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Mesozoic radiolarians from the western part of the Atsumi Peninsula, Southwest Japan

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ABSTRACT

The western part of the Atsumi Peninsula is underlain mainly by the Upper Paleozoic-Mesozoic sedimentary complex composed of chert, siliceous shale, shale and sandstone. Middle Triassic radiolarians such as *Triassocampe coronata* Bragin were obtained from bedded chert. Early Jurassic radiolarians of the *Parahsuum simplum* and *Trillus elkhornensis* zones were obtained from bedded chert, bedded siliceous shale and shale. Middle Jurassic radiolarians of the *Laxtorum* (?) *jurassicum* and *Tricolocapsa plicarum* zones were obtained from bedded siliceous shale and shale. On the basis of lithology and radiolarian fossils, the sedimentary complex of the western part of the Atsumi Peninsula is divided into three units: Lower to Middle Jurassic melange unit that consists of chert and shale, Middle Jurassic sandstone and shale unit that consists of sandstone and shale, and Middle to Upper? Jurassic sandstone and chert unit that consists of sandstone and chert.

INTRODUCTION

The western part of the Atsumi Peninsula, central Japan, is situated in the Sanbagawa-Mikabu and Chichibu terranes. Ishii (1927) was the first to describe the geology of this area. He reported sandstone, shale, radiolarian chert, limestone and greenstone from the Chichibu terrane; he also noted the occurrence of peridotite, gabbro, serpentinite, and the rocks of the Mikabu Formation that consists of phyllite, psammitic schist and amphibolite from the Sanbagawa terrane. As to fossils, a few papers have briefly reported the occurrence of radiolarian fossils from chert and shale in this area (Nagai and Ishikawa, 1995; Ohba and Adachi, 1995). However, most of fundamental geologic information still remains undescribed. In Kamishima Island, the western extension of the Atsumi Peninsula, Ohba (1997) revealed that the Triassic-Middle Jurassic sedimentary complex, correlatable to the Togano Group (Matsuoka, 1984a), contacts directly with the metamorphic complex of the Sanbagawa-Mikabu terrane; the Northern Chichibu and Kurosegawa(1)

(1) In this paper, the definition of the Kurosegawa terrane is after Yoshikura et al. (1990): it consists of the constituents of the Kurosegawa Tectonic Zone (Ichikawa et al., 1956), the late Paleozoic chaotic complex and the well-bedded clastic sequences of late Paleozoic, Triassic and Jurassic ages.

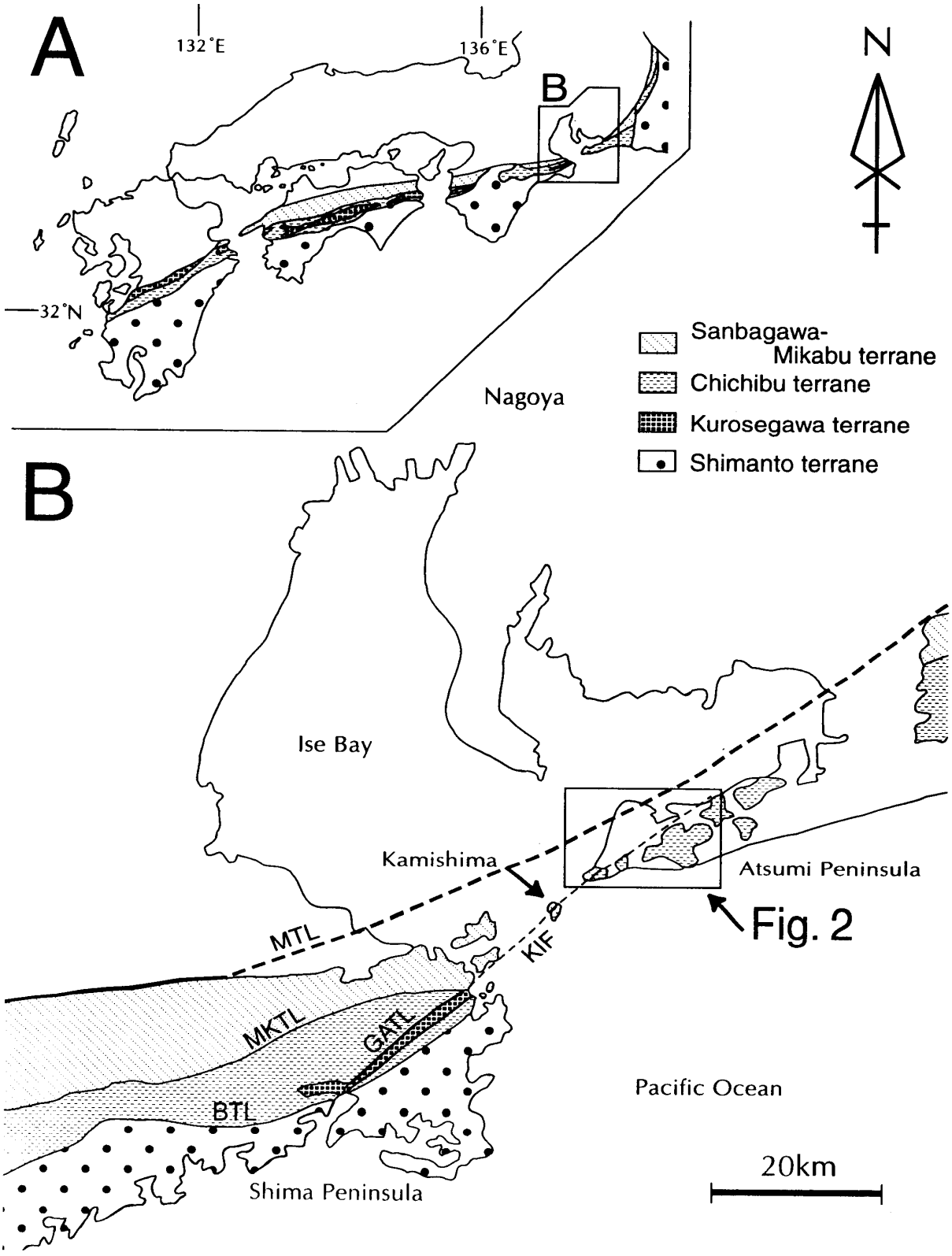


Fig. 1. Index map of the Chichibu terrane in the Atsumi Peninsula area. MTL: Median Tectonic Line, MKTL: Mikabu Tectonic Line, GATL: Gokasho-Arashima Tectonic Line, KIF: Kamishima-Irago Fault (new name), BTL: Butsuzo Tectonic Line.

terranes are missing in Kamishima Island. To understand above problem, the geology and tectonic framework of the Atsumi Peninsula, I made the detailed field investigation on this area including the adjacent Shima Peninsula and Kamishima Island, and dated some chert, siliceous shale and shale, using radiolarians. In this paper, I report their modes of occurrence and assemblage features. The stratigraphic correlation with the Shima Peninsula and other areas in the Chichibu terrane as well as the tectonic framework of this area will also be discussed briefly.

