Non-Tethyan Triassic Radiolaria from New Zealand and northeastern Siberia

Yoshiaki AITA
Department of Geology, Faculty of Agriculture, Utsunomiya University,
350 Mine, Utsunomiya 321-8505 (Japan)
aida@cc.utsunomiya-u.ac.jp

Nikita Yu. BRAGIN
Geological Institute, Russian Academy of Sciences,
Pyzhevsky 7, 109017 Moscow (Russia)
bragin@ginran.msk.su

Aita Y. & Bragin N. Yu. 1999. — Non-Tethyan Triassic Radiolaria from New Zealand and northeastern Siberia, *in* De Wever P. & Caulet J.-P. (eds), InterRad VIII, Paris/Bierville 8-13 septembre 1997, *Geodiversitas* 21 (4) : 503-526.

ABSTRACT
Well-preserved Middle Triassic radiolarian faunas have been documented from phosphatic nodules collected from the Waipapa Terrane, New Zealand and the Omolon Massif, northeastern Siberia, respectively. Both New Zealand and northeastern Siberia faunas include many species that are well-known from European Tethys area, including *Silicarmiger costatus costatus* Dumitrica, Kozur & Mostler, 1980 which indicates an early Ladinian age. These Tethyan species occur with abundant non-Tethyan radiolarians that are characteristic of these faunas. Distinctive pylomate spumellarians are described herein as a new genus *Glomeropyle* Aita & Bragin. This genus has not been recognized in Middle Triassic sequences of Europe, Japan, Southeast Asia or North America. Seven new Middle Triassic species are described: *Glomeropyle aurora*, *Glomeropyle boreale*, *Glomeropyle poinui*, *Glomeropyle* (?) *galagala*, *Glomeropyle grantmackiei*, *Glomeropyle mahinepuaensis*, *Glomeropyle waipapaensis*. They do not have Tethyan affinities and are only known from northern and southern high latitudes. They are Triassic Radiolaria with a bipolar distribution pattern.

KEY WORDS
Radiolaria,
non-Tethyan,
Middle Triassic,
New Zealand,
Siberia,
new species,
Glomeropyle n. gen.

RÉSUMÉ

Radiolaires triasiques non téthysiens de Nouvelle-Zélande et du Nord-Est de la Sibérie.

Des radiolaires bien conservés du Trias moyen ont été découverts dans des nodules phosphatés provenant des formations Waipapa, en Nouvelle-Zélande et du massif Omolon, au Nord-Est de la Sibérie. Les deux faunes comprennent de nombreuses espèces bien connues en Europe de la zone téthysienne, incluant *Silicarmiger costatus costatus* Dumitrica, Kozur & Mostler, 1980 qui indiquent un âge Ladinien inférieur. Ces espèces téthysiennes existent avec de nombreux radiolaires non-téthysiens, caractéristiques de ces faunes. Parmi eux des spumellaires à pylome sont décrits dont le nouveau genre *Glomeropyle* Aita & Bragin. Ce genre n'avait pas encore été trouvé dans les séries du Trias moyen d'Europe, du Japon, d'Asie du Sud-Est et d'Amérique du Nord. Sept nouvelles espèces du Trias moyen sont décrites : *Glomeropyle aurora*, *G. boreale*, *G. poinui*, *G.* (?) *galagala*, *G. grantmackiei*, *G. mahinepuaensis*, *G. waipapaensis*. Elles n'ont pas d'affinités téthysiennes et sont seulement connues dans les hautes latitudes (Nord et Sud). Ces faunes triasiques ont donc une distribution bipolaire.

MOTS CLÉS
radiolaires,
non-Téthys,
Trias moyen,
Nouvelle-Zélande,
Sibérie,
nouvelle espèce,
Glomeropyle n. gen.

INTRODUCTION

In recent years radiolarians have provided valuable information on the age of previously undated strata, improvements to correlation both within terranes and between terranes, and in the assessment of paleobiogeographic affinities (Aita & Spörli 1992, 1994). Recently, distinctive non-Tethyan radiolarian faunas have been found in Middle Triassic strata in both New Zealand and northeastern Siberia (Fig. 1), (Aita *in* Matsuoka *et al.* 1996: 204-206; Bragin *in* Matsuoka *et al.*

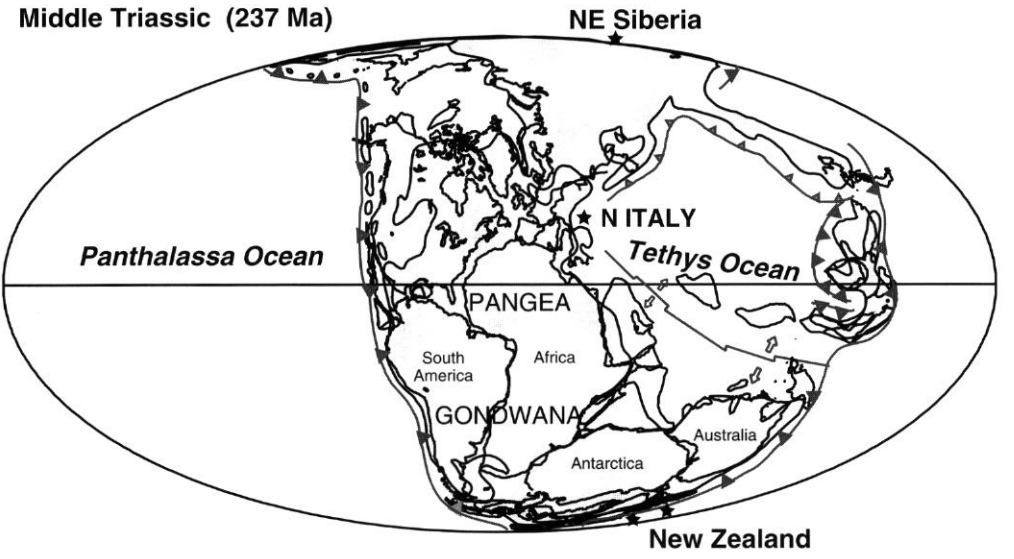


FIG. 1. — Paleogeographic map of the Middle Triassic (Ladinian-Anisian) at 237 million years ago (Ma), showing localities cited in this study in New Zealand, northeastern Siberia and northern Italy (modified from Scotese 1997; Smith *et al.* 1994).

1996: 209). Although geographically distant, the faunas of both areas are very similar and almost of correlative age. They both include distinctive spumellarians with pylome. These taxa have never been reported from Tethyan areas (Dumitrica *et al.* 1980; Kozur & Mostler 1994; Kozur *et al.* 1996; Dumitrica pers. comm.), Japan (Yao 1982; Sugiyama 1997; Ohtaka *et al.* 1998), or the Philippines (Yeh 1990). In this paper, we describe and illustrate these high-latitude taxa, including one new genus and seven new species. In addition, we briefly summarize the lithostratigraphy of the radiolarian-bearing sequences in New Zealand and in northeastern Siberia.

TRIASSIC RADIOLARIA IN WAIPAPA AND CAPLES TERRANES, NEW ZEALAND

Waipapa Terrane, Mahinepua Peninsula, Northland

The Waipapa Terrane is one of five Mesozoic terranes recognized in the North Island, New Zealand (Fig. 2). It lies in the northeastern and central part of the North Island and consists of spilitic basalts, radiolarian cherts, green argillites, and terrigenous clastics (Aita & Spörli 1992). Although these rocks are metamorphosed to

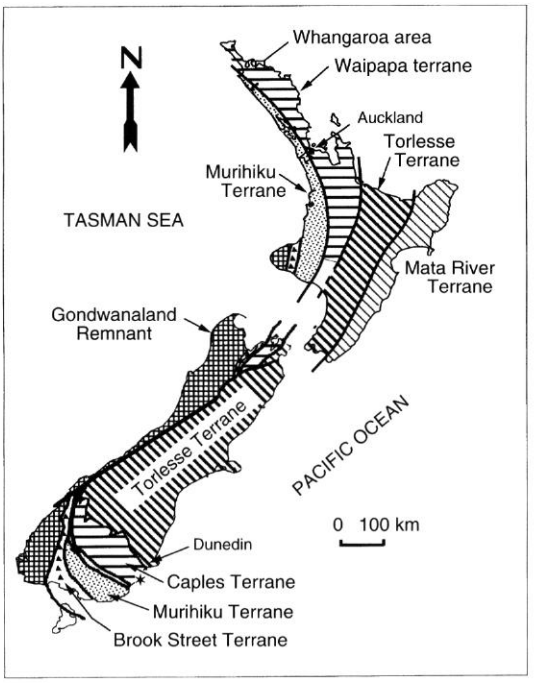


Fig. 2. — Map showing basement terranes of New Zealand and location of Whangaroa area (squared area) in the Waipapa Terrane, modified from Aita & Spörli (1992) and Roser *et al.* (1993). *, Bull Creek in the Caples Terrane.

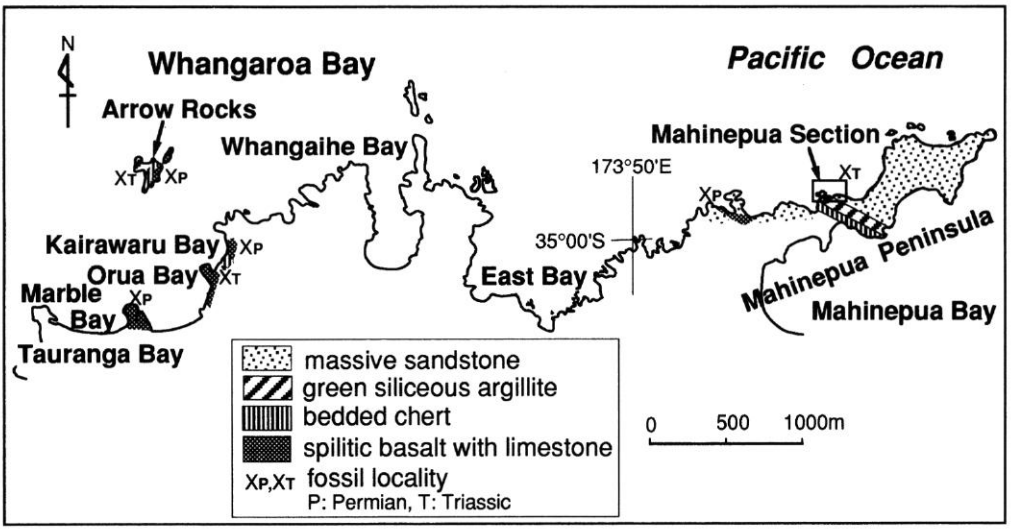


Fig. 3. — Geological map of the Whangaroa area, Northland, New Zealand and location of the Mahinepua Section (squared area) in the Waipapa Terrane, and fossil localities. **XP**, Permian age; **XT**, Triassic age.

