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Triassic and Jurassic radiolarians from the Tamba Terrane in the Nishizu district, Fukui, Southwest Japan

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Abstract: The Tamba Terrane exposed in Southwest Japan is composed mainly of basalt, limestone, chert, mudstone and sandstone, and is characterized by a chaotic mixture of these rocks; *i.e.*, slabs of basalt, limestone, chert, mudstone and sandstone are embedded in pelitic mixed rock. Few biostratigraphical studies in the Nishizu district, located at a southwestern part of Fukui Prefecture, have previously been appeared and some of them described the occurrence of Permian, Triassic and Jurassic radiolarians. However, age of clastic rocks such as mudstone and siliceous mudstone in this district are still unknown, because these radiolarians were yielded only from cherts. Through the present work, about 430 rock samples of chert, siliceous mudstone and mudstone were collected to extract radiolarians from the Nishizu district and its adjacent area, and Triassic and Jurassic radiolarians were detected from 15 samples. As a result, they can give the rocks additional ages as follows; Triassic, Early and Middle Jurassic for cherts, Late Triassic and Jurassic for siliceous mudstones, and Early to Middle Jurassic for mudstones.

1. Introduction

The Nishizu district in a southwestern part of Fukui Prefecture is situated in a mountainous region and underlain by the Tamba Terrane (Fig. 1). Regional geologic works around this district have been carried out since 1950's and the outline of lithologic assemblages and geologic structures were clarified (*e.g.*, Isomi and Kuroda, 1958; Tsukano, 1965; Ito *et al.*, 1982).

In the last two decades, some reports on the occurrence of radiolarians indicating ages of the rocks of the Tamba Terrane in this district were presented; Ito *et al.* (1982) detected Triassic and Early Jurassic radiolarians, Kido (1986) obtained Late Permian radiolarians, Fujii (1991) found Early to probably Middle Jurassic radiolarians, and recently Nakae (2001) served a new chronological data of late Early, middle Middle and middle Late Permian radiolarians to this district. However, these radiolarians were only came from cherts, and age of other rocks including clastic rocks has not been clarified yet.

I have studied the geology of the Nishizu district under a mapping project of the Geological Survey of Japan, and found some radiolarians of Permian, Triassic and Jurassic ages from various kinds of the rocks in the district. As I've already reported the occurrence of Permian radiolarians from cherts (Nakae, 2001), I intend to describe Triassic and Jurassic radiolarians from cherts, siliceous mudstones and mudstones in this paper.

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2. Geologic setting

The Tamba Terrane in Southwest Japan is generally considered to be formed along the eastern margin of Asia in Jurassic, and is composed mainly of late Paleozoic basalt-limestone-chert complexes and Triassic to middle or late Jurassic chert-clastics complexes together with pelitic mixed rock (*e.g.*, Nakae, 1993). The late Paleozoic complexes, most of which are Permian, commonly occur as sheet-like shaped slabs on large scale. The Triassic to Jurassic chert-clastics complexes are also exposed as large sheet-like slabs, in which the cherts and clastic rocks are arranged in sequence.

The Tamba Terrane is divided into several tectonostratigraphic units on the basis of the lithologic assemblage, age and internal geologic structure. Around the Nishizu district, for example, the Tada, Shimonegori, Kouchi and Mukugawa Complexes in the Kumagawa district (Nakae and Yoshioka, 1998) and the Kashimagari, Obanashi, Suganami, Tone and Arihara Complexes in the Tsuruga district (Kurimoto *et al.*, 1999) are distinguished each other. In the Nishizu district, equivalents of the Tada, Shimonegori and Kouchi Complexes are present, and their detailed discrimination and description will be given by the next report (Nakae, in press).

Keywords: Triassic, Jurassic, radiolaria, chert, siliceous mudstone, mudstone, Tamba Terrane, Nishizu district, Fukui

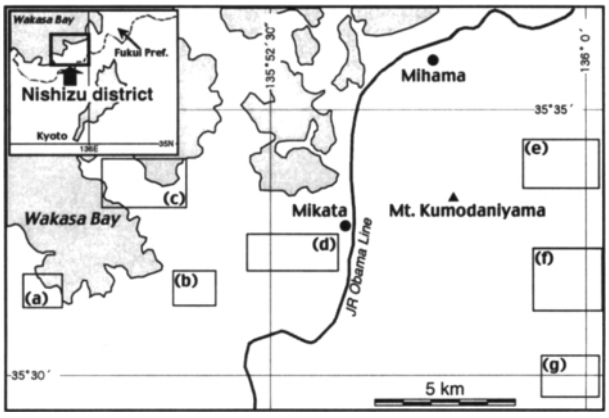

Fig. 1 Index map showing a part of the Nishizu district and its adjacent area, southwestern Fukui Prefecture.
Open squares with (a)-(g) indicate localities of the samples, details of which are given in Fig. 2.

