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Update in species identification of the Mariana Radiolarian Fauna (Jurassic–Cretaceous transition age) from the northwest Pacific

Atsushi MATSUOKA*

Abstract

The Mariana Radiolarian Fauna, dated around the Jurassic–Cretaceous boundary, is an extremely well-preserved fossil fauna. Since 256 morphotypes in the fauna were listed and figured in 1998, 10 new species were described in the same rock sample of D181-R003. A total of 206 species and six subspecies were described in samples of latest Jurassic to early Early Cretaceous in age from the West Tethys (Germany, Italy), Antarctica, Asia (Japan, Russia, China), and the Indian Ocean. The results of updated identification of the Mariana Radiolarian Fauna are presented. A large number of morphotypes are still waiting for scientific description. The relation of the Mariana Radiolarian Fauna with the ongoing activities of the Berriasian Working Group of the International Subcommission on Cretaceous Stratigraphy on the Jurassic–Cretaceous boundary issue is discussed. In addition, the Mariana Radiolarian Fauna and its usage for research, education and outreach activities are introduced.

Keywords: fossil Lagerstätten, Jurassic–Cretaceous boundary, Mariana Radiolarian Fauna, new species, education–outreach.

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Introduction

The Mariana Radiolarian Fauna (Matsuoka, 2025), dated around the Jurassic–Cretaceous boundary, is an extremely well-preserved fossil fauna. It was recovered from the outer slope of the Mariana Trench by a submersible "Shinkai 6500" (Ogawa et al., 1994). A unique characteristic of the fauna is that radiolarian shells are still in the state of opal-A although the rock is dated as old as some 140 Ma (Ogawa et al., 1996, 1998). A single rock sample (D181-R003) of tuffaceous clayey radiolarite is regarded as one of fossil Lagerstätten (Seilacher et al., 1985) because it contains an extremely-well preserved radiolarian fauna with diversified species composition as many as 400 morphotypes (Fig. 1). A total of 256 morphotypes were listed and figured in Matsuoka (1998). In that time, many of morphotypes were not identified at the species level. Since then, several components of the Mariana Radiolarian Fauna were described as new species (Li et al., 2011; Li and Sashida, 2012, 2013). In addition, many new radiolarian taxa of latest Jurassic (Tithonian) to early Early Cretaceous (Berriasian, Valanginian) age have been proposed from Germany (Dumitrica and Zügel, 1998, 2002, 2003, 2008; Dumitrica, 2013), the Antarctica Peninsula (Kiessling, 1999), Japan (Hori, 1999), Russia (Vishnevskaya and Murchey, 2002; Kemkin and Taketani, 2004), Tibet in China (Wu et al., 2017), Italy (Dumitrica et al., 2022), and the Indian Ocean off Australia (Baumgartner et al., 2023). In this paper, taxonomic names of the Mariana Radiolarian Fauna are updated following the above-mentioned descriptive works.

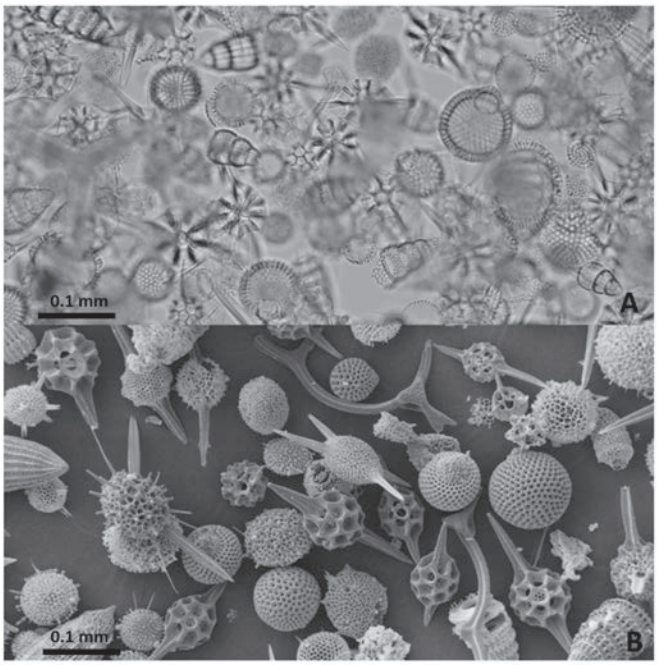


Fig. 1. Mariana Radiolarian Fauna from sample D181-R003.
A: Light microscope image, B: Scanning electron microscope image.

A story around the Mariana Radiolarian Fauna from its discovery to the present situation was summarized in Matsuoka (2025). The fauna has been utilized not only for scientific research but also for education and outreach activities for more than 30 years. The relation of the Mariana Radiolarian Fauna with the ongoing activities of the Berriasian Working Group of the International Subcommission on Cretaceous Stratigraphy on the Jurassic–Cretaceous boundary issue is discussed. In addition, the Mariana Radiolarian Fauna and its usage for research, education and outreach activities are presented. Playing cards with scanning electron microscope images of the Mariana Radiolaria Fauna is introduced as one of examples for education and outreach purposes.

Taxonomic research on the Mariana Radiolarian Fauna

Taxonomic examination on the Mariana Radiolarian Fauna itself was performed by Li and her colleagues. Li et al. (2011) established two new entactinarian genera of *Marianasphaera* and *Shinkaiera* and described *Marianasphaera ogawai* Li & Sashida, *Marianasphaera multispinosa* Li & Sashida, and *Shinkaiera robusta* Li & Sashida as new species. Li and Sashida (2012) described *Paracubocostylus tetrayurta* Li & Sashida and *Tetraspina simplex* Li & Sashida as new genus and new species together with *Shinkaiera pacifica* Li & Sashida and *Shinkaiera robusta* Li & Sashida. Li and Sashida (2013) gave new names for vallupine species: *Vallupus gracilis* Li & Sashida, *Mesovallupus brevispina* Li & Sashida, and *Neovallupus mediforma* Li & Sashida. A total of 10 new species of seven genera (four new) were introduced for the Mariana Radiolarian Fauna.

Taxonomic research on latest Jurassic and early Early Cretaceous radiolarians since 1998

Radiolarian assemblages spanning in age from latest Jurassic (Tithonian) to early Early Cretaceous (Berriasian, Valanginian) have been described all over the world. Some papers proposed new genera and species that are included in the Mariana Radiolarian Fauna as well. An early Tithonian radiolarian fauna has been reported from the Solnhofen area in south Germany (Zügel, 1997; Dumitrica, 2013; Dumitrica and Zügel, 1998, 2002, 2003, 2008). Southern hemisphere Tithonian–Berriasian radiolarian assemblages were described from the Antarctica Peninsular (Kiessling, 1999). Hori (1999) reported a Tithonian radiolarian fauna from an accretionary complex in the Ashio belt, central Japan. New latest Jurassic to earliest Cretaceous radiolarian species and subspecies were described from several localities in Russia (Vishnevskaya and Murchey, 2002; Kemkin and Taketani, 2004). Wu et al. (2017) described a Berriasian radiolarian fauna from a single chert block within melange in southern Tibet, China. Dumitrica et al. (2022) described Valanginian faunas from Sardinia, Italy. Baumgartner et al. (2023) reported Early Cretaceous radiolarians from the northeastern Indian Ocean, off Australis. Newly proposed taxa with author name(s) by the above-mentioned works are introduced below.

1. Early Tithonian radiolarian fauna from the Solnhofen area, southern Germany

Zügel (1997) discovered a well-preserved radiolarian fauna of early Tithonian age from the Mühlheim Member of the Mörnsheim Formation in the Solnhofen area, southern Germany. Sample Mue 22 contains the most abundant and diversified radiolarian fossils. The fauna is herein called the Solnhofen Radiolarian Fauna. Components of the fauna were described by Dumitrica and Zügel (1998, 2002, 2003, 2008) and Dumitrica (2013). A total of 85 new species were introduced for the Solnhofen Radiolarian Fauna. Sample Mue 22 is regarded as another example of fossil Lagerstätten of early Tithonian age.

Dumitrica and Zügel (1998) newly described *Hexapylocapsa anachoreta* Dumitrica & Zügel, under the new Family Hexapylocapsidae of the Order Nassellaria.

Dumitrica and Zügel (2002) established two new genera and species *Mendacastrum baumgartneri* Dumitrica & Zügel and *Domuzdagia deweveri* Dumitrica & Zügel under the new Family Mendacastridae and Domuzdagiidae, respectively.

Dumitrica and Zügel (2003) examined the occurrences of mono- and dicyrtid nassellarians in lower Tithonian sequences of the Solnhofen area and described 9 new genera and 53 new species from sample Mue 22: *Arachnoplecta architectonica* Dumitrica & Zügel, *Tetrarchiplagia ramosa* Dumitrica & Zügel, *Tetrarchiplagia tithoniana* Dumitrica & Zügel, *Turriseiffelus invalidissimus* Dumitrica & Zügel, *Turriseiffelus invalidus* Dumitrica & Zügel, *Turriseiffelus yaoi* Dumitrica & Zügel, *Saitoum ambiguum* Dumitrica & Zügel, *Saitoum bicorniculatum* Dumitrica & Zügel, *Saitoum curtipes* Dumitrica & Zügel, *Saitoum*? *delicatum* Dumitrica & Zügel, *Saitoum differtum* Dumitrica & Zügel, *Saitoum kapewinteri* Dumitrica & Zügel, *Saitoum labeosum* Dumitrica & Zügel, *Saitoum macilentum* Dumitrica & Zügel, *Saitoum reticulatum* Dumitrica & Zügel, *Saitoum virgulispina* Dumitrica & Zügel, *Saitulpus neojurassicus* Dumitrica & Zügel, *Saitulpus retrospina* Dumitrica & Zügel, *Saitulpus spinipes* Dumitrica & Zügel, *Pseudopoulpus crassispinosus* Dumitrica & Zügel, *Pseudopoulpus tenuihirsutus* Dumitrica & Zügel, *Takoum takemurai* Dumitrica & Zügel, *Tripedocorbis tardus* Dumitrica & Zügel, *Acuticassis gotica* Dumitrica & Zügel, *Cassideus biannulatus* Dumitrica & Zügel, *Cassideus deweveri* Dumitrica & Zügel, *Cassideus scalariconus* Dumitrica & Zügel, *Sanniopileus stultisissimus* Dumitrica & Zügel, *Sanniopileus stultus* Dumitrica & Zügel, *Reticulotubulus tintinnabulum* Dumitrica & Zügel, *Cornutella tella* Dumitrica & Zügel, *Tertonium curvicornum* Dumitrica & Zügel, *Tertonium rectum* Dumitrica & Zügel, *Toritenum corpulentum* Dumitrica & Zügel, *Toritenum hirsutum* Dumitrica & Zügel, *Anaticapitula clauda* Dumitrica & Zügel, *Anaticapitula germanica* Dumitrica & Zügel, *Anaticapitula pennata* Dumitrica & Zügel, *Anaticapitula tenera* Dumitrica & Zügel, *Napora aranea* Dumitrica & Zügel, *Napora avirostrum* Dumitrica & Zügel, *Napora bondoca* Dumitrica & Zügel, *Napora cristata* Dumitrica & Zügel, Napora divaricata Dumitrica & Zügel, *Napora matsuokai* Dumitrica & Zügel, *Napora modesta* Dumitrica & Zügel, *Napora pyramis* Dumitrica & Zügel, *Napora schaudibergensis* Dumitrica & Zügel, *Napora timida* Dumitrica & Zügel, *Poculinapora marsupiala* Dumitrica & Zügel,

Poculinapora poculigera Dumitrica & Zügel, *Poculinapora spathulipes* Dumitrica & Zügel, and *Poculinapora tripartita* Dumitrica & Zügel.

Dumitrica and Zügel (2008) examined saturnalid radiolarians and described 10 new species of the genera *Spongosaturninus*, *Moebicircus*, and *Acanthocircus*: *Spongosaturninus corpulentus* Dumitrica & Zügel, *Spongosaturninus matsuokai* Dumitrica & Zügel, *Spongosaturninus kiesslingi* Dumitrica & Zügel, *Spongosaturninus medioangustus* Dumitrica & Zügel, *Spongosaturninus radius* Dumitrica & Zügel, *Spongosaturninus tortuosus* Dumitrica & Zügel, *Moebicircus ruthae* Dumitrica & Zügel, *Acanthocircus calvus* Dumitrica & Zügel, *Acanthocircus spelae* Dumitrica & Zügel, and *Acanthocircus echinocircus* Dumitrica & Zügel.

Dumitrica (2013) described entactinarian radiolarians including 10 new genera and 19 new species: *Isometractinia wonae* Dumitrica, *Isometractinia fimbriata* Dumitrica, *Triumbraculum brauni* Dumitrica, *Tardentactinia echinata* Dumitrica, *Tardentactinia longispinosa* Dumitrica, *Tardentactinia oregonensis* Dumitrica, *Lententactinia nummulitica* Dumitrica, *Hollandocachonia haeckeli* Dumitrica, *Sphaerentofurca aranea* Dumitrica, *Sphaerentofurca endotetrahedron* Dumitrica, *Sphaerentofurca polygonata* Dumitrica, *Stylentofurca kiesslingi* Dumitrica, *Stylentofurca tortilis* Dumitrica, *Stylentofurca serrata* Dumitrica, *Stylentofurca polyacantha* Dumitrica, *Stylentofurca rara* Dumitrica, *Zuegelifurca germanica* Dumitrica, *Spongentofurca arcuata* Dumitrica, and *Odoghertites tithonianus* Dumitrica.

2. Tithonian–Berriasian radiolarian fauna from the Antarctica Peninsula

Kiessling (1999) reported a Tithonian–Berriasian radiolarian succession from the type section of the Ameghino Formation on the Antarctic Peninsula. In applying North American zonation of Pessagno et al. (1987), Zone 4 and Zone 5 were recognized in the succession. Three hundred and fifty-nine species in total were found in the succession. Newly described taxa include the following 28 species and two subspecies: *Actinomma frigida* Kiessling, *Actinomma interessanta* Kiessling, *Actinomma longinggapensis* Kiessling, *Actinomma verwirra* Kiessling, *Gorgansium steigeri* Kiessling, *Protovallupus diffifilis* Kiessling, *Praeconocaryomma*? *matsuokai* Kiessling, *Suna echiodes concava* Kiessling, *Hexastylus*? *grahamensis* Kiessling, *Emiluvia lowercoonensis polaris* Kiessling, *Emiluvia parvinodosa* Kiessling, *Homoeoparonaella elegans yangi* Kiessling, *Higumastra scassoi* Kiessling, *Acanthocircus dumitricai* Kiessling, *Paronaella coalescenda* Kiessling, *Tripocyclia crassa* Kiessling, *Orbiculiforma*? *hullae* Kiessling, *Teichertus hypnoticus* Kiessling, *Spongostaurus australis* Kiessling, *Spongotripus*? *pujanai* Kiessling, *Octodendron*? *superfragilis* Kiessling, *Mita weddellensis* Kiessling, *Perispyridium serratum* Kiessling, *Perispyridium trifolium* Kiessling, *Parvicingula judae* Kiessling, *Praeparvicingula*? *proiecta* Kiessling, *Pseudopoulpus spinosus* Kiessling, *Napora irregularis* Kiessling, *Napora pacifica* Kiessling, and *Zhamoidellum boehmi* Kiessling.

