

Geologic Age of the Kamiyoshida Unit of the Chichibu Belt, Kanto Mountains, Japan

By

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Abstract Late Early to early Middle Jurassic radiolarians were first recovered from the Kamiyoshida unit in the northern part of the Chichibu belt, Kanto mountains, central Japan. The unit has been regarded as Middle to Late Jurassic age. The late Early to early Middle radiolarians identified are as follows: *Laxtorum*(?) *jurassicum* ISOZAKI and MATSUDA, *Laxtorum*(?) *hichisoense* ISOZAKI and MATSUDA, *Hsuum* cf. *fukazawaense* SASHIDA, *Hsuum* aff. *hisuikyoense* ISOZAKI and MATSUDA, *Canoptum* sp., *Parahsuum simplum* YAO. The unit contains also Middle to early Late Jurassic radiolarinas such as *Parvicingula dhimenaensis* BAUMGARTNER, *Stichomitra*(?) *takanoensis* AITA, *Dicatomytrella*(?) *kamoensis* MIZUTANI and KIDO, *Sethocapsa yahazuensis* AITA, *Sethocapsa* cf. *funatoensis* AITA, *Stichocapsa convexa* YAO, *Stichocapsa japonica* YAO, *Eucyrtidium unumaense* YAO, *Tricolocapsa convexa* MATSUOKA. In the northern Chichibu belt, the former radiolarians occur from the northern part of the Kamiyoshida unit, while the latter younger ones are found from the southern part of the unit. The older part of the unit, chaotic sediments including melangé, is biostratigraphically correlated to the Kazahaya-toge unit consisting of the turbidite sequence, one of the tectonic units of the northern Chichibu belt. These evidences suggest that the formation of accretionary complex of the Chichibu belt has commenced in early Jurassic.

Introduction

So-called chert-clastic sequences are widely developed within accretionary complexes of the Japanese islands. They are considered to have been formed due to subduction process characterized by tectonic piles and/or sedimentary melangé through mingling of oceanic materials and trench-fill deposits. For biostratigraphic and tectonic analyses of such sequences, fossil radiolarians are one of the most important clue to geologic age determination. During the past two decades many workers have concentrated to establish zonation in the complex. Pioneer works for this purpose are the studies of YAO (1972, 1979) and ICHIKAWA and YAO (1976). An excellent study on Triassic to Jurassic radiolarian zonation was made by YAO *et al.* (1980), and this was later revised by MATSUOKA and YAO (1986). As the Early Jurassic radiolarian biostratigraphy in particular, there are important contributions by ISOZAKI and MATSUDA (1985), HORI (1986, 1988), and HORI and YAO (1988), and HORI and OTSUKA (1989) in

the Mino belt of the Inner Zone. On the other hand, Early Jurassic radiolarians from the Outer Zone were studied by KISHIDA and SUGANO (1982), KISHIDA and HISADA (1985), HISADA and KISHIDA (1986), SASHIDA (1988, 1992), SASHIDA and IGO (1985), SATO *et al.* (1986), and UENO *et al.* (1990). We also reported Early Jurassic radiolarians from the clastic unit, the Kazahaya-toge unit, of the northern part of the Chichibu belt, Kanto mountains (IJIMA *et al.*, 1993).

The purpose of this paper is to offer new data on radiolarian age obtained from the chert dominant facies, the Kamiyoshida unit, of the northern part of the Chichibu belt, Kanto mountains, central Japan. The unit contains late Early to early Middle Jurassic species of such genera as *Hsuum*, *Laxtorum*(?) and *Parahsuum*, in addition to Middle to Late Jurassic radiolarians. These paleontological data are important to consider a tectonic development of the Outer Zone of the Japanese islands.

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Geologic Setting

The basement sedimentary rocks of the Kanto mountains have been considered to be of late Carboniferous to Triassic on the basis of fusulinids and conodonts. Radiolarian biostratigraphic works, however, clearly show that the Jurassic strata are widely developed and most of them are regarded as accretionary complex including various sized exotic blocks of chert, limestone and greenstone in shaly matrix (*e.g.*, SASHIDA *et al.*, 1982; HISADA, 1984). The geology of the northern part of the Chichibu belt, Kanto mountains, consists of four lithologic units: the Kazahaya-toge, Kamiyoshida, Manba, and Kashiwagi (Fig. 1). These units form structurally a gently dipping thrust pile, probably a part of a huge nappe. These units have been regarded as the Middle to Late Jurassic from a defined evidence of radiolarians (IJIMA *et al.*, 1990). Among them the Kazahaya-toge unit, characterized by rather coarse-grained clastic rocks, is considered to be of late Early to early Middle Jurassic in age because of the cooccurrence of *Laxtorum*(?) cf. *jurassicum* ISOZAKI and MATSUDA, *Hsuum* cf. *fukazawaense* SASHIDA and *Parahsuum* sp. (IJIMA *et al.*, 1993).