GEOLOGIC OUTLINE OF THE WESTERN ATSUMI PENINSULA

The Upper Paleozoic-Mesozoic complex of the western Atsumi Peninsula area belongs to the Sanbagawa-Mikabu and Chichibu terranes (Fig. 1). The Sanbagawa-Mikabu terrane in this area is bordered on the south by the Kamishima-Irago Fault (new name, Fig. 2).

The metamorphic complex of the Sanbagawa-Mikabu terrane trends northeast-southwest and dips steeply to the north or south. It mainly comprises phyllite and schist originated from sandstone, shale, chert and greenstone. Greenstones of the Sanbagawa-Mikabu terrane, characterized by tholeiite affinity, are likely to have originated from MORB, island arc tholeiite (IAT) and ocean island tholeiite (OIT) (Ohba and Morishita, 1997).

The sedimentary complex of the Chichibu terrane trends east-west and dips to the north or south. The distribution and general trend of the Chichibu terrane are cut by the Kamishima-Irago Fault, but the trend is parallel to the Kamishima-Irago Fault near the fault (Fig. 2). Nagai and Ishikawa (1995) reported *Parahsuum simplum* Yao from shale. Ohba and Adachi (1995) reported *Tricolocapsa plicarum* Yao from bedded chert in the southern part. However, detailed geologic and stratigraphic correlation with the Chichibu terrane of other districts has not been made.

GEOLOGY OF THE CHICHIBU TERRANE IN THE WESTERN PART OF THE ATSUMI PENINSULA

The Chichibu terrane can be divided into three units, that is, Unit-A, Unit-B and Unit-C, on the basis of lithology and radiolarian fossils (Fig. 2). The Unit-A is melange that consists of chert and shale. The Unit-B is relatively coherent unit that consists of sandstone and shale. The Unit-C occurs in the southwestern part of the Atsumi Peninsula and consists of chert, sandstone and pebbly shale.

Chert of the Unit-A is massive white, bedded white, bedded gray to pale green or bedded reddish brown. Chert includes a small amount of siliceous shale, shale and pebbly shale. In the outcrop, blocks of many types of chert are bordered by faults. Some faults have fault gouge. Therefore, chert of the Unit-A can be regarded as melange block that is accompanied by a small amount of siliceous shale, shale and pebbly shale. Shale is laminated, gray to

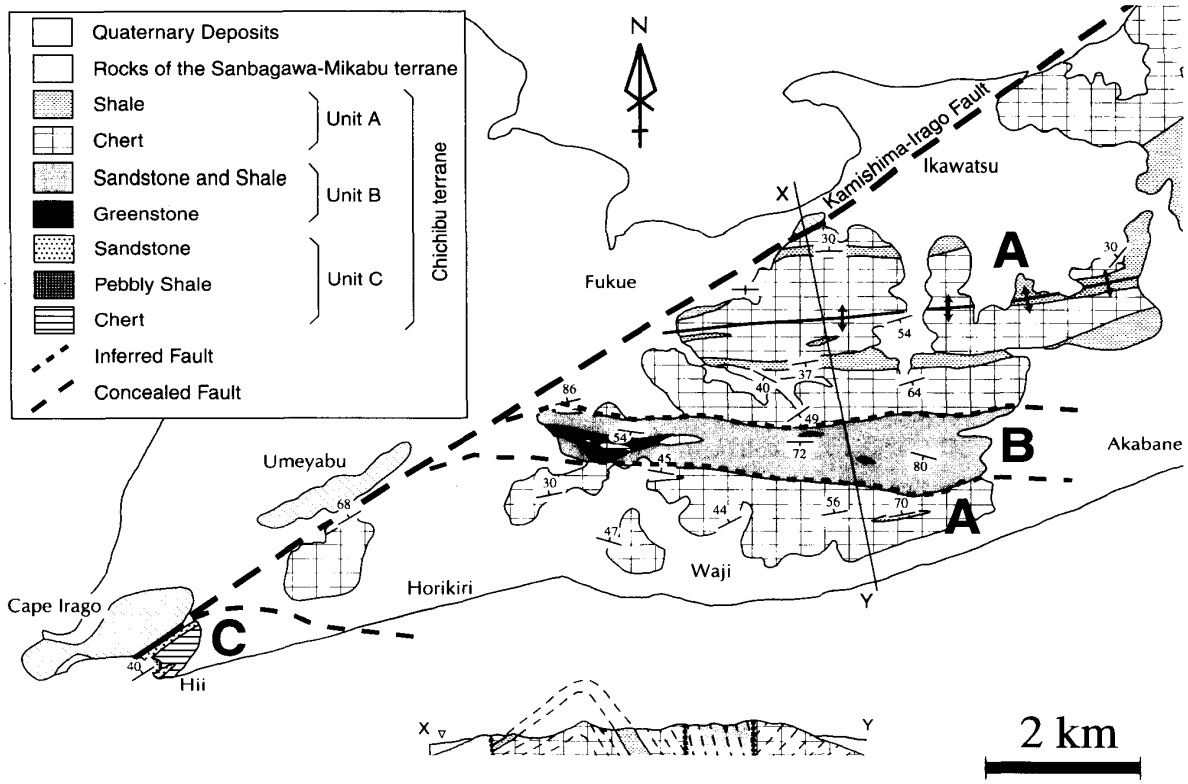


Fig. 2. Geologic map of the western part of the Atsumi Peninsula area.

black but yellowish brown in weathered part. Siliceous shale is stratified, gray to pale green, in part silty and is associated with chert. Pebbly shale includes lenticular sandstone blocks. Cherts of the Unit-A yield Early to Middle Permian (Nagai and Ishikawa, 1995), Middle Triassic, Early Jurassic radiolarians.