3. Tithonian radiolarian fauna from the Ashio terrane in central Japan

Hori (1999) reported a Tithonian radiolarian fauna from an accretionary complex in the Ashio belt, central Japan. Newly described taxa include the following 13 species and one subspecies: *Orbiculiforma*? *plana* Hori, *Dactyliodiscus*? *rotundus* Hori, *Sethocapsa hexagona* Hori, *Xitus reticulatus* Hori, *Pseudoeucyrtis cylindrata* Hori, *Pseudoeucyrtis levis* Hori, *Stichocapsa praepulchella* Hori, *Stichocapsa*? *yamizoensis* Hori, *Cinguloturris fusiformis* Hori, *Parvicingula robusta* Hori, *Ristola altissima nodosa* Hori, *Spongocapsula conica* Hori, *Spongocapsula daigoensis* Hori, and *Spongocapsula ovum* Hori.

4. Tithonian–Berriasian radiolarian fauna from the Boreal realm in Russia

Vishnevskaya and Murchey (2002) reported Late Jurassic and Early Cretaceous radiolarian faunas from the Boreal realm in Russia and described two new subspecies: *Parvicingula blowi sibirica* Vishnevskaya & Murchey from the upper Tithonian–lower Berriasian in the Koryak Mountains and *Stichocapsa devorata arctica* Vishnevskaya & Murchey from upper Volgian in the Volga Basin, equivalent of upper Tithonian–lower Berriasian in the Tethyan realm.

5. Tithonian radiolarian fauna from the Taukha Terrane in Southern Sikhote-Alin, Russian Far East

Late Jurassic radiolarian faunas from an accretionary complex, called the Taukha Terrane in Russian Far East were reported by Kemkin and Taketani (2004). They described three new Tithonian radiolarian species: *Stichocapsa*? *pseudoconvexa* Kemkin & Taketani, *Sethocapsa taukhaensis* Kemkin & Taketani, and *Cinguloturris primorika* Kemkin & Taketani.

6. Berriasian radiolarian fauna from southern Tibet, China

Wu et al. (2017) reported a total of 29 Berriasian species including six new species from a chert sample (80-R1), an olistolith of the Zongzhou Formation in southern Tibet, China. Newly described six species are *Godia cylindraca* Wu, Xu & Yang, *Godia obesa* Wu, Xu & Yang, *Hiscocapsa*? *mirifica* Wu, Xu & Yang, *Svinitzium paradepressum* Wu, Xu & Yang, *Svinitzium variabilis* Wu, Xu & Yang, and *Xiphostylus*? *globosus* Wu, Xu & Yang.

7. Valanginian radiolarian fauna from Sardinia, Italy

Dumitrica et al. (2022) examined radiolarian biostratigraphy in the Lower Cretaceous of Sardinia, Italy. Newly described 42 species are *Praeconocaryomma thurowi* Dumitrica, *Alievium eurasicum* Dumitrica, *Alievium incomptum* Dumitrica, *Alievium rotundum* Dumitrica, *Becus coronatus* Dumitrica, *Godia*? *lens* Dumitrica, *Godia*? *lenticulata* Dumitrica, *Eucyrtidiellum sardoum* Dumitrica, *Gongylothorax oculoporus* Dumitrica, *Arcanicapsa*? *alieviana* Dumitrica, *Arcanicapsa*? *simplicissima* Dumitrica, *Williriedelum occultithorax* Dumitrica, *Williriedellum cordiforme* Dumitrica, *Williriedellum labeosum* Dumitrica, *Cryptamphorella circumthoracica* Dumitrica, *Cryptamphorella crassilabrosa* Dumitrica,

Hiscocapsa aitai Dumitrica, *Hiscocapsa lagunculoides* Dumitrica, *Hiscocapsa rugosacutis* Dumitrica, *Hiscocapsa tuberculata* Dumitrica, *Hiscocapsa ventriosa* Dumitrica, *Doliocapsa erbae* Dumitrica, *Doliocapsa fovopora* Dumitrica *Doliocapsa mediterranea* Dumitrica, *Doliocapsa utoi* Dumitrica, *Doliocapsa weisserti* Dumitrica, *Ocellicapsa ruthae* Dumitrica, *Squinabollum elegans* Dumitrica, *Amphipyndax zyabrevi* Dumitrica, *Archaeodictyomitra inflara* Dumitrica, *Archaeodictyomitra dienii* Dumitrica, *Archaeodictyomitra longipora* Dumitrica, *Archaeodictyomitra massarii* Dumitrica, *Archaeodictyomitra robustovum* Dumitrica, *Archaeodictyomitra judae* Dumitrica, *Archaeodictyomitra humerosa* Dumitrica, *Archaeodictyomitra conicoscalaris* Dumitrica, *Archaeodictyomitra pumila* Dumitrica, *Svinitzium irregulare* Dumitrica, *Tethysetta reducta* Dumitrica, *Pseudoxitus wui* Dumitrica, and *Novixitus quadripartitus* Dumitrica.

8. Early Cretaceous radiolarian fauna from the northeastern Indian Ocean

Baumgartner et al. (2023) reported Early Cretaceous radiolarians at ODP Leg 123, Site 765 in the northeastern Indian Ocean. Seven genera were newly proposed: *Nodosphaera*, *Praewindalia*, *Pachycingula*, *Archaeotanella*, *Morchella*, *Fusitanella*, and *Argofusus*. Newly described 30 species are *Nodosphaera spinifera* Baumgartner & Li, *Hemicryptocapsa*? *exgyrum* Baumgartner & Li, *Praewindalia luoi* Baumgartner & Li, *Windalia aitai* Baumgartner & Li, *Windalia argoensis* Baumgartner & Li, *Windalia menhira* Baumgartner & Li, *Windalia pinguis* Baumgartner & Li, *Windalia*? *confusa* Baumgartner & Li, *Windalia barremoaptiana* Baumgartner & Li, *Pachycingula biporata* Baumgartner & Li, *Pachycingula magnicupula* Baumgartner & Li, *Parvicingula acantha* Baumgartner & Li, *Parvicingula sassetta* Baumgartner & Li, *Tethysetta elongata* Baumgartner & Li, *Tethysetta kathara* Baumgartner & Li, *Tethysetta pagodhika* Baumgartner & Li, *Archaeotanella conica* Baumgartner & Li, *Archaeotanella gondwanensis* Baumgartner & Li, *Archaeotanella gorda* Baumgartner & Li, *Morchella minima* Baumgartner & Li, *Morchella ovalis* Baumgartner & Li, *Morchella urquhartae* Baumgartner & Li, *Fusitanella mikei* Baumgartner & Li, *Fusitanella dictyoides* Baumgartner & Li, *Fusitanella tyroidalis* Baumgartner & Li, *Fusitanella spinifex* Baumgartner & Li, *Argofusus primitivus* Baumgartner & Li, *Argofusus mays* Baumgartner & Li, *Argofusus magnus* Baumgartner & Li, and *Argofusus haigi* Baumgartner & Li.

Update in identification of the Mariana Radiolarian Fauna

As reported in the previous section, many new species have been described since 256 morphotypes of the Mariana Radiolarian Fauna in sample D181-R003 were illustrated in 1998 (Matsuoka, 1998). Ten new species were described in the same sample (D181-R003). A total of 206 species and six subspecies were described in samples of latest Jurassic to early Early Cretaceous in age from the West Tethys (Germany, Italy), Asia (Japan, Russia, China), and the

Indian Ocean.

Scanning electron microscope (SEM) images with quality higher than those in Matsuoka (1998) of the 256 morphotypes are presented in Plates 1–16. Table 1 shows the results of updated identification of the Mariana Radiolarian Fauna. The numbers in Table 1 correspond to those in the 16 plates. When any modifications from the previous statement by Matsuoka (1998) have been applied, taxonomic names and/or author name(s) are indicated in bold and red.

As seen in Table 1, many specimens do not have species names yet. As stated herein, more than 200 species were described as new species worldwide. During the present work, the author has realized that most articles presented here did not mention intra-specific variation in morphology. Extensive descriptive works including detailed morphological analysis are essentially needed for the Mariana Radiolarian Fauna.

Mariana Radiolarian Fauna and the Jurassic–Cretaceous boundary issue

Despite being one of the most significant geological sequence boundaries in the Mesozoic Era, the Jurassic–Cretaceous boundary (JKB) remains undefined. It is the last "System" boundary in the geological time scale without a designated Global Boundary Stratotype Section and Point (GSSP). In 2020, the former Berriasian Working Group (BWG) proposed a GSSP candidate for the JKB (Wimbledon et al., 2020a, b), but it was not supported by the International Subcommission on Cretaceous Stratigraphy. A new BWG was organized in 2021 and has worked constantly toward this goal (Grabowski et al., 2026). The activity of the BWG is at a stage in determining the primary marker for the JKB as of the spring in 2026.

The Mariana Radiolarian Fauna comes from sample D181-R003, one of fossil Lagerstätten in northwestern Pacific, and contains as many as 400 morphotypes. The stratigraphic position of the rock sample is regarded within the *Pseudodictyomitra carpatica* Zone in the framework of the radiolarian zonation applicable for the western Pacific and Japan (Matsuoka, 1992, 1995; Matsuoka and Ito, 2019). Although the fauna has been dated as an early Berriasian age (Matsuoka, 1998), this age assignment can be changed depending on the definition of the JKB.

Sample Mue 22 from the Solnhofen area, southern Germany is another example of fossil Lagerstätten and contains more than 400 species of the Solnhofen Radiolarian Fauna. The fauna is dated as an early Tithonian age on the basis of co-occurring ammonoid fauna (Zügel, 1997). It is true that the Solnhofen Radiolarian Fauna is a little older than the Mariana Radiolarian Fauna. As stated in this paper, 85 new species were described for the fauna since the discovery of the sample.

Radiolarian diversity patterns in the latest Jurassic–earliest Cretaceous is discussed by Kiessling (2002). On the basis of his estimation, the Mariana Radiolarian Fauna and the Solnhofen Radiolarian Fauna produce two largest records of 300–600 species number among

coeval radiolarian faunas worldwide. These two faunas can be expected to provide a fundamental data set on morphological change in radiolarian shells from latest Jurassic to earliest Cretaceous, making clear evolutionary trends in many radiolarian lineages. This can contribute to establishing the primary marker among radiolarian taxa for determining the JKB.

Mariana Radiolarian Fauna and its usage for research, education and outreach activities

The Mariana Radiolarian Fauna has been utilized not only for scientific research but also for education and outreach activities for more than 30 years since its discovery (Matsuoka, 2025). Enlarged models of radiolarian shells produced by microfocus X-ray CT and additive manufacturing technologies have been used for scientific research and education–outreach activities (e.g. Teshima et al., 2010, 2024; Matsuoka et al., 2012; Yoshino et al., 2015). Peculiar morphology of multi-segmented nassellarians with a spirally coiled shell was reported from the Mariana Radiolarian Fauna (Ito et al., 2024a). A detailed morphology of a single specimen that is used for the joker of playing cards is introduced as an example of re-investigation on a specific specimen among research collections (Ito and Matsuoka, 2024). The same specimen is selected to demonstrate the management of the radiolarian collection in Niigata University (Ito and Matsuoka, 2025).

Fantastic photomicrographic images of the Mariana Radiolarian Fauna have been utilized for calendars, a pictorial book, plastic document files, playing cards, and others (Ito et al., 2024b; Matsuoka, 2025). Radiolarian calendars of the years 2019, 2022, 2023, and 2025, produced by the Image Mission Inc., demonstrate the Mariana Radiolarian Fauna (Matsuoka, 2025). A large number of SEM images of the fauna are used for a pictorial book (Kanchiku and Matsuoka, 2019).

A set of playing cards was produced using SEM images of the Mariana Radiolarian Fauna and is for sale by the Image Mission Co. Inc. Fifty-three species are selected for the cards from the 256 morphotypes illustrated in Matsuoka (1998). One specimen for the joker is an undescribed species while 52 specimens for cards from one (Ace) to 13 (King) in spades, clubs, hearts, and diamonds are selected from already-described species. These species for the playing cards are presented in Table 1. When these cards are systematically arranged in a specific way indicated in Fig. 2, cards with black mark of spades and clubs are nassellarian species while cards with red mark of hearts and diamonds are spumellarian species. In addition, taxonomically closely-related species are located next to each other. The radiolarian playing cards are, of course, a game tool. At the same time, they are a kind of educational toy.

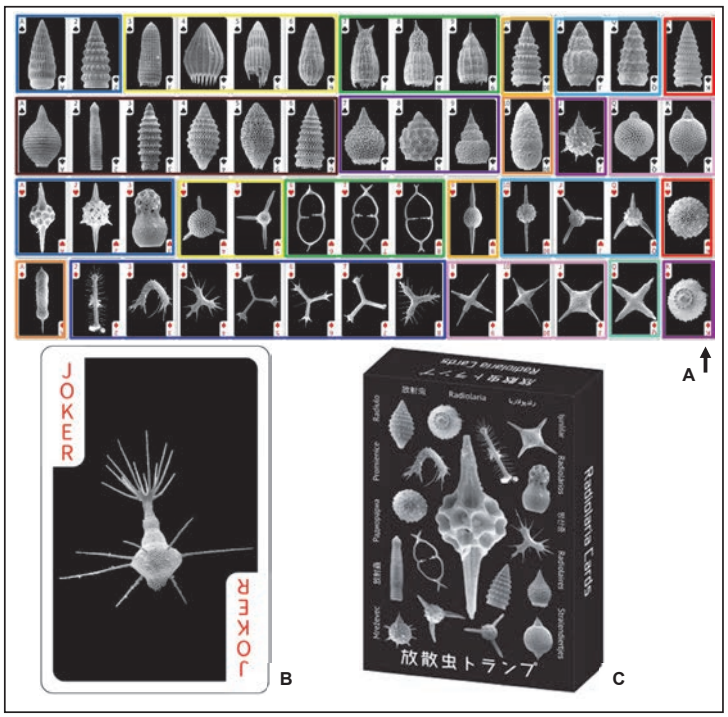


Fig. 2. Radiolarian playing cards. A: A complete set of 52 cards, B: Joker, C: Package of radiolarian playing cards. Cards with black mark of spades and clubs are nassellarian species while cards with red mark of hearts and diamonds are spumellarian species. Specimens surrounded by color rectangular belong to the same family.