The Kamiyoshida unit consists dominantly of mudstone and siliceous mudstone including various-sized chert blocks. Existence of strongly brecciated cherts and chert-breccia intercalations suggests that the unit have been formed as collapse deposits in relation with subduction-accretion process. A generalized columnar section of the chert-clastics sedimentary rocks of the unit cannot be written, because the mode of occurrence of the rocks is "block-in-matrix". This unit is widely distributed between the Kanna-gawa area to north and Chichibu basin area to south. As shown in

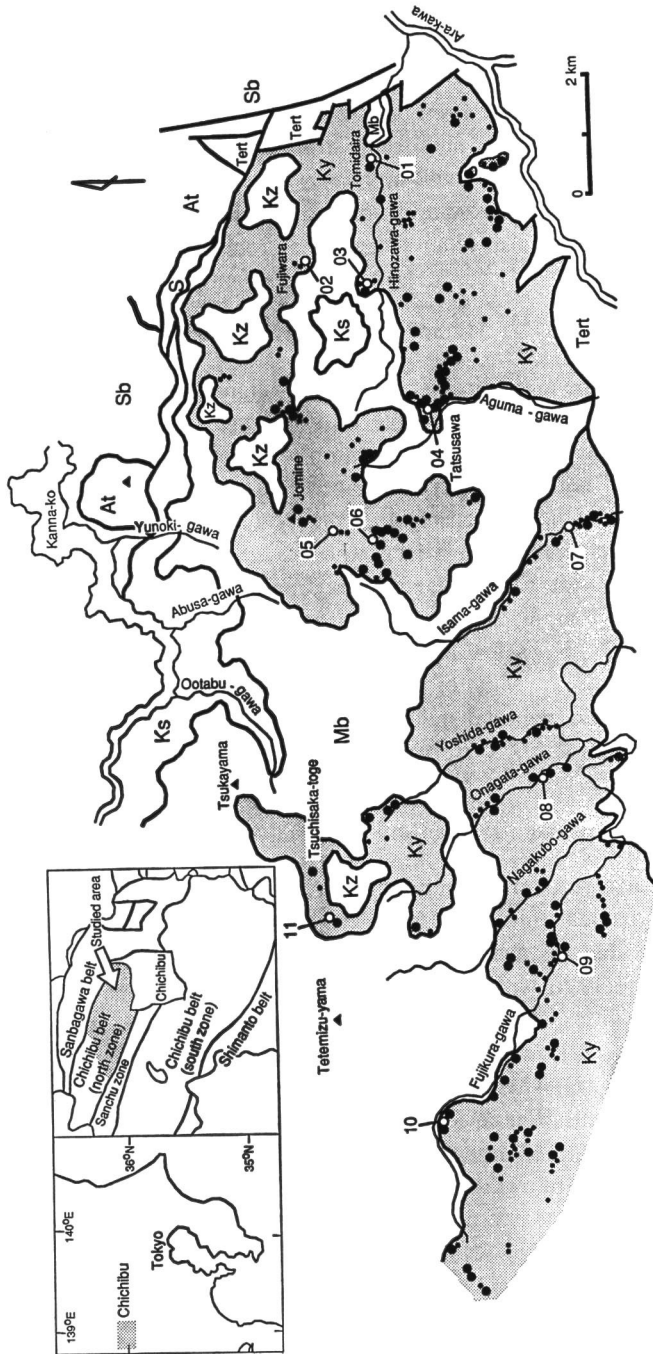


Fig. 1. Index and simplified geotectonic maps showing sample localities of the northern part of the Chichibu belt, Kanto mountains. Sb: Sanbagawa metamorphic belt, Kz: Kazehaya-toge unit, Ks: Kashiwagi unit, Mb: Manba unit, Ky: Kamiyoshida unit, At: Cretaceous Atokura Formation, S: serpentinite. Radiolarians were found from sites of open and larger solid circles.

