007, 8: -013)
**9:** Spumellaria gen. et sp. indet. (GSJ F18101-001)
**10-20:** *Entactinia*? spp. (10: GSJ F18101-004, 11: -003, 12: -015, 13: 005, 14: -009, 15: -008, 16: -012, 17: -014, 18: -010, 19: -006, 20: -002)

**IJ2703** (Locality Ic-3: Northeast of Imajō)
**21:** *Pantanellium* sp. (GSJ F18102-017)
**22-23:** Pantanelliidae gen. et sp. indet. (22: GSJ F18102-015, 23: -013)
**24-25:** *Praewilliriedellum*? spp. (24: GSJ F18102-016, 25: -014)
**26:** *Praezhamoidellum*? sp. (GSJ F18102-009)
**27:** *Eucyrtidiellum unumaense* (Yao) (GSJ F18102-008)
**28:** *Lantus* sp. cf. *L. sixi* Yeh (GSJ F18102-005)
**29:** *Lantus*? sp. (GSJ F18102-010)
**30-34:** *Parahsuum* spp. (30: GSJ F18102-001, 31: -003, 32: -002, 33: -007, 34: -004)
**35:** Nassellaria gen. et sp. indet. (GSJ F18102-012)
**36:** *Praeparvicingula*? sp. (GSJ F18102-011)

All scale bars are equal to 0.1 mm.


IJ1502g
Plate 1
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IJ2202
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IJ2703
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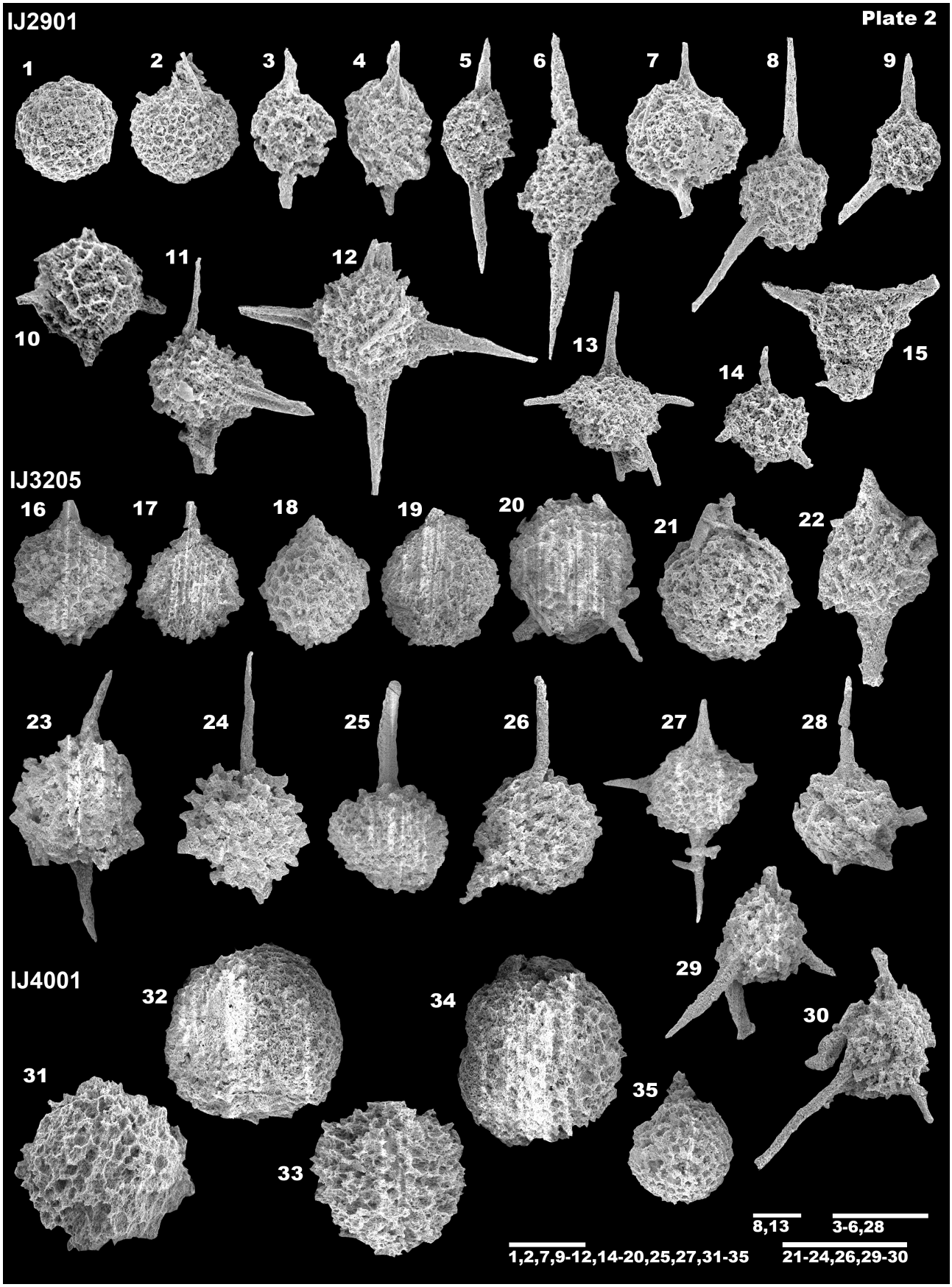
Plate 2 SEM images of Triassic to Middle Jurassic radiolarians from the Imajō district.