Shale of the Unit-A is black massive or laminated and includes a small amount of chert, siliceous shale and sandstone. Shale showing generally east-west direction is black in fresh surface but yellowish brown in weathered part. It occurs widely in the eastern part. Siliceous shale is pale green to gray and well-stratified and associated with bedded chert or shale. Judging from the strike and dip of chert and shale as well as radiolarian fossil from shale, an east-west trending anticline is developed in the northern part of the Chichibu terrane (Fig. 2). Chert appears to grade into shale or to be bordered by fault. Siliceous shales and shales of the Unit-A yield Early to early Middle Jurassic radiolarians.

Sandstone and shale of the Unit-B consist of alternating sandstone and shale. Sandstone is gray, occurs in shale as lenticular blocks, and has sedimentary structures such as graded bedding and parallel lamination in part. Shale of sandstone-shale alternation is black and yields middle Middle Jurassic radiolarians. Greenstone, massive, vesicular, green, gray or black, occurs in sandstone and shale of the Unit-B (Fig. 2). It is fault-bounded with

sandstone and shale. Massive gray greenstone blocks occur in sheared green to greenish black greenstone matrix. They partly include limestone blocks whose size is up to 50 cm. The origin of greenstone has not been clarified yet.

The Unit-C consists of chert and sandstone. In the northern part, pebbly shale including conglomerate, sandstone, bedded siliceous shale and chert blocks is exposed. Judging from the mode of occurrence, sandstone is regarded as sandstone dike in chert and siliceous shale. The Unit-C is correlatable with the Togano Group in central Shikoku because chert yields middle Middle Jurassic radiolarians (Ohba and Adachi, 1995) and sandstone dikes from massive sandstone cut chert layers.

RADIOLARIAN FOSSILS

1: Unit-A

Well-preserved radiolarians were obtained from the sedimentary complex in the study area (Fig. 3, Table 1). Triassic radiolarians, *Triassocampe* sp., *Triassocampe coronata* Bragin, *Pseudostylosphaera japonica* (Nakaseko and Nishimura) and *Eptingium* sp. cf. *E. manfredi* Dumitrica were found from bedded chert (JMP-2557). These fossils indicate the Middle Triassic *Triassocampe coronata* Assemblage-zone of Matsuoka et al. (1994). Triassic radiolaria, *Eptingium* sp. cf. *E. manfredi* Dumitrica occurs from bedded chert

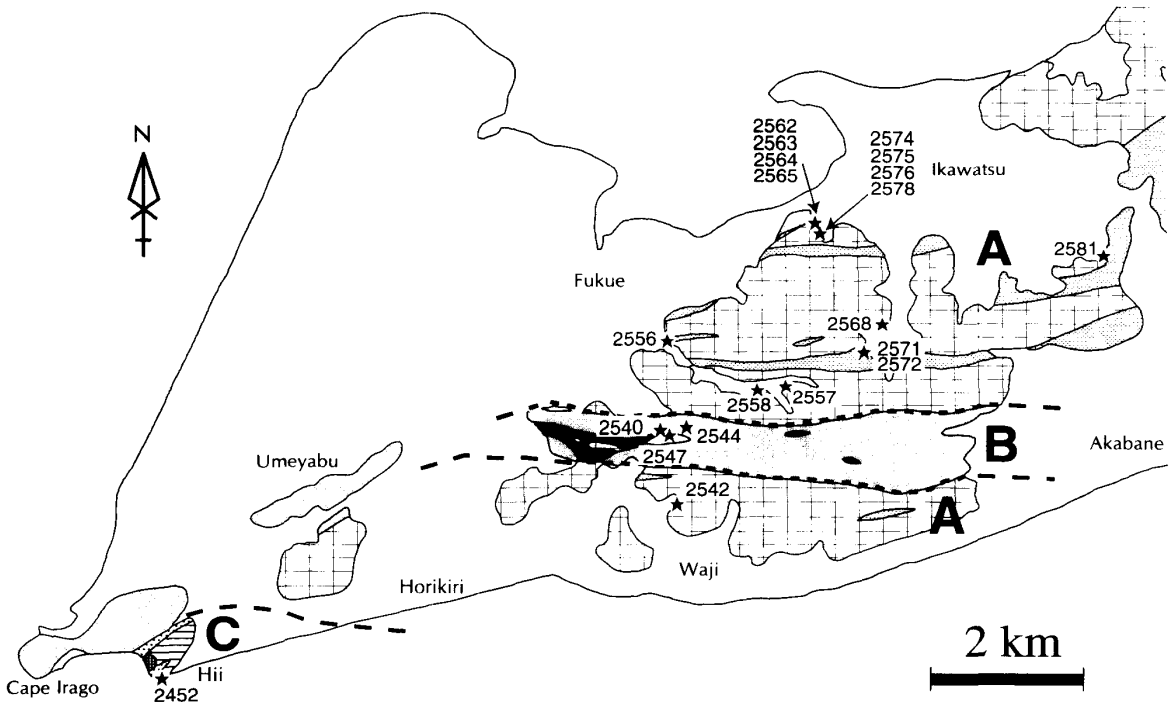


Fig. 3. Map showing radiolarian fossil localities.