Conclusions

The Mariana Radiolarian Fauna was obtained in 1993 by a Japanese submersible "Shinkai 6500". A single rock sample of tuffaceous clayey radiolarite (D181-R003) is regarded as one of fossil Lagerstätten because it contains extremely-well preserved radiolarian shells as many as 400 morphotypes. Since the initial report of the faunal composition was published in 1998, more than 200 new species have been described all over the world around the Jurassic–Cretaceous boundary. This paper attempts to update species identification for the Mariana Radiolarian Fauna. As shown in Table 1, many morphotypes have still no formal names. When taxonomic works of the fauna are completed, this can contribute not only to scientific research but also to education and outreach activities.

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Table 1. List of radiolarian species of the Mariana Radiolarian Fauna in Matsuoka (1998) and the present study. The numbers correspond to those in Plates 1–16. The right column shows the mark for each of the radiolarian playing cards (Fig. 2).

	Matsuoka (1998)	Matsuoka (2026), this study	Card
1	*Gongylothorax baumgartneri* Schaaf	*Gongylothorax baumgartneri* Schaaf	
2	*Gongylothorax favosus* Dumitrica	*Gongylothorax favosus* Dumitrica	
3	*Gongylothorax* (?) sp. 1	*Gongylothorax* (?) sp. 1	
4	*Tricolocapsa* sp. aff. *T. parvipora* Tan	*Tricolocapsa* sp. aff. *T. parvipora* Tan	
5	*Cryptamphorella* sp. 1	***Williriedellum gilkei* Dumitrica**	
6	*Cryptamphorella dumitricai* Schaaf	*Cryptamphorella dumitricai* Schaaf	
7	*Tricolocapsa campana* Kiessling	*Tricolocapsa campana* Kiessling	
8	*Tricolocapsa* sp. aff. *T. campana* Kiessling	***Kozurium* (?) *hindei* (Tan)**	
9	*Zhamoidellum* sp. aff. *T. ventricosum* Dumitrica	*Zhamoidellum* sp. aff. *T. ventricosum* Dumitrica	
10	*Zhamoidellum ovum* Dumitrica	*Zhamoidellum ovum* Dumitrica	
11	*Williriedellum* sp. 1	*Williriedellum* sp. 1	
12	*Williriedellum* (?) sp. 4	*Williriedellum* (?) sp. 4	
13	*Williriedellum carpathicum* Dumitrica	*Williriedellum carpathicum* Dumitrica	♣Q
14	*Williriedellum* (?) sp. 2	*Williriedellum* (?) sp. 2	
15	*Williriedellum* (?) sp. 3	*Williriedellum* (?) sp. 3	
16	*Hemicryptocapsa capita* Tan	*Hemicryptocapsa capita* Tan	♣K
17	*Stichocapsa* sp. aff. *S. renzae* Schaaf	*Stichocapsa* sp. aff. *S. renzae* Schaaf	
18	*Stichocapsa* sp. 3	*Stichocapsa* sp. 3	
19	*Stichocapsa* sp. 4	*Stichocapsa* sp. 4	
20	*Stichocapsa* sp. 2	*Stichocapsa* sp. 2	
21	*Stichocapsa* sp. 5	***Doliocapsa*** sp. 5	
22	*Stichocapsa* sp. 6	***Doliocapsa erbae* Dumitrica**	
23	*Stichocapsa* sp. 7	***Doliocapsa*** sp. 7	
24	*Stichocapsa* sp. 8	***Doliocapsa*** sp. 8	
25	*Sethocapsa* sp. 1	*Sethocapsa* sp. 1	
26	*Sethocapsa* sp. 2	*Sethocapsa* sp. 2	
27	*Sethocapsa trachyostraca* Foreman	***Arcanicapsa*** *trachyostraca* **(Foreman)**	♣J
28	*Sethocapsa* sp. aff. *S. pseudouterculus* Aita	***Crococapsa*** sp. aff. ***C.*** *pseudouterculus* Aita	
29	*Sethocapsa* sp. 5	***Squinabolum*** sp. 5	
30	*Sethocapsa* sp. 6	***Squinabolum*** sp. 6	
31	*Sethocapsa* sp. 7	***Squinabolum*** sp. 7	
32	*Sethocapsa* sp. 8	***Squinabolum*** sp. 8	
33	*Stichocapsa* (?) sp. 9	*Stichocapsa* (?) sp. 9	
34	*Stichocapsa* (?) sp. 10	*Stichocapsa* (?) sp. 10	
35	*Stichocapsa* (?) sp. 11	*Stichocapsa* (?) sp. 11	
36	*Stichocapsa* (?) sp. 12	*Stichocapsa* (?) sp. 12	
37	*Stichocapsa pulchella* (Ruest)	***Campanomitra*** *pulchella* (**Rüst**)	
38	*Stichocapsa* (?) sp.13	*Stichocapsa* (?) sp.13	
39	*Stichocapsa* (?) sp. 14	*Stichocapsa* (?) sp. 14	
40	*Stichocapsa* (?) sp. 15	*Stichocapsa* (?) sp. 15	
41	*Stichocapsa* sp. aff. *S. horokanaiensis* Kawabata	***Crococapsa*** sp. aff. ***C.*** *horokanaiensis* Kawabata	

42	*Stichocapsa* (?) sp. 16	*Stichocapsa* (?) sp. 16	
43	*Stichocapsa* (?) sp. 17	*Stichocapsa* (?) sp. 17	
44	*Stichocapsa* (?) sp. 18	*Stichocapsa* (?) sp. 18	
45	*Stichocapsa* sp. 19	***Crococapsa*** sp. 19	
46	*Stichocapsa* sp. 20	***Crococapsa subcrassitestata* (Aita)**	
47	*Stichocapsa* sp. 21	***Doliocapsa*** sp. 21	
48	*Bagotum* (?) sp. 1	*Bagotum* (?) sp. 1	
49	*Xitus spicularius* (Aliev)	*Xitus spicularius* (Aliev)	♠Q
50	*Xitus alievi* (Foreman)	*Xitus alievi* (Foreman)	
51	*Neorelumbra buwaydahensis* Kiessling	*Neorelumbra buwaydahensis* Kiessling	♠J
52	*Neorelumbra* sp. aff. *N. tippitae* Kiessling	*Neorelumbra* sp. aff. *N. tippitae* Kiessling	
53	*Stichomitra* sp. 3	*Stichomitra* sp. 3	
54	*Stichomitra* (?) sp. aff. *S.* (?) *matsuokai* Hull	*Stichomitra* (?) sp. aff. *S.* (?) *matsuokai* Hull	
55	*Neorelumbra* sp. 1	*Neorelumbra* sp. 1	
56	*Xitus* sp. 5	*Xitus* sp. 5	
57	*Stichomitra* (?) sp. 4	*Stichomitra* (?) sp. 4	
58	*Crolanium* (?) sp. 1	*Crolanium* (?) sp. 1	
59	*Pseudoeucyrtis* (?) sp. 3	*Pseudoeucyrtis* (?) sp. 3	
60	*Xitus* sp. 2	*Xitus* sp. 2	
61	*Mirifusus odogherti* Jud	*Mirifusus* ***odoghertyi*** Jud	
62	*Parvicingula* sp. aff. *P. bluefordae* Hull	*Parvicingula* sp. aff. *P. bluefordae* Hull	
63	*Pseudoeucyrtis* sp. 1	*Pseudoeucyrtis* sp. 1	
64	*Crolanium triquetrum* Pessagno	*Crolanium triquetrum* Pessagno	
65	*Praeparvicingula* sp. 1	*Praeparvicingula* sp. 1	
66	*Praeparvicingula* (?) sp. 5	*Praeparvicingula* (?) sp. 5	
67	*Xitus* sp. 4	*Xitus* sp. 4	
68	*Xitus* (?) sp. 8	*Xitus* (?) sp. 8	
69	*Praecaneta* sp. 3	*Praecaneta* sp. 3	
70	*Praecaneta* sp. 4	*Praecaneta* sp. 4	
71	*Praecaneta cosmoconica* (Foreman)	*Praecaneta cosmoconica* (Foreman)	♣6
72	*Triversus* (?) sp. 1	*Triversus* (?) sp. 1	
73	*Tethysetta ovoidala* Dumitrica	*Tethysetta ovoidala* Dumitrica	♣5
74	*Tethysetta boesii* (Parona)	*Tethysetta boesii* (Parona)	♣4
75	*Tethysetta dhimanaensis* (Baumgartner)	*Tethysetta dhimanaensis* (Baumgartner)	
76	*Tethysetta columna* (Ruest)	*Tethysetta columna* (**Rüst**)	♣3
77	*Triversus* sp. 2	*Triversus* sp. 2	
78	*Xitus* sp. 6	*Xitus* sp. 6	
79	*Xitus* (?) sp. 7	*Xitus* (?) sp. 7	
80	*Xitus* sp. aff. *X. channelli* Jud	*Xitus* sp. aff. *X. channelli* Jud	
81	*Pseudoeucyrtis acus* Jud	*Pseudoeucyrtis acus* Jud	
82	*Pseudoeucyrtis* (?) *fusus* Jud	*Pseudoeucyrtis* (?) *fusus* Jud	
83	*Katroma* (?) sp. 1	*Katroma* (?) sp. 1	Joker
84	*Podobursa* (?) sp. 4	*Podobursa* (?) sp. 4	

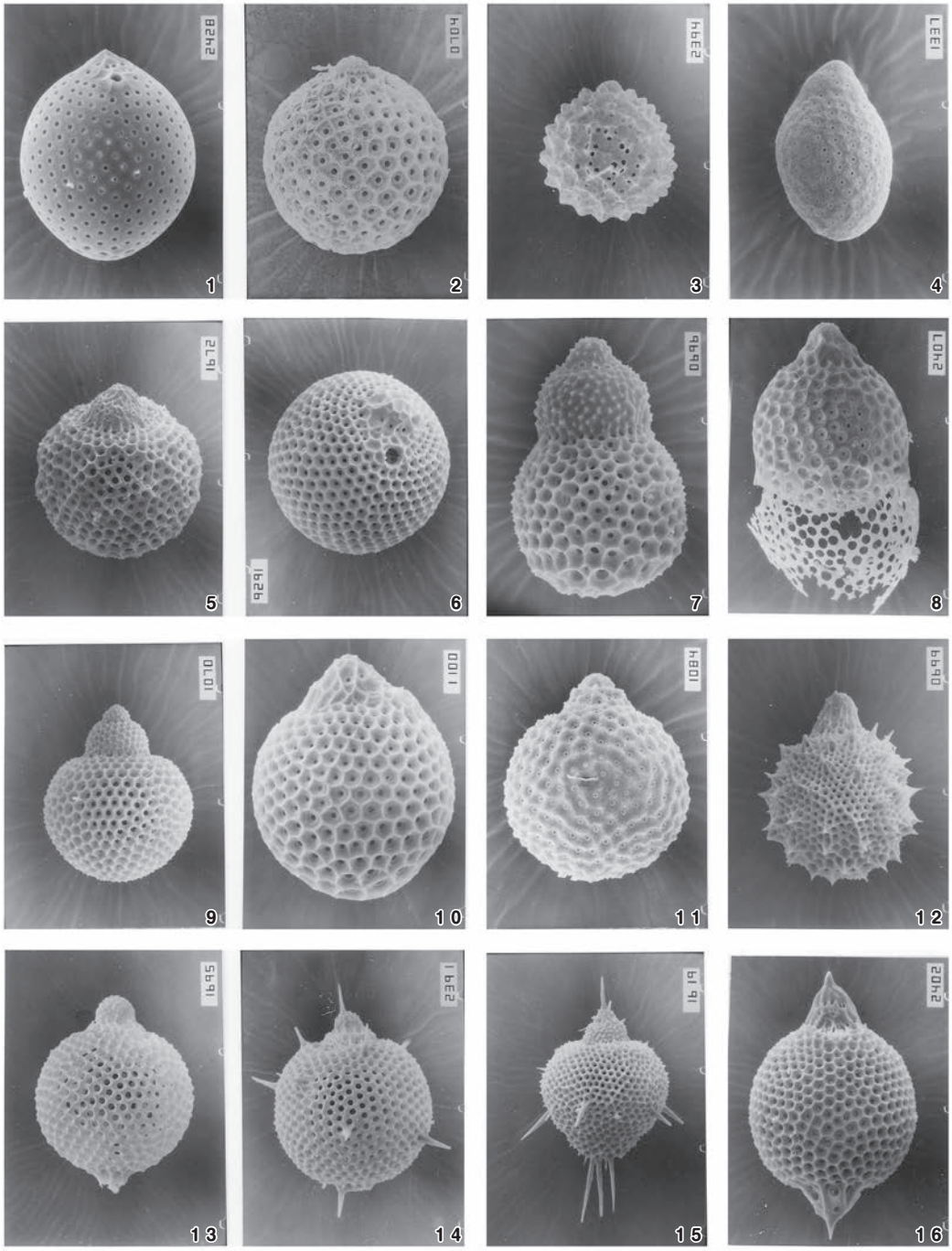
85	*Podobursa triacantha triacantha* (Fischli)	*Podobursa triacantha triacantha* (Fischli)	
86	*Podobursa triacantha* ssp. 1	*Podobursa triacantha* ssp. 1	
87	*Podobursa* (?) sp. 5	*Podobursa* (?) sp. 5	
88	*Pseudoeucyrtis* (?) sp. 2	*Pseudoeucyrtis* (?) sp. 2	
89	*Syringocapsa limatum* Foreman	*Syringocapsa limatum* Foreman	
90	*Syringocapsa* sp. aff. *S. limatum* Foreman	*Syringocapsa* sp. aff. *S. limatum* Foreman	
91	*Podobursa* sp. 1	*Podobursa* sp. 1	
92	*Podobursa* sp. 2	*Podobursa* sp. 2	
93	*Podobursa* sp. 3	*Podobursa* sp. 3	
94	*Artocapsa* (?) *amphorella* Jud	*Artocapsa* (?) *amphorella* Jud	
95	*Syringocapsa spinosa* (Squinabol)	*Syringocapsa spinosa* (Squinabol)	
96	*Pseudoeucyrtis hanni* (Tan)	*Pseudoeucyrtis hanni* (Tan)	
97	*Mita* sp. 1	*Mita* sp. 1	
98	*Archaeodictyomitra excellens* (Tan)	***Apiaromitra*** *excellens* (Tan)	♠3
99	*Thanarla* sp. 1	*Thanarla* sp. 1	
100	*Thanarla conica* (Aliev)	*Thanarla conica* (Aliev)	♠4
101	*Thanarla sixi* (Yang)	*Thanarla sixi* (Yang)	♠5
102	*Archaeodictyomitra* sp. aff. *A. tumandae* Dumtrica	*Archaeodictyomitra* sp. aff. *A. tumandae* Dumtrica	
103	*Mita* sp. 3	*Mita* sp. 3	
104	*Mita* sp. 2	*Mita* sp. 2	
105	*Mictyoditra* (?) *ramocosta* Dumitrica	*Mictyoditra* (?) *ramocosta* Dumitrica	♠6
106	*Mictyoditra thiensis* (Tan)	*Mictyoditra thiensis* (Tan)	
107	*Obesacapsula* (?) sp. 1	*Obesacapsula* (?) sp. 1	
108	*Obesacapsula rusconensis* Baumgartner	*Obesacapsula rusconensis* Baumgartner	♣9
109	*Obesacapsula polyedra* (Steiger)	*Obesacapsula polyedra* (Steiger)	♣8
110	*Obesacapsula breggiensis* Jud	*Obesacapsula breggiensis* Jud	♣7
111	*Obesacapsula* sp. aff. *O. lucifer* (Baumgartner)	*Obesacapsula* sp. aff. *O. lucifer* (Baumgartner)	
112	*Cinguloturris cylindra* Kemkin & Rudenko	*Cinguloturris cylindra* Kemkin & Rudenko	♠10
113	*Hsuum feliformis* Jud	*Hsuum feliformis* Jud	♠7
114	*Hsuum* sp. 1	*Hsuum* ***arabicum*** **Dumitrica**	♠8
115	*Hsuum arabicum* Dumitrica	*Hsuum arabicum* Dumitrica	
116	*Hsuum* sp. aff. *H. arabicum* Dumitrica	*Hsuum* sp. aff. *H. arabicum* Dumitrica	
117	*Hsuum tamanense* Yang	*Hsuum tamanense* Yang	♠9
118	*Hsuum* (?) sp. 2	*Hsuum* (?) sp. 2	
119	*Pseudodictyomitra* sp. 3	*Pseudodictyomitra* sp. 3	
120	*Pseudodictyomitra* sp. 1	*Pseudodictyomitra* sp. 1	
121	*Loopus primitivus* (Matsuoka & Yao)	*Loopus primitivus* (Matsuoka & Yao)	♠1
122	*Loopus* (?) sp. C	*Loopus* (?) sp. C	
123	*Pseudodictyomitra carpatica* (Lozyniak)	*Pseudodictyomitra carpatica* (Lozyniak)	♠2
124	*Pseudodictyomitra* (?) sp. 2	*Pseudodictyomitra* (?) sp. aff. ***P. (?) yamizoensis*** **(Hori)**	
125	*Pseudodictyomitra* (?) *okamurai* Mizutani	*Pseudodictyomitra* (?) *okamurai* Mizutani	
126	*Candissa* sp. 1	*Candissa* sp. 1	
127	*Candissa* sp. 2	*Candissa* sp. 2	