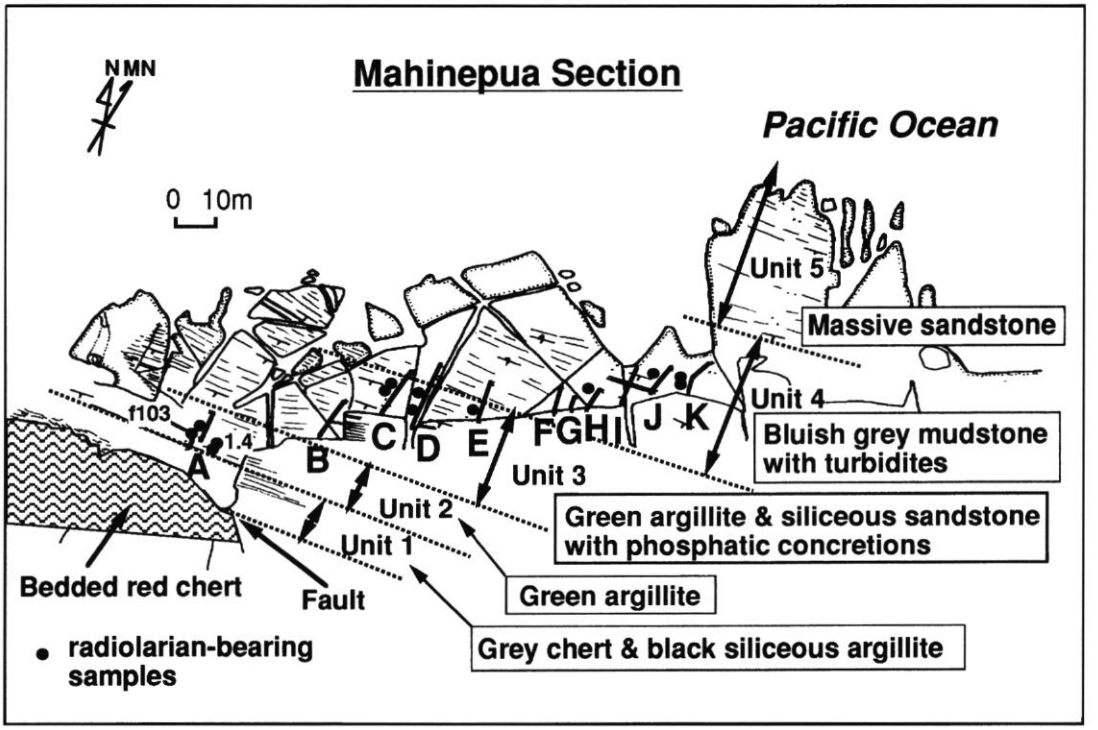


FIG. 4. — Geological sketch map showing wave-cut bench exposures on Mahinepua Peninsula, Northland, New Zealand. Five stratigraphic units are recognized. Measured sections from A to K and location of radiolarian samples are indicated. Sample PO4/f103 (= field No. MAH-3.5): Grid reference P04/88618928, Whangaroa sheet P04, New Zealand 1:50,000 topographical map series NZMS 260.

prehnite-pumpellyite facies (Black 1994), phosphatic concretions hosted within green argillite have yielded well-preserved radiolarian faunas (Sakai *et al.* 1998).

In general, the ages of the radiolarian faunas in the Waipapa Terrane show that an older Permian-Triassic complex occurs in the north and a younger, Triassic-Jurassic complex is in the south (Aita & Spörli 1992; Spörli *et al.* 1989; see also Black 1997). Both complexes consist of very similar lithologic sequences characterized by radiolarian chert, green argillite and terrigenous mudstone and sandstone although the older complex also has some spilitic basalt with associated limestone lenses.

In the Whangaroa area, located in the northern part of the Waipapa Terrane, the older Waipapa rocks are well exposed in sections at Arrow Rocks, Marble Bay, Orua Bay, Kairawaru Bay, and Mahinepua Peninsula (Fig. 3).

Bedded cherts in this area are of Late Permian age (Aita & Spörli 1992) while Late Triassic radiolarians from phosphatic concretions within green argillite at Mahinepua have been reported by Aita in Matsuoka *et al.* (1996). Detailed investigations of the Waipapa Terrane by a Japanese and New Zealand collaborative research project in 1995 and 1996 revealed that the hemipelagic green argillite at Mahinepua ranges from Middle to Late Triassic in age (Takemura *et al.* 1998).

A re-examination of the Permian fusulinid limestones from Orua Bay by Leven & Grant-Mackie (1997) resulted in the identification of *Yabeina globosa* (Yabe, 1906) and *Lepidolina shiraiwaensis* Ozawa, 1925, and established correlation with the *Yabeina-Lepidolina* zone of the Midian Stage. Leven & Grant-Mackie (1997) attribute the Midian to the Late Permian, but following Jin *et*

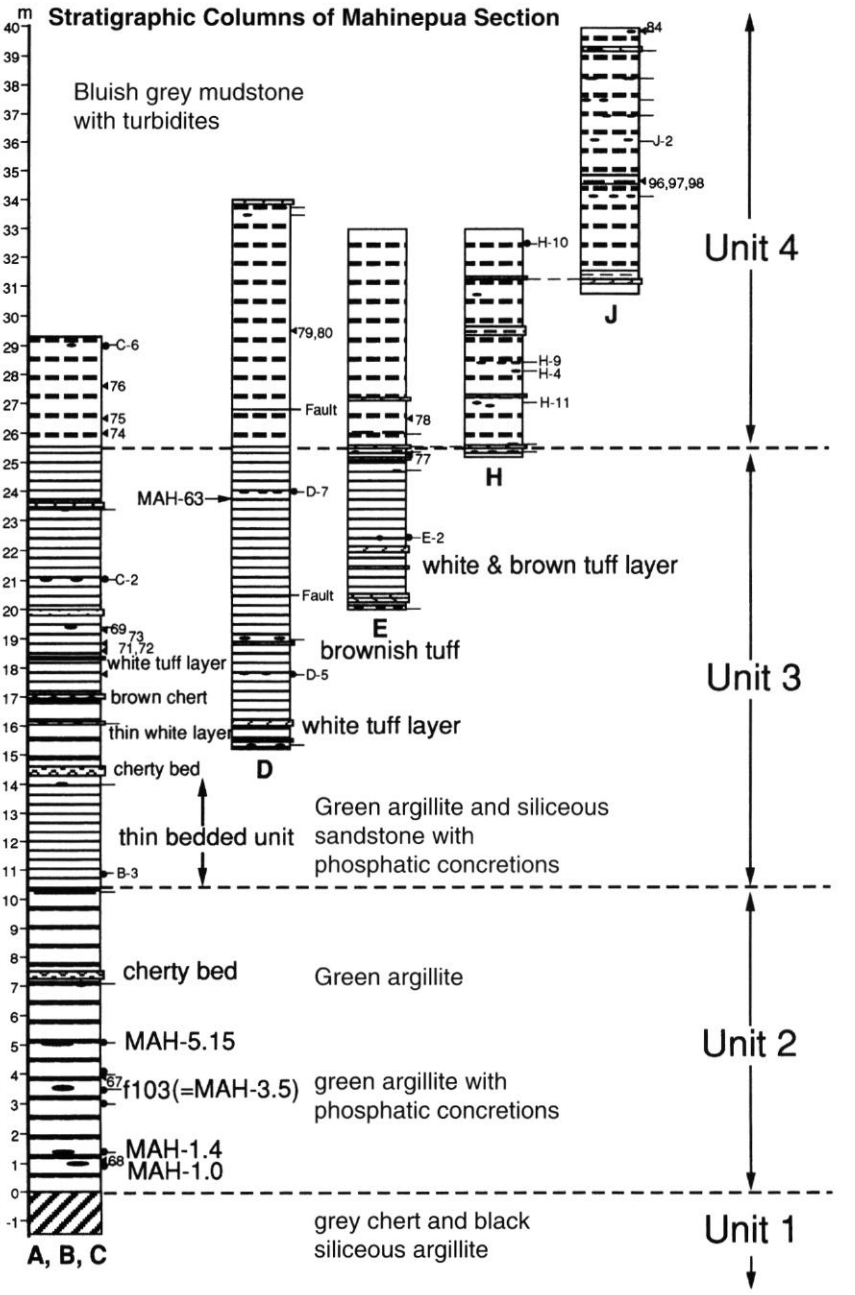


FIG. 5. — Stratigraphic columns in the Mahinepua Section, Waipapa Terrane, New Zealand. Composite columns show lithologic composition of four units and horizons of radiolarian-bearing samples.

al. (1997), the Midian is correlated with the Late Middle Permian Capitanian Stage. More recently, the lithostratigraphy and radiolarian biostratigraphy of the Late Permian to Middle Triassic succession at Arrow Rocks has been described (Takemura *et al.* 1998, 1999 in this volume).

TABLE 1. — Radiolarian faunal list for Mahinepua, Bull Creek (New Zealand) and Dzugadzak River (Northeast Siberia) and occurrence of radiolarians from Buchenstein Limestone, Recoaro (Northern Italy).

	NEW ZEALAND Waipapa Terrane	NEW ZEALAND Caples Terrane	NE SIBERIA Omolon Massiv	N ITALY Vicentinian Alps
Locality	Mahinepua	Bull Creek	Dzugadzak River	Recoaro
Sample or Unit	PO4/f103	H45f074	7438-89-1	Buchenstein
Field No.	MAH-3.5	YABC-26	Unit 10	Limestone
Spongopallium contortum Dumitrica, Kozur & Mostler	X			X
Spongopallium aff. *koppi* (Lahm)			X	X
Spongopallium sp.	X	X		X
Cryptostephanidium longispinosum (Sashida)	X			X
Hindeosphaera sp.			X	X
Pseudostylosphaera sp.		X		X
Eptingium sp.	X			X
Kahlerosphaera sp.	X			X
Plafkerium (?) sp.	X			X
Stauracontium (?) sp.			X	X
Archaeosemantis sp.	X	X		X
Parentactinia inerme Dumitrica	X	X	X	X
Parentactinia pugnax Dumitrica	X	X	X	X
Pentactinorbis mostleri Dumitrica	X			X
Pentactinorbis sp.	X			X
Glomeropyle aurora Aita, n. sp.	X			
Glomeropyle boreale Bragin, n. sp.	X		X	
Glomeropyle poinui Aita, n. sp.	X			
Glomeropyle (?) *galagala* Aita, n. sp.	X	X		
Glomeropyle grantmackiei Aita, n. sp.	X	X		
Glomeropyle mahinepuaensis Aita, n. sp.	X			
Glomeropyle waipapaensis Aita, n. sp.	X			
Silicarmiger costatus costatus Dumitrica, Kozur & Mostler	X	X	X	X
Silicarmiger cf. *latus* Kozur & Mostler			X	
Silicarmiger sp.				X
Foremanellina aranea Dumitrica	X			X
Foremanellina expansolabrum Dumitrica		X		X
Foremanellina sp.		X		X
Recoaroella sp.		X		X
Triassospongocyrtis sp.		X		X
Hozmadia cf. *reticulata* Dumitrica, Kozur & Mostler	X			X
Hozmadia sp.	X	X	X	X
Goestlingella sp.	X			X
Poulpus sp.	X		X	X
Pachus (?) sp.			X	
Laxtorum (?) sp.		X	X	
Simple multicyrtoids	X	X		

MAHINEPUA SECTION

Mahinepua section is located on the northern side of Mahinepua Peninsula (Fig. 3), east of the Whangaroa area, North Island, New Zealand.

