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New radiolarian species from Late Jurassic chert-terrigenous deposits of the Taukha Terrane, Southern Sikhote-Alin

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Abstract. Late Jurassic and Early Cretaceous well preserved radiolarians are obtained from the Taukha Terrane in the southern Sikhote-Alin, Russia. The Taukha Terrane consists of three tectono-stratigraphic units, the Erdagou, Gorbousha and Skalistorechenka units. Three new species (*Stichocapsa* (?) *pseudoconvexa*, *Sethocapsa taukhaensis* and *Cinguloturris primorika*) are described from Late Jurassic chert-terrigenous sequences of the Gorbousha Unit cropping out in the Roudnaya River and Koreyskaya River areas, and their stratigraphic ranges are made precise.

Key words: Late Jurassic, new species, Radiolaria, Russia, Sikhote-Alin, Taukha Terrane

Introduction

The Taukha Terrane, located in the southeastern part of the Sikhote-Alin folded belt, represents a fragment of an Early Cretaceous accretionary prism that was accreted to the eastern margin of the Khanka-Bureya paleocontinent at the end of the Early Cretaceous (Barremian-Albian) (Figure 1A). The structure and genesis of the terrane was decoded by careful studies including lithological, structural and especially biostratigraphic research of individual sections of the terrane and their correlation with each other.

During this research, huge amounts of data about Jurassic to Early Cretaceous radiolarian fossils were accumulated (Kemkin *et al.*, 1992; Kemkin and Rudenko, 1993, 1994; Kemkin and Khanchuk, 1994; Kemkin, 1996a, 1996b; Kemkin *et al.*, 1997; Kemkin and Kemkina, 1998, 1999; Kemkin *et al.*, 1999 and others). Especially detailed studies of radiolarian assemblages were carried out in the Roudnaya River area of Dalnegorsk Town and the Koreyskaya River area (Kemkin and Kemkina, 1999; Kemkin *et al.*, 1999). The investigated assemblages of Late Jurassic and Early Cretaceous radiolarians are characterized by a large number of well preserved specimens and rich species diversity. Most of them are also well

known in other regions (Europe, America, Japan etc.) and allow us to determine the age of the deposits rather confidently. Nevertheless, some species have not been described yet. We have found some new species from the chert-terrigenous deposits of the Gorbousha Unit distributed in the Koreyskaya River and Roudnaya River areas. The descriptions and occurrences of these new radiolarian species are given.

Geological setting

The Taukha Terrane is separated from the neighbouring Samarka and Zhouravlevka terranes by faults (Figure 1A). According to new data (Kemkin and Kemkina, 2000), the terrane consists of three tectono-stratigraphic units which overlie each other and are similar in lithology and structure, but differ in the age of the rocks (Figure 1B). Each unit is composed of paleo-oceanic deposits (mainly cherty and carbonate facies) in the lowest part. Toward their middle part, the units gradually change from these facies to terrigenous rocks derived from the continental margin. The terrigenous rocks are then replaced by olistostrome.

The lower unit (Erdagou Unit) is represented by Late Jurassic to Early Cretaceous (Berriasian) cherts and clayish cherts overlying Middle Jurassic (Callovian) basalts (Erdagou Suite) and followed by