(JMP-2562). Pale-green to gray bedded cherts (JMP-2542, 2568, 2578, 2581) yield Early Jurassic radiolarians of *Parahsuum* sp., *Parahsuum simplum* Yao, *Parahsuum* sp. cf. *P. ovale* Hori and Yao and *Eucyritidiellum disparile* Nagai and Mizutani indicating the *Parahsuum simplum* zone to the *Trillus elkhornensis* zone of Matsuoka (1995). Bedded siliceous shales (JMP-2572, 2576) yield Early Jurassic radiolarians of *Eucyrtidiellum* sp., *Trillus* sp. cf. *T. elkhornensis* Pessagno and Blome, *Pseudocrucella* (?) sp., *Parahsuum* (?) sp. aff. *P.* (?) *magnum* Takemura and so on; these indicate the *Parahsuum simplum* zone to the *Trillus elkhornensis* zone of Matsuoka (1995). Bedded siliceous shale (JMP-2547) yields Middle Jurassic radiolarians of *Eucyritidiellum disparile* Nagai and Mizutani, *Transhsuum hisuikyoense* (Isozaki and Matsuda) and *Hsuum matsuokai* (Isozaki and Matsuda) and so on, indicating the *Laxtorum* (?) *jurassicum* zone of Matsuoka (1995). Shales (JMP-2556, 2558, 2563, 2564, 2565, 2571, 2574, 2575) yield Jurassic radiolarians. Well-preserved Jurassic radiolarians, *Parahsuum* sp., *Parahsuum* sp. aff. *P. longiconicum* Sashida, *Parvicingula nanoconica* Hori and Otsuka, *Laxtorum* (?) sp., *Hsuum* (?) sp. 1 of Baumgartner et al. (1995), *Hsuum matsuokai* (Isozaki and Matsuda), *Transhsuum hisuikyoense* (Isozaki and Matsuda), indicate the *Parahsuum simplum*, *Trillus elkhornensis* and *Laxtorum* (?) *jurassicum* zones of Matsuoka (1995).

Since radiolarian-bearing cherts generally occur as lenticular bodies, the Unit-A can be regarded as the Lower to lower Middle Jurassic melange unit.

2: Unit-B

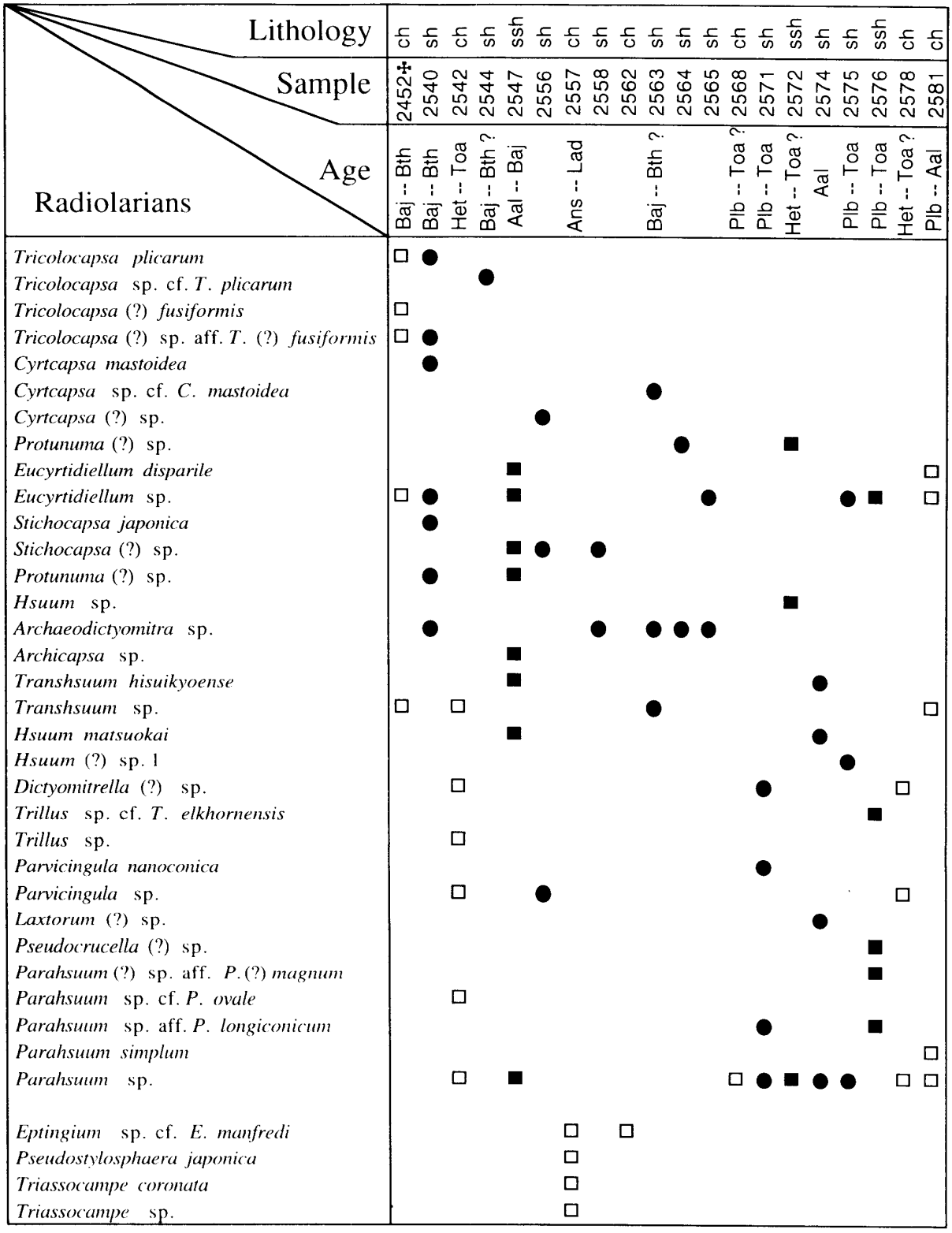
Massive black shale (JMP-2540) yields Middle Jurassic radiolarians such as *Tricolocapsa plicarum* Yao, *Tricolocapsa* (?) sp. aff. *T.* (?) *fusiformis* Yao and *Cyrtocapsa mastoidea* Yao, indicating the Middle Jurassic *Tricolocapsa plicarum* zone of Matsuoka (1995). Poorly-preserved radiolaria, *Tricolocapsa* sp. cf. *T. plicarum* Yao, has been found from shale part of turbidite (JMP-2544). The Unit-B is regarded as the middle Middle Jurassic sandstone and shale unit.