**IJ2901** (Locality Ic-4: Yashirodani)
**1:** *Archaeocenosphaera* sp. (GSJ F18103-015)
**2:** Spumellaria gen. et sp. indet. (GSJ F18103-006)
**3-4:** *Pantanellium*? spp. (3: GSJ F18103-010, 4: -011)
**5:** *Pseudostylosphaera* sp. (GSJ F18103-009)
**6:** *Pseudostylosphaera* sp. A sensu Sugiyama (1992) (GSJ F18103-008)
**7:** *Protopsium* sp. (GSJ F18103-014)
**8:** *Cryptostephanidium* sp. cf. *C. longispinosum* (Sashida) (GSJ F18103-003)
**9:** *Cryptostephanidium japonicum* (Nakaseko and Nishimura) (GSJ F18103-007)
**10-11:** *Plafkerium*? spp. (10: GSJ F18103-001, 11: -002)
**12:** *Plafkerium*? *antiquum* Sugiyama (GSJ F18103-004)
**13-14:** Spumellaria gen. et sp. indet. (13: GSJ F18103-005, 14: -012)
**15:** *Eptingium*? sp. (GSJ F18103-013)

**IJ3205** (Locality Ic-5: Northwest of Somayama)
**16-22:** Spumellaria gen. et sp. indet. (16: GSJ F18104-014, 17: -003, 18: -010, 19: -016, 20: -012, 21: -001, 22: -007)
**23-25:** *Protopsium* spp. (23: GSJ F18104-008, 24: -005, 25: -015)
**26:** Spumellaria gen. et sp. indet. (GSJ F18104-002)
**27:** *Plafkerium*? sp. (GSJ F18104-011)
**28-30:** Spumellaria gen. et sp. indet. (28: GSJ F18104-004, 29: -013, 30: -006)

**IJ4001** (Locality Ic-6: Hashitate)
**31-35:** Spumellaria gen. et sp. indet. (31: GSJ F18105-001, 32: -002, 33: -003, 34: -004, 35: -005)

All scale bars are equal to 0.1 mm.