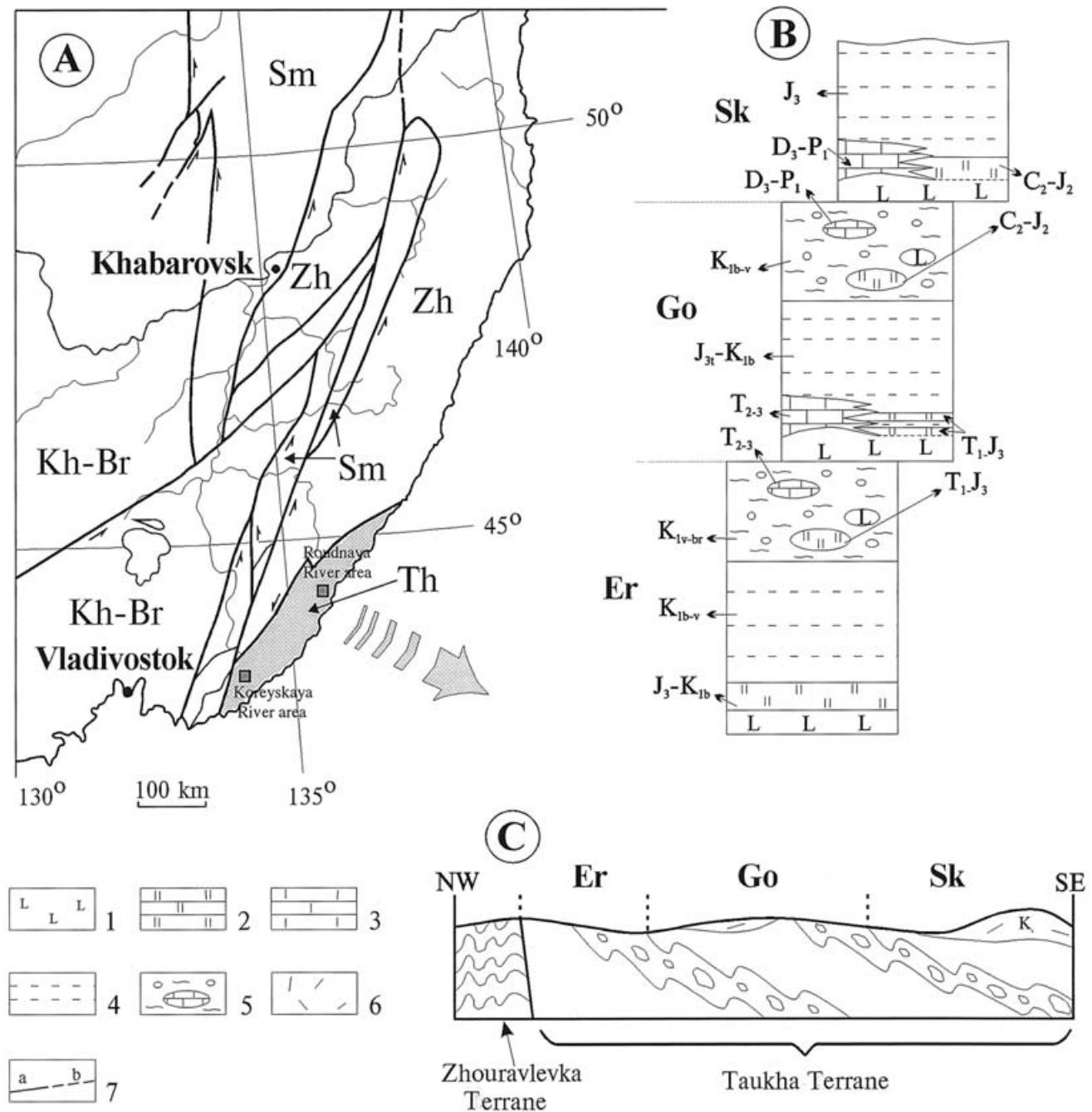


Figure 1. Tectonic map of the Sikhote-Alin region (A), tectonostratigraphic column (B) and generalized cross-section (C) of the Taukha Terrane (after Kemkin *et al.*, 1999).

Kh-Br: Khanka-Bureya Superterrane, Sm: Samarka Terrane, Zh: Zhouravlevka Terrane, Th: Taukha Terrane, Er: Erdagou Unit, Go: Gorbousha Unit, Sk: Skalistorechenka Unit.

1: basalt, 2: chert, 3: limestone, 4: turbidite, 5: olistostrome, 6: Late Cretaceous volcanic rock, 7: character of contact between the lithological units; conformable (a) and estimated (b).

Berriasian-Valanginian turbidite deposits (Silinka Suite). The thickness of the cherts together with basalts is about 150 m, whereas the thickness of terrigenous rocks is estimated at 2500 m (Golozubov and Khanchuk, 1995). However, it is possible that the turbidite part is repeated tectonically several times. The turbidites conformably and gradually replace chert rocks by a set of siliceous mudstone and mudstone. Valanginian-Barremian olistostrome also conformably overlies the turbidites. The thickness of the olistostrome layers fluctuates from 100–200 to 400 m in different areas.