128	*Svinitzium* (?) sp. 1	*Svinitzium* (?) sp. 1	
129	*Praecaneta* (?) sp. 6	*Praecaneta* (?) sp. 6	
130	*Svinitzium pseudopuga* Dumitrica	*Svinitzium pseudopuga* Dumitrica	♠K
131	*Svinitzium* sp. aff. *S. depressum* (Baumgartner)	*Svinitzium* sp. aff. *S. depressum* (Baumgartner)	
132	*Svinitzium depressum* (Baumgartner)	*Svinitzium depressum* (Baumgartner)	
133	*Svinitzium* (?) sp. 2	*Svinitzium* (?) sp. 2	
134	*Amphipyndax* (?) sp. 1	*Amphipyndax* (?) sp. 1	
135	*Xitus* sp. 3	*Xitus* sp. 3	
136	*Amphipyndax* (?) sp. 2	*Amphipyndax* (?) sp. 2	
137	*Mirifusus dianae* (Karrer)	*Mirifusus dianae* (Karrer)	♣1
138	*Ristola altissima* (Ruest)	*Ristola altissima* (**Rüst**)	♣2
139	*Solenotryma* (?) *ichikawai* Matsuoka & Yao	*Solenotryma* (?) *ichikawai* Matsuoka & Yao	♣10
140	*Podocapsa furcata* Steiger	*Podocapsa furcata* Steiger	
141	Nassellaria gen. et sp. indet.	Nassellaria gen. et sp. indet.	
142	Nassellaria gen. et sp. indet.	Nassellaria gen. et sp. indet.	
143	*Sciadiocapsa* (?) sp. 1	*Sciadiocapsa* (?) sp. 1	
144	*Deflandrecyrtium* (?) sp. 1	*Deflandrecyrtium* (?) sp. 1	
145	*Cyrtocalpis* sp. 1	*Cyrtocalpis* sp. 1	
146	*Cyrtocalpis* sp. 2	*Cyrtocalpis* sp. 2	
147	*Artostrobium* sp. 1	*Artostrobium* sp. 1	
148	*Artostrobium* sp. 2	*Artostrobium* sp. 2	
149	*Artostrobium* (?) sp. 3	*Artostrobium* (?) sp. 3	
150	*Artostrobium* (?) sp. 4	***Anaticapitula clauda* Dumitrica & Zügel**	
151	*Jacus* (?) sp. aff. *J.* (?) *italicus* Jud	***Anaticapitula tenera* Dumitrica & Zügel**	
152	*Artostrobium* (?) sp. 5	*Artostrobium* (?) sp. 5	
153	Nassellaria gen. et sp. indet.	Nassellaria gen. et sp. indet.	
154	*Saitoum* (?) sp. 1	*Saitoum* (?) sp. 1	
155	*Bipedis* (?) sp. 1	*Bipedis* (?) sp. 1	
156	*Bipedis* (?) sp. 2	*Bipedis* (?) sp. 2	
157	*Saitoum pagei* Pessagno	*Saitoum pagei* Pessagno	
158	*Saitoum elegans* De Wever	*Saitoum elegans* De Wever	
159	*Napora* sp. 1	*Napora* sp. 1	
160	*Napora* sp. 3	*Napora* sp. 3	
161	*Pantanellium lanceola* (Parona)	*Pantanellium lanceola* (Parona)	♥1
162	*Pantanellium oligoporus* (Vinassa)	*Pantanellium oligoporus* (Vinassa)	
163	*Pantanellium* (?) *berriasianum* Baumgartner	*Pantanellium* (?) *berriasianum* Baumgartner	♥2
164	*Pantanellium* sp. aff. *P. deflectum* Yang	*Pantanellium* sp. aff. *P. deflectum* Yang	
165	*Vallupus japonicus* Kawabata	*Vallupus japonicus* Kawabata	♥3
166	*Protovallupus* sp. 1	*Protovallupus* sp. 1	
167	Xiphostylidae gen. et sp. indet. 1	Xiphostylidae gen. et sp. indet. 1	
168	*Xiphostylus* sp. 1	*Xiphostylus* sp. 1	
169	*Tripocyclia mascula* Yang	*Tripocyclia mascula* Yang	
170	*Triactoma kellumi* Pessagno & Yang	*Triactoma kellumi* Pessagno & Yang	♥4

171	*Triactoma luciae* Jud	*Triactoma luciae* Jud	♥5
172	*Triactoma* sp. aff. *T. kellumi* Pessagno & Yang	*Triactoma* sp. aff. *T. kellumi* Pessagno & Yang	
173	*Lanubus* sp. 1	*Lanubus* sp. 1	
174	*Lanubus* sp. 2	*Lanubus* sp. 2	
175	*Parvivacca* sp. 2	*Parvivacca* sp. 2	
176	*Parvivacca* sp. 1	*Parvivacca* sp. 1	
177	*Acanthocircus trizonalis* (Ruest)	***Dicerosaturnalis*** *trizonalis* **(Rüst)**	♥6
178	*Acanthocircus dicranacanthos* (Ruest)	***Dicerosaturnalis*** *dicranacanthos* **(Rüst)**	♥7
179	*Acanthocircus* sp. aff. *A. dicranacanthos* (Ruest)	***Spongosaturninus* sp.**	
180	*Acanthocircus furiosus* Jud	***Moebicircus*** *furiosus* **(Jud)**	♥8
181	*Acanthocircus longispinosus* Donofrio & Mostler	***Moebicircus ruthae* Dmitrica & Zügel**	
182	*Acanthocircus squinaboli* Donofrio & Mostler	*Acanthocircus squinaboli* Donofrio & Mostler	
183	*Acanthocircus italics* (Squinabol)	*Acanthocircus* ***echinocircus* Dmitrica & Zügel**	
184	*Acanthocircus multidentatus* (Squinabol)	*Acanthocircus multidentatus* (Squinabol)	
185	*Archaeospongoprunum imlayi* Pessagno	*Archaeospongoprunum imlayi* Pessagno	♥9
186	Orbiculiformidae gen. et sp. indet.	Orbiculiformidae gen. et sp. indet.	
187	*Archaeospongoprunum* sp. aff. *A. nianquensis* Wu	*Archaeospongoprunum* sp. aff. *A. nianquensis* Wu	
188	*Stylosphaera* (?) sp. 1	*Stylosphaera* (?) sp. 1	
189	Actinomidae gen. et sp. indet.	Actinomidae gen. et sp. indet.	
190	*Archaeospongoprunum* (?) sp. 1	*Archaeospongoprunum* (?) sp. 1	
191	*Wilvemia* sp. 1	*Wilvemia* sp. 1	
192	*Archaeospongoprunum* (?) sp. 2	*Archaeospongoprunum* (?) sp. 2	
193	*Acaeniotyle umbilicata* (Ruest)	*Acaeniotyle umbilicata* (**Rüst**)	♥10
194	*Acaeniotyle* sp. 1	*Acaeniotyle* sp. 1	
195	Acaeniotylidae gen. et sp. indet. 1	Acaeniotylidae gen. et sp. indet. 1	
196	Acaeniotylidae gen. et sp. indet. 2	Acaeniotylidae gen. et sp. indet. 2	
197	*Acastea diagorophona* (Foreman)	*Acastea* ***diaphorogona*** (Foreman)	♥J
198	*Acastea bipes* Yang	*Acastea bipes* Yang	♥Q
199	*Acasten* sp. 1	***Acusten ordinarius* Yang**	
200	Acaeniotylidae gen. et sp. indet. 3	Acaeniotylidae gen. et sp. indet. 3	
201	Acaeniotylidae gen. et sp. indet. 4	Acaeniotylidae gen. et sp. indet. 4	
202	Acaeniotylidae gen. et sp. indet. 5	Acaeniotylidae gen. et sp. indet. 5	
203	*Praeconosphaera spinosa* Yang	*Praeconosphaera spinosa* Yang	♥K
204	*Praeconocaryomma* sp. aff. *P. scatebra* Hull	*Praeconocaryomma* sp. aff. *P. scatebra* Hull	
205	*Archicapsa* (?) sp. 1	*Archicapsa* (?) sp. 1	
206	*Actinomma* sp. 4	*Actinomma* sp. 4	
207	Spumellaria gen. et sp. indet.	Spumellaria gen. et sp. indet.	
208	*Archaeocenosphaera* (?) sp. 1	*Archaeocenosphaera* (?) sp. 1	
209	*Paronaella pristidentata* Baumgartner	*Paronaella pristidentata* Baumgartner	♦4
210	*Archaeotritrabs gracilis* Steiger	*Archaeotritrabs gracilis* Steiger	♦5
211	*Tritrabs ewingi* (Pessagno)	*Tritrabs ewingi* (Pessagno)	♦6
212	*Halesium* sp. 1	*Halesium* sp. 1	
213	*Homoeoparonaella peteri* Jud	*Homoeoparonaella peteri* Jud	♦7