3: Unit-C

No radiolarian fossils were obtained from rocks of the Unit-C. Ohba and Adachi (1995) have reported middle Middle Jurassic radiolarians such as *Tricolocapsa* (?) sp. aff. *T.* (?) *fusiformis* Yao, *Tricolocapsa* (?) *fusiformis* Yao, *Tricolocapsa plicarum* Yao, *Eucyrtidiellum* sp. and *Hsuum* sp. from gray bedded chert (JMP-2452) interbedded with sandstone. Since chert is middle Middle Jurassic in age, the Unit-C ranges from middle Middle Jurassic to late Middle Jurassic, and possibly even Late Jurassic.

The Unit-C may be regarded as the middle Middle Jurassic to Upper Jurassic chert and sandstone unit that partly includes pebbly shale.

Table 1. List of radiolarians from the western part of the Atsumi Peninsula.



ch : chert (□), ssh : siliceous shale (■), sh : shale (●), ✣ : after Ohba and Adachi (1995), Ans : Anisian, Lad : Ladinian, Het : Hettangian, Plb : Pliensbachian, Toa : Toarcian, Aal : Aalenian, Baj : Bajocian, Bth : Bathonian.

THE STRATIGRAPHIC CORRELATION OF THE STUDY AREA WITH THE CHICHIBU TERRANE IN THE SHIMA PENINSULA AND CENTRAL SHIKOKU

Lithology and age of the Chichibu terrane in central Shikoku, the Shima and Atsumi Peninsulas are shown in Fig. 4.

The Unit-C, the middle Middle to Upper Jurassic unit, consists mainly of chert and sandstone and can be correlated with the Unit A on Kamishima Island (Ohba, 1997) and the Tsuiji Group (Saka and Tezuka, 1988) in the eastern Shima Peninsula. These are correlative with the Togano Group in central Shikoku because of the similarity in age and lithology, namely Middle Jurassic radiolarian chert and siliceous shale with sandstone dikes.

The Upper Paleozoic to Middle Jurassic sedimentary complexes like the Unit-A of the Atsumi Peninsula occur in places in the Outer Zone of Southwest Japan. They are reported from the Northern Chichibu terrane (Hada and Kurimoto, 1990; Matsuoka, 1996) such as the Nakatsuyama Unit and the Niyodogawa Unit (Hada and Kurimoto, 1990) and also from the southern part of the Kurosegawa terrane such as the Aonomine Group in the Shima Peninsula (Kato et al., 1984; Umeda, 1997), the Furuyochi and Ohirayama Formations in central Shikoku (Matsuoka, 1984b; Takeshima and Hada, 1986). In the

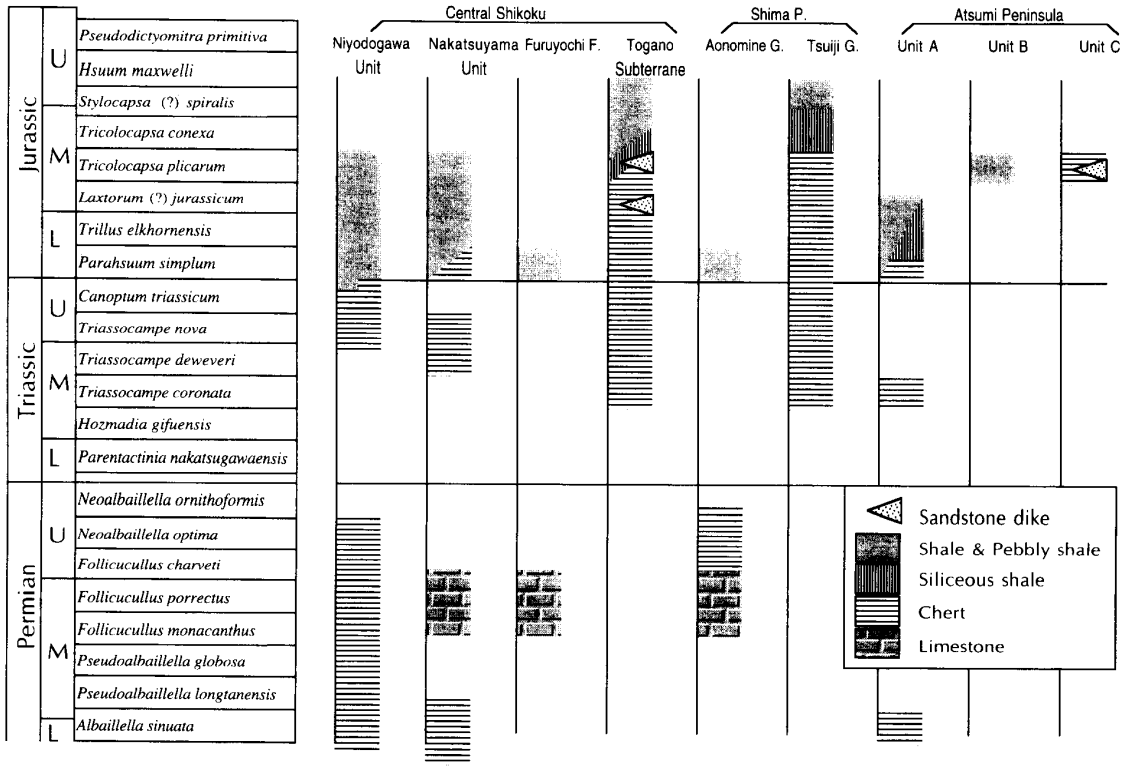


Fig. 4. Lithology and age of the Chichibu terrane in central Shikoku, the Shima and Atsumi Peninsulas compiled from Hada and Kurimoto (1990), Matsuoka (1984b), Matsuoka (1996), Umeda (1997), Ohba and Adachi (1995), Yamagiwa and Saka (1967) and Saka and Tezuka (1988).

Atsumi Peninsula, no rocks of the Kurosegawa terrane have been found. Thus, the Unit-A of the Atsumi Peninsula is difficult to place whether it belongs to the Northern Chichibu terrane or the Lower to Middle Jurassic sedimentary complex in the southern part of the Kurosegawa terrane. Judging from descriptions of Matsuoka and Yao (1990) and Matsuoka (1992, 1996), the Unit-A appears to belong to the Northern Chichibu terrane. In their definition, only the Togano and Sanbosan subterranes (Matsuoka, 1992) except for the Triassic to lower Middle Jurassic sedimentary complexes belong to the Southern Chichibu terrane.