Fig. 1, the distribution area of the unit can be divided into three parts. One is from south of Hinozawa, along the ridge from FUJIWARA to Mt. JOMINE, the second around Tsuchisaka-toge separately, and the third from the Isama-gawa through Onagata-gawa to Fujikura-gawa. The unit has been considered to be Middle to early Late Jurassic on the basis of the occurrence of such radiolarians as *Stichocapsa japonica* YAO, *Tricolocapsa* cf. *plicarum* YAO, *Protounuma* sp., *Eucrytidiellum* sp., *Hsuum* sp., *Parvicingula* sp. (IJIMA *et al.*, 1990). However, additional data on radiolarians reported here indicate that the unit includes also older sedimentary rocks of Jurassic age.

Method and Materials

Samples of mudstone and siliceous mudstone weighing about 500 g were collected from the Kamiyoshida unit. The sample localities are shown in Figure 1 with the distribution of the tectonic units. Each sample examined was crushed into small fragments and treated with dilute hydrofluoric acid for ten or more hours, and then rinsed with tap water. Undissolved residues retained on a 200 mesh sieve was washed with water for further cleaning. Relatively well-preserved specimens were hand-picked using thin hair pencils under binocular microscope, and then observed by a scanning electron microscope. Among 300 or more samples radiolarian remains were found from about 100 samples, but a few percent of samples contain radiolarians helpful for geologic age determination. Most of radiolarian specimens treated in this study have been recrystallized due to regional metamorphism and do not, therefore, retain their internal structures.

Jurassic radiolarians from the Kamiyoshida unit

Radiolarians have recovered abundantly from the mudstone and siliceous mudstone of the Kamiyoshida unit of the northern part of the Chichibu belt. But well-preserved ones available for age determination are very rare due to recrystallization and deformation associated with regional metamorphism. A list of the radiolarians from the selected localities is shown in Table 1.

Locality 01: This is located at Tomidaira along Hinozawa-gawa, Minano-machi, Saitama Prefecture (Fig. 1), where are developed dark grey to black mudstone including small blocks of chert, limestone and greenstone. A part of the unit of this locality is lithologically similar to the Manba unit. The mudstone from this locality contains abundant radiolarians as follows: *Hsuum* cf. *fukazawaense* SASHIDA (Fig. 2: 8), *H.* aff. *hisuikyoen* ISOZAKI and MATSUDA (Fig. 2: 9, 10 and 11), *Laxtrorum*(?) *jurassicum* ISOZAKI and MATSUDA (Fig. 2: 1, 2, and 3), *L.*(?) cf. *jurassicum* ISOZAKI and MATSUDA (Fig. 2: 4 and 5), *L.*(?) *hichisoense* ISOZAKI and MATSUDA (Fig. 2: 6), *L.*(?) cf. *hichisoense* ISOZAKI and MATSUDA (Fig. 2: 7), *Obesacapsa* sp. (Fig. 3: 24 and 25), *Stichocapsa* sp. (Fig. 3: 18), *Tricolocapsa* aff. *plicarum* YAO, *T.* sp. (Fig. 3: 28 and 29), etc. Some species of them are diagnostic of the *Parahsuum*(?) *grande* assemblage-zone to *Hsuum*