The Tamba Terrane in the Nishizu district is exhibited by a chaotic mixture of the constituent rocks, and strikes at nearly E-W or NNE-SSW with gently to steeply dipping (see Fig. 1 of Nakae, 2001). The mixed feature is characterized by slabs of basalt, limestone, chert and clastic rock which are embedded in pelitic mixed rock. As mentioned by Nakae (2001), slabs can be classified into two types in scale and shape for convenience' sake; one is small-sized lenticular and the other is large-scale sheet-like. The former has the width of 100 to 500 m and the length of 300m to 5 km, and basalt, limestone, chert, mudstone and sandstone individually make a single slabs in general. On the contrary, the latter is ordinarily more than 500 m wide and 5 km long, and in particular basalt accompanied by chert forms a sheet-like slab of greater scale, for example, more than 1 km wide and 10 km long. Hence in this case, it was called 'basalt-chert composite' slabs (Nakae, 2001).

The pelitic mixed rocks generally consist of early to late Jurassic foliated mudstones including metric-sized blocks of late Paleozoic basalt and limestone, Permian to middle Jurassic chert and early to middle Jurassic clastic rock.

3. Sample localities and description of lithology

About 430 rock samples were collected from the Nishizu district and its adjacent area. In the laboratory, the samples were soaked in dilute HF solution (5%) for 10 to 15 hours, and sieved through 200# mesh. After the procedure, radiolarians were obtained from 15 samples, three samples of which yielded Triassic species and the remains included Jurassic ones. The rock samples treated herein will be described as follows and those localities are shown in Fig. 2.

Table 1 List of radiolarians from cherts.

Locality No.	1	2	3	4	5	
Sample No.	NZ31-04	NZ32-03	NZ38-05a	NZ85-02b	NZ85-06	NZ85-07
Lithology	chert					
Archaeosemantis sp.	■					
Entactinia (?) sp.					■	
Eucyrtidiellum sp. A		■				
Pantanellium cf. *kluense* PESSAGNO et BLOME		■				
Pantanellium (?) spp.				■	■	■
Parahsuum sp.		■				
Sarla (?) sp.	■					
Stichocapsa tegiminis YAO			■			
Stichocapsa spp.		■		■		■
Syringocapsa sp.						■
Tricolocapsa cf. *rüsti* TAN			■			
Tricolocapsa sp.			■			
Spumellaria gen.et sp. indet					■	

Table 2 List of radiolarians from siliceous mudstones and mudstones.
sil : siliceous mudstone, ms : mudstone.

Locality No.	6		7	8	9	10	11	12	13
Sample No.	NZ68-05	NZ68-06	NZ81-07a	NZ32-02	NZ49-02	NZ61-05	NZ65-03	NZ82-02	NZ84-15
Lithology	sil			ms					
Archaeodictyomitra sp. A				■					
Archaeodictyomitra sp. B								■	
Bagotum spp.									■
Betraccium perilense CARTER			■						
Betraccium deweveri PESSAGNO et BLOME			■						
Canoptum sp.									■
Eucyrtidiellum spp.	■	■			■				
Hsuum spp.	■	■					■	■	■
Pantanellium cf. *riedeli* PESSAGNO				■					
Parahsuum spp.							■	■	■
Paronaella sp.								■	
Parvicingula (?) sp.				■		■			
Pseudodictyomitra (?) spp.	■	■							
Tranhsuum sp.									■
Tricolocapsa plicarum YAO				■					
Tricolocapsa cf. *rüsti* TAN				■					
Tricolocapsa spp.	■							■	
Unuma spp.		■		■				■	
Yamotoum (?) sp.				■					
Multisegmented Nassellaria gen., indet.	■		■						

3.1 Chert

Six samples of chert were collected from five localities. The samples **NZ31-04** and **NZ32-03** were respectively gathered at Locs. 1 and 2 along forest roads east of Matsuya, Mikata Town (Fig. 2f, Loc. 1 is out of the Nishizu district). Cherts including Loc. 1 lies under siliceous mudstones, which yielded early Middle Jurassic radiolarians (locality 3 of Kido, 1986), and Loc. 2 is about 500 m north of the localities 1 and 2 of Kido (1986), where Late Permian radiolarians occurred from. These cherts are dark grey in color and well bedded. The sample **NZ38-05a** was obtained from Loc. 3 beside the Yokotanigawa River, northeast of Tashiro, Mikata Town (Fig. 2e). At this locality, grey