IJ2901
Plate 2
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IJ3205
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IJ4001
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21-24,26,29-30

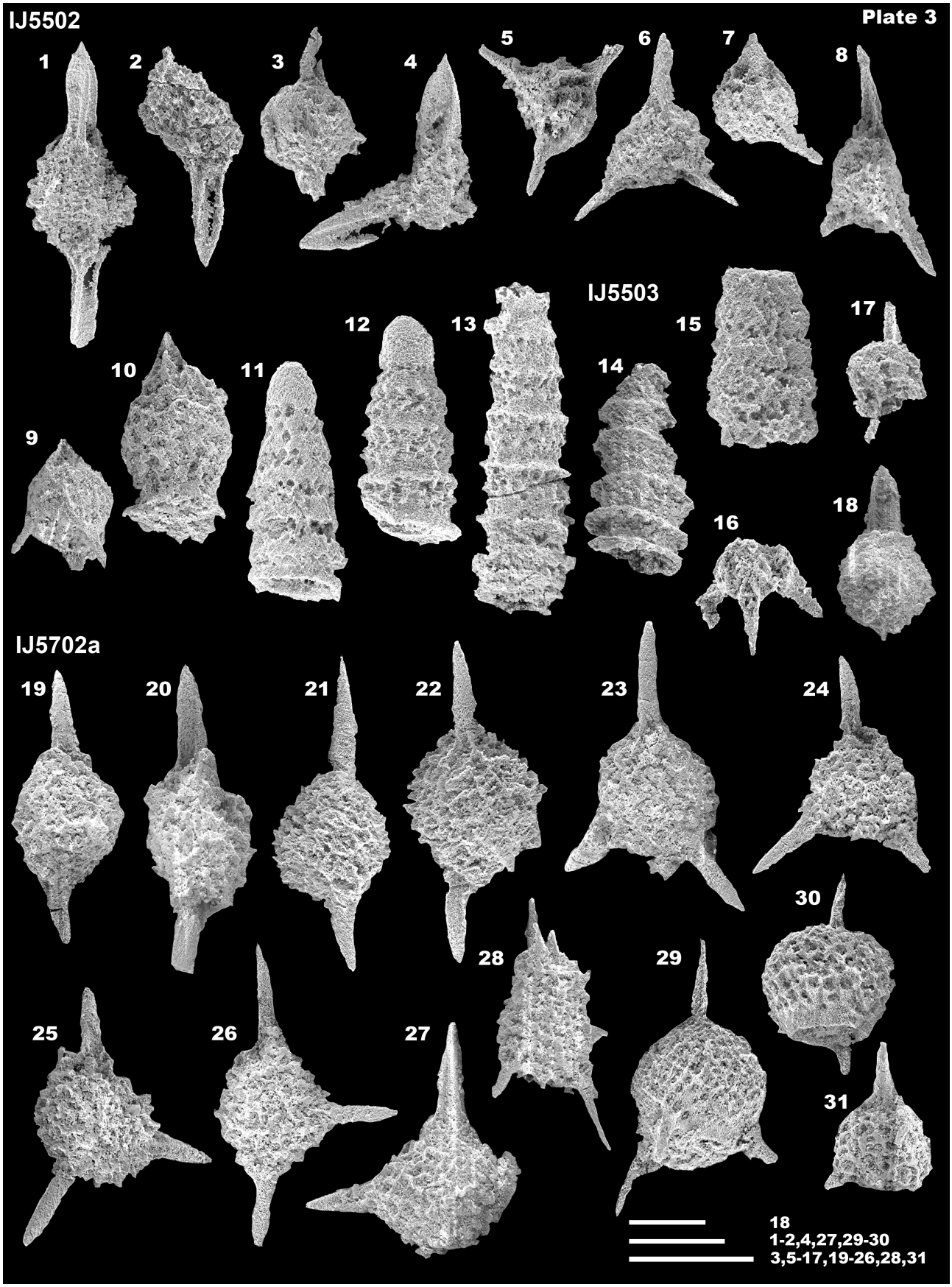
Plate 3 SEM images of Triassic to Middle Jurassic radiolarians from the Imajō district.