In the Shima Peninsula area, Early Jurassic radiolarians of the *Parahsuum simplum* zone from shale of the Aonomine Group (Yamagiwa and Saka, 1967) have been reported by Umeda (1997). The Aonomine Group is the Lower to Middle Jurassic melange unit that consists mainly of chert, sandstone and pebbly shale having sandstone, chert, greenstone and limestone blocks. Thus the Unit-A of the Atsumi Peninsula can be correlated with the Aonomine Group. The Aonomine Group has been considered to belong to the Kurosegawa terrane (Saka et al., 1988; Isozaki et al., 1992). However, it is questionable to consider the Jurassic accretionary complex as the Kurosegawa terrane. Then the Unit-A of the Atsumi Peninsula and the Aonomine Group of the Shima Peninsula should belong to the Chichibu terrane except for the Togano and Sanbosan subterranes.

The Unit-B consisting of Middle Jurassic sandstone and shale is younger than the Unit-A. The Unit-B cannot be correlative with other formations in the Chichibu terrane because its detailed geologic structure and relation to the Unit-A are not clear. Thus, at present, the Unit-B is separated from the Unit-A although it may be a younger part of the Unit-A.

STRUCTURE OF THE SANBAGAWA-MIKABU AND CHICHIBU TERRANES, IN THE SHIMA AND ATSUMI PENINSULAS AREA

The Mikabu Tectonic Line has been considered to border the Sanbagawa-Mikabu terrane from the Chichibu terrane. According to the current view, the Kamishima-Irago Fault can be regarded as the Mikabu Tectonic Line. However, the Mikabu Tectonic Line crosses the Kamishima-Irago Fault in the east of the Shima Peninsula (Fig. 1). As noted previously, the trend of sedimentary complex of the Chichibu terrane also crosses the Kamishima-Irago Fault. Therefore, the Kamishima-Irago Fault should not be a primary fault that separated Sanbagawa-Mikabu terrane from the Chichibu terrane. The Gokasho-Arashima Tectonic Line, which separates the Northern Chichibu terrane from the Kurosegawa terrane in the eastern Shima Peninsula area (Saka et al., 1988), also cuts the Chichibu terrane. Since the trend of the Kamishima-Irago Fault and the Gokasho-Arashima Tectonic Line is the same and they appear to continue, the Kamishima-Irago Fault is supposed to link up with the Gokasho-Arashima Tectonic Line rather than the Mikabu Tectonic Line.

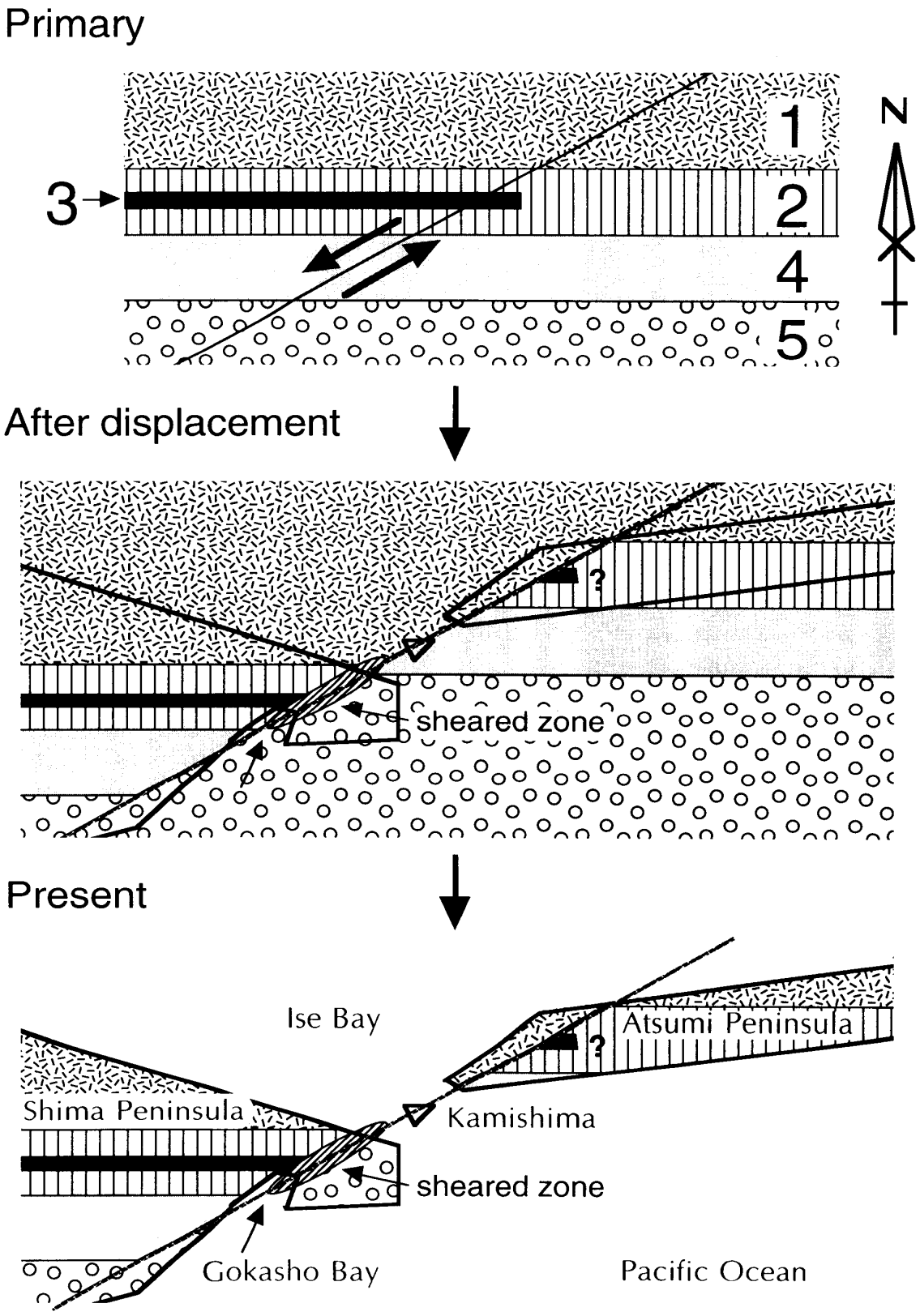


Fig. 5. Tectonic history in the Shima and Atsumi Peninsulas area. 1: Sanbagawa-Mikabu terrane, 2: Jurassic sedimentary complex except for the Togano and Sanbosan subterranes, 3: Kurosegawa terrane, 4: Togano and Sanbosan subterranes, 5: Shimanto terrane.