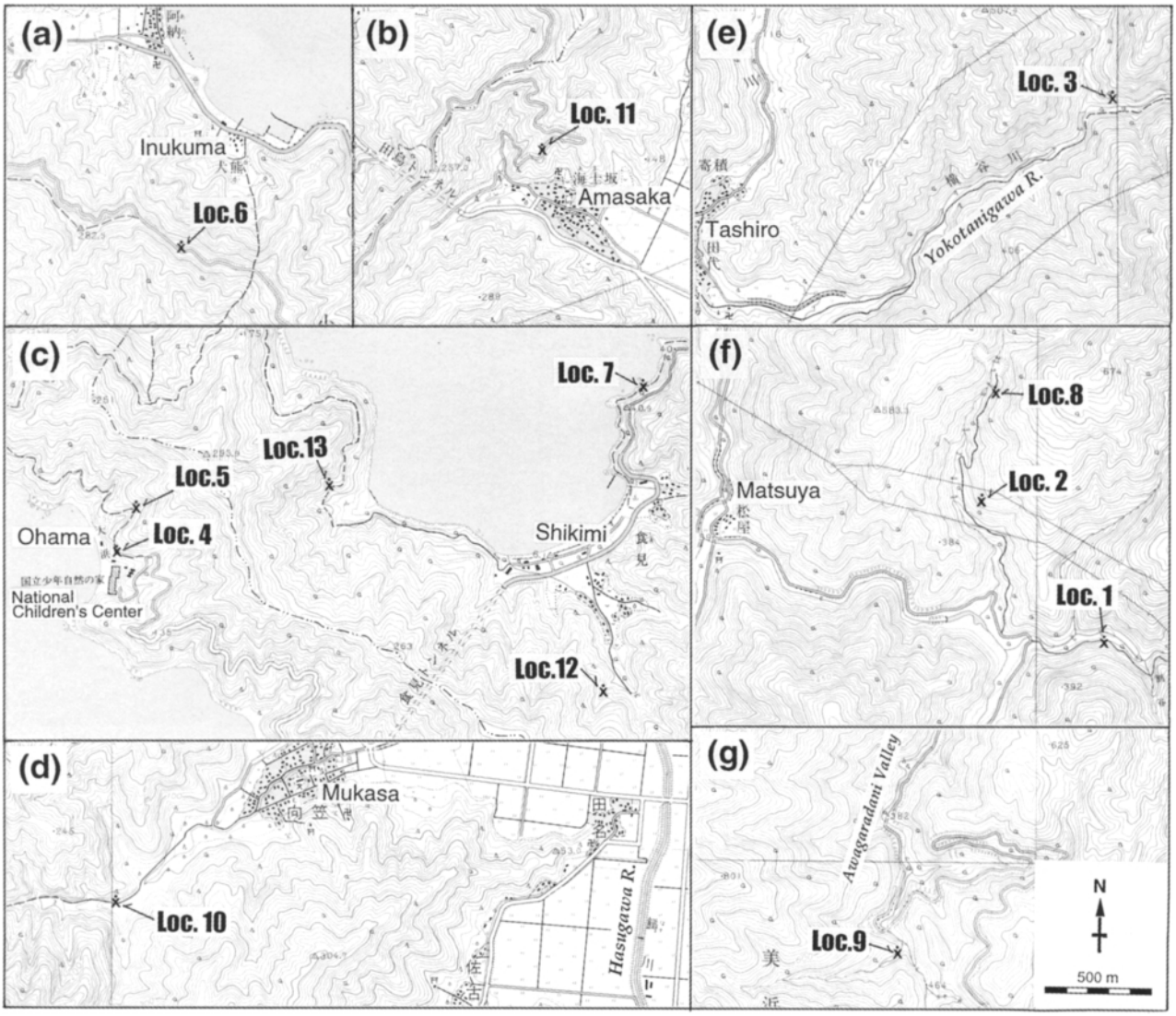

Fig. 2 Localities of Triassic and Jurassic radiolarians in the Nishizu district and its adjacent area. Parts of 1 : 25,000 topographic maps of "Nishizu", "Mikata", "Daguchi" and "Kumagawa" published from the Geographical Survey Institute of Japan, are used. (a) NZ68-05 and NZ68-06 (Loc. 6) south of Inukuma, (b) NZ65-03 (Loc. 11) at Amasaka, (c) NZ85-02b (Loc. 4), NZ85-06 and NZ85-07(Loc. 5) at Ohama, NZ81-07a (Loc. 7), NZ82-02 (Loc. 12) and NZ84-15 (Loc. 13) around Shikimi, (d) NZ61-05 (Loc. 10) southwest of Mukasa, (e) NZ38-05a (Loc. 3) northeast of Tashiro, (f) NZ31-04 (Loc. 1), NZ32-03 (Loc. 2) and NZ32-02 (Loc. 8), east of Matsuya, and (g) NZ49-02 (Loc. 9) along Awagaradani Valley.

bedded chert, dark grey siliceous mudstone and black scaly mudstone of pelitic mixed rock cropout in this order, and the sample was obtained from the point about 50 cm beneath the boundary between the chert and siliceous mudstone. Locs. 2 and 3 belong to the same 'basalt-chert composite' slabs, whereas Loc. 1 is included in an other one. North of Ohama, Obama City, the samples **NZ85-02b** (Loc. 4), **NZ85-06** and **NZ85-07** (Loc. 5) were obtained from a series of outcrops along the road connecting with National Children's Center. They are included in a small-sized lenticular slab, but laminated mudstone is intercalated between Locs. 4 and 5. Cherts at these localities are well-bedded, but the color is different; grey for Loc. 4 and reddish brown for Loc. 5.