**IJ5502** (Locality Ic-7: West of Okunono)
**1:** *Pseudostylosphaera japonica* (Nakaseko and Nishinura) (GSJ F18117-015)
**2-3:** *Pseudostylosphaera* spp. (2: GSJ F18117-017, 3: -013)
**4:** *Eptingium* sp. cf. *E. manfredi* Dumitrică (GSJ F18117-018)
**5-8:** *Cryptostephanidium* spp. (5: GSJ F18117-007, 6: -014, 7: -010, 8: -012)
**9:** Nassellaria gen. et sp. indet. (GSJ F18117-008)
**10:** *Bulbocyrtium* sp. A sensu Sugiyama (1997) (GSJ F18117-020)
**11:** *Triassocampe* sp. aff. *T. diordinis* Bragin 1991 sensu Sugiyama (1992) (GSJ F18117-001)
**12-13:** *Triassocampe deweveri* Nakaseko and Nishimura (12: GSJ F18117-003, 13: -004)

**IJ5503** (Locality Ic-8: West of Okunono)
**14:** *Triassocampe* sp. (GSJ F18118-002)
**15:** Multisegmented Nassellaria gen. et sp. indet (GSJ F18118-003)
**16-17:** Poulpidae gen. et sp. indet. (16: GSJ F18118-005, 17: -006)
**18:** *Hindeosphaera* sp. cf. *H. spinulosa* (Nakaseko and Nishimura) (GSJ F18118-007)

**IJ5702a** (Locality Ic-9: West of Yunō)
**19-22:** *Pseudostylosphaera* spp. (19: GSJ F18119-003, 20: -011, 21: -010, 22: -006)
**23-25:** *Cryptostephanidium* spp. (23: GSJ F18119-002, 24: -001, 25: -005)
**26-27:** *Plafkerium*? spp. (26: GSJ F18119-012, 27: -009)
**28:** Spumellaria gen. et sp. indet. (GSJ F18119-013)
**29-30:** *Hozmadia* sp. cf. *H. gifuensis Sugiyama* (29: GSJ F18119-007, 30: -004)
**31:** *Hozmadia rotunda* (Nakaseko and Nishimura) (GSJ F18119-008)

All scale bars are equal to 0.1 mm.