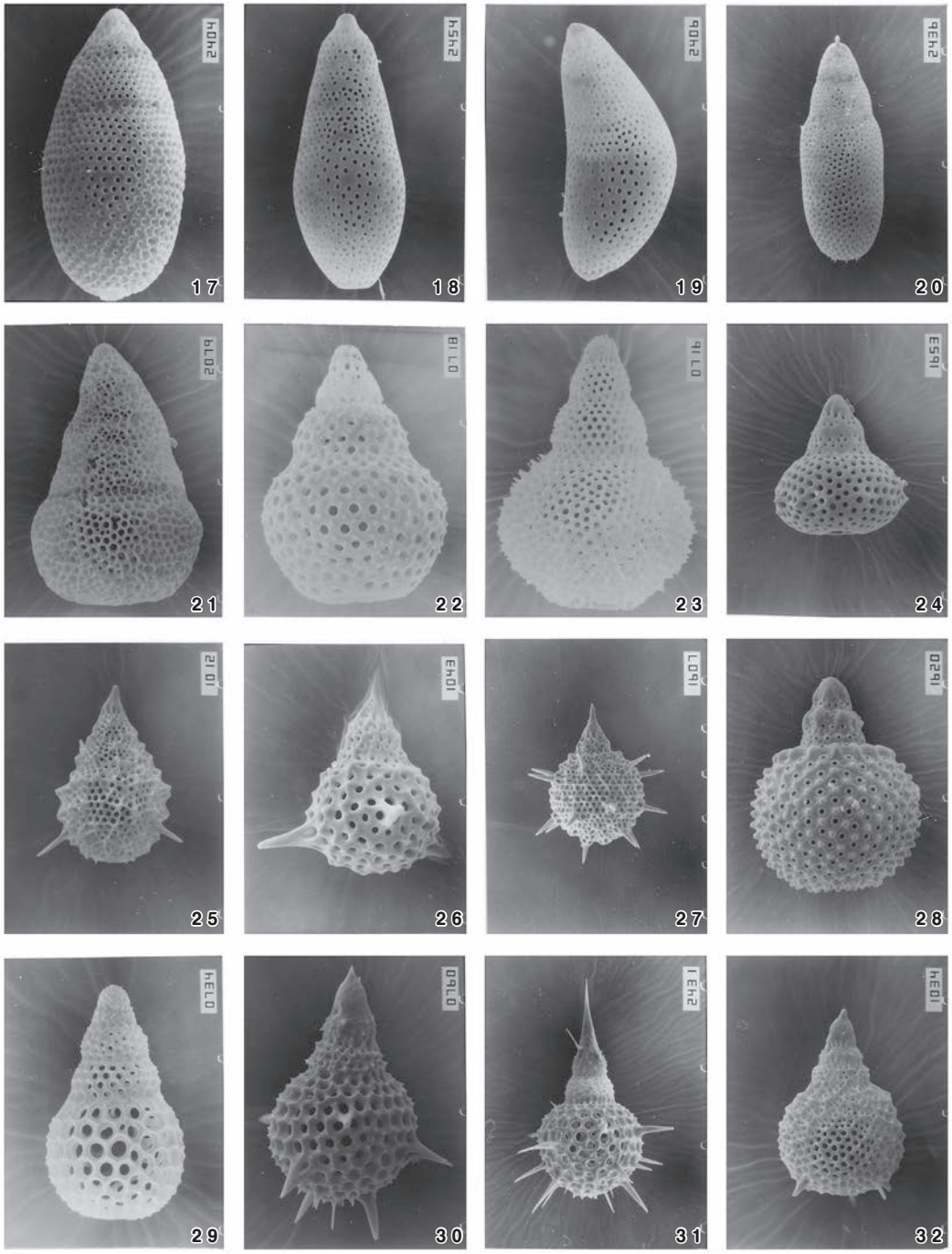
214	*Anglobracchia* sp. 1	*Anglobracchia* sp. 1	
215	*Paronaella* sp. 1	*Paronaella* sp. 1	
216	*Anglobracchia* (?) *portmanni* Baumgartner	*Anglobracchia* (?) *portmanni* Baumgartner	
217	*Halesium* sp. 2	***Anglobracchia* (?) *portmanni* Baumgartner**	♦8
218	*Deviatus hipposidericus* (Foreman)	*Deviatus hipposidericus* (Foreman)	♦3
219	*Cyclastrum* (?) *trigonum* (Ruest)	*Cyclastrum* (?) *trigonum* (**Rüst**)	
220	*Paronaella* (?) sp. 2	*Paronaella* (?) sp. 2	
221	*Alievium* sp. 1	*Alievium* sp. 1	
222	*Alievium* sp. 2	*Alievium* sp. 2	
223	*Bistarkum irazuense* (Aita)	*Bistarkum irazuense* (Aita)	♦1
224	*Ditrabs sansalvadorensis* (Pessagno)	*Ditrabs sansalvadorensis* (Pessagno)	♦2
225	*Staurocyclia martini* Ruest	*Staurocyclia martini* **Rüst**	
226	*Spongostaurus compactus* Kiessling	*Spongostaurus compactus* Kiessling	♦J
227	*Emiluvia* sp. aff. *E. fontata* Hull	*Emiluvia* sp. aff. *E. fontata* Hull	
228	*Emiluvia* sp. aff. *E. pessagnoi* Foreman	*Emiluvia* sp. aff. *E. pessagnoi* Foreman	
229	*Crucella linda* Hull	*Crucella linda* Hull	♦9
230	*Crucella theokaftensis* Baumgartner	*Crucella theokaftensis* Baumgartner	♦10
231	*Higmastra inflata* Baumgartner	*Higmastra inflata* Baumgartner	♦Q
232	*Emiluvia* sp. cf. *E. pessagnoi* Foreman	*Emiluvia* sp. cf. *E. pessagnoi* Foreman	
233	*Crucella* (?) sp. 1	*Crucella* (?) sp. 1	
234	*Emiluvia* sp. aff. *E. omanensis* Kiessling	*Emiluvia* sp. aff. *E. omanensis* Kiessling	
235	*Emiluvia* (?) sp. 1	*Emiluvia* (?) sp. 1	
236	*Crucella* (?) sp. 2	*Crucella* (?) sp. 2	
237	*Crucella collina* Jud	*Crucella collina* Jud	
238	*Advena* sp. 1	*Advena* sp. 1	
239	*Advena* sp. 2	*Advena* sp. 2	
240	*Staurosphaera* (?) sp. 1	*Staurosphaera* (?) sp. 1	
241	*Orbiculiforma* sp. 1	*Orbiculiforma* sp. 1	
242	*Orbiculiforma* sp. aff. *O. teres* Hull	*Orbiculiforma* sp. aff. *O. teres* Hull	
243	*Orbiculiforma* sp. 3	*Orbiculiforma* sp. 3	
244	*Orbiculiforma* (?) sp. 4	*Orbiculiforma* (?) sp. 4	
245	*Pseudoaulophacus* (?) sp. 1	*Pseudoaulophacus* (?) sp. 1	
246	*Pseudoaulophacus* (?) *florealis* Jud	*Pseudoaulophacus* (?) **sp. aff. P. (?)** *florealis* Jud	♦K
247	*Actinomma* sp. 1	*Actinomma* sp. 1	
248	*Becus* sp. 1	*Becus* sp. 1	
249	*Actinomma* sp. 2	*Actinomma* sp. 2	
250	*Actinomma* sp. aff. *A. matsuokai* Sashida & Uematsu	*Actinomma* sp. aff. *A. matsuokai* Sashida & Uematsu	
251	*Actinomma tochidaniensis* Sashida & Uematsu	*Actinomma tochidaniensis* Sashida & Uematsu	
252	*Actinomma* sp. 3	*Actinomma* sp. 3	
253	*Hexastylus* (?) sp· 1	*Hexastylus* (?) sp· 1	
254	*Hexastylus* (?) sp. 2	*Hexastylus* (?) sp. 2	
255	*Hexastylus* (?) sp. 3	*Hexastylus* (?) sp. 3	
256	*Falsocromyodrymus* (?) sp. 1	*Falsocromyodrymus* (?) sp. 1	

Plate 1



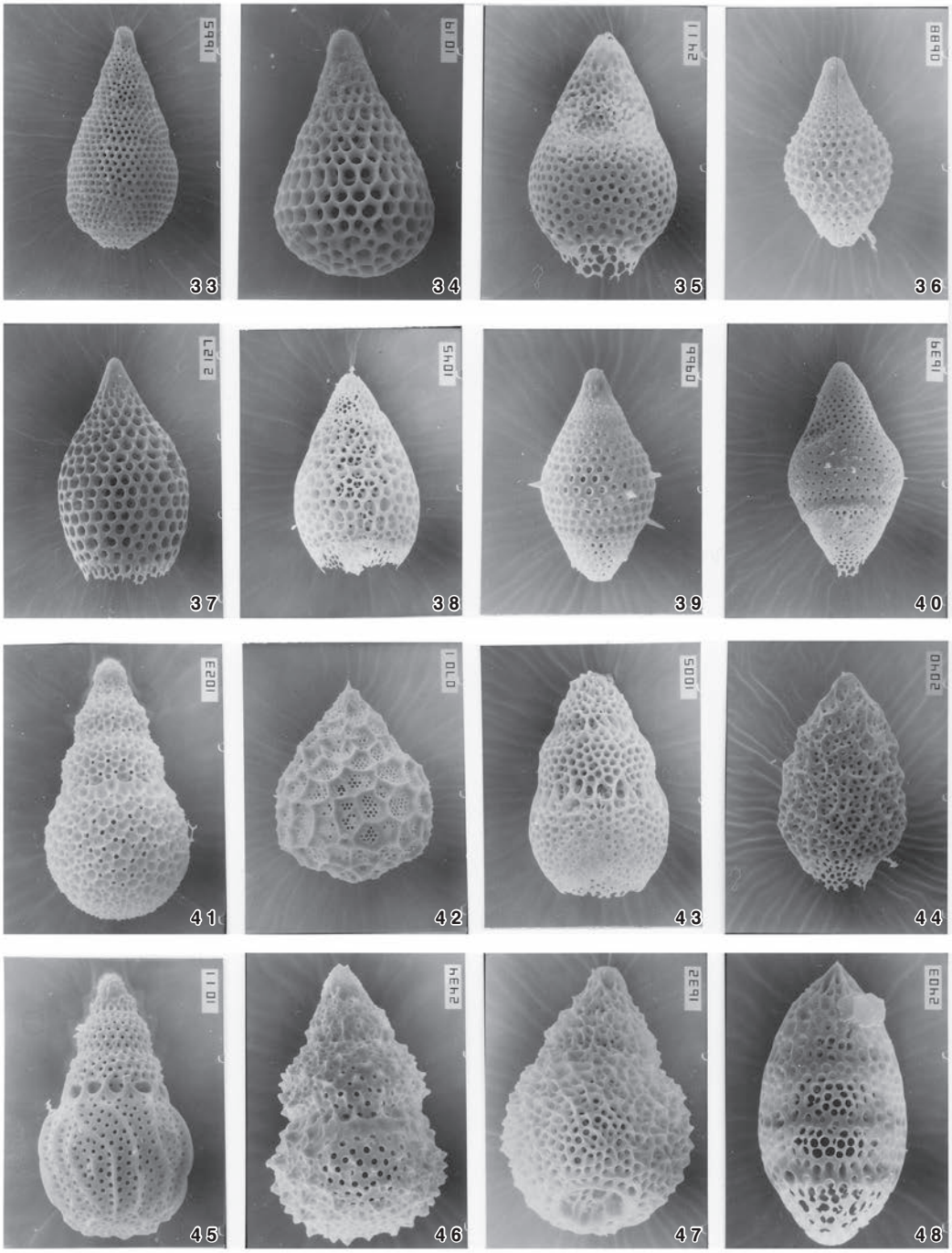
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 2



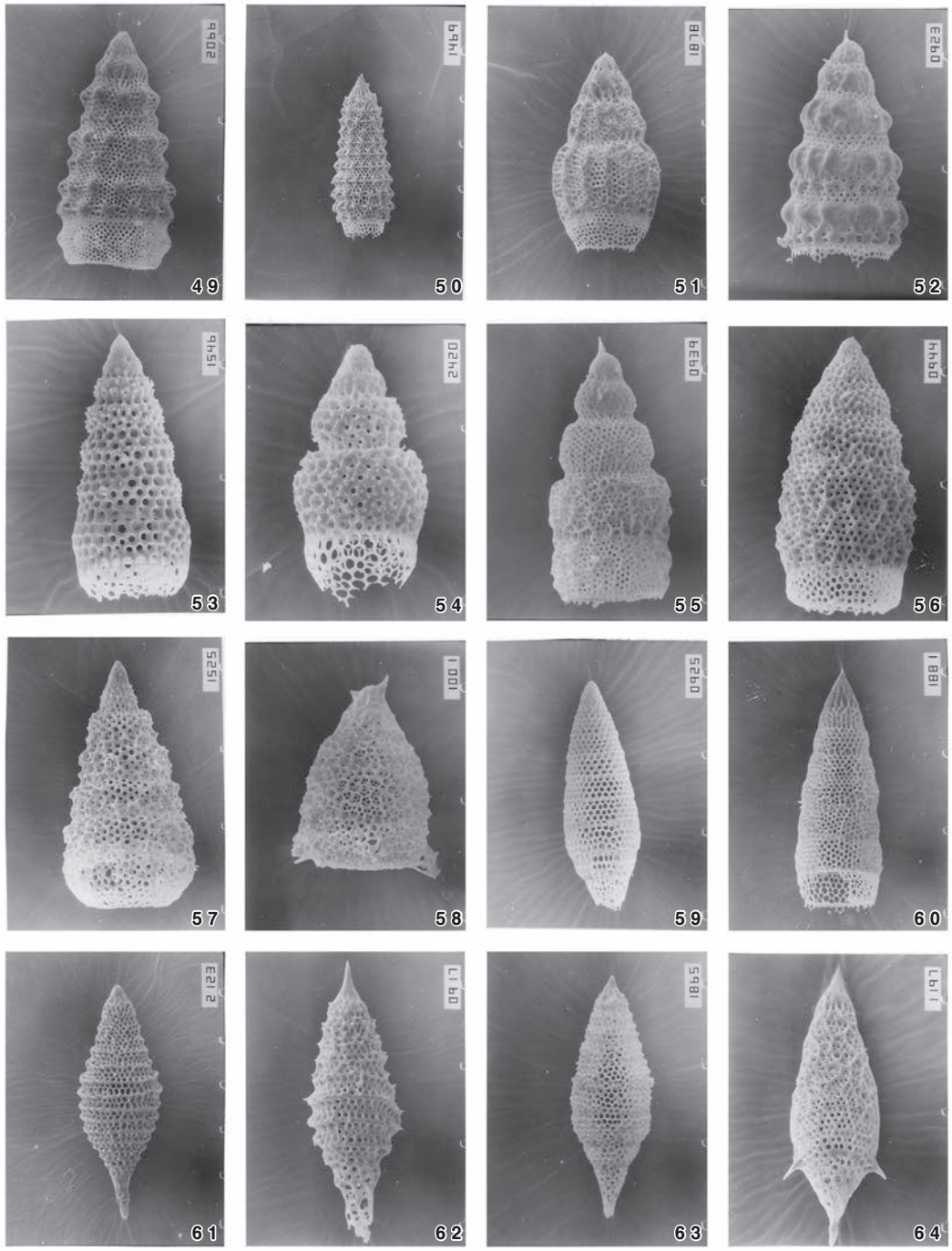
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 3