3.2 Siliceous mudstone

Three samples of siliceous mudstone were collected from two localities. The samples **NZ68-05** and **NZ68-06** were came from an outcrop at Loc. 6 along a forest road south of Inukuma, Obama City (Fig. 2a). This siliceous mudstone is dark grey in color and weakly bedded, and lithologically changes to chert downward at the outcrop. The siliceous mudstone together with the underlying chert forms a small-sized lenticular slab. The sample **NZ81-07a** was obtained from Loc. 7 northeast of Shikimi, Mikata Town (Fig. 2c). This siliceous mudstone is black in

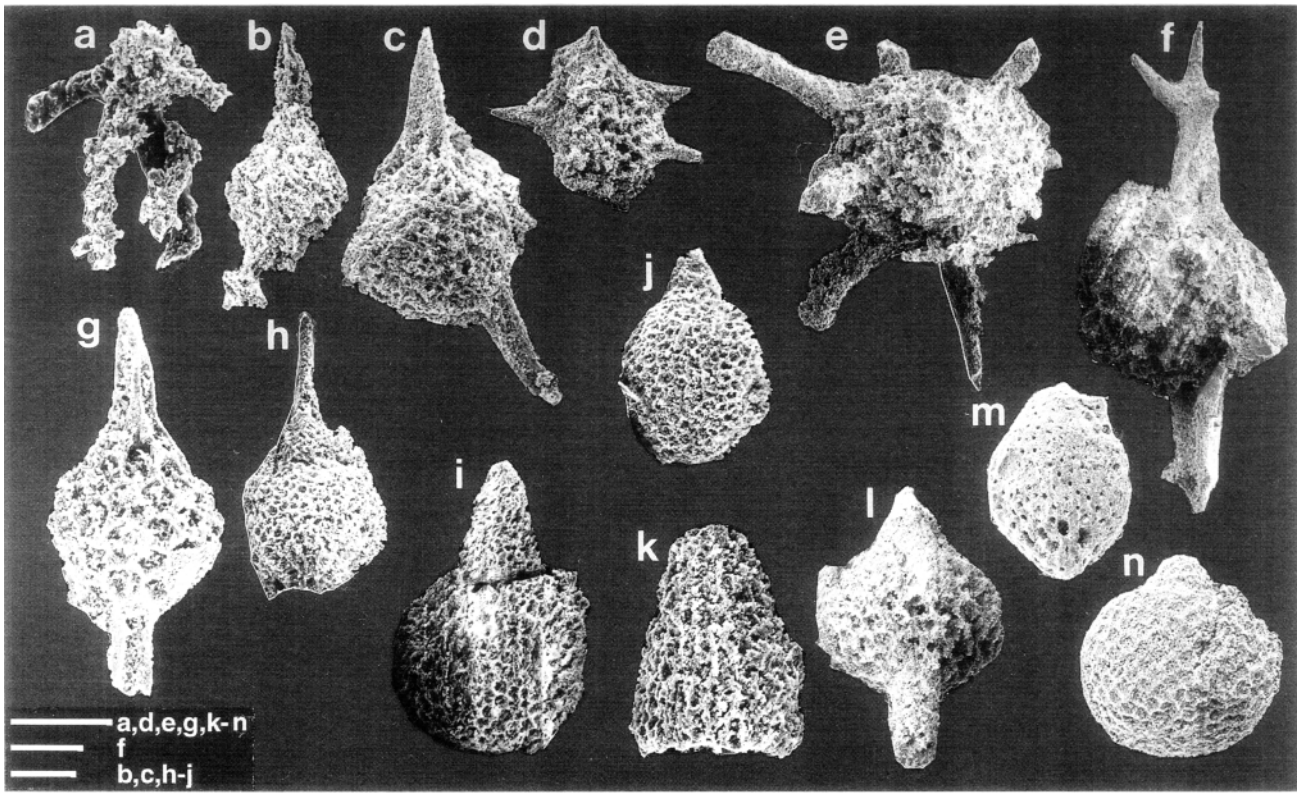

Fig. 3 SEM microphotographs of selected Triassic and Early Jurassic radiolarians from cherts.
a : *Archaeosemantis* sp. (NZ31-04), b-c : *Sarla* (?) sp. (NZ31-04), d-e : *Entactinia* (?) sp. (NZ85-06), f : Spumellaria gen. et sp. indet. (NZ85-06), g : *Pantanellium* sp. cf. *P. kluense* Pessagno et Blome (NZ32-03), h : *Eucyrtidiellum* sp. A (NZ32-03), i-j : *Stichocapsa* sp. (NZ32-03), k : *Parahsuum* sp. (NZ32-03), l : *Syringocapsa* sp. (NZ85-07), m : *Stichocapsa tegiminis* Yao (NZ38-05a), n : *Tricolocapsa* sp. cf. *T. ristti* Tan (NZ38-05a). All scale bars are equal to 0.5μm.

color and forms a small block of tens of centimeter, which is enveloped by mudstone matrix of the pelitic mixed rock, together with metric-sized clasts of sandstone, chert and basalt.

3.3 Mudstone

Six mudstone samples were collected from six localities. The sample **NZ32-02** was came from mudstone matrix of the pelitic mixed rock at Loc. 8, east of Matsuya, Mihama Town (Fig. 2f). The sample **NZ49-02** was gotten from Loc. 9 along Awagaradani valley, Mikata Town (Fig. 2g, out of the Nishizu district). The mudstone at this locality is dark grey in color and includes silty laminae, and is stratigraphically situated between chert and sandstone. The samples **NZ61-05** was obtained from Loc. 10, southwest of Mukasa, Mikata Town (Fig. 2d). This slaty mudstone is dark grey in color, and is stratigraphically located upon siliceous mudstone. The sample **NZ65-03** was obtained from Loc. 11, at Amasaka, Mikata Town (Fig. 2b). Around this locality, slaty mudstone, sandstone and alternating beds of sandstone and mudstone cropout, and the slaty mudstone, dark grey and intercalated with silty laminae, was sampled. The samples **NZ82-02** (Loc. 12) and **NZ84-15** (Loc. 13) respectively occur south and northwest of Shikimi, Mikata Town (Fig. 2c). NZ82-02 was came from silty mudstone of thin-bedded alternating beds of sandstone and mudstone, whereas NZ84-15 is a black mudstone gotten from matrix of the pelitic mixed rock, which contains chert blocks of metric-sized.