IJ5502
Plate 3
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IJ5503
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IJ5702a
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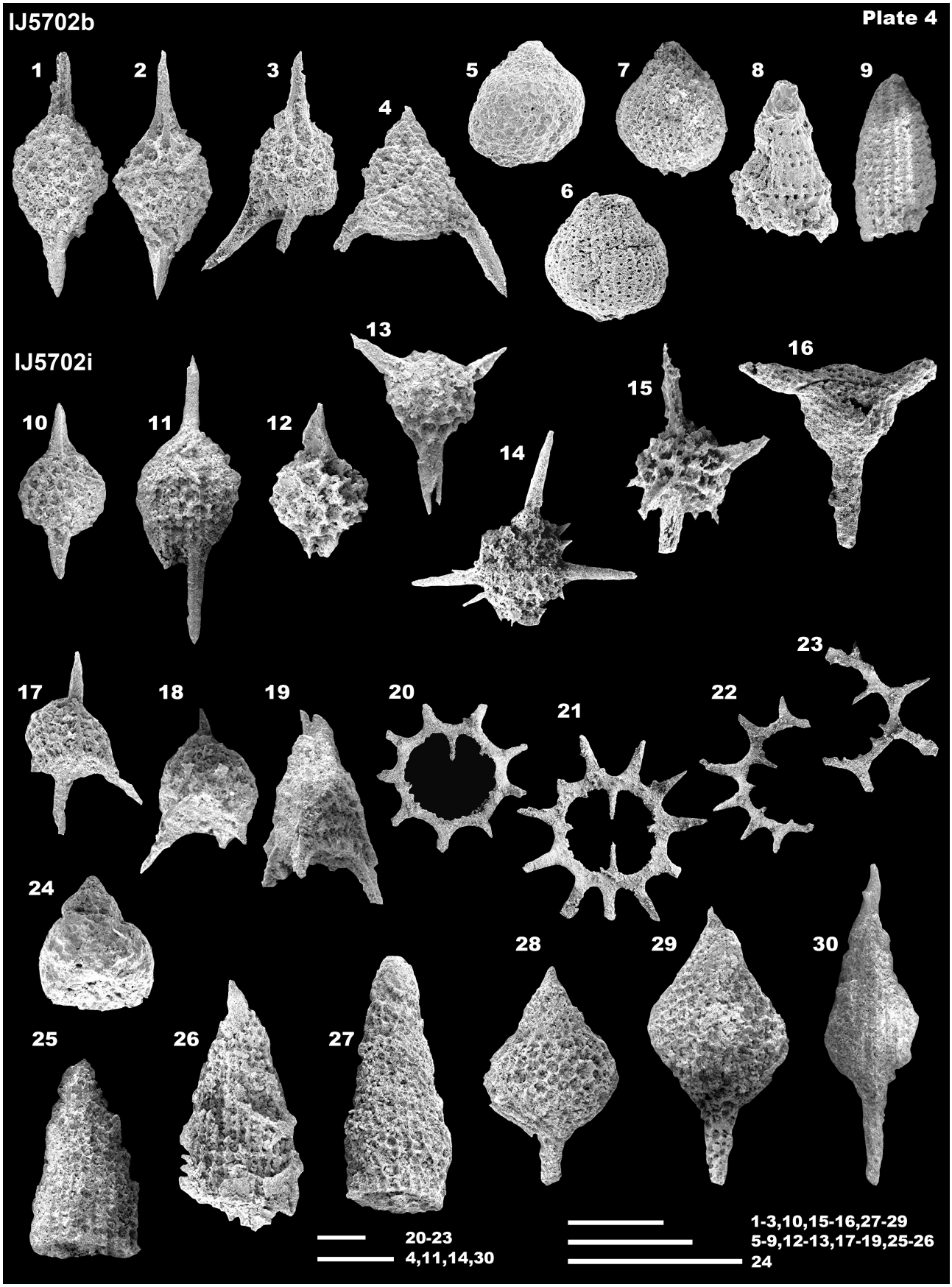
Plate 4 SEM images of Triassic to Middle Jurassic radiolarians from the Imajō district.

**IJ5702b** (Locality Ic-9: West of Yunō)
**1-2:** *Pantanellium* sp. cf. *P. foveatum* Mizutani and Kido (1: GSJ F18120-005, 2: -006)
**3-4:** *Napora* spp. (3: GSJ F18120-003, 4: -004)
**5:** *Praezhamoidellum yaoi* Kozur (GSJ F18120-007)
**6-7:** *Striatojaponocapsa plicarum* (Yao) (6: GSJ F18120-008, 7: -009)
**8:** *Dictyomitrella* sp. (GSJ F18120-002)
**9:** Multisegmented Nassellaria gen. et sp. indet. (GSJ F18120-001)

**IJ5702i** (Locality Ic-9: West of Yunō)
**10:** *Pantanellium* sp. cf. *P. tanuense* Pessagno and Blome (GSJ F18121-006)
**11-12:** *Pantanellium* spp. (11: GSJ F18121-009, 12: -015)
**13:** *Gorgansium* sp. cf. *G. gongyloideum* Kishida and Hisada (GSJ F18121-014)
**14:** Spumellaria gen. et sp. indet. (GSJ F18121-019)
**15:** *Thurstonia* sp. (GSJ F18121-020)
**16:** *Teesium*? sp. (GSJ F18121-018)
**17-18:** Poulpidae gen. et sp. indet. (17: GSJ F18121-012, 18: -011)
**19:** *Diceratigalea* sp. (GSJ F18121-010)
**20-23:** *Mesosaturnalis* spp. (20: GSJ F18121-021, 21: -022, 22: -023, 23: -024)
**24:** *Eucyrtidiellum* sp. (GSJ F18121-017)
**25:** *Parahsuum* sp. (GSJ F18121-001)
**26:** *Elodium* sp. cf. *E. pessagnoi* Yeh and Cheng (GSJ F18121-003)
**27:** *Hsuum* sp. (GSJ F18121-002)
**28:** *Katroma angusta* Yeh (GSJ F18121-008)
**29-30:** *Katroma* spp. (29: GSJ F18121-007, 30: -005)

All scale bars are equal to 0.1 mm.