The fossil locality is PO4/f103 (= field No. MAH-3.5), grid reference PO4/886892 in the archival New Zealand Fossil Record File maintained by the Geological Society of New Zealand, i.e. locality No. f103 in map sheet PO4 of the 1:50,000 series NZMS260. It lies in the lower part of Unit 2 (Fig. 4).

The complete section consists of red bedded

chert (20 m thick), green siliceous argillite (25.5 m), bluish grey mudstone with turbidites (30 m), and massive sandstone (> 100 m) in ascending order (Figs 4, 5). This is a typical "chert-green argillite-clastics" sequence which is considered to represent a stratigraphically continuous accretionary sequence from pelagic (bedded chert) and hemipelagic (green argillite) facies to terrigenous facies (blue-grey mudstone and massive sandstone). Black phosphatic concretions from many horizons within the green argillite yielded diverse, well-preserved radiolarian faunas of Middle to Late Triassic age.

The Mahinepua Section is subdivided into five units as follows (Figs 4, 5):

Unit 1. Grey chert and black siliceous argillite .. .. 5 m.

Unit 2. Green argillite with lenticular phosphatic bands ..... 10 m.

Unit 3. Well bedded green argillite and siliceous sandstone with phosphatic concretions and intercalated thin white tuff ..... 15 m. The lower 4 m is thin bedded.

Unit 4. Bluish grey mudstone with turbidites .... 30 m. Many turbidites layers of 10-20 cm thickness are intercalated with mudstones.

Unit 5. Massive sandstone ..... 100 m.

The radiolarian fauna in the basal part of Unit 2 includes *Pseudostylosphaera spinulosa* (Nakaseko & Nishimura, 1979), *Glomeropyle aurora* n. sp., *Hozmadia* aff. *pyramidalis* Gorican, 1990 *in* Gorican & Buser, 1990. Sample f103 (= field No. MAH-3.5) is a black phosphatic concretion taken from 3.5 m above the base of this unit and contains well-preserved Middle Triassic radiolarians. The fauna is dominated by abundant Spumellaria including *Spongopallium contortum* Dumitrica, Kozur & Mostler, 1980, *Plafkerium* (?) sp., *Eptingium* (?) sp., *Parentactinia inerme* Dumitrica, *P. pugnax* Dumitrica, 1978, *Pentactinorbis mostleri* Dumitrica, 1978, and *Cryptostephanidium longispinosum* (Sashida, 1991). In addition, *Glomeropyle aurora* n. sp., *G. poinui* n. sp., *G.* (?) *galagala* n. sp., *G. grant-*

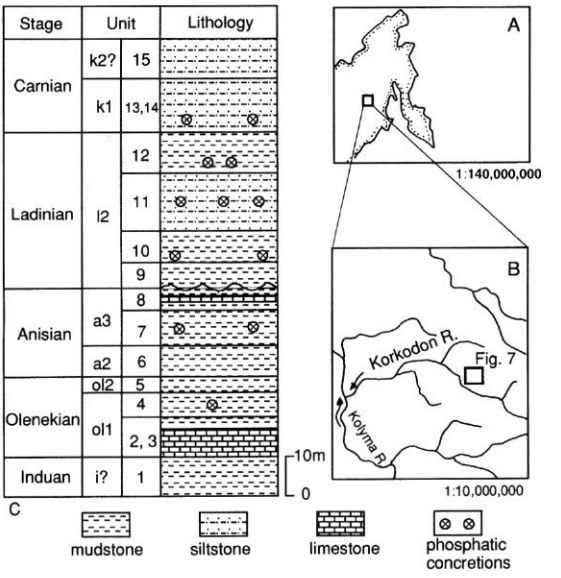


FIG. 6. — Geographic location (**A**, **B**) and stratigraphic column (**C**) for the Triassic section at Zhilny Creek, left bank, of Dzugadzak River (Omolon Massif, northeastern Siberia). Location map B showing the studied section (squared area, Fig. 7). Symbols on the left side of the stratigraphic column are: (1) stage and substage: **i?**, probably Induan; **ol1**, early Olenekian; **ol2**, late Olenekian; **a2**, middle Anisian; **a3**, late Anisian; **l2**, late Ladinian; **k1**, early Carnian; **k2?**, probably middle Carnian; (2) number of stratigraphic unit as described herein.

mackiei n. sp., *G. mahinepuaensis* n. sp. and *G. waipapaensis* n. sp. are present. The nassellarians include *Silicarmiger costatus costatus* Dumitrica, Kozur & Mostler, *Foremanellina aranea* Dumitrica, 1982, *Hozmadia* cf. *reticulata* Dumitrica, Kozur & Mostler, 1980, *Hozmadia* aff. *pyramidalis* Gorican and an undescribed form of *Poulpus*. This assemblage is considered to be of early Ladinian age.

The first appearance of *Capnuchosphaera* including *C. colemani* Blome, 1983, is recorded in the middle part of Unit 3. Numerous undescribed spumellarians belonging to the genera *Capnuchosphaera* De Wever, 1979, *Dumitricasphaera* Kozur & Mostler, 1979, *Karnospongella* Kozur & Mostler, 1981, *Pantanellium* Pessagno, 1977, *Sarla* Pessagno, 1979, *Welirella* Dumitrica, Kozur & Mostler, 1980, *Xenorum* Blome, 1984 are also present in this unit, and a Late Triassic age is inferred.

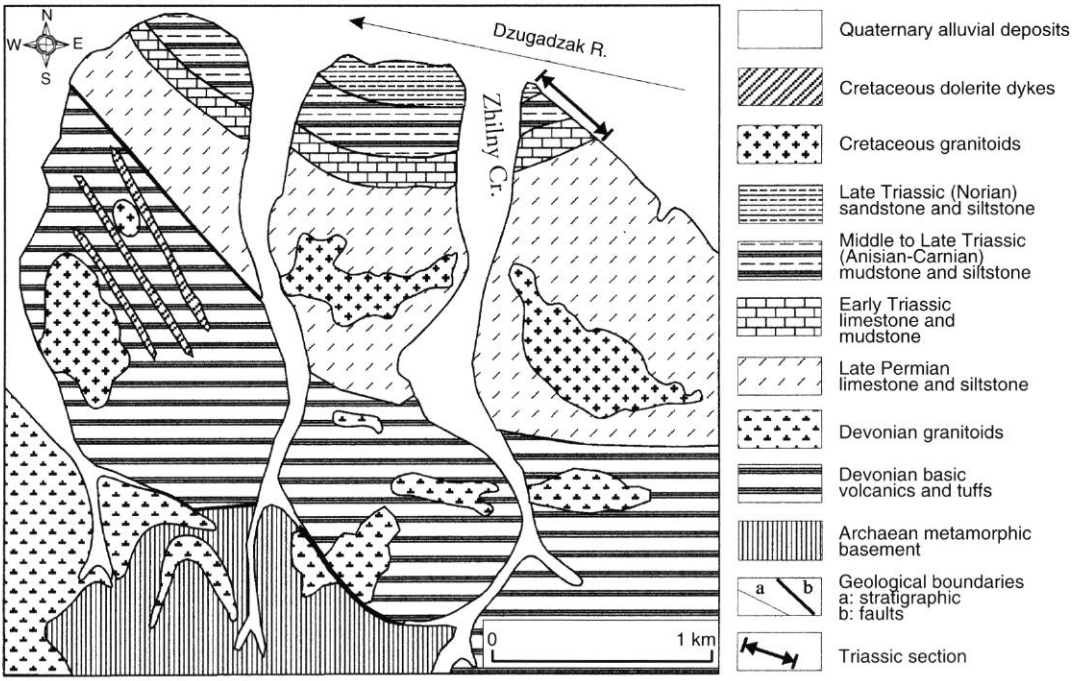


FIG. 7. — Geological map of the study area, left bank of Dzugadzak River.

CAPLES TERRANE, BULL CREEK, OTAGO

An additional fossil locality, H45/f074 (= field No. YABC-26; grid reference H45/884437) lies 500-600 m south of the mouth of Bull Creek on the Otago coast, southeast of Milton, South Island, New Zealand.

The locality is within Caples Terrane (Fig. 2). Some workers consider the Caples Terrane to be the southern extension of the Waipapa Terrane based on spatial relations and tectonic reconstructions of basement terranes (Spörli 1978). Radiolarians of Triassic and possible Middle-Late Jurassic ages have been reported from the "Chrystalls Beach Complex" along this section of the Otago Coast (Hada *et al.* 1988). Detailed examination (by Y. Aita) of radiolarians from phosphatic nodules in argillite from the Tuapeka Group exposed at Bull Creek have established that the faunas are of Middle Triassic age and that there are no Jurassic faunas. The Tuapeka Group rocks are best exposed on the South Otago coast between Chrystalls Beach and Taieri Mouth and are characterised by non-schistose sandstone and argillite with minor chert and phosphatic concretions. Roser *et al.* (1993), from trace element analysis, showed that the eastern Tuapeka Group rocks on the Otago coast display active continental margin felsic provenance, contain more of Torlesse-like sandstones and less mafic sandstone. On the other hand, Adams & Graham (1997) analysed Rb-Sr whole-rock isochrons and K-Ar whole rock ages of metagreywacke sequences in the Torlesse and Caples Terranes. According to their data, Bull Creek samples have an initial $^{87}Sr/^{86}Sr$ isotopic ratio of 0.70568 suggesting a provenance of "uncertain" terrane affinity corresponding to the "Waipapa-type" zone, but different from true Caples and Torlesse-type zones (Adams & Graham 1997). Thus geochronological and geologic data from Bull Creek samples show a similarity between Caples and Waipapa Terrane rocks.

RADIOLARIAN CORRELATION AND FAUNAL AFFINITY

The radiolarian fauna from the basal part of the Mahinepua Section, Waipapa Terrane, is remar-

kably similar to the early Ladinian assemblages from Bull Creek. Early Ladinian species in common to both Mahinepua and Bull Creek faunas include *Silicarmiger costatus costatus* Dumitrica, Kozur & Mostler, *Parentactinia inerme* Dumitrica, *P. pugnax* Dumitrica, and *Spongopallium contortum* Dumitrica, Kozur & Mostler (Table 1). Recent work by Black (1994) suggests that the rocks in the type area (Omahuta-Puketi in southwest Northland) of the Waipapa Terrane, are different from other Waipapa rocks and may be a North Island extension or correlative of the Caples Terrane. However, radiolarian faunal similarities suggest that the northern Waipapa Terrane has close paleobiogeographic affinities with the easternmost Caples Terrane.