The middle unit (Gorbousha Unit) consists of Middle to Late Triassic limestone (Tetyukha Suite) with high-titanium alkaline basalts at the base (400–500 m thickness). Early Triassic to Late Jurassic cherts and clayish cherts (about 100 m) analogously change to late Tithonian to Berriasian turbidites (Gorbousha Suite), and then to Berriasian-Valanginian olistostrome. The thickness of the turbidites in different slides is 350–700 m (Volokhin *et al.*, 1990; Bragin, 1991 and others). The thickness of the olistostrome deposit is the same as that of the Erdagou Unit.

The upper unit (Skalstorechenka Unit) is composed of Late Devonian to Early Permian limestone (Skalstorechenka Suite) associated with high-titanium alkaline basalts (about 400 m) and Carboniferous to Middle Jurassic chert rocks overlapped by Late Jurassic turbidites (Pantovyi Creek Suite). The thickness of the chert and clastic deposits is not clear because they only have fragmentary outcrops.

The apparent structure of the Taukha Terrane shows inverted stratigraphy because the older marine formations and correspondingly overlapping terrigenous rocks (including olistostromes) comprise the upper structural levels of the terrane, and younger units comprise the base (Figure 1C). However, within each structural unit the stratigraphic succession is normal (from older to younger). Such structure of the terrane results from successive accretion of different-placed units from sea-floor spreading centre sites of a paleo-oceanic plate (Kemkin and Kemkina, 2000).

Radiolarian assemblages

In the Roudnaya River area (Dalnegorsk Town), twelve successive Jurassic to Early Cretaceous radiolarian assemblages were distinguished from the chert-terrigenous sequence of the Gorbousha Unit outcropping along the left bank of the Roudnaya River (Kemkin and Kemkina, 1998, 1999). They are the *Parahsuum longiconicum*, *Hsuum altile*, *Parahsuum grande*, *Parahsuum hiconocosta*, *Hsuum mirabundum*,

Hsuum matsuokai, *Triactoma tithonianum*, *Archaeodictyomitra minoensis*, *Pseudodictyomitra okamurai*, *Xitus gifuensis*, *Pseudodictyomitra carpatica* and *Cecrops* sp. assemblages. However, we think that the *Pseudodictyomitra okamurai* assemblage should be deleted from this list and included in the *Archaeodictyomitra minoensis* assemblage because the species composition of the two assemblages is rather the same. The age of each assemblage and the stratigraphical position of each sample of the section are shown in Figure 2. Among the eleven assemblages, the species composition and age assignment of Late Jurassic and Early Cretaceous assemblages are as follows:

The *Archaeodictyomitra minoensis* assemblage was extracted from the boudinaged fragments of cherts (sample P-6) in the contact zone of cherts and cherty mudstones and green cherty mudstones (samples P-5, 86-14). This radiolarian assemblage is characterized by rich specific diversity and contains mainly nassellarian genera. They are *Archaeodictyomitra*, *Xitus*, *Mirifusus*, *Hsuum*, *Sethocapsa*, *Pseudodictyomitra*, *Stichocapsa* and others. The age of the assemblage is middle Oxfordian to late Kimmeridgian. The assumed lower age boundary is based on the first appearance of the index species (Baumgartner *et al.*, 1995). The upper age limit is restricted by the last appearance of *Wrangellium okamurai* (= *Pseudodictyomitra okamurai* Mizutani) (Baumgartner *et al.*, 1995). The assemblage is comparable in age with that of the upper part of the *Stylocapsa* (?) *spiralis* zone and *Hsuum maxwelli* zone (Matsuoka, 1995) described in Japan. It should be noted that within the assemblage there are several morphological forms that are more common in the Early Cretaceous time. They are similar to *Pseudodictyomitra nuda* and *Pseudodictyomitra leptocnica*.

The *Xitus gifuensis* assemblage was also found in green cherty mudstones (samples P-4, P-3). *Archaeodictyomitra* and *Xitus