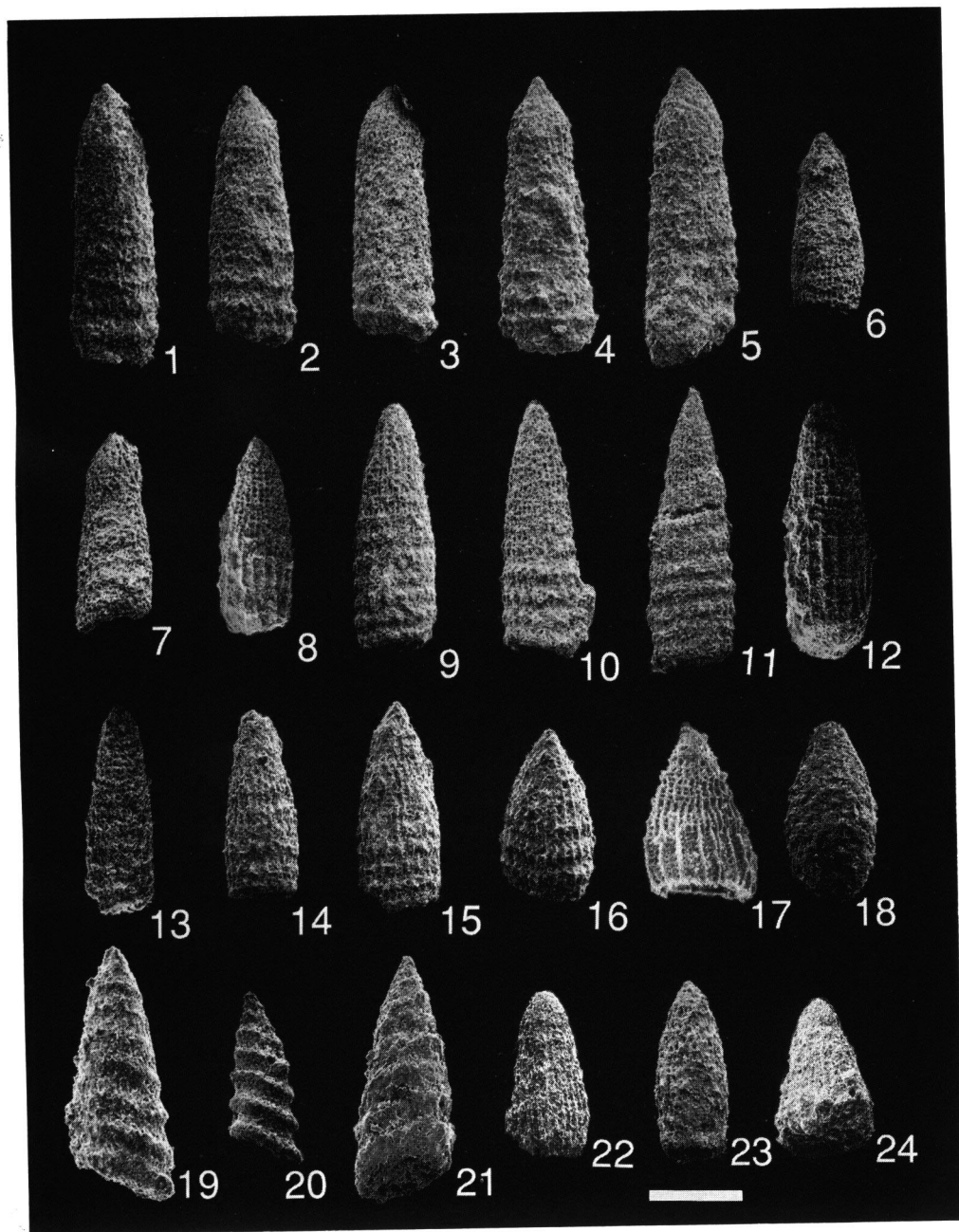
hisuikyoense assemblage-zone of late Early to early Middle Jurassic proposed by YAO (1982) and revised by HORI (1990). These zones are partly coeval with the *Laxtorum*(?) *jurassicum* zone of southwest Japan (MATSUOKA & YAO, 1986) and of the Kanto mountains (SASHIDA, 1988, 1992). Similar assemblage of radiolarins was reported from the northern Chichibu belt of the Kanto mountains (IJIMA *et al.*, 1993). Geologic range of *L.*(?) *jurassicum* first described by ISOZAKI and MATSUDA (1985) from the Mino belt has been considered to be late Pliensbachian to Bajocian(?). Co-existence of *L.*(?) *jurassicum* ISOZAKI and MATSUDA, *Hsuum* cf. *fukazawaense* SASHIDA and *H.* aff. *hichisoense* ISOZAKI and MATSUDA from this locality consequently indicates that the geologic age of the Kamiyoshida unit is of late Early to early Middle Jurassic and the unit can be correlated with the Kazahaya-toge unit reported by IJIMA *et al.* (1993).

Locality 02: The Kamiyoshida unit forms a part of imbricated thrust sheet piles together with the Kashiwagi, Manba and Kazahaya-toge units (Fig. 1). This locality at FUJIWARA, north of Hinozawa-gawa, Minano-machi, is situated near the fault boundary with the Manba unit. A number of radiolarians were found from dark grey mudstone and siliceous mudstone of this locality, but most of them are ill-preserved due to deformation and recrystallization. The following ones are identified such as *Hsuum*(?) sp., *Stichocapsa* sp. and *Tricolocapsa* sp. (Fig. 3: 27).