Although most mudstones form small-sized lenticular or large-scale sheet-like slabs, only the mudstones of NZ32-02 (Locs. 8) and NZ84-15 (Loc. 13) are of the pelitic mixed rock.

4. Radiolarians

All radiolarians detected from the Nishizu district and its adjacent area are listed in Tables 1 and 2, and SEM-microphotos of selected species are indicated in Figs. 3, 4 and 5.

Although most radiolarians in the samples cannot be identified in species level due to their poor preservation, some species indicative of late Triassic to middle Jurassic ages are recognized. They are characterized by an abundance of multisegmented Nassellaria and minor amounts of Spumellaria. Followings are representative and diagnostic radiolarians; *Archaeodictyomitra* sp. A, *Archaeodictyomitra* sp. B,

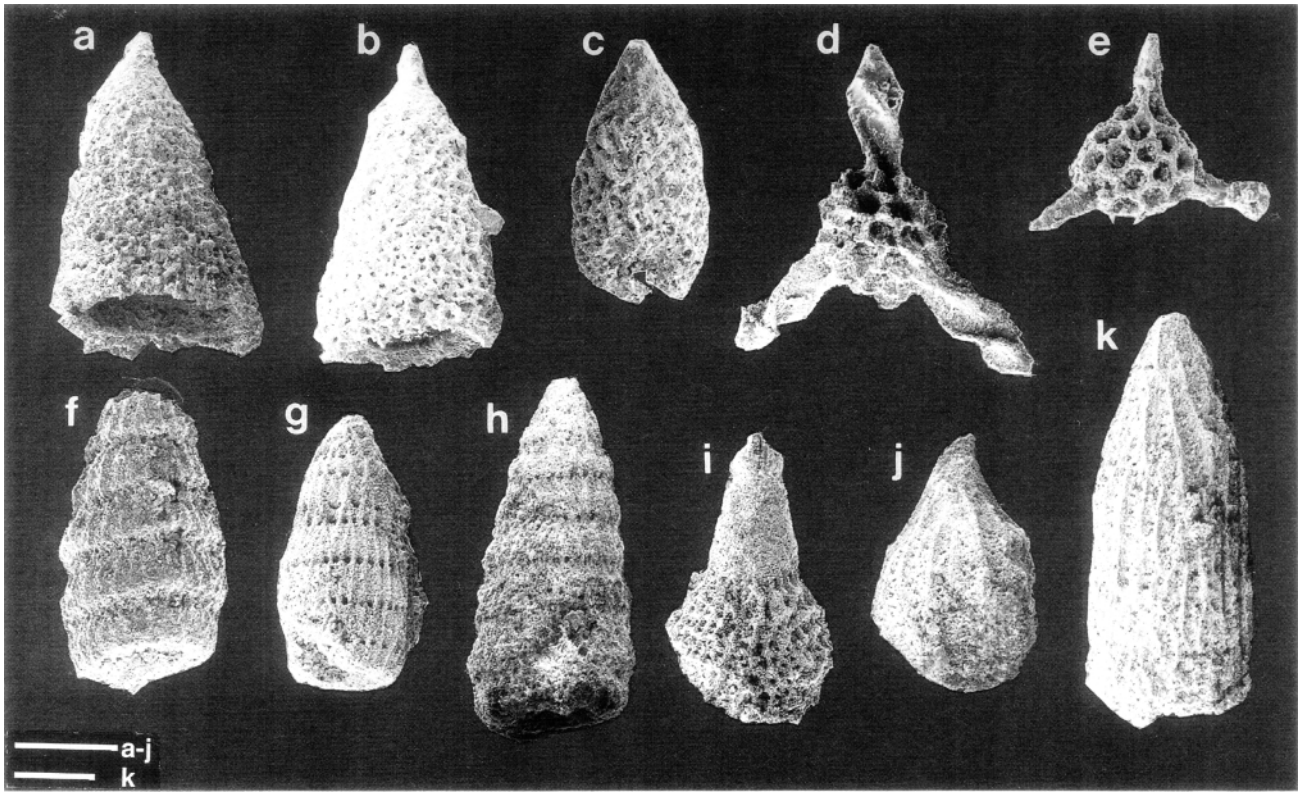

Fig. 4 SEM microphotographs of selected Triassic and Jurassic radiolarians from siliceous mudstones.
a-c : Nassellaria gen. et sp. indet. (NZ81-07a), d : *Betraccium deweveri* Pessagno et Blome (NZ81-07a), e : *Betraccium perilense* Carter (NZ81-07a), f : *Pseudodictyomitra* (?) sp. (NZ68-05), g-h : *Pseudodictyomitra* (?) sp. (NZ68-06), i : Nassellaria gen. et sp. indet. (NZ68-05), j : *Unuma* sp. (NZ68-06), k : *Hsuum* sp. (NZ68-05). All scale bars are equal to 0.5μm.