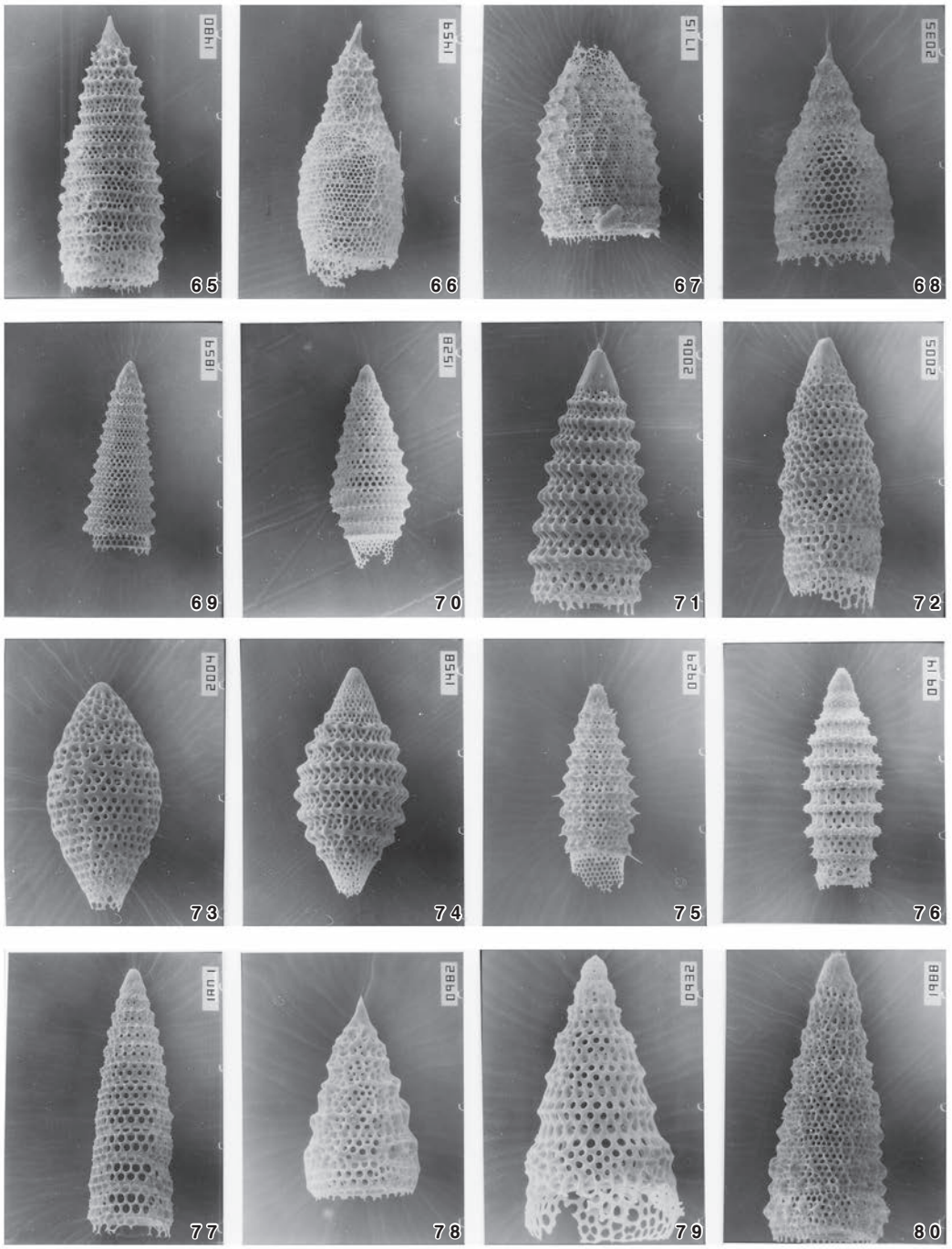
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 4



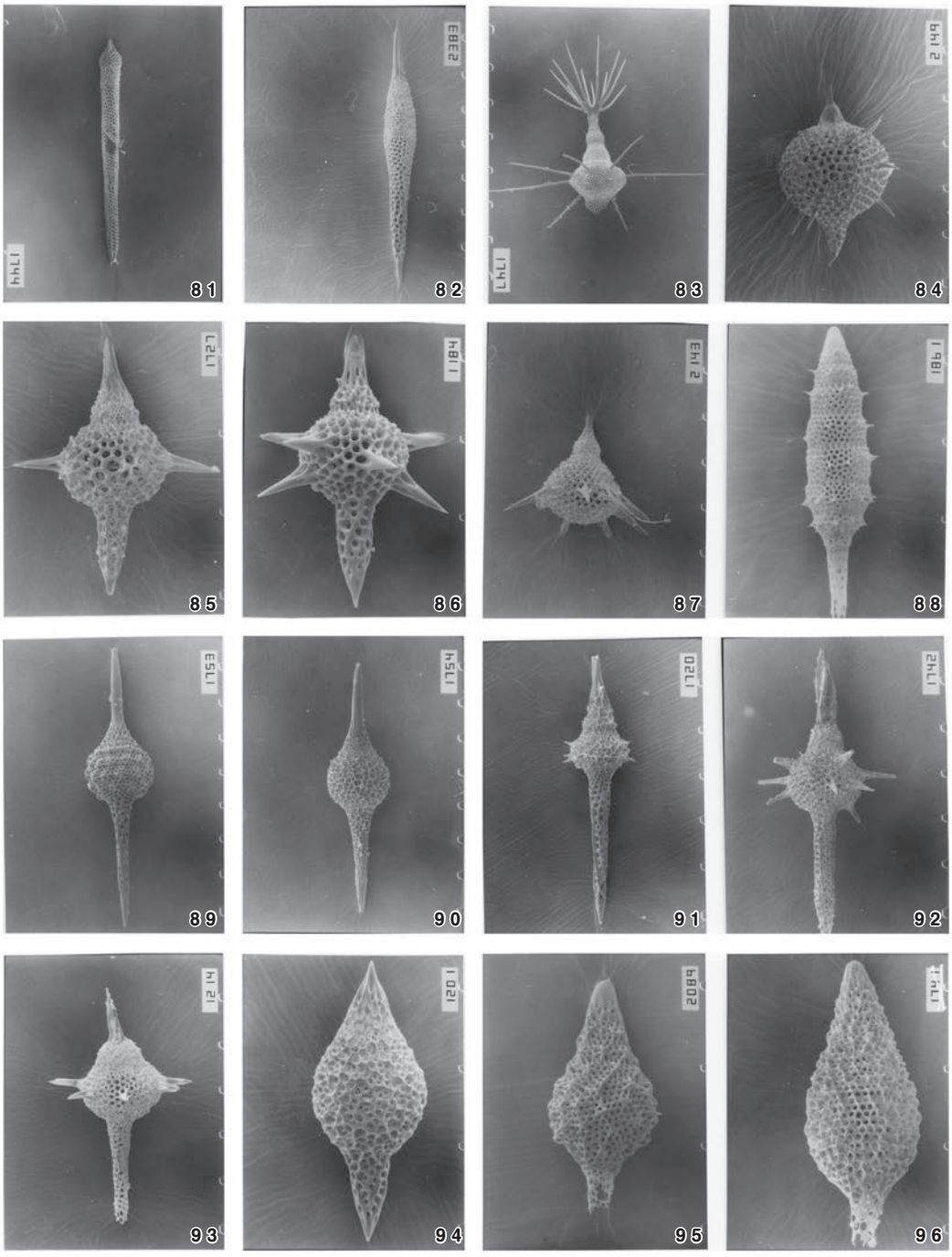
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 5



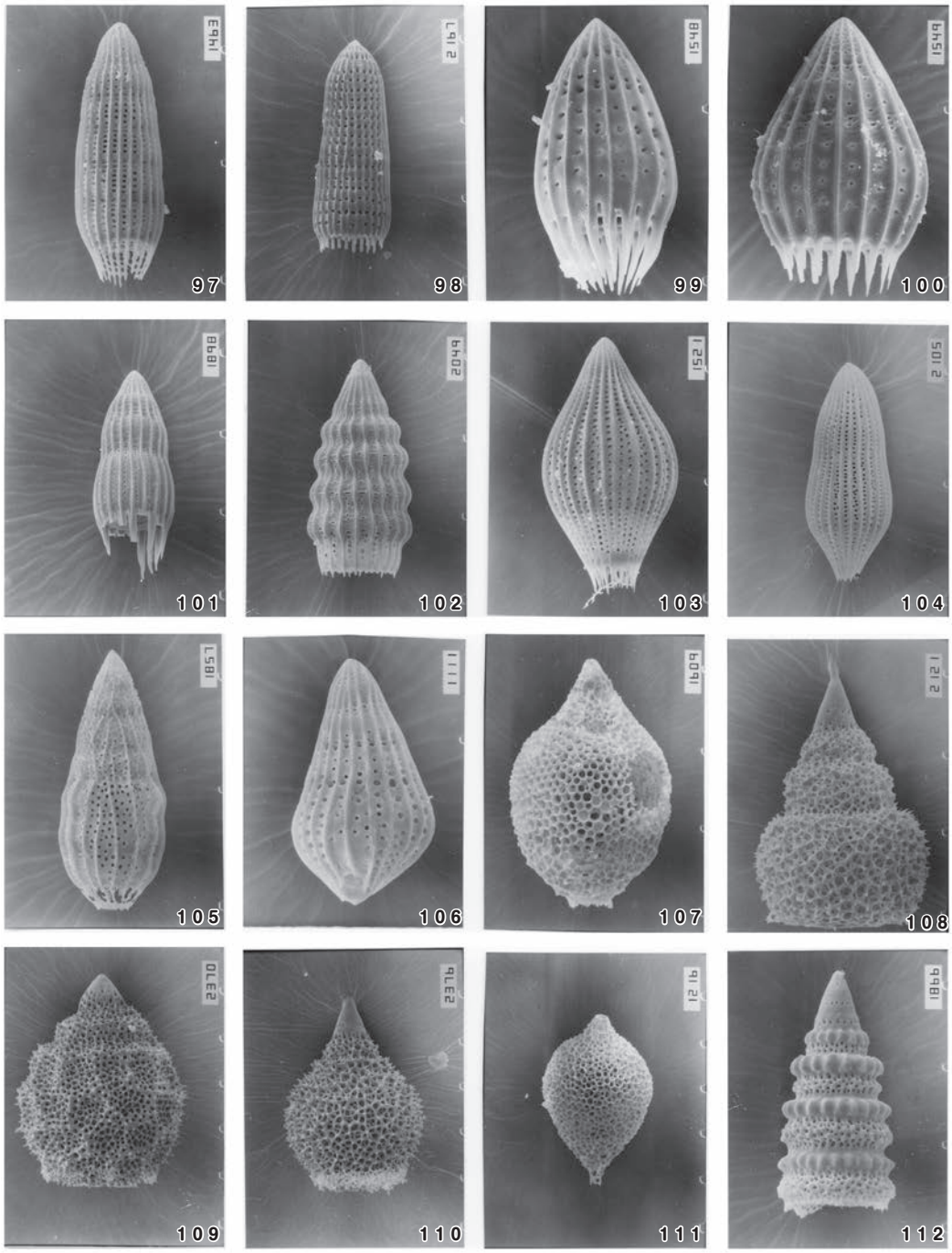
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 6



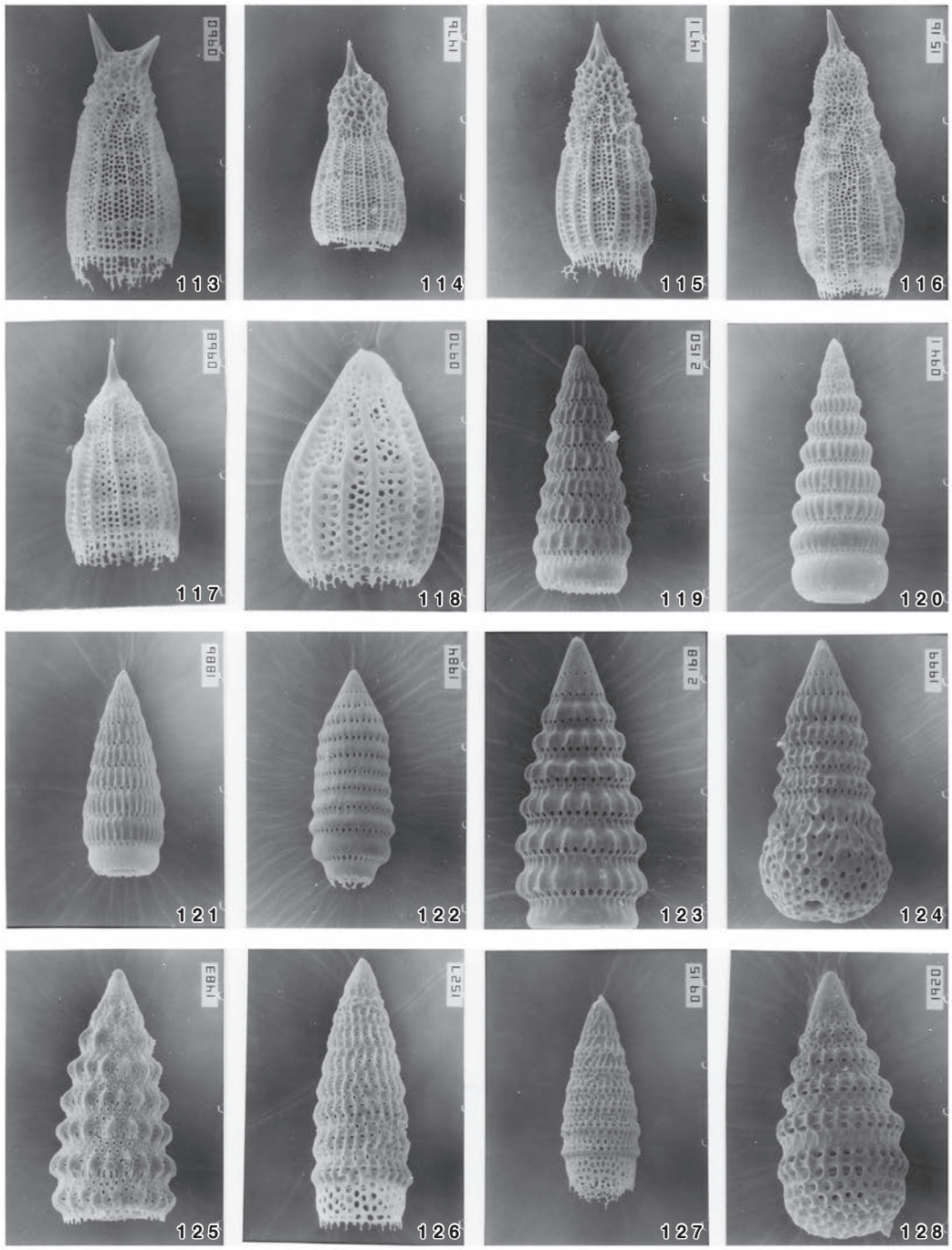
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 7