Locality 03: This locality at Shigeki along Hinozawa-gawa, Minano-machi, is structurally on similar geologic situation of the locality 02. Mudstone samples from this site contains *Canoptum* sp., *Hsuum* sp., *H.*(?) sp., *Parvicingula* sp., *Stichocapsa* sp., *Tricolocapsa* sp. and *Willireidellum* sp. Among them, characteristic genera *Canoptum* is biostratigraphically important because it occurs exclusively from Late Triassic to Early Jurassic as described by PESSAGNO *et al.* (1979) and PESSAGNO and POISSON (1981) from North America and Turkey. Species of the genus *Canoptum* have been reported from the Chichibu belt (KISHIDA & HISADA, 1985; MIYAMOTO & KUWAZURU, 1993; SUZUKI, 1993; SUZUKI & ITAYA, 1994) and the Mino belt (TAKADA & ISOZAKI, 1986; IMAZATO & OTOH, 1993). Judging from co-occurrence of the genus and other radiolarians the geologic age of the unit of this site may be of Early Jurassic.

Locality 04: This locality, Tatsusawa, Minano-machi, is near the boundary with the Manba unit along Aguma-gawa, west of locality 03, and on a similar structural situation like the localities 02 and 03. Mudstone samples contain such radiolarians as *Archaeodictyomitra*(?) sp., *Canutus* sp. (Fig. 3: 10), *Cyrtocapsa* sp., *Eucyrtidiellum* sp.,

Fig. 2. Scanning electron micrographs of Jurassic radiolarians from the Kamiyoshida unit of the northern Chichibu belt. 1, 2 and 3 (Loc. 01): *Laxtorum*(?) *jurassicum* ISOZAKI and MATSUDA, 4 and 5 (Loc. 01): *Laxtorum*(?) cf. *jurassicum* ISOZAKI and MATSUDA, 6 (Loc. 01): *Laxtorum*(?) *hichisoense* ISOZAKI and MATSUDA, 7 (Loc. 01): *Laxtorum*(?) cf. *hichisoense* ISOZAKI and MATSUDA, 8 (Loc. 01): *Hsuum* cf. *fukazawaense* SASHIDA, 9, 10 and 11 (Loc. 01): *Hsuum* aff. *hisuikyoense* ISOZAKI and MATSUDA, 12 (Loc. 01), 13 (Loc. 01), 14, 15, and 16 (Loc. 04): *Hsuum* sp., 17 (Loc. 07): *Hsuum*(?) sp., 18 (Loc. 05): Gen. et sp. indet., 19 (Loc. 11) and 20 (Loc. 05): *Canoptum* sp., 21 (Loc. 11): *Canoptum*(?) sp., 22 (Loc. 04): *Parahsuum simplicum* YAO, 23 (Loc. 04): *Parahsuum* sp., 24 (Loc. 04): *Parahsuum*(?) sp. Scale bar: 100 μ m for all figures.