On Kamishima Island and Cape Irago, the sedimentary complex correlatable with the Togano Group directly contacts with rocks of the Sanbagawa-Mikabu terrane. This means that the Northern Chichibu and Kurosegawa terranes are absent. In this area, the distribution of the Sanbagawa-Mikabu and Chichibu terranes is shifted northward in the Atsumi Peninsula. Furthermore, the general trend of the Chichibu terrane is cut by the Kamishima-Irago Fault and Gokasho-Arashima Tectonic Line.

Summarizing the above, the Gokasho-Arashima Tectonic Line and the Kamishima-Irago Fault are not primary faults that separate the Kurosegawa terrane from the Northern Chichibu terrane and the Chichibu terrane from the Sanbagawa-Mikabu terrane respectively. They can be regarded as sinistral strike-slip faults that cut the original distribution of the Sanbagawa-Mikabu, Northern Chichibu, Kurosegawa, Togano-Sanbosan and Shimanto terranes. As a result of the sinistral displacement, the Northern Chichibu and Kurosegawa terranes are missing on Kamishima Island and Cape Irago (Fig. 5).

SUMMARY

The Chichibu terrane in the western part of the Atsumi Peninsula can be divided three units on the basis of lithology and radiolarian fossils: (1) Lower to lower Middle Jurassic melange unit (Unit-A) that can be correlative with the Northern Chichibu terrane, (2) middle Middle Jurassic sandstone and shale unit (Unit-B) that may be correlative with the Northern Chichibu terrane, (3) middle Middle to Upper Jurassic ? sandstone and chert unit (Unit-C) that can be correlative with the Togano Group in central Shikoku.

The Kamishima-Irago Fault that borders the Sanbagawa-Mikabu terrane from the Chichibu terrane is not a primary fault but a sinistral-strike slip fault that cuts the primary distribution of the Sanbagawa-Mikabu, Chichibu and Shimanto terranes.

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PLATE 1

1 *Eptingium* sp. cf. *E. manfredi* Dumitrica (66210/2557)
2 *Pseudostylosphaera japonica* (Nakaseko and Nishimura) (66217/2557)
3 *Triassocampe* sp. (66213/2557)
4 *Triassocampe coronata* Bragin (66216/2557)
5-8, 13 *Parahsuum* sp. (5: 66424/2574, 6: 65860/2542, 7: 66469/2578, 8: 66325/2563, 13: 66371/2568)
9 *Parahsuum* sp. aff. *P. longiconicum* Sashida (66470/2578)
10–11 *Parahsuum simplum* Yao (10: 66497/2581, 11: 66487/2581)
12 *Parahsuum* sp. cf. *P. ovale* Hori and Yao (65845/2542)
14 *Dictyomitrella* sp. (65861/2542)
15–16 *Eucyrtidiellum* sp. (66494/2581)
17 *Eucyrtidiellum disparile* Nagai and Mizutani (66501/2581)
18 *Pseudocrucella* (?) sp. (66467/2578)