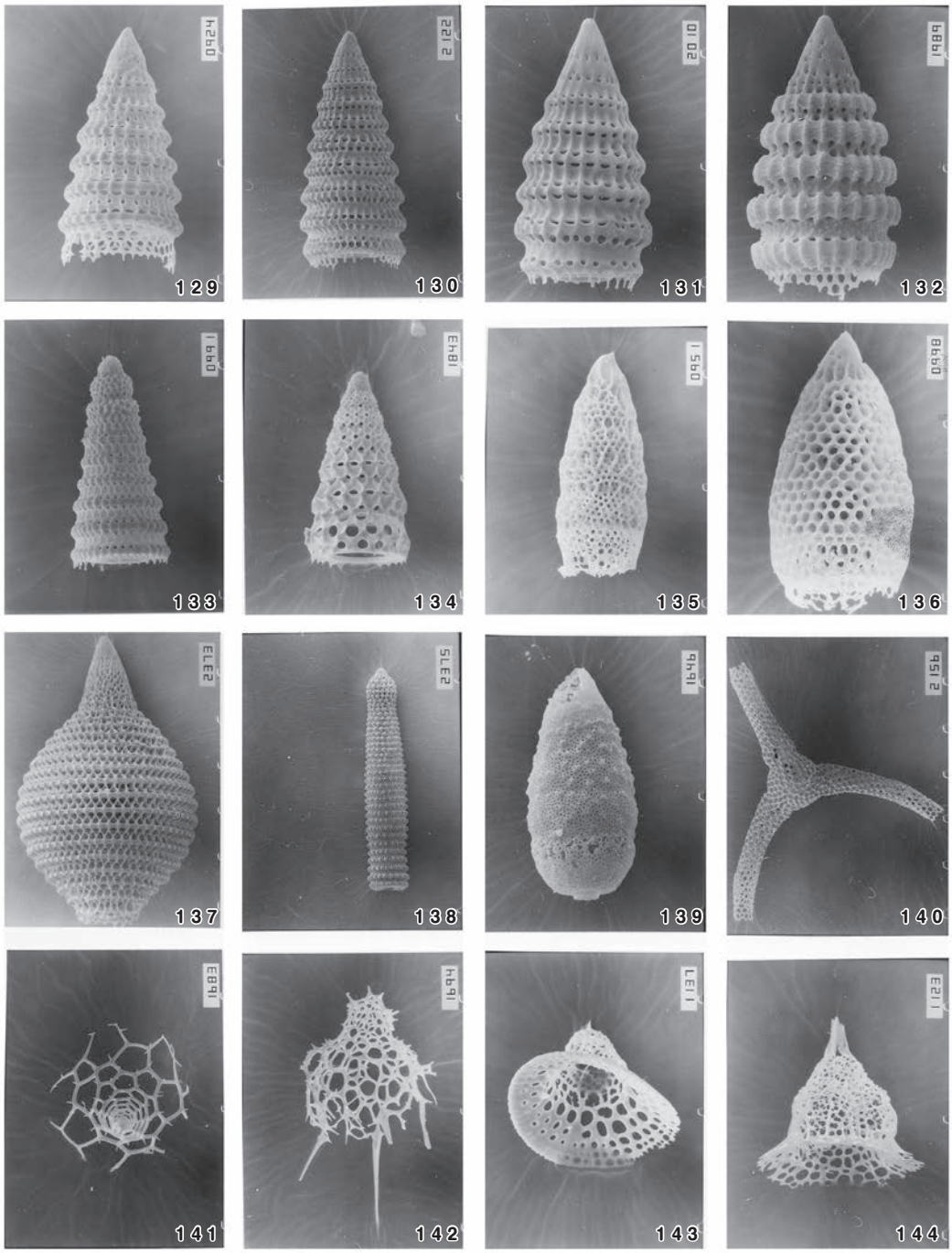
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 8



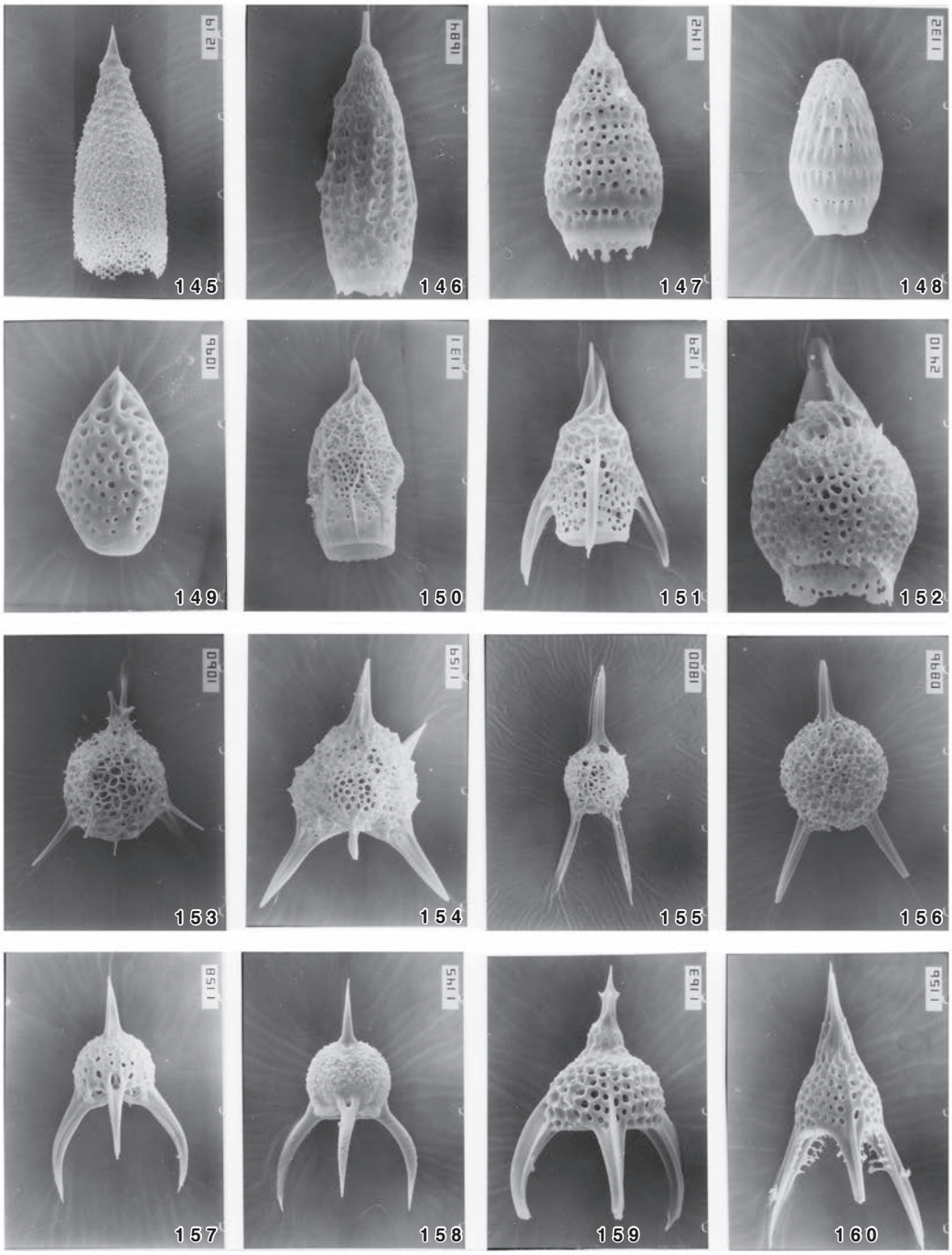
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 9



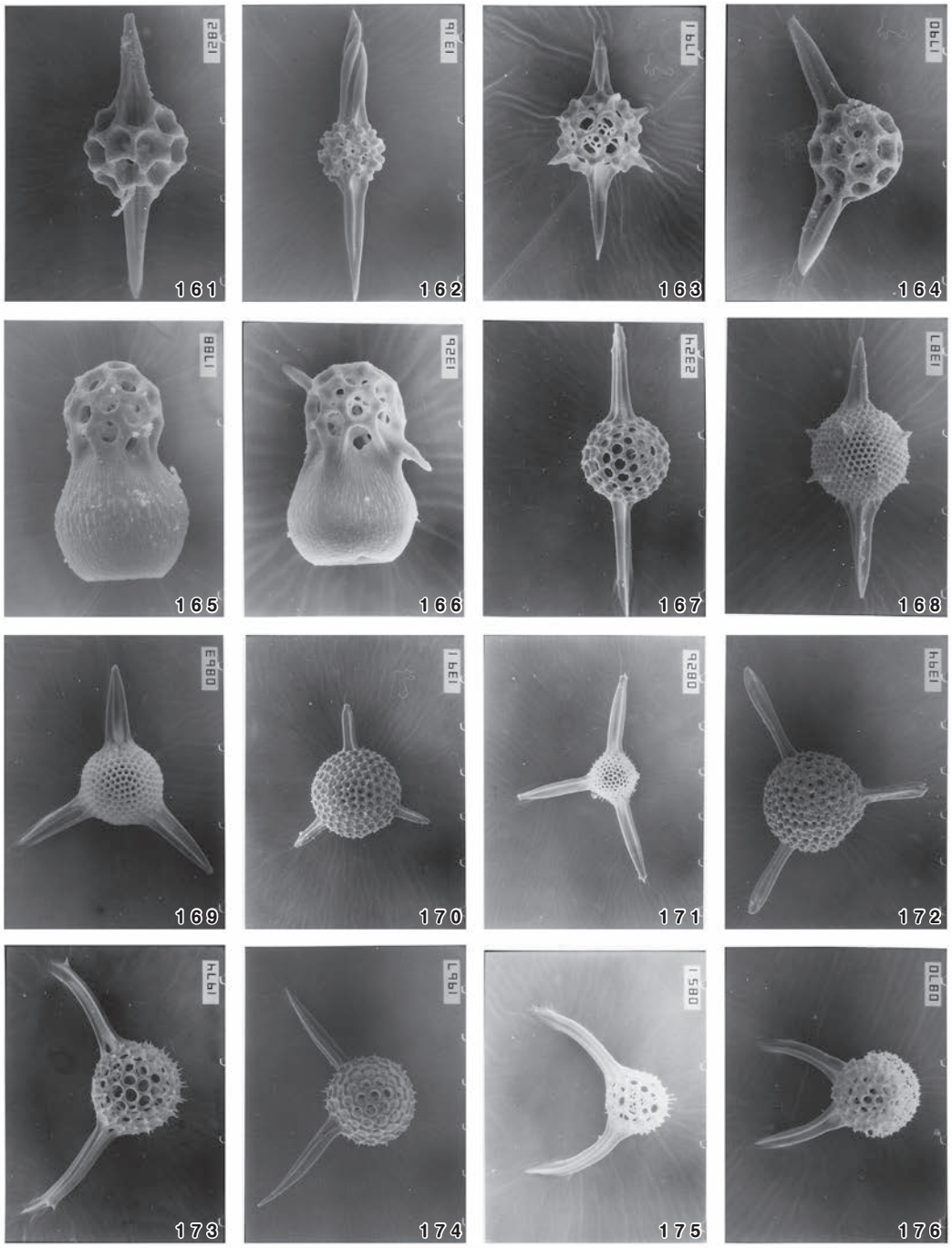
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 10



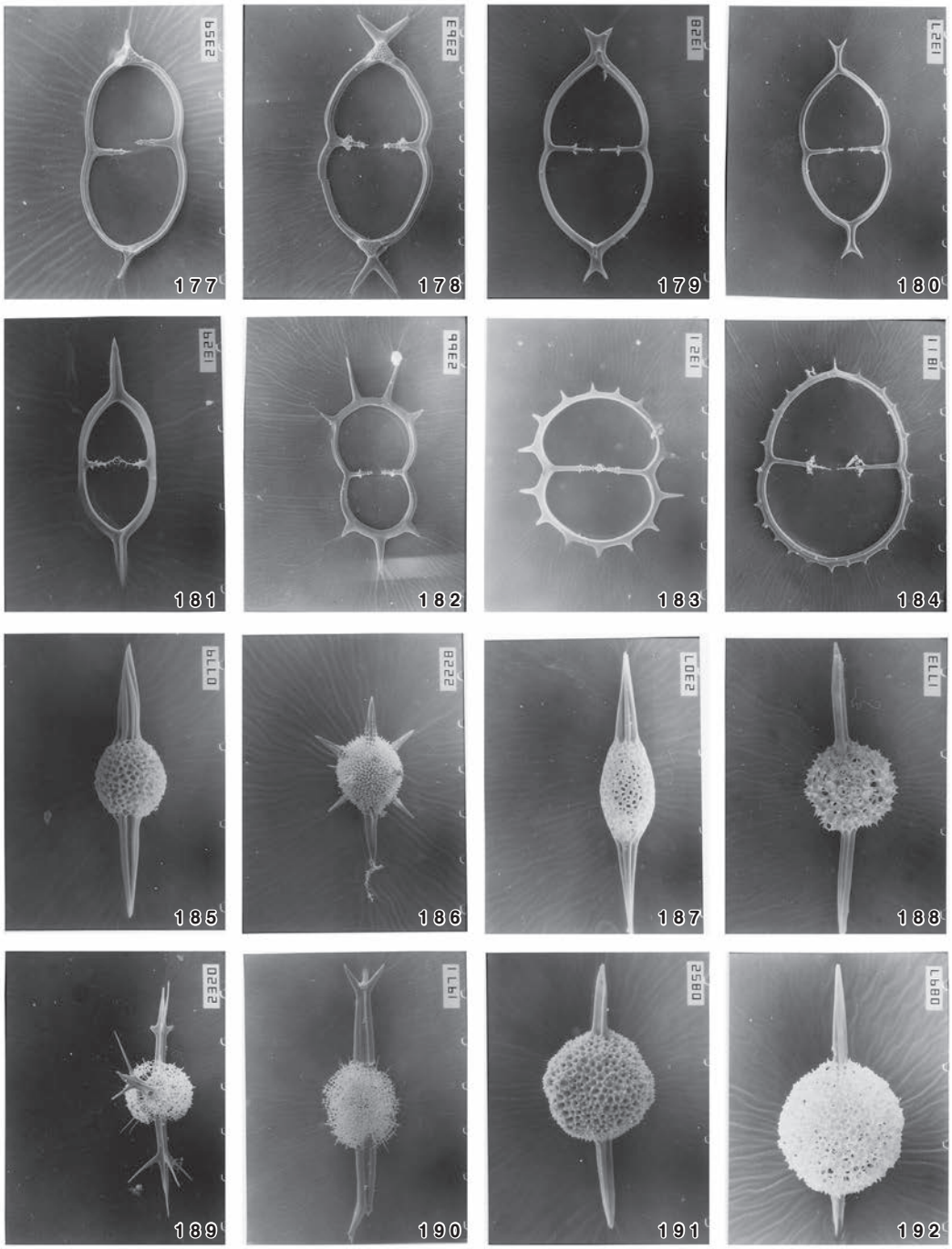
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 11