Betraccium deweveri Pessagno et Blome, *Betraccium perilense* Carter, *Eucyrtidiellum* sp. A, *Pantanellium* sp. cf. *P. kluense* Pessagno et Blome, *Pantanellium* sp. cf. *P. riedeli* Pessagno, *Stichocapsa tegiminis* Yao, *Tricolocapsa plicarum* Yao, *Tricolocapsa* sp. cf. *T. riisti* Tan.

4.1 Spumellaria

Two forms of *Betraccium* were recognized in this work. *Betraccium deweveri* (Fig. 4d) was first described by Pessagno and Blome (1980) from upper Norian formation in Queen Charlotte Islands, British Columbia. Characteristic features of *B. deweveri* are that primary spines display extreme torsion of ridges and grooves. *Betraccium perilense* (Fig. 4e) was also reported from Queen Charlotte Islands, British Columbia by Carter (1993), and it quite differs from *B. deweveri* by lacking torsion of ridges and grooves of primary spines. Ranges of *B. deweveri* and *B. perilense* are upper Norian (Pessagno and Blome, 1980) and upper Norian and Rhaetian (Carter, 1993), respectively.

Poorly preserved and damaged as two forms of *Pantanellium* are, they can be identified; one is *P.* cf. *kluense* (Fig. 3g), the other is *P.* cf. *riedeli* (Fig. 5s). According to Pessagno and Blome (1980), *P. kluense* was first reported from the upper Triassic to lower Jurassic Kunga Formation, Queen Charlotte Islands, British Columbia, and is characterized by having an ellipsoidal shell and poorly developed nodes at their vertices. Although a part of spines and pore frames of the obtained specimen are lack and fairly broken, their morphological features including shape of the shell and spines are similar to *P. kluense*. The other form is similar to *P. riedeli*, but slightly differs from the latter by having an ellipsoidal shell and shorter polar spines. On the range of *P. riedeli*, obviously different ranges were proposed by two papers. Pessagno (1977a) described *P. riedeli* from upper Kimmeridgian to Berriasian formation in California, although age of the first appearance is uncertain. Yao (1997) reported its occurrence from siliceous mudstone of middle to late Bajocian age at Inuyama, Japan.

Radiolarians shown in Fig. 3a and Fig. 3b-c are too poorly preserved to make an identification, but it seems to be like species of *Archaeosemantis* and *Sarla*, respectively. Range of *Sarla* is Triassic, probably from lower Carnian to upper Norian (Pessagno *et al.*, 1979; Blome, 1984).