scale bars = 0.1 mm

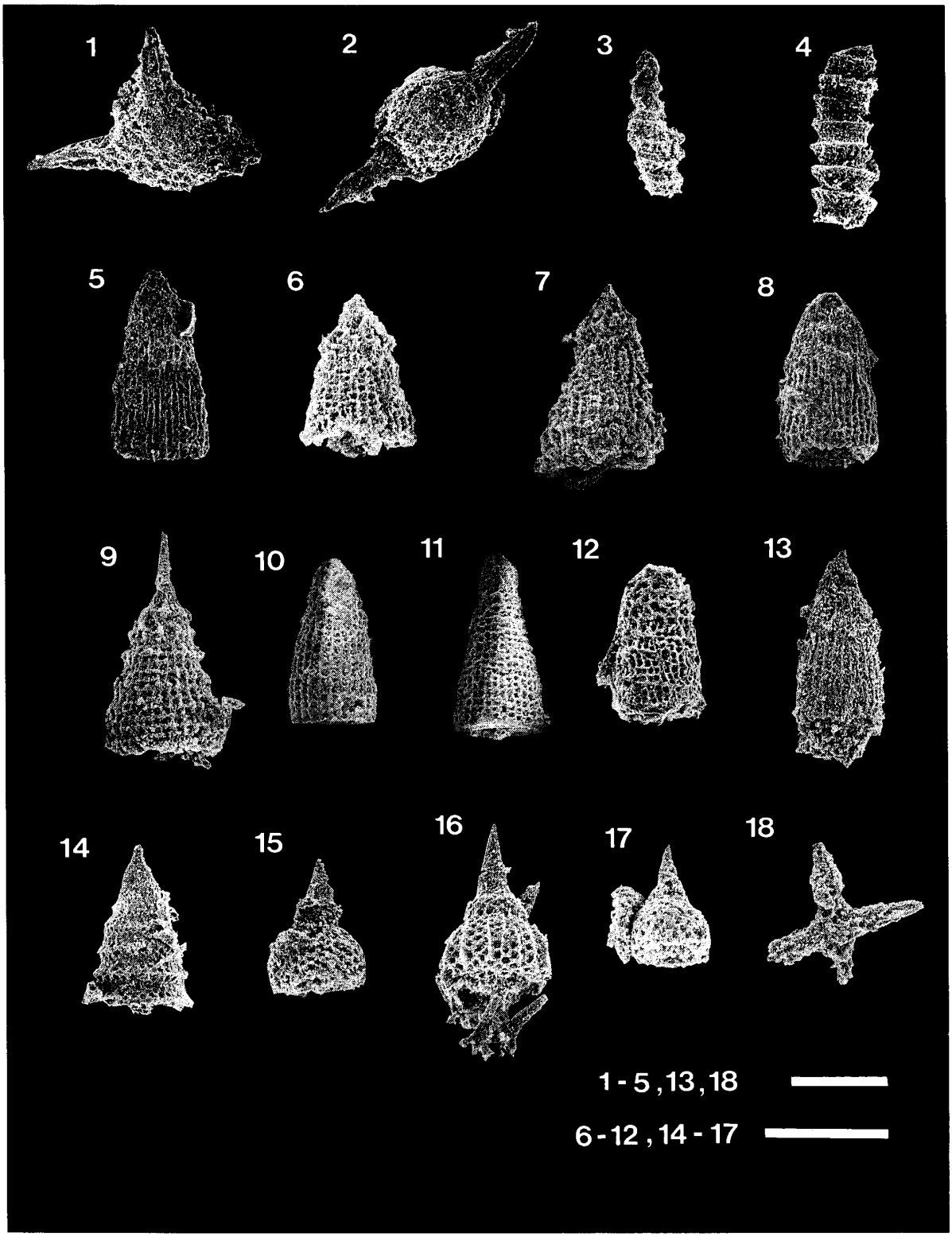
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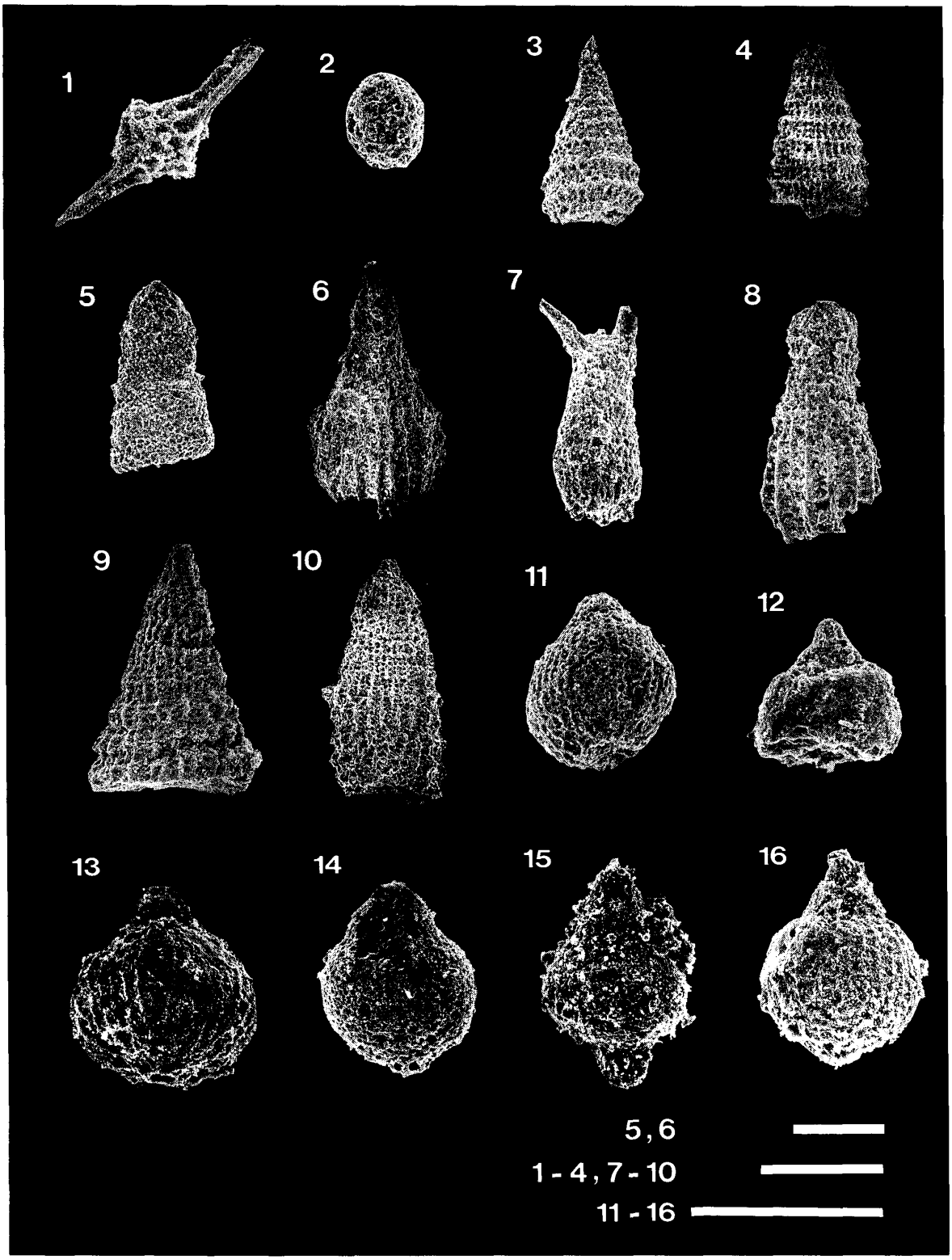
PLATE 2

1 *Trillus* sp. cf. *T. elkhornensis* Pessagno and Blome (66458/2576)
2 *Archicapsa* sp. (65905/2547)
3 *Parvicingula nanoconica* Hori and Otsuka (66466/2578)
4 *Parahsuum* (?) sp. aff. *P.* (?) *magnum* Takemura (66443/2576)
5 *Laxtorum* sp. (66425/2574)
6 *Hsuum matsuokai* (Isozaki and Matsuda) (65941/2547)
7 *Hsuum* sp. 1 of Baumgartner et al. (66436/2575)
8 *Hsuum* (?) sp. (66345/2572)
9 *Transhsuum* sp. (66342/2563)
10 *Transhsuum hisuikyoense* (Isozaki and Matsuda) (65954/2547)
11 *Tricolocapsa* (?) sp. (66330/2563)
12 *Eucyrtidiellum* sp. (66357/2565)
13 *Tricolocapsa plicarum* Yao (65800/2540)
14 *Tricolocapsa* (?) sp. aff. *T.* (?) *fusiformis* Yao (65821/2540)
15 *Cyrtocapsa mastoidea* Yao (65813/2540)
16 *Tricolocapsa* sp. cf. *T. plicarum* Yao (65873/2544) scale bars = 0.1 mm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