In addition, both Mahinepua and Bull Creek faunas contain many species (Table 1) known from the early Ladinian (Fassanian) part of the Buchenstein Limestone in the Southern Alps of Europe (Dumitrica, Kozur & Mostler 1980; Gorican & Buser 1990; Kozur & Mostler 1994; Kozur *et al.* 1996). The Recoaro Limestone, of typical Tethyan affinity (Vicentinian Alps, northern Italy) is known to yield more than 250 radiolarian species (Lahm 1984; Baumgartner *et al.* 1997). However, it includes no forms of the new genus *Glomeropyle* (Table 1), whereas Mahinepua and Bull Creek faunas include abundant specimens and a number of forms of the new genus *Glomeropyle* (described herein). This genus may be restricted to high latitude affinity. The common occurrence of this genus, including especially *G. grantmackiei* n. sp. and *G.* (?) *galagala* n. sp. is characteristic of the early Ladinian Bull Creek fauna of the Caples Terrane, South Island. Undescribed species of the genera *Poulpus* De Wever, 1979, *Hozmadia* Dumitrica, Kozur & Mostler, 1980, and *Plafkerium* Pessagno, 1979, are also present. The presence of simple multicyrtoids and the absence of the genus *Ladinocampe* Kozur, 1984 may characterize the Southern Hemisphere high latitude fauna in terms of paleobiogeographic affinity.

TRIASSIC RADIOLARIA IN SIBERIA

Dzugadzak River Section, Omolon Massif

Radiolaria are present in the Dzugadzak Section of the Omolon Massif (northeastern Siberia). The Omolon Massif is regarded as a microcontinent with Pre-Cambrian metamorphic basement and a sedimentary cover of Paleozoic and Mesozoic age (Fig. 7). Triassic rocks in this region were deposited in oceanic conditions as hemipelagites. They are represented predominantly by claystones and mudstones with rare limestones and contain ammonoids, pseudoplanktonic bivalves, foraminifers and radiolarians. Benthic fossils are relatively rare (Dagys *et al.* 1979; Egorov *et al.* 1987; Dagys *et al.* 1991; Dagys & Konstantinov 1995; Egorov & Bragin 1995).

The Triassic section is located on the left bank of Dzugadzak River in its middle reaches. The following units are exposed as follows (Figs 6, 7):

1a. Lower Triassic, Induan Stage (?)

Unit 1. Pale-grey claystones with poorly preserved brachiopods ..... 10 m.

1b. Lower Triassic, Lower Olenekian

Unit 2. Pale-grey bituminous platy and massive limestone with rareintercalations of grey mudstone ..... 7 m.

Unit 3. Grey, dark-grey and brownish-grey mudstone with intercalations (0.1 m) of grey limestone and brownish-grey claystone ..... 3 m.

Unit 4. Grey and dark-grey thin-bedded mudstone with intercalations (0.1-0.2 m) of black caustobiolithic shale with rare phosphoritic concretions containing poorly preserved Radiolaria ..... 6.5 m.

Units 2-4 are characterized by conodonts and bivalves confirming the presence of the early Olenekian: *hedenstroemi* and *tardus* zones.

1c. Upper Olenekian Stage

Unit 5. Dark-grey mudstone with *Claraia aranea* Tozer ..... 4 m.

2a. Middle Triassic, Middle Anisian

Unit 6. Dark-grey and black thin-bedded mud-

stone with ammonoid *Czekanowskites decipiens* (Mojsisovics). Lower contact of this bed erosional with a stratigraphic gap representing early Anisian time ..... 8 m.

2b. Middle Triassic, Upper Anisian

Unit 7. Dark-grey and black mudstone with numerous phosphoritic concretions, with the ammonoid *Amphipopanoceras dzenginense* Archipov and radiolarians *Triassothamnulus* (?) sp., *Entactinia* sp., *Pseudostylosphaera* (?) sp. ex gr. *P. fragilis* (Bragin, 1991), *P.* (?) sp., Spongodiscoidea (?) gen. indet., *Spongopallium* (?) sp., *Stauracontium* (?) sp., *Triassocampe* (?) sp. .. 9 m.

Unit 8. Dark-grey and black mudstone and siltstone with phosphoritic concretions and beds of grey fine sandstone, black caustobiolithic shale and brownish-grey bituminous limestone with the ammonoid *Parafrechites sublaqueatus* (Bytschkov, 1968) ..... 8 m.

2c. Ladinian

Unit 9. Black thin-bedded mudstone interbedded with grey, yellow and white claystone and dark-grey bituminous limestone with *Daonella prima* Kiparisova, 1937 ..... 5.5 m.

Unit 10. Dark-grey and black mudstone and caustobiolitic shale with numerous phosphoritic concretions containing the ammonites *Arctoptychites omolojensis* Archipov, 1974 (lower 2.5 m), *Arctogymnites* cf. *spectori* Archipov, 1974, *Indigirophyllites oimekonensis* Popov, 1946 (5-5.5 m above base), algae *Tasmanites* sp., and Radiolaria: *Archaeocenosphaera* sp., *Entactinia* sp., *Ferresium* (?) sp., *Hindeosphaera* (?) sp., *Hozmadia* (?) sp., *Laxtorum* (?) sp., *Pachus* (?) sp., *Parentactinia pugnax* Dumitrica, *P.* cf. *inerme* Dumitrica, 1978, *Praenanina* sp., *Poulpus* sp., *Glomeropyle boreale* n. sp., *Silicarmiger costatus costatus* Dumitrica, Kozur & Mostler, 1980, *S.* cf. *latus* Kozur & Mostler, 1994, Spongodiscoidea gen. & sp. indet., *Spongopallium* aff. *koppi* (Lahm, 1984), *Stauracontium* (?) sp. ....6.5 m.

Unit 11. Black platy siltstone interbedded with yellow and white claystone, with rare phosphoritic concretions containing cephalopods *Arctoptychites* sp., *Indigirophyllites* sp., *Gryponautilus* sp. ex gr. *G. kegalensis* Sobolev, 1989 (1-1.2 m above base), *Nathorstites* sp. cf. *N. mclearni* Tozer, 1961, *Aristoptychites kolymensis* Kiparisova, 1961 (13.3 m above base) ..... 15 m.

Unit 12. Black thin-laminated mudstone with abundant phosphoritic concretions containing cephalopods: *Nathorstites mclearni* Tozer, *Aristoptychites kolymensis* Kiparisova, 1961 (1-2 m above base), *Sphaerocladiscites omolojensis* Bytschkov, 1968, *Indigirophyllites oimekonensis* Popov, *Nathorstites mcconnelli* (Whiteaves, 1889), *Sinuplicorhynchia kegalensis* Dagys, 1965 (2.8-9.7 m above base), *Nathorstites lindstroemi* (Boehm, 1903), *Sphaerocladiscites omolojensis* Bytschkov (9.7-10.3 m above base), and Radiolaria: *Archaeocenosphaera* sp., *Pseudostylosphaera* sp., *Ferresium* (?) sp. ..... 10.5 m.

Unit 13. Black mudstone with abundant phosphoritic concretions with cephalopods *Nathorstites lindstroemi* Bohm, *Sphaerocladiscites omolojensis* Bytschkov (1.3-2.3 m above base), *Proclydonautilus aniamensis* (Shimansky, 1957) (4.1-6 m above base) ..... 11.6 m.

3. Late Triassic, Carnian

Unit 14. Dark-grey bituminous siltstone with abundant phosphoritic concretions with *Discophyllites* sp., *Stolleyites* cf. *tenuis* (Stolley, 1911), *Proclydonautilus aniamensis* (Shimansky), *Cenoceras boreale* Dagys & Sobolev, 1989 (0-0.3 m above base), *Proclydonautilus aniamensis* (Shimansky), *Pennospiriferina popovi* Dagys, 1965, *Pennospiriferina* (*Dentospiriferina*) *costata* Dagys, 1965, *P.* (*D.*) *pepeliaevi* Dagys, 1965 (1.1-3 m above base), *Holcorhynchia tibetica* (Bittner, 1899) (4.5 m above base), and Radiolaria: *Pseudostylosphaera* sp., *Ferresium* sp. ..... 2 m.

Unit 15. Black platy siltstone with rare phosphoritic concretions and macrofossils: *Discophyllites taimyrensis* Popov, 1961, *Cenoceras boreale* Dagys & Sobolev, *Pennospiriferina* (*Dentospiriferina*) *costata* Dagys, *Planirhynchia yakutica* Dagys, 1965 (4.5-4.9 m above base) ..... 10 m.

Unit 16. Dark-grey massive and platy bioturbated siltstone with rare carbonate concretions containing *Discophyllites taimyrensis* Popov, and *Pennospiriferina* (*Dentospiriferina*) *costata* Dagys (5.3 m above base) ..... 8 m.

Unit 10 of this section contains the most diverse radiolarian assemblage including *Glomeropyle boreale* n. sp. and ammonoids which are common in northeastern Siberia, but not present in the low-latitude regions. This sequence was originally interpreted as early Ladinian (Dagys *et al.* 1979) but has been redetermined as the lower part of the late Ladinian (Dagys *et al.* 1991; Dagys & Konstantinov 1995). This conclusion was based on ammonoid data. However, radiolarian faunas have closer affinity with early Ladinian assemblages, based on the presence of such taxa as *Parentactinia pugnax* Dumitrica, *P.* cf. *inerme* Dumitrica, *Silicarmiger costatus costatus* Dumitrica, Kozur & Mostler, *S.* cf. *latus* Kozur & Mostler, *Spongopallium* aff. *koppi* (Lahm).
The variance of these two age interpretations require further research.
The age ranges of the key radiolarian taxa may be longer than presently understood and there is as yet poor correlation between ammonoid zones of high- and low-paleolatitude Ladinian sections.

CONCLUSIONS

Radiolarian faunas of Middle Triassic age from New Zealand and northeastern Siberia have been documented. They are characterized by abundant occurrences of non-Tethyan species including seven new species of *Glomeropyle* n. gen. (described herein). Although the fauna includes many species known from the European Tethyan sequences, the presence of *Glomeropyle* n. gen. is only known from southern and northern high latitudes during Middle Triassic time. In terms of Triassic paleobiogeography these radiolarian faunas appear to reflect a bipolar latitudinal pattern. Further examination of New Zealand and Siberian radiolarian faunas are required in order to establish Boreal and Austral faunal differentiation from Tethyan forms.

In New Zealand, the Mahinepua early Ladinian fauna in the Waipapa Terrane has a non-Tethyan affinity and is similar to that in the Caples Terrane. Furthermore, the Mahinepua Section offers great potential for establishment of a standard radiolarian biostratigraphy for Middle and Late Triassic successions that accumulated in southern high latitudes along the margin of Gondwanaland.

SYSTEMATIC PALEONTOLOGY

Type specimens of species authored by Aita are deposited at the Geology Department, Utsunomiya University (UTU), and of species authored by Bragin are deposited at the Geological Institute (GIN), Russian Academy of Sciences.