4.2 Nassellaria

Two types of *Archaeodictyomitra* were mor-

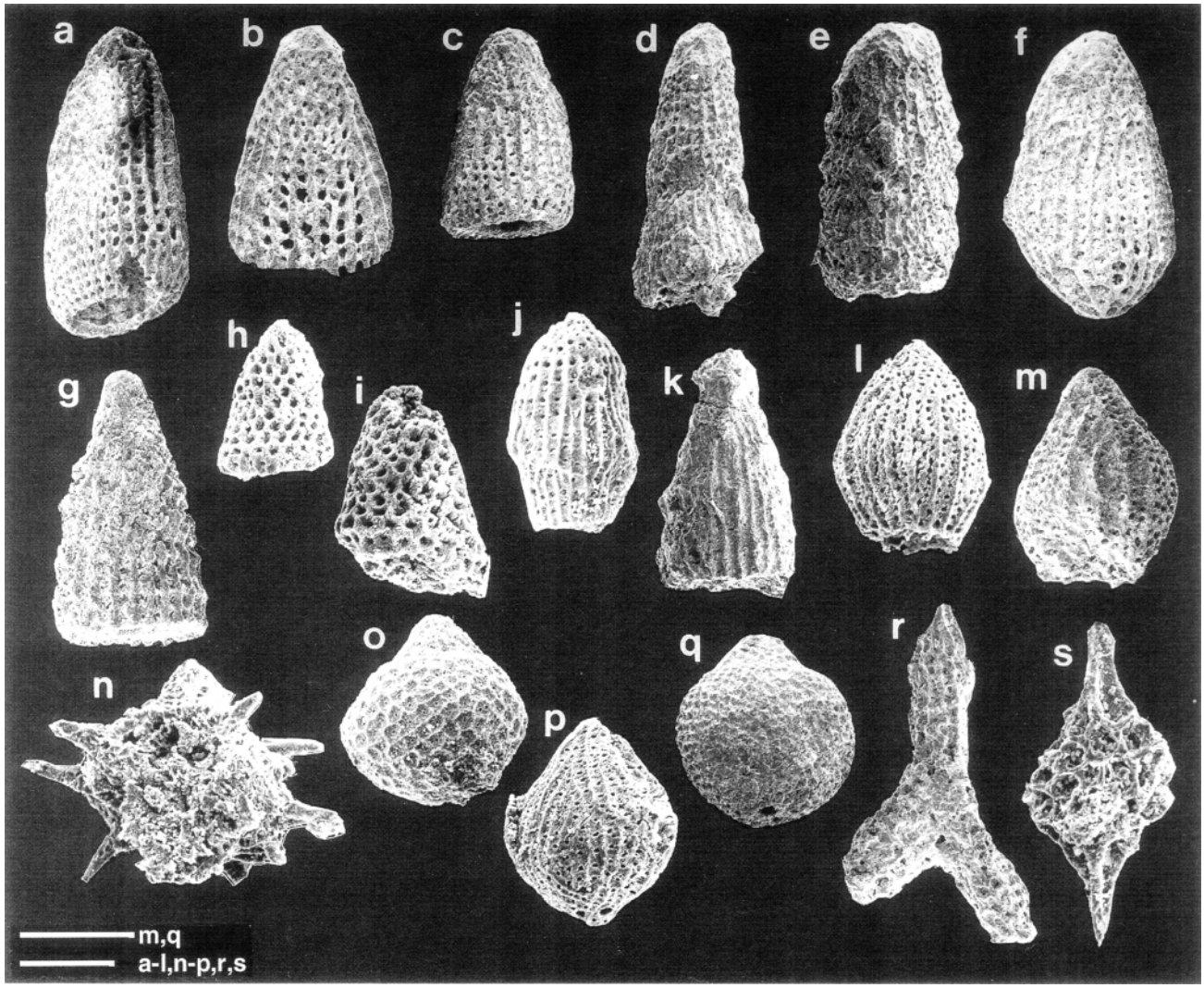

Fig. 5 SEM microphotographs of selected Jurassic radiolarians from mudstones.
a-c : *Parahsuum* sp. (NZ84-15), d-e : *Parahsuum* sp. (NZ82-02), f : *Bagotum* sp. (NZ84-15), g : *Transhsuum* sp. (NZ84-15), h-i : *Parvicingula* (?) sp. (NZ32-02), j : *Archaeodictyomitra* sp. A (NZ32-02), k : *Archaeodictyomitra* sp. B (NZ82-02), l : *Unuma* sp. (NZ32-02), m : *Unuma* sp. (NZ82-02), n : *Yamatoum* (?) sp. (NZ32-02), o : *Tricolocapsa* sp. cf. *T. rüsti* Tan (NZ32-02), p : *Tricolocapsa plicarum* Yao (NZ32-02), q : *Tricolocapsa* sp. (NZ82-02), r : *Paronaella* sp. (NZ82-02), s : *Pantanellium* sp. cf. *P. riedeli* Pessagno (NZ32-02). All scale bars are equal to 0.5μm.

phologically distinguished in this work; one is *A.* sp. A (Fig. 5j) and the other is *A.* sp. B (Fig. 5k). *A.* sp. A is closely related to *A. apiarium*, which was redefined by Pessagno (1977b), but differs from *A. apiarium* by the number of longitudinal costae being fewer. *A.* sp. A is also similar to *A. minoensis* described by Mizutani (1981) in whole shape of the shell, however it is unlike to *A. minoensis* by lacking well-developed circumferential ridges.

Eucyrtidiellum sp. A (Fig. 3h) resembles some species of *Eucyrtidiellum* in having pores on surface, but differs from *E. gujoensis* described by Takemura and Nakaseko (1986) by having a smaller and slenderer thorax, and from *E.* sp. f of Nagai (1988) by having narrow pore frames.

The obtained *Stichocapsa tegiminis* (Fig. 3m) is slightly smaller than the holotype defined by Yao (1979), but is almost same in external whole shape and morphological features such as indistinct strictures at thorax-abdomen and abdomen-forth segment joints. According to Matsuoka and Yao (1986) and Matsuoka (1995), *S. tegiminis* was yielded from middle part of the *Laxtorum* (?) *jurassicum* Zone to the *Tricolocapsa plicarum* Zone, corresponding to upper Aalenian and lower Bathonian.

Tricolocapsa sp. cf. *T. rüsti* (Fig. 3n and 5o) and *T. plicarum* (Fig. 5p) are ones of the most characteristic and diagnostic species of the middle Jurassic, especially *T. plicarum* defined by Yao (1979) ranges from Bajocian to middle Callovian (Matsuoka, 1995).

5. Discussion

5.1 Age of cherts

Two Triassic species, *Archaeosemantis* sp. and *Sarla* (?) sp. were detected from NZ31-04. The range of both genera is Upper Triassic, and the latter is probably from lower Carnian to upper Norian (Pessagno, 1979; Blome, 1984).

NZ32-03 yielded Triassic to Jurassic radiolarians including *Pantanellium* cf. *kluense*, *Eucyrtidiellum* sp. A, *Parahsuum* sp. and *Stichocapsa* sp.; the range of *P.* cf. *kluense* is probably from Rhaetian to Hettangian (Pessagno and Blome, 1980), and the latter three are Jurassic species. However, one of them, *Parahsuum* sp. existed in early Jurassic in age and *P. kluense* disappeared within Hettangian, thus the age of this sample is early Early Jurassic.

Tricolocapsa cf. *rüsti* and *Stichocapsa tegiminis* obtained from NZ38-05a are representative species of the *Hsuum hisuikyoense* Assemblage (Yao, 1984), and Matsuoka and Yao (1986) assigned the age of this assemblage to Aalenian (early Middle Jurassic).