IJ5702b
Plate 4
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IJ5702i
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5-9,12-13,17-19,25-26
24

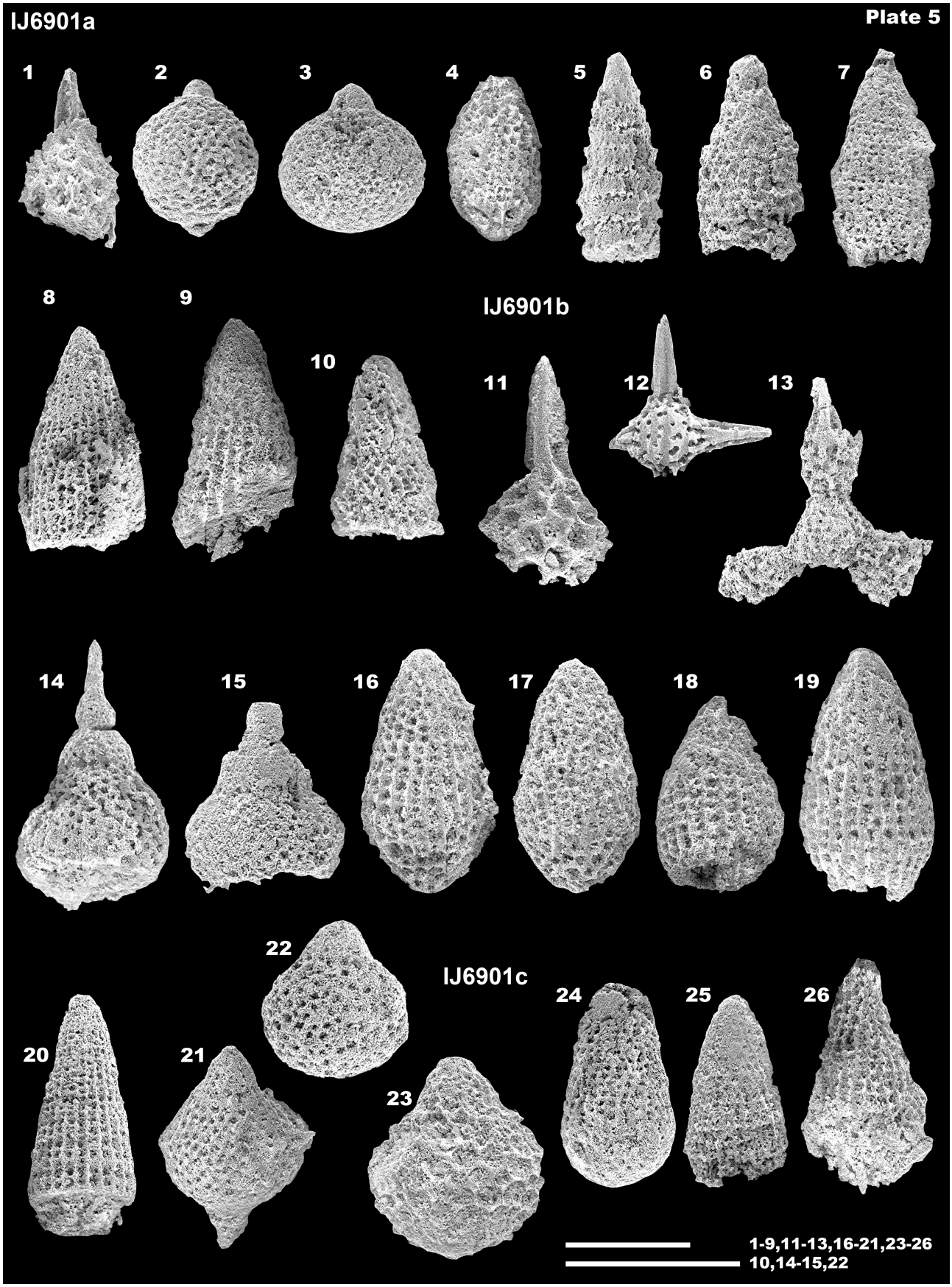
Plate 5 SEM images of Triassic to Middle Jurassic radiolarians from the Imajō district.