Suborder SPUMELLARIA Ehrenberg, 1875

Glomeropyle Aita & Bragin, n. gen.

TYPE SPECIES. — *Glomeropyle aurora* Aita n. sp.

ETYMOLOGY. — Latin, *glomero-* form into a ball; Greek *pyle-* gate, orifice, opening.

OCCURRENCE. — Middle Triassic, Anisian to Ladinian. Waipapa Terrane, North Island and Caples Terrane, South Island, New Zealand. Omolon Massif, northeastern Siberia.

DIAGNOSIS. — Shell of variable small to large size, subspherical, with open subcircular aperture and pylome, with or without primary spines; wall very thick, multi-layered, with internal cavity, with or without internal spicule, without medullary shells.

REMARKS

Glomeropyle n. gen. differs from the Tertiary *Prunopyle* Dreyer, 1889, emend Kozlova *in* Kozlova & Gorbovetz, 1966 by having a heavy thick-walled shell without medullary shells. It differs from *Sphaeropyle* Dreyer, 1889 by having a less spherical outer shell with pores irregularly arranged, and variable in size, and without medullary shells.
Although there are a number of species known from the Middle Triassic of New Zealand and

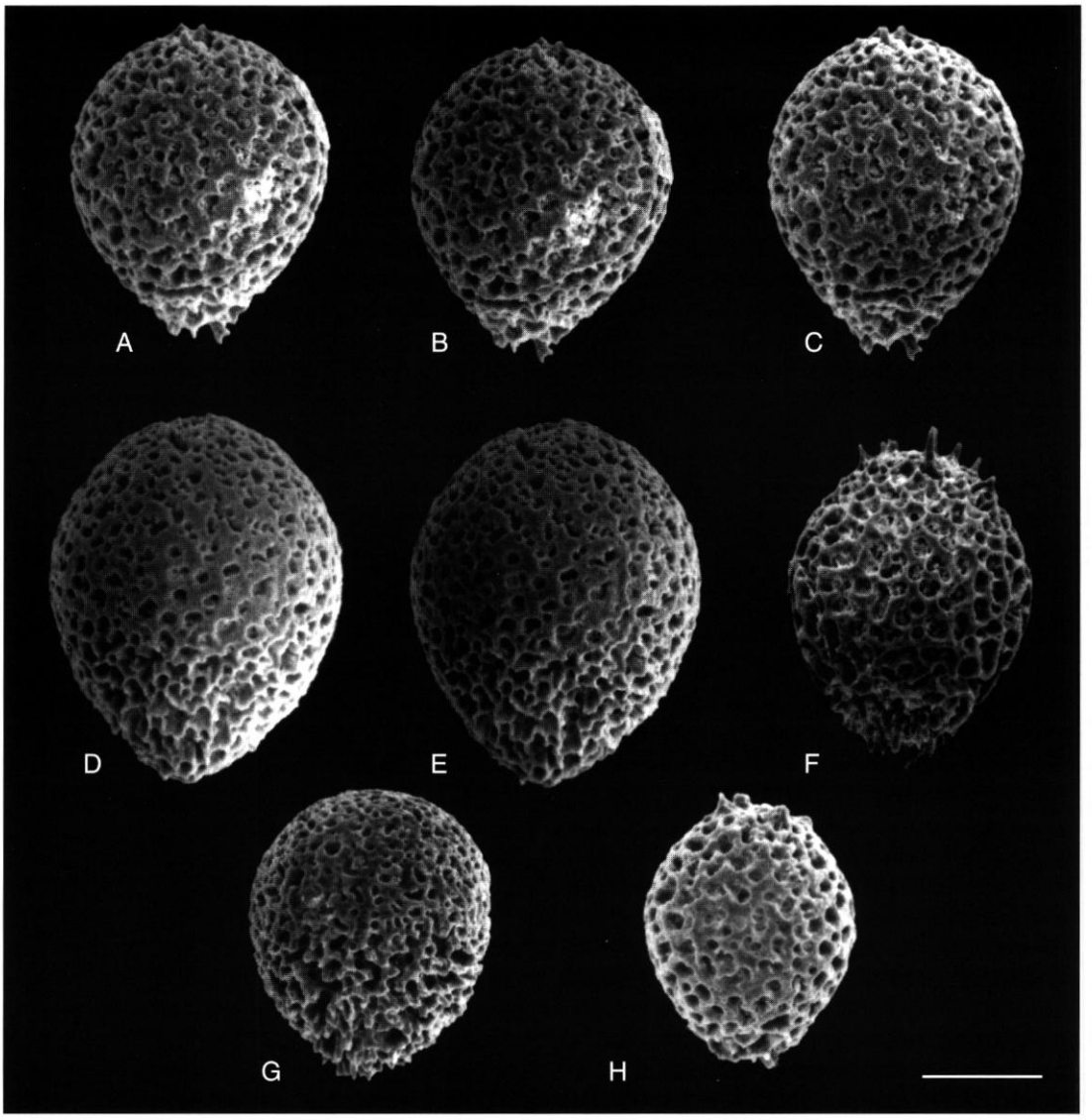


FIG. 8. — *Glomeropyle aurora* Aita, n. sp.; **A-C**, holotype (photo Nos 31101, 31102 & 31107); **A**, **B**, stereograph, **C**, lateral view; **D**, **E**, paratype (photo Nos 31123, 31125), stereograph; **F**, paratype (photo No. 31106); **G**, **H**, photo Nos 31109, 31110. Sample MAH-3.5, Unit 2, Mahinepua Peninsula, North Island, New Zealand. Scale bar: 100 µm.

Russia, however, no record of forms resembling any species of *Glomeropyle* n. gen. has been found from Middle Triassic sequences in the Europe, Japan, Southeast Asia or North America. Thus, this genus appears to be restricted to northern and southern high latitude areas, suggesting a bipolar biogeographic distribution.

Glomeropyle aurora Aita, n. sp.
(Fig. 8A-H)

TYPE MATERIAL. — Holotype: UTU101 (Fig. 8A-C). Paratypes: UTU102 (Fig. 8D, E), UTU103 (Fig. 8F).

TYPE LOCALITY. — All specimens from sample PO4/f103 (= MAH-3.5), Mahinepua Peninsula.

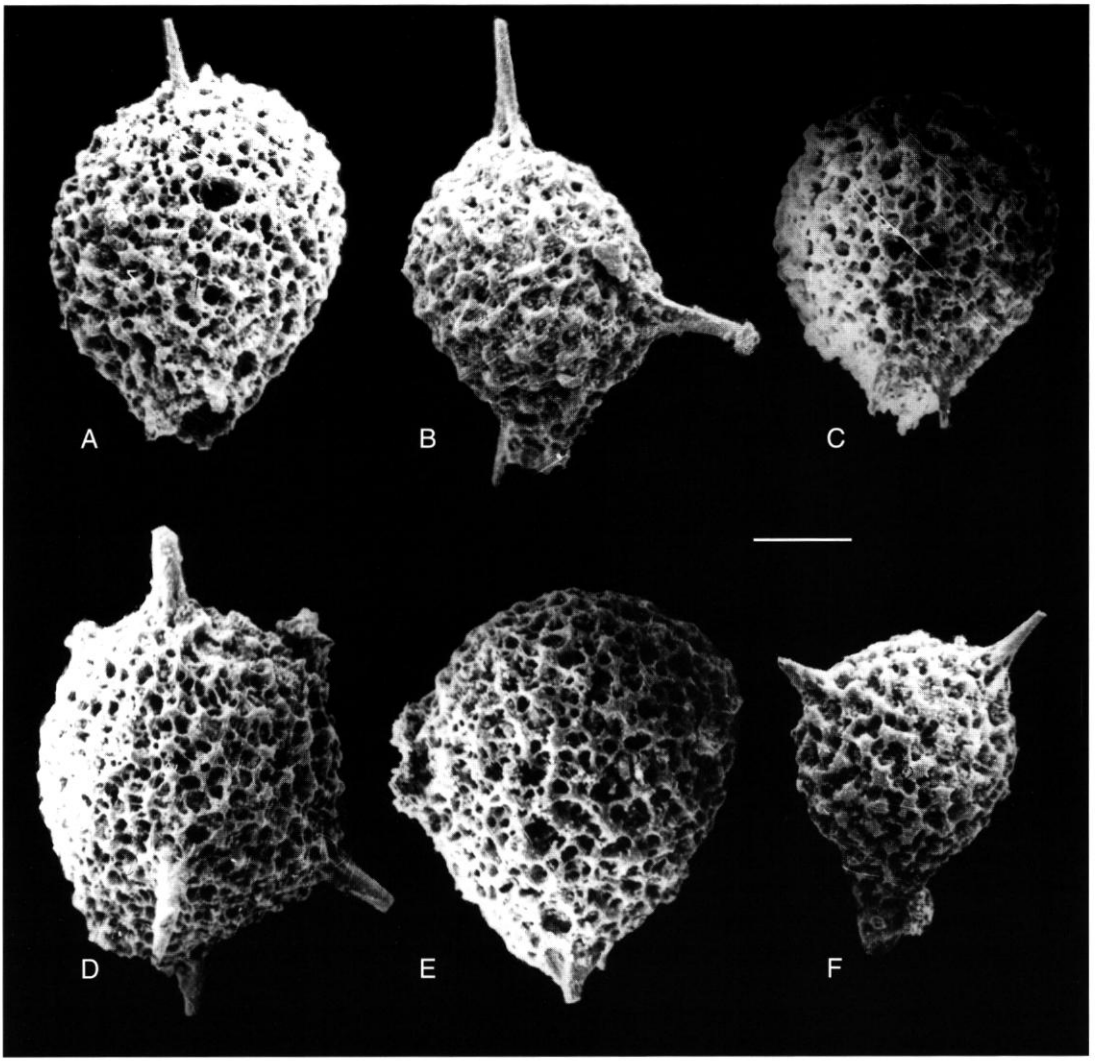


FIG. 9. — *Glomeropyle boreale* Bragin, n. sp.; **A**, holotype; **B-F**, paratypes. Northeastern Siberia, Omolon Massif, Dzugadzak River, Middle Triassic, Ladinian, Unit 10. Scale bar: 100 µm.

AGE. — Middle Triassic (Anisian to early Ladinian).

ETYMOLOGY. — Latin, *aurora*, dawn, morning.

OCCURRENCE. — Lower green argillite (sample MAH-3.5), Mahinepua Peninsula, Whangaroa area, Waipapa Terrane, North Island, New Zealand.

MEASUREMENTS. — Maximum width: 180-250 µm, height: 200-305 µm, thickness of shell wall: 10-15 (max. 20) µm.

DESCRIPTION

Relatively small, ovoidal shell with a few spines or clusters of short spines at one pole and with a short pylome at the other pole. Cortical shell usually thin-walled; upper part hemispherical, lower half part tapering, inverted conical with an aperture. Pores subcircular to irregular in shape, with or without pore frames. Pylome less developed, with a few short spines. Aperture narrow,

two to three times as wide as thickness of shell wall. No medullary shells recognized.