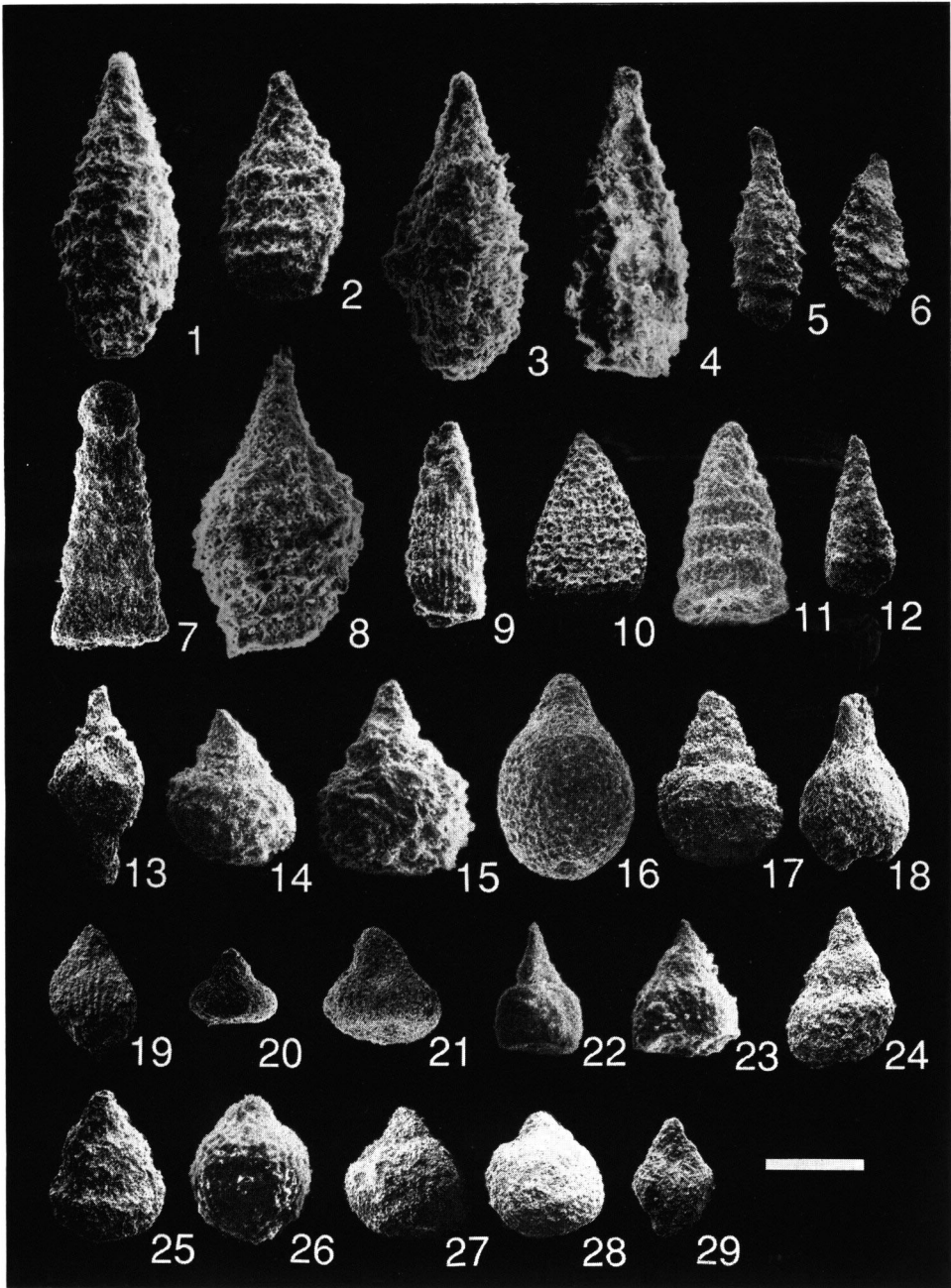
Hsuum sp. (Fig. 2: 14, 15 and 16), *H.*(?) sp., *Parahsuum simplum* YAO (Fig. 2: 22), *P.* sp. (Fig. 2: 23), *P.*(?) sp. (Fig. 2: 24), *Sethocapsa* sp., *Stichocapsa japonica* YAO, *S.* cf. *japonica* YAO, *Stichocapsa* sp., *Stichomitra* sp., *Tricolocapsa* aff. *plicarum* YAO, *T.* sp., and *Unuma*(?) sp. Among them, *Parahsuum simplum* YAO is a diagnostic species of *Parahsuum simplum* assemblage zone described by YAO (1984) from the Kii-Yura area of the Chichibu belt, and the geologic age of the zone is of Early Jurassic (late Pliensbachian to Toacian ?). *Stichocapsa japonica* is a characteristic species from *Hsuum* sp. B assemblage zone (late Early Jurassic) to *Unuma echinatus* assemblage zone (Middle Jurassic) (YAO, 1984). Affinities of *S. japonica* YAO is reported with *Laxtorum*(?) *jurassicum* ISOZAKI and MATSUDA, *Parahsuum simplum* YAO, and other radiolarians from *Parahsuum grande* assemblage-zone (late Early Jurassic: Toarcian ? to early Middle Jurassic: Aalenian ?) to *Hsuum hisuikyoense* assemblage-zone (early Middle Jurassic: Aalenian ? to Bajocian) in Inuyama area of the Mino belt (HORI, 1990). On the other hand, same species are known from late Middle Jurassic in the Sambosan belt in Shikoku (AITA, 1987). However, existence of the species of *Parahsuum simplum* YAO suggests that the age of this unit is late Early Jurassic to early Middle Jurassic.

Locality 05: This locality is south of Mt. Jomine, Minano-machi. Radiolarian assemblage from mudstone of the unit is similar to those of locality 03. They are *Canoptum* sp. (Fig. 2: 20), *Parvicingula* sp. (Fig. 3: 5 and 6), *Stichocapsa* sp., and *Tricolocapsa* sp. The geologic age of the assemblage will be Early Jurassic.