**IJ6901a** (Locality Ic-10: South of Kōno)
**1:** *Pantanellium* sp. (GSJ F18127-010)
**2:** *Williriedellum*? sp. (GSJ F18127-009)
**3:** *Praezhamoidellum*? sp. (GSJ F18127-011)
**4:** *Bagotum* sp. (GSJ F18127-008)
**5:** *Corum*? sp. (GSJ F18127-001)
**6-7:** *Stichomitra* spp. (6: GSJ F18127-002, 7: -006)
**8-9:** *Parahsuum* spp. (8: GSJ F18127-007, 9: -003)
**10:** Multisegmented Nassellaria gen. et sp. indet. (GSJ F18127-004)

**IJ6901b** (Locality Ic-10: South of Kōno)
**11:** *Pantanellium* sp. (GSJ F18128-010)
**12:** *Emiluvia* sp. (GSJ F18128-011)
**13:** *Paronaella* sp. cf. *P. notabilis* Whalen and Carter (GSJ F18128-012)
**14:** *Eucyrtidiellum gunense* Cordey (GSJ F18128-007)
**15:** *Eucyrtidiellum* sp. (GSJ F18128-008)
**16-17:** *Bagotum maudense* Pessagno and Whalen (16: GSJ F18128-004, 17: -005)
**18-19:** *Broctus ruesti* Yeh (18: GSJ F18128-003, 19: -002)
**20:** *Parahsuum* sp. (GSJ F18128-001)
**21:** *Katroma brevitubus* Dumitrica and Goričan (GSJ F18128-006)
**22:** *Praezhamoidellum* sp. cf. *P. convexa* (Yao) (GSJ F18128-009)

**IJ6901c** (Locality Ic-10: South of Kōno)
**23:** *Praezhamoidellum* sp. cf. *P. yaoi* Kozur (GSJ F18129-004)
**24:** *Bagotum modestum* Pessagno and Whalen (GSJ F18129-003)
**25:** Multisegmented Nassellaria gen. et sp. indet. (GSJ F18129-001)
**26:** *Hsuum* sp. (GSJ F18129-002)

All scale bars are equal to 0.1 mm.


IJ6901a
Plate 5
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IJ6901b
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IJ6901c
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10,14-15,22

# 西南日本南条山地における遠洋性チャートから産出した三畳紀–中期ジュラ紀放散虫 ー 第１部．今庄地域

**中江　訓**

## 要　旨

西南日本福井県中央部に位置する南条山地の主要域には，玄武岩・石灰岩・チャート・泥岩・砂岩などの多様な岩石から構成される堆積岩複合岩体が分布する．南条山地におけるこれらの岩石のうち27地点のチャートについて，含有される放散虫化石の検討を行った．その結果，今庄地域では10地点14試料からSpumellaria目ならびにEntactinaria目が卓越する三畳紀群集とNassellaria目が卓越するジュラ紀群集が産出した．本報告ではこれらの放散虫化石群集を記載するとともに，その種構成に基づき今庄地域に分布するチャートの地質時代は前期三畳紀 (Olenekian?) 〜中期ジュラ紀 (Bajocian) に至ると結論した．

**難読・重要地名**

Fukui：福井，Hashitate：橋立，Imajō：今庄，Kanmuri Yama：冠山，Kōno：河野，Minamiechizen：南越前，Mino：美濃，Nagahama：長浜，Nanjō：南条，Ōgiri：大桐，Okunono：奥野々，Somayama：杣山，Tochinoki-tōge：栃ノ木峠，Yashirodani：社谷，Yogo：余呉，Yunō：湯尾．