NZ85-02b, NZ85-06 and NZ85-07 yielded some radiolarians, *Pantanellium* (?) sp., *Stichocapsa* sp., *Syringocapsa* sp. and/or *Entactinia* (?) sp. These radiolarians are considered to be Triassic or Jurassic species. Some of their generic name are doubtful and not confirmed yet, but *Stichocapsa* is one of Jurassic genera. Thus, NZ85-02b and NZ85-07 are probably Jurassic samples. On the other hand, NZ85-06 having *Entactinia* (?) sp. is possible to be Triassic one.

5.2 Age of siliceous mudstones

NZ68-05 and NZ68-06 yielded Jurassic radiolarians including *Eucyrtidiellum* sp., *Hsuum* sp., *Tricolocapsa* sp., *Unuma* sp. and others, but these species cannot assign ages to the samples any more.

Triassic Spumellarians, *Betraccium deweveri* and *B. perilense* were detected from NZ81-07a. The range of these two species is upper Norian (Pessagno and Blome, 1980 ; Sugiyama, 1997), and upper Norian to Rhaetian (Carter, 1993), respectively, thus NZ81-07a is middle Late Triassic sample.

5.3 Age of mudstones

NZ32-02 yielded many radiolarians; *Archaeodictyomitra* sp. A, *Pantanellium* cf. *riedeli*, *Parvicingula* (?) sp., *Tricolocapsa plicarum*, *T.* cf. *rüsti*, *Unuma* sp. and others. Among them, *T.* cf. *rüsti* mostly occurs in the *Hsuum hisuikyoense* Assemblage (Yao, 1984) and *T. plicarum* is a diagnostic species of the *Unuma echinatus* Assemblage (Yao, 1984). The *H. hisuikyoense* Assemblage and the overlying *U. echinatus* Assemblage Zones are considered to be within Aalenian (Matsuoka, 1995), and to range from Bajocian to upper Bathonian (Yao, 1986) or to lower Bathonian (Matsuoka, 1995), respectively. On the other hand, obviously different ranges were proposed for the age of *P. riedeli*, as mentioned before; from Kimmeridgian to Berriasian (Pessagno, 1977a), and from middle to upper Bajocian (Yao, 1997). The obtained specimen similar to *P. riedeli* is probably assigned to Bajocian, because of the coexistence with *T. plicarum* and *T.* cf. *rüsti*. In the result, the age of NZ32-02 is ascribed to early Middle Jurassic.

Eucyrtidiellum sp. from NZ49-02 and *Parvicingula* (?) sp. from NZ61-05 commonly appeared in early Jurassic, and are abundantly recognized in middle and late Jurassic samples. However, the detailed ages of these two samples cannot be decided.

NZ65-03 and NZ82-02 yielded early Jurassic *Parahsuum* sp., accompanied by *Hsuum* sp. and/or *Paronaella* sp., but these samples are also impossible to show their detailed age.

NZ84-15 is characterized by early to middle Jurassic species. Genera *Bagotum* and *Parahsuum* are representatives of early Jurassic and genus *Transhsuum* is well known in middle and late Jurassic. On the basis of the above, it is quite difficult to decide which is better as the age of this sample, early Jurassic or middle Jurassic.

6. Conclusion

Triassic and Jurassic radiolarians from the Tamba Terrane in the Nishizu district and its adjacent area, southwestern Fukui Prefecture, were discriminated and examined. The results are as follows; (1) fifteen samples including six cherts, three siliceous mudstones and six mudstones yielded Triassic and Jurassic radiolarian assemblages, (2) three of the chert samples are respectively assign to Late Triassic, early Early Jurassic and early Middle Jurassic in age, whereas the remains are probably Triassic and Jurassic, (3) siliceous mudstones yielded Triassic and Jurassic radiolarians, the former species of which are middle Late Triassic, (4) Early to Middle Jurassic is adopted for the age of the mudstones, and especially one of them indicates early Middle Jurassic in age.

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福井県西津地域の丹波テレーンから産出した三畳紀・ジュラ紀放散虫

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要 旨

福井県南西部の西津地域及びその周辺に分布する丹波テレーンのチャート，珪質泥岩，泥岩から三畳紀及びジュラ紀の放散虫化石を産出した．この地域の丹波テレーンは主に玄武岩・石灰岩・チャート・泥岩・砂岩から構成され，これらが複雑に混在した特徴をもっている．本地域周辺における従来の化石層序学的研究によってペルム紀・三畳紀・ジュラ紀の放散虫化石の産出が報告されていたが，その詳細な地質年代は明らかにされていない．本研究で新たに得られた放散虫化石によって，チャートは後期三畳紀・前期ジュラ紀の前半・中期ジュラ紀の前半，珪質泥岩は後期三畳紀の中頃及びジュラ紀，泥岩は中期ジュラ紀の中頃ないし前期-中期ジュラ紀の年代を示すことが判明した．

難読・重要地名：Tamba：丹波，Nishizu：西津，Inukuma：犬熊，Amasaka：海士坂，Ohama：大浜，Shikimi：食見，Mukasa：向笠，Hasugawa R.：鰐川，Tashiro：田代，Yokotanigawa R.：横谷川，Matsuya：松屋，Awagaradani：粟柄谷