REMARKS
This species differs from *Glomeropyle poinui* Aita n. sp. in its smaller size and thinner shell, and by having a few spines or clusters of short spines at one pole.

Glomeropyle boreale Bragin, n. sp.
(Fig. 9A-F)

Pylentonemidae (?) gen. indet. – Egorov & Bragin 1995, fig. 2 (10-12).

TYPE MATERIAL. — Holoype GIN No. 7438-89-1 (Fig. 9A).

TYPE LOCALITY. — Omolon Massif, Dzugadzak River.

AGE. — Middle Triassic (Ladinian).

ETYMOLOGY. — Greek, *boreios*, god of the north wind.

OCCURRENCE. — Middle Triassic, Ladinian. Omolon Massif, northeastern Siberia.

MEASUREMENTS. — Maximum width of shell: 230-330 µm, height with pylome tube: 310-385 µm, diameter of aperture: 55-75 µm, length of spines: 50-120 µm.

DESCRIPTION
Large subspherical or roughly ellipsoidal shell with well-developed subcircular aperture forming short pylome. Small short rod-like spines are present around aperture, three of them longer than others. Outer shell with two visible layers; outer layer with polygonal (trigonal to pentagonal) commonly irregular pore frames with apophyses and massive nodes at vertices. Inner layer with small irregular pore frames.
Shell wall very thick, inner cavity small, inner structure unclear. One or more primary spines present, each with triangular in cross-section proximally, rod-like distally. Sometimes primary spines are absent.

REMARKS
Glomeropyle boreale Bragin, n. sp. differs from *G. mahinepuaensis* Aita, n. sp. in having a rougher shell surface, and in its larger and more clearly defined polygonal pore frames with massive nodes at vertices.

Glomeropyle poinui Aita, n. sp.
(Fig. 10A-F)

TYPE MATERIAL. — Holotype: UTU104 (Fig. 10A, B). Paratypes: UTU105 (Fig. 10C, D), UTU106 (Fig. 10E).

TYPE LOCALITY. — All specimens from sample PO4/f103 (= MAH-3.5), Mahinepua Peninsula.

AGE. — Middle Triassic (early Ladinian).

ETYMOLOGY. — Maori, *poinui*, a large ball.

OCCURRENCE. — Lower green argillite (sample MAH-3.5), Mahinepua Peninsula, Whangaroa area, Waipapa Terrane, North Island, New Zealand.

MEASUREMENTS. — Maximum width: 265-310 µm, height: 310-355 µm, thickness of shell wall: 25-30 (max. 40) µm.

DESCRIPTION
Large spherical to subspherical shell with a short pylome. Cortical shell thick-walled with numerous subcircular to irregular small pores. Pores variable in size usually without distinct pore-frames, but rarely with polygonal pore-frames. Overall outline smooth, but area around pylome rough. Aperture narrow. No medullary shells recognized.

REMARKS
Glomeropyle poinui Aita n. sp. resembles *Glomeropyle aurora* Aita n. sp. in overall shape, but it is distinguished by its large size (> 265 µm in maximum width) and thicker shell wall commonly with smooth surface.

Glomeropyle* (?) *galagala Aita, n. sp.
(Fig. 11A-C)

TYPE MATERIAL. — Holotype: UTU107 (Fig. 11A, B).

TYPE LOCALITY. — Sample PO4/f103 (= MAH-3.5), Mahinepua Peninsula.

AGE. — Middle Triassic (early Ladinian).

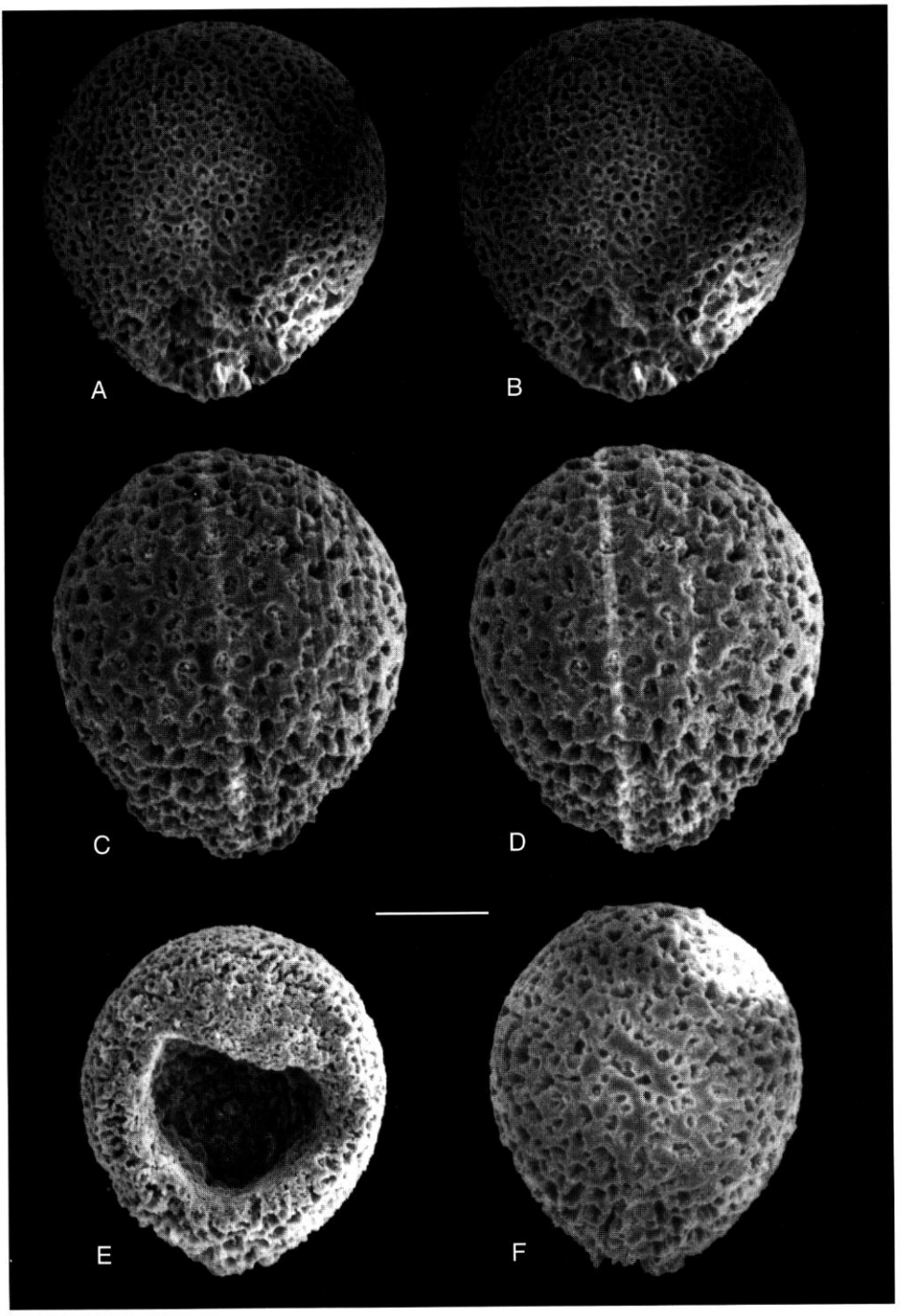


FIG. 10. — *Glomeropyle poinui* Aita, n. sp.; **A**, **B**, holotype, stereograph (photo Nos 31104, 31105); **C**, **D**, paratype stereograph (photo Nos 31126, 31127); **E**, paratype (photo No. 31128); **F**, photo No. 31135. Sample MAH-3.5, Unit 2, Mahinepua Peninsula, North Island, New Zealand. Scale bar: 100 µm.

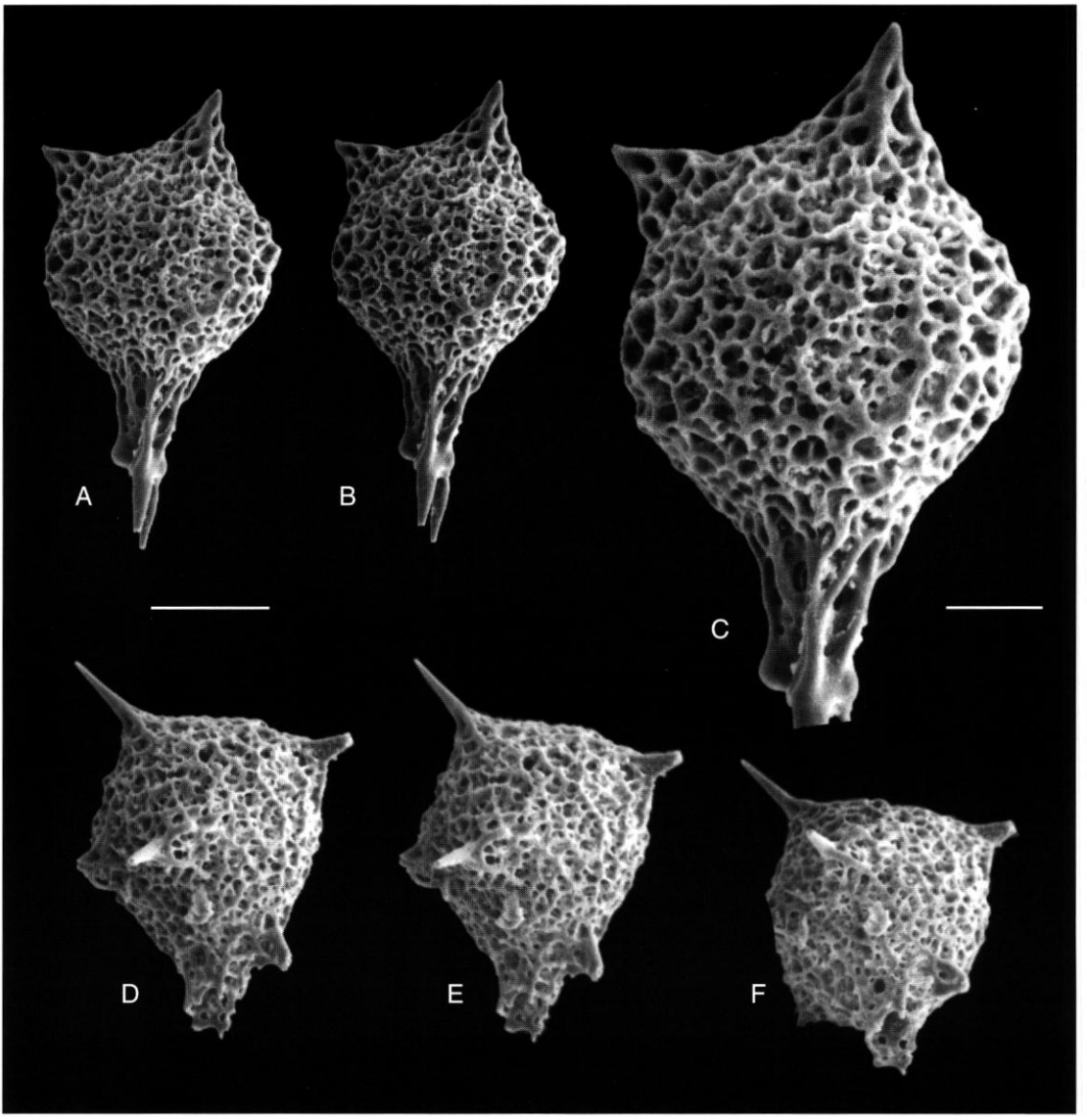


FIG. 11. — **A-C**, *Glomeropyle* (?) *galagala* Aita, n. sp.; **A**, **B**, holotype, stereograph (photo Nos 31075, 31076); **C**, close-up view, holotype (photo No. 31077); **D-F**, *Glomeropyle grantmackiei* Aita, n. sp.; holotype (photo Nos 31089, 31090, 31092); **D**, **E**, stereograph; **F**, oblique basal view. Sample MAH-3.5, Unit 2, Mahinepua Peninsula, North Island, New Zealand. Scale bars: A, B, D-F, 100 µm; C, 50 µm.