Locality 06: This locality, Isama, Yoshida-machi, Saitama Prefecture, is also south of Mt. Jomine. Most of radiolarians from this site are recrystallized and hardly identifiable. Only two species of *Stichocapsa* sp. (Fig. 3: 17) and *Syringocapsa* sp. (Fig. 3: 13) are recognized and they may indicate the Jurassic age.

Locality 07: Abundant radiolarian remains are found from this locality along Isama-gawa, Yoshida-machi. Mudstone contains the following species of *Dictyomitrella*(?) *kamoensis* MIZUTANI and KIDO (Fig. 3: 11), *Dictyomitrella*(?) sp., *Eucyrtidiellum* cf. *unumaense* YAO (Fig. 3: 23), *Eucyrtidiellum* sp., *Hsuum* sp., *Parvicingula dhimenaensis* BAUMGARTNER, *Parvicingula* sp., *Stichocapsa japonica* YAO, *Stichocapsa*, sp., *Tricolocapsa conexa* MATSUOKA (Fig. 3: 26), and *Tricolocapsa* sp. According to MIZUTANI

Fig. 3. Scanning electron micrographs of Jurassic radiolarians from the Kamiyoshida unit of the northern Chichibu belt. 1 and 2 (Loc. 07): *Parvicingula dhimenaensis* BAUMGARTNER, 3 and 4 (Loc. 09): *Parvicingula* cf. *dhimenaensis* BAUMGARTNER, 5 and 6 (Loc. 05): *Parvicingula* sp., 7 (Loc. 08): *Stichomitra*(?) *takanoensis* AITA, 8 (Loc. 11): *Mirifusus* sp., 9 (Loc. 08): *Archaeodictyomitra* sp., 10 (Loc. 04): *Canutus* sp., 11 (Loc. 07): *Dictyomitrella*(?) *kamoensis* MIZUTANI and KIDO, 12 (Loc. 06): Gen. et sp. indet., 13 (Loc. 06): *Syringocapsa* sp., 14 (Loc. 09): *Sethocapsa yahazuensis* AITA, 15 (Loc. 09): *Sethocapsa* cf. *funatoensis* AITA, 16 (Loc. 09): *Stichocapsa convexa* YAO, 17 (Loc. 06), 18 (Loc. 01) and 19 (Loc. 07): *stichocapsa* sp., 20 (Loc. 07): *Stichocapsa japonica* YAO, 21 (Loc. 08): *Stichocapsa* cf. *japonica* YAO, 22 (Loc. 09): *Eucyrtidiellum unumaense* YAO, 23 (Loc. 07): *Eucyrtidiellum* cf. *unumaense* YAO, 24 and 25 (Loc. 01): *Obesacapsula* sp., 26 (Loc. 07): *Tricolocapsa conexa* MATSUOKA, 27 (Loc. 02), 28 and 29 (Loc. 01): *Tricolocapsa* sp. Scale bar: 100 μ m for all figures.



and KIDO (1983) and YAO (1984), the range of the species of *Dictyomitrella kamoensis* MIZUTANI and KIDO is from late Middle to early Late Jurassic, and affinities of the species are known from late Early to Middle Jurassic. When NAGAI and MIZUTANI (1990) discussed the morphological change of *Eucyrtidiellum* in relation to the radiolarian assemblage zone, the species of *E. unumaense* is considered to range from *Tricolocapsa plicarum* zone, through *Tricolocapsa conexa* zone, to *Stylocapsa(?) spiralis* zone by MATSUOKA and YAO (1986), and from *Unuma echinatus* zone to *Dictyonitrella(?) kamoensis-Pantanellium foveatum* zone by MIZUTANI and KIDO (1983). AITA (1987) reported the species of *D.(?) kamoensis* from the *Eucyrtidiellum unumaense* zone (Callovian) to *Gongylothorax sakawaensis* zone (Oxfordian) in the Sambosan belt of Shikoku, with species of *Eucyrtidiellum unumaense* YAO, *Parvicingula dhimenaensis* BAUMGARTNER, *Stichocapsa conexa* MATSUOKA, *Stichomitra(?) takanoensis* AITA, *Tricolocapsa plicarum*, etc. Although most of the species from mudstone of this locality indicate the age to be from Middle to Late Jurassic, co-existence of *S. conexa* (MATSUOKA, 1983) with *D.(?) kamoensis* suggests that the age of this unit is between late Middle and early Late Jurassic.