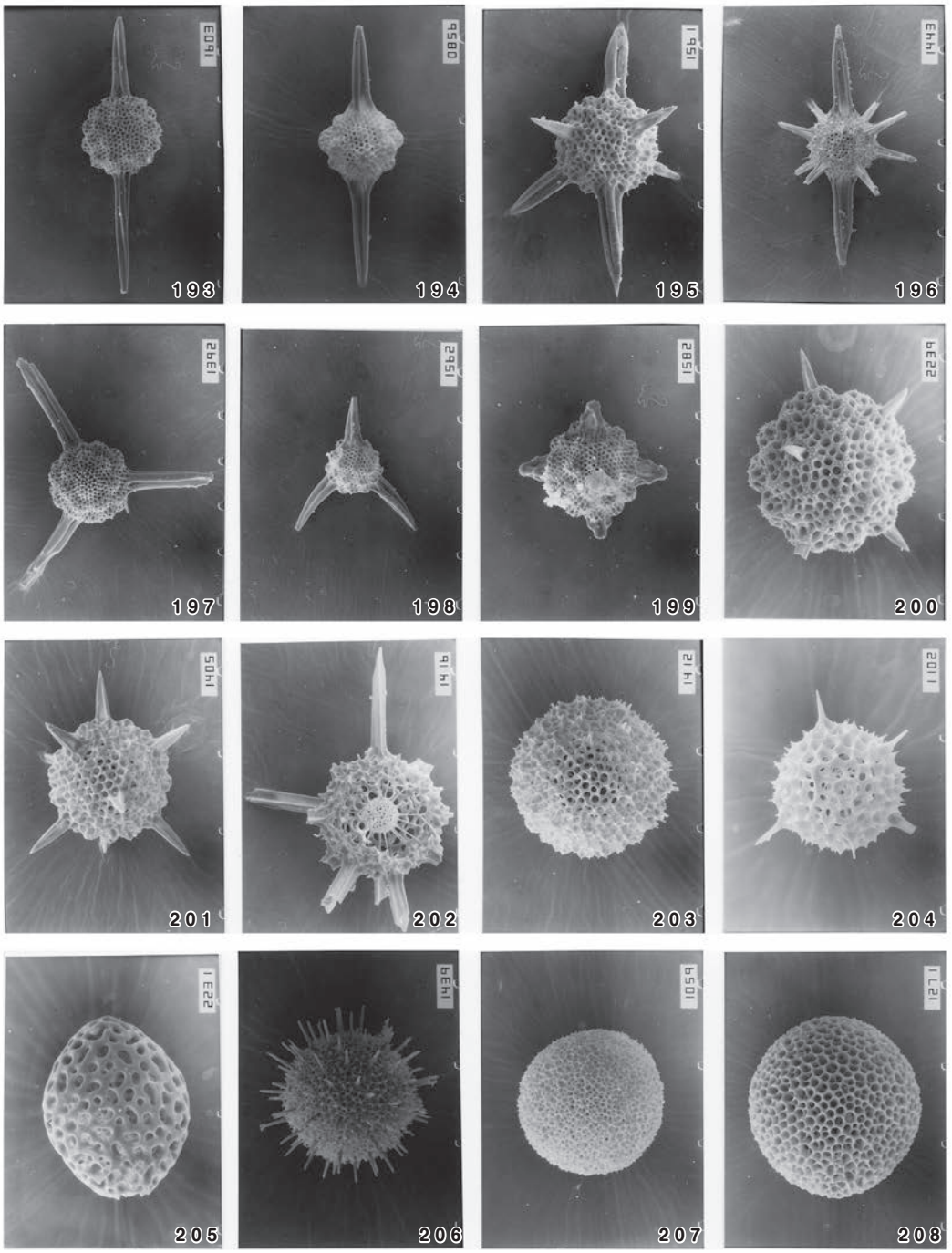
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 12



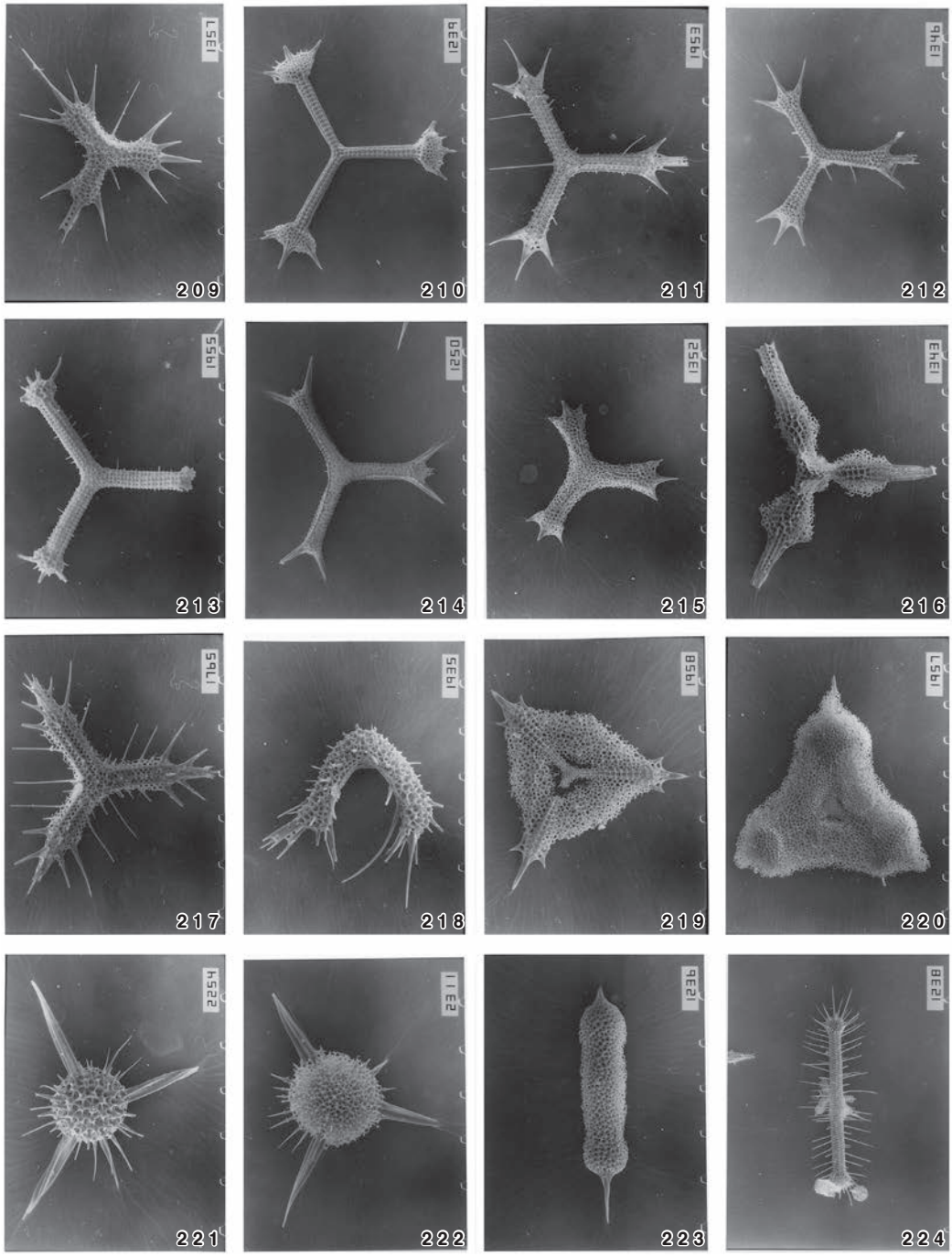
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 13



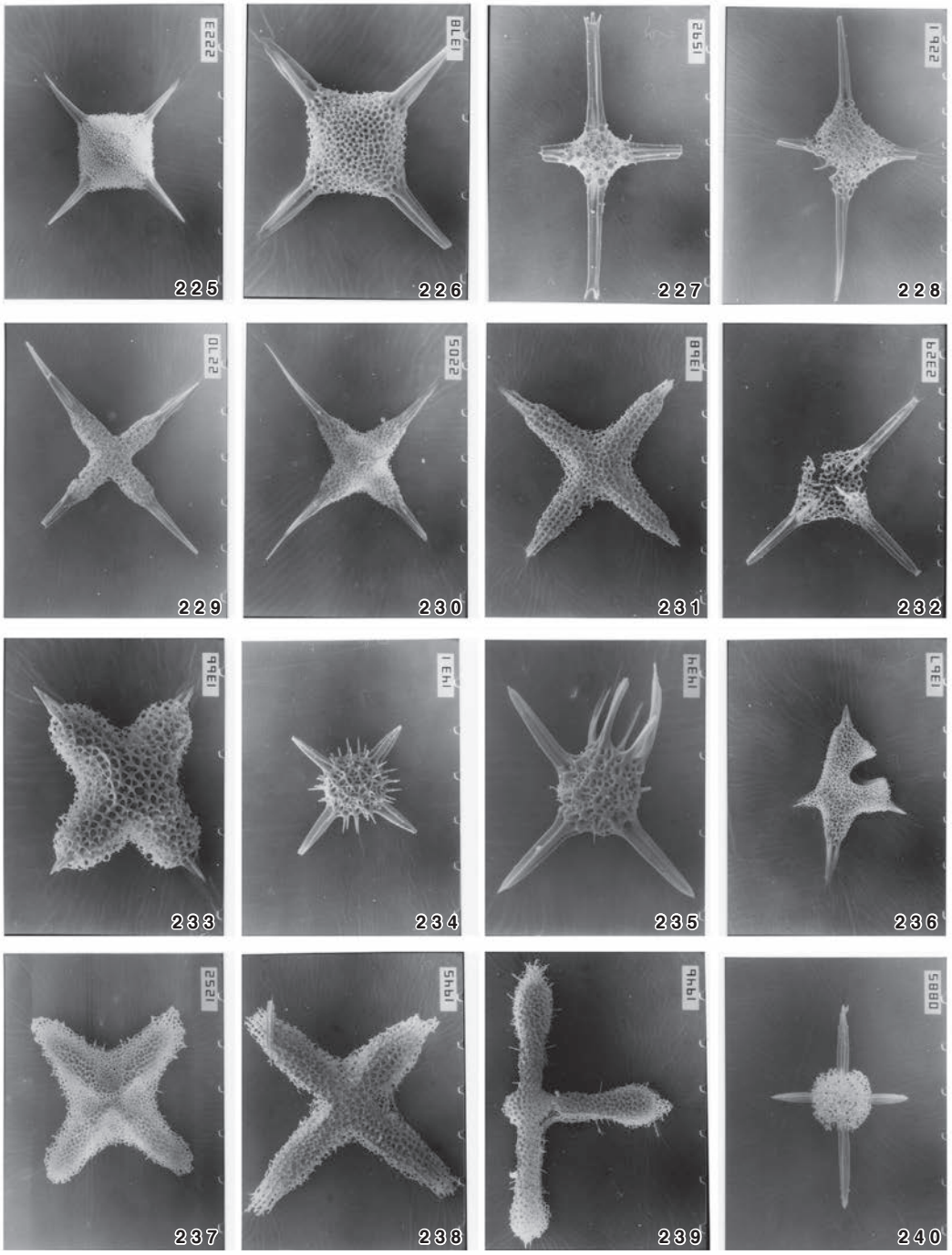
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 14



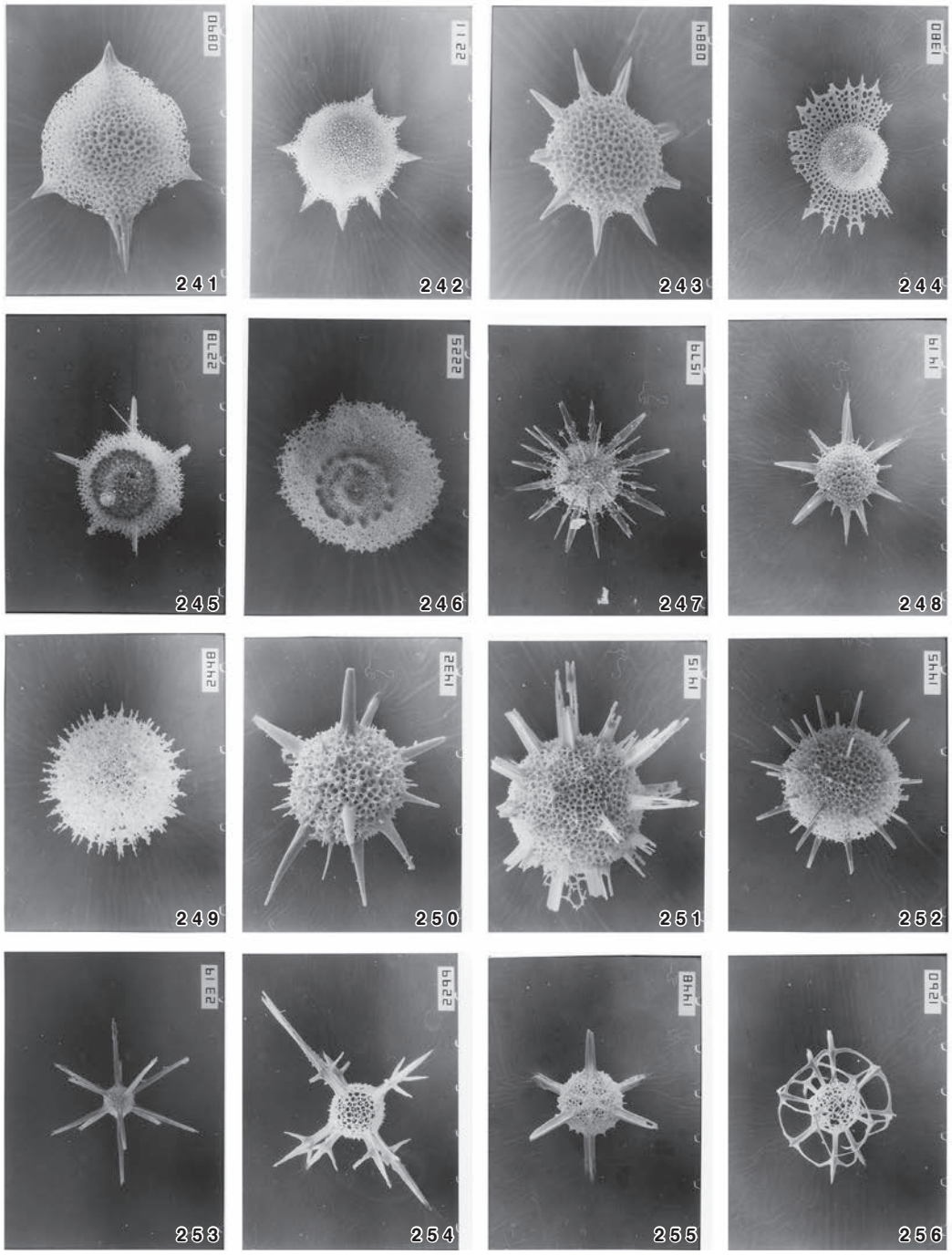
The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 15



The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

Plate 16



The number for each photograph corresponds to that in Table 1. One interval of the scale put in the margin of each photograph indicates 0.1 mm.

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