ETYMOLOGY. — Japanese, *galagala*, a rattle.

OCCURRENCE. — Lower green argillite (sample MAH-3.5), Mahinepua Peninsula, Whangaroa area, Waipapa Terrane, North Island; Bull Creek (sample YABC-26), Caples Terrane, South Island, New Zealand.

MEASUREMENTS. — Maximum width of shell: 210 µm (holotype 194 µm), height of shell: 220 µm (holotype 188 µm), length of spines: 70, 50 µm (holotype 62.5, 50 µm), length of pylome:100 µm (holotype 150 µm).

DESCRIPTION

Spherical shell with two conical spines at one

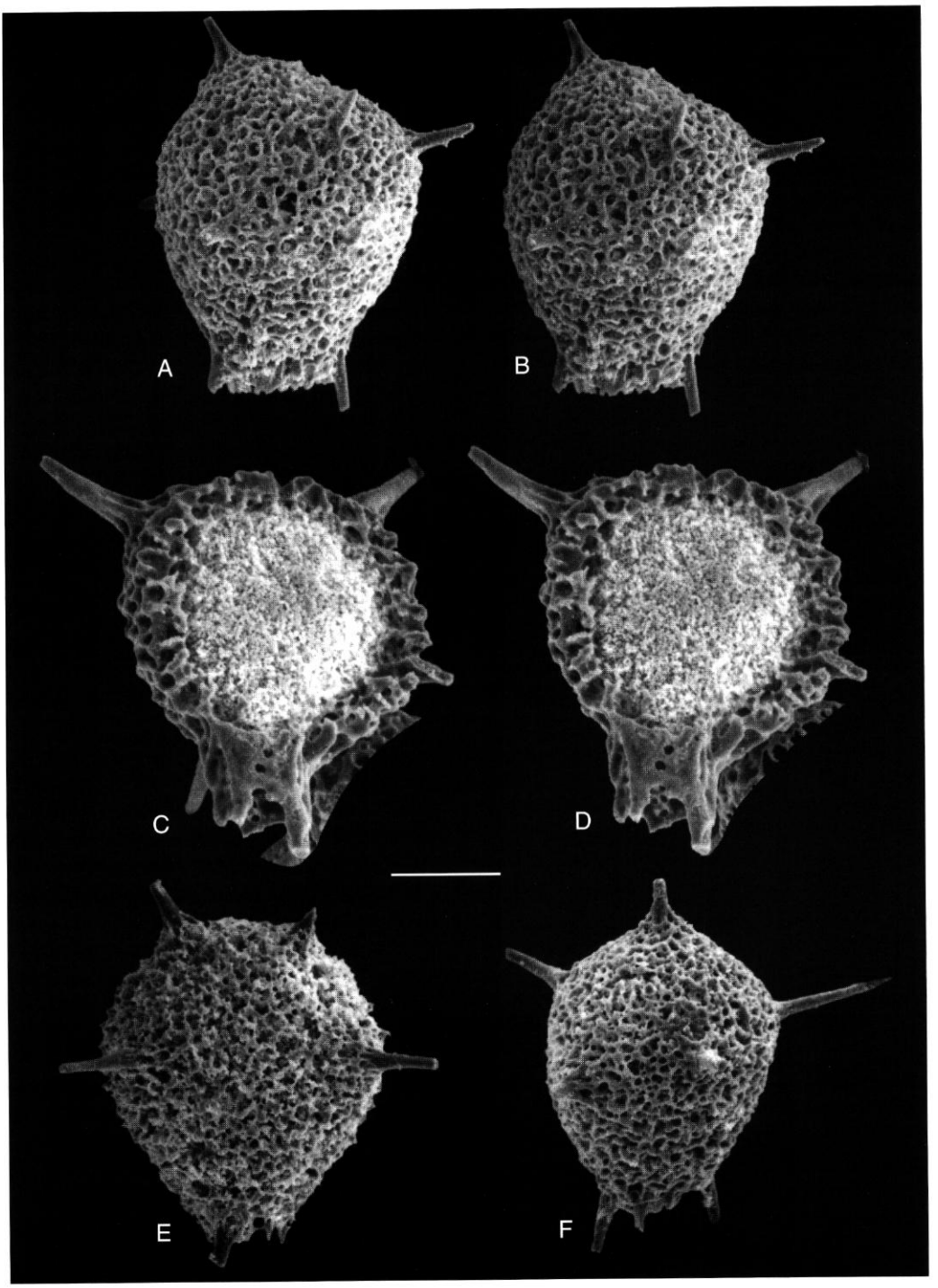


FIG. 12. — *Glomeropyle grantmackiei* Aita, n. sp.; **A**, **B**, paratype, stereograph (photo Nos 31066, 31067); **C**, **D**, stereograph (photo Nos 31098, 31097); **E**, (photo No. 31072); **F**, paratype (photo No. 31073). Sample YABC-26, Bull Creek, Caples Terrane, Otago, South Island. Scale bar: 100 µm.

end and a developed pylome at the other end. Cortical shell double layered with rough ridged surface; outer layer with triangular to polygonal coarse mesh consisting of interconnecting bars; inner layer fine meshed but unclear in detail. Two distinct conical spines forming angle of 60°. Angles between one pole and each spine asymmetric, 20° and 40°. Pylome well-developed, with long spines, sometimes forming a long perforate hollow tube. Usually two or three minute spines fused at ends, forming a rod-like stout spine.

REMARKS

This species is questionably assigned to the genus *Glomeropyle* Aita & Bragin, n. gen. because it has approximately spherical shell and has two distinct horn like spines.

Glomeropyle grantmackiei Aita, n. sp.
(Figs 11D-F, 12A-F)

TYPE MATERIAL. — Holotype: UTU108 (Fig. 11D-F). Paratypes: UTU109 (Fig. 12A, B), UTU110 (Fig. 12F).

TYPE LOCALITY. — Holotype: sample PO4/f103 (= MAH-3.5), Mahinepua Peninsula. Paratypes: sample H45/f074 (= field No. YABC-26), Bull Creek.

AGE. — Middle Triassic (early Ladinian).

ETYMOLOGY. — This species is named for Professor Jack A. Grant-Mackie, Department of Geology, The University of Auckland, in honour of his significant contribution to paleontology in New Zealand.

OCCURRENCE. — Rare in the lower green argillite (sample MAH-3.5), Mahinepua Peninsula, Whangaroa area, Waipapa Terrane, North Island; common to abundant in Bull Creek (sample YABC-26), Caples Terrane, South Island, New Zealand.

MEASUREMENTS. — Maximum width of shell: 200-345 µm, height of shell: 215-325 µm, length of pylome: 38-70 µm, width of aperture: 40-70 µm, thickness of shell: 40-60 µm, length of spines: 70-120 µm.

DESCRIPTION

Large hemispherical, thick-walled shell with a well-developed pylome. Cortical shell consisting of a thick outer layer with coarse spongy meshwork and a thin inner spongy layer. Pores numerous, irregular in shape, variable in size, closely spaced, separated by intervening bars. Rather long, stout, rod-like slender spines are sparsely distributed; four or five spines recognized on the visible side. Each spine three-bladed up to middle of basal portion and with grooves only at base. Aperture well-defined, medium-sized, forming a cylindrical to sometimes tubular pylome, with two to three descending spines.

REMARKS

Glomeropyle grantmackiei Aita n. sp. has a relatively broad morphological variation. It includes such morphotypes as those ornamented with ridged, and nodose surfaces on the inflated subspherical shell. Very heavy massive rod-like spines are developed on many specimens from the phosphatic nodule sample of Bull Creek, Caples Terrane.

Glomeropyle mahinepuaensis Aita, n. sp.
(Fig. 13A-J)

TYPE MATERIAL. — Holotype: UTU111 (Fig. 13A, B). Paratypes: UTU112 (Fig. 13D, E), UTU113 (Fig. 13H, I).

TYPE LOCALITY. — All specimens from sample PO4/f103 (= MAH-3.5), Mahinepua Peninsula.

AGE. — Middle Triassic (early Ladinian).

ETYMOLOGY. — This species is named for Mahinepua Peninsula, Whangaroa area, Northland, New Zealand, as the type locality.

OCCURRENCE. — Common in the lower green argillite (sample MAH-3.5), Mahinepua Peninsula, Whangaroa area, Waipapa Terrane, North Island, New Zealand.

MEASUREMENTS. — Maximum width of shell: 144-250 µm, height of shell: 138-280 µm, length of spines: 25-55 µm, length of pylome: 18-50 µm.