Locality 08: Many radiolarian remains are found from this locality along the Onagata-gawa, Yoshida-machi, but the identified species and genera are as follows: *Eucyrtidiellum* sp., *Hsuum* sp., *H.(?)* sp., *Parvicingula* sp., *Ristola* sp., *Stichocapsa* aff. *japonica* YAO (Fig. 3: 21), *S.* sp., and *Stichomitra(?) takanoensis* AITA (Fig. 3: 7). The range of species of *Stichocapsa japonica* is from late Early to Middle Jurassic (YAO, 1982). On the other hand, AITA (1987) pointed out that the range of species of *Stichomitra(?) takanoensis* is from *E. unumaense* zone (Callovian) to *Gongylothorax sakawaensis* zone (Oxfordian) in the Sambosan belt of Shikoku. The age based on co-existence of these microfossils is probably Middle Jurassic.

Locality 09: Mudstone from this locality, at Suneya along Fujikura-gawa, Ogano-machi, Saitama Prefecture, contains such radiolarians as *Cyrtocapsa* sp., *Eucyrtidiellum unumaense* YAO, *E.* sp., *Hsuum* sp., *H.(?)* sp., *Napora* sp., *Parvicingula* cf. *dhimenaensis* BAUMGARTNER (Fig. 3: 3 and 4), *P.* sp., *Sethocapsa yahazuensis* AITA (Fig. 3: 14), *Sethocapsa* cf. *funatoensis* AITA (Fig. 3: 15), *Stichocapsa robusta* MATSUOKA, *S.* sp., and *Tricolocapsa* sp. As mentioned above, the species of *E. unumaense* are known to occur from *Tricolocapsa plicarum* zone to *Stylocapsa(?) spiralis* zone and indicate latest Early to early Late Jurassic. The species of *S. yahazuensis* and *S. funatoensis*, described by AITA (1987) from the Sambosan belt of Shikoku, range from Callovian, through Oxfordian, to Kimmeridgian. The age of the species *P. dhimenaensis* and *S. robusta* is assigned to late Middle to Late Jurassic. The radiolarian assemblage of this site shows Middle Jurassic, probably late Middle Jurassic age.

Locality 10: This locality is situated at an upper course of the Fujikura-gawa, Ogano-machi, where radiolarians such as *Hsuum* sp., *Stichocapsa convexa* YAO (Fig. 3: 16), and *S.* sp. occur. These indicate Middle to early Late Jurassic age.

Locality 11: The Kamiyoshida unit including this locality is isolately distributed around Tsuchisaka-toge, Yoshida-machi, Saitama Prefecture. From the mudstone

of this site the following radiolarians are found: *Archaeodictyomitra* sp., *Canoptum* sp., *C.(?)* sp., *Hsuum* sp., *Mirifusus* sp., *Parvicingula* sp., and *Tripocyelia* sp. Occurrence of the genus *Canoptum* indicating the range from Late Triassic to Early Jurassic, as mentioned at the localities 03 and 05, is important for age determination. Co-existence with other radiolarians suggests that the age of this site is Early Jurassic.

Concluding Remarks

The radiolarian biostratigraphic study on the northern part of the Chichibu belt, Kanto mountains, central Japan, yielded the following results:

1) Late Early to early Middle Jurassic radiolarians were newly found from the Kamiyoshida unit consisting of a chert-clastic sequence, in addition to Middle to Late Jurassic ones. They are *Canoptum* sp., *Hsuum* cf. *fukazawaense*, *H.* aff. *hisuikyoense*, *Laxtorum(?) jurassicum*, *L.(?) hichisoense*, *Parahsuum simplum*, etc.

2) The radiolarian assemblage of the Kamiyoshida unit includes two biostratigraphically different types. One ranges from the late Early to early Middle Jurassic and the other ranges from the late Middle to early Late Jurassic.

2) The occurrence of the older radiolarian assemblage from the Kamiyoshida unit indicates that the unit can be partly correlated to the Kazahaya-toge unit, a turbidite sequence described by IJIMA *et al.* (1993). Such older assemblage of the Kamiyoshida unit tends to be distributed in northern side of the northern Chichibu belt of the Kanto mountains together with the Kazahaya-toge unit, while younger one of the Kamiyoshida unit occupies the southern side near the Chichibu basin.

3) The new biostratigraphic informations coming from the Kamiyoshida unit tell us that those both units as accretionary complexes have been formed in relation to subduction during the late Early to Middle Jurassic. And the younger radiolarian assemblage of the Kamiyoshida unit supports a prolonged duration of the subduction into Late Jurassic age.

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