DESCRIPTION

Cortical shell pyriform with an opening at one end bearing a short pylome. Pores small, subcircular to subangular, irregularly arranged. Overall shell with rough surface of numerous small nodes at vortex of pore-frames. Slender, cylindri-

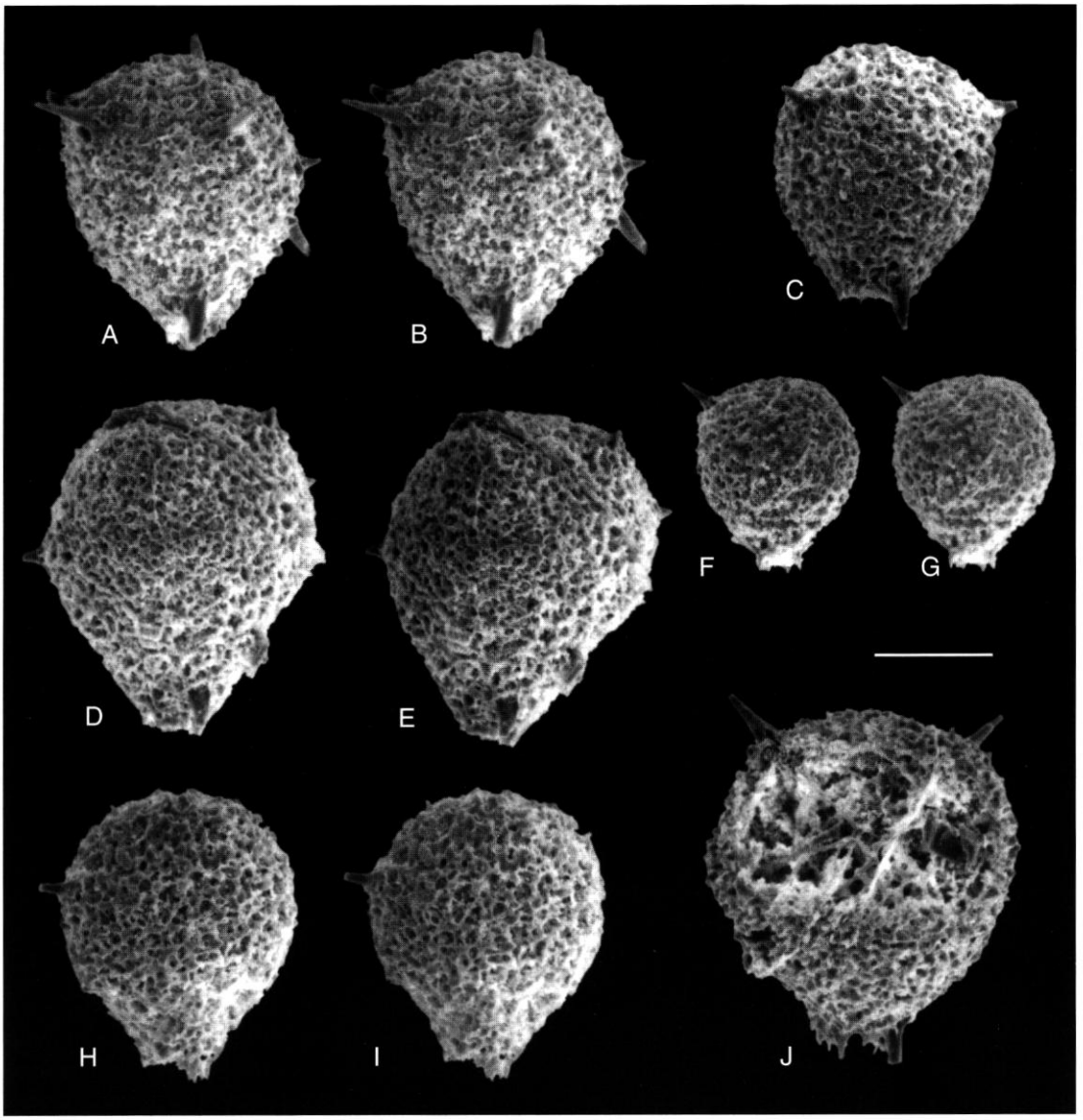
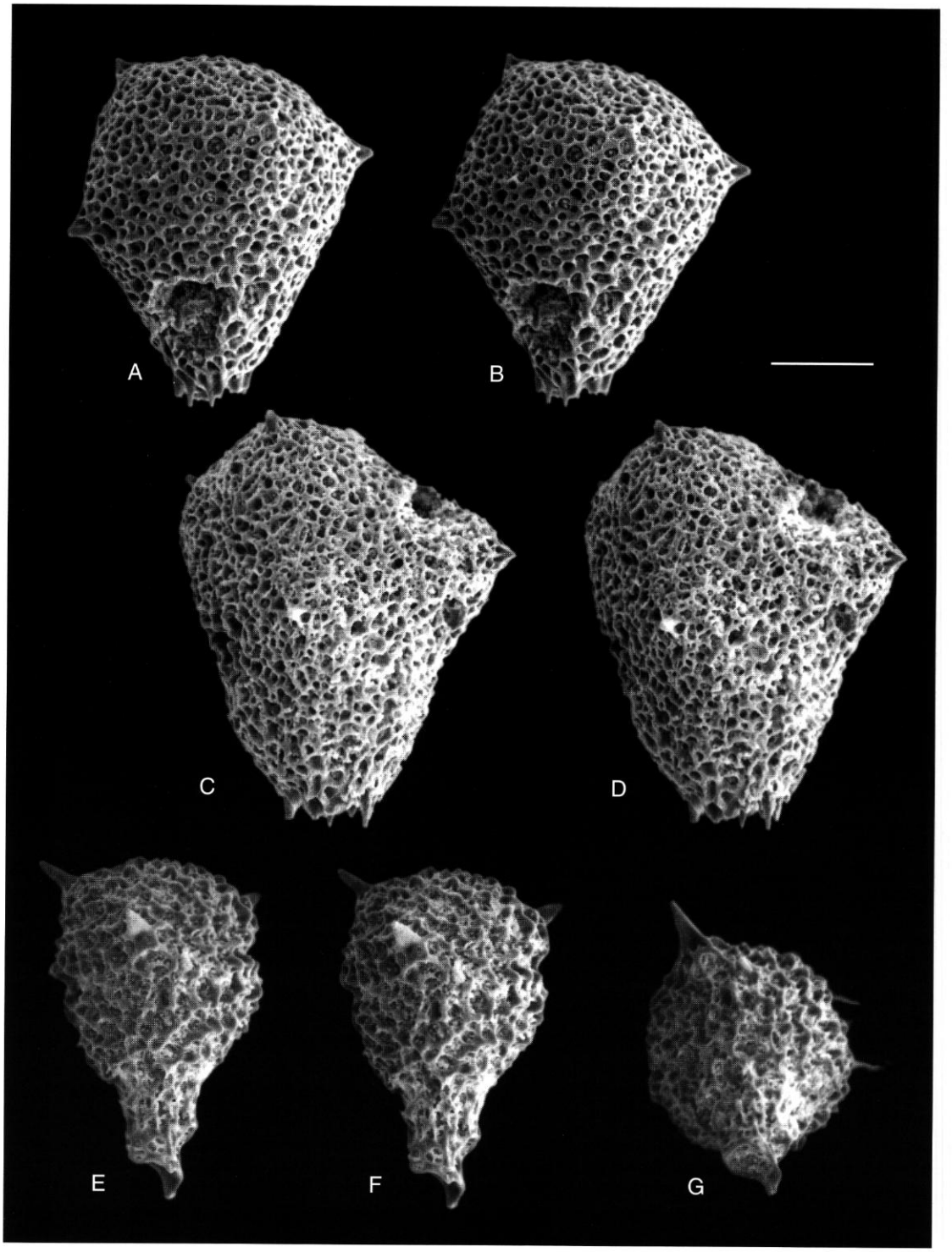


FIG. 13. — *Glomeropyle mahinepuaensis* Aita, n. sp. ; **A**, **B**, holotype, stereograph (photo Nos 31111, 31112); **C**, photo No. 31119; **D**, **E**, paratype, stereograph (photo Nos 31113, 31114); **F**, **G**, paratype, stereograph (photo Nos 31129, 31130); **H**, **I**, paratype, stereograph (photo Nos 31116, 31115); **J**, photo No. 31117. Sample MAH-3.5, Unit 2, Mahinepua Peninsula, North Island, New Zealand. Scale bar: 100 µm.

cal, short spines widely spaced and developed from the shell surface. Between two and five spines rise upward and at least two spines extend downwards. Pylome well-developed with a short stout descending spine and many minute spines. No medullary shell recognized.

REMARKS

Glomeropyle mahinepuaensis Aita, n. sp. resembles *Glomeropyle grantmackiei* Aita, n. sp. in overall shape, but is distinguished from the latter in having a smaller shell, thinner shell wall and shorter, more slender spines. This species differs


A
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from *Glomeropyle aurora* Aita, n. sp. by having rather rough, pointed nodes on the shell surface and more frequently arranged short spines.

Glomeropyle waipapaensis Aita, n. sp.
(Fig. 14A-D)

TYPE MATERIAL. — Holotype: UTU114 (Fig. 14A, B).

TYPE LOCALITY. — Sample PO4/f103 (= MAH-3.5), Mahinepua Peninsula.

AGE. — Middle Triassic (early Ladinian).

ETYMOLOGY. — This species is named for the Waipapa Terrane, a typical accretionary complex of Triassic to Jurassic age, including spilite, chert, green argillite, sandstone, and minor limestone, North Island, New Zealand.

OCCURRENCE. — Lower green argillite (sample MAH-3.5), Mahinepua Peninsula, Whangaroa area, Waipapa Terrane, North Island, New Zealand.

MEASUREMENTS. — Holotype: maximum width of shell: 269 µm, height of shell: 313 µm, length of spines: 25 µm, length of pylome: 31 µm.

DESCRIPTION

Large thick-walled shell, upper half dome-shaped and lower funnel-shaped, with rather ridged surface. Very short, pointed spines are sparsely distributed at apex between four facets; four spines recognized on the visible side. Shell probably double-layered; inner layer is unclear, but intervening bars are visible. Pores closely-spaced, circular to subcircular, variable in size, irregularly arranged with rectangular, pentagonal to hexagonal pore-frames. Ridges or small knobs are developed from apex of pore-frames. Pylome well-developed, with teeth-like spines.

REMARKS

This species resembles *Glomeropyle grantmackiei* Aita, n. sp. in having a similar shape and size. However, it differs from the latter in having more circular to subcircular pores on the shell, is less spinose, and has very short pointed spines.

FIG. 14. — **A-D**, *Glomeropyle waipapaensis* Aita, n. sp.; **A**, **B**, holotype, stereograph (photo Nos 31079, 310785); **C**, **D**, stereograph (photo Nos 31081, 31084). **E-G**, *Glomeropyle* cf. *grantmackiei* Aita, n. sp. (photo Nos 31087, 31088, 31091); **E**, **F**, stereograph; **G**, basal view. Sample MAH-3.5, Unit 2, Mahinepua Peninsula, North Island, New Zealand. Scale bar: 100 µm.

Acknowledgements

We are grateful to Prof. Toyosaburo Sakai for valuable advice and encouragement on an aspect of radiolarian study. We thank Chris Hollis (Geological Survey of Japan) and Jack A. Grant-Mackie (The University of Auckland) for improvement of the early draft of this paper. Dr Paulian Dumitrica kindly provided comments on the taxonomy and information on Tethyan species. Atsushi Takemura (Hyogo Teacher's University), Rie S. Hori (Ehime University), Kazuto Kodama (Kochi University), Bernhard Spörli (University of Auckland) and Toyosaburo Sakai (Utsunomiya University) assisted with sampling at the Mahinepua Section in New Zealand. Hamish Campbell (Institute of Geological & Nuclear Sciences) greatly improved the manuscript. We thank P. Dumitrica and A. Ohler for reviews. This work was partly supported by grants from the Ministry of Education Grants-in-Aid International Scientific Research: 1995 and 1996 to Prof. T. Sakai (Project No. 07041085).

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Submitted for publication on 11 March 1998;
accepted on 1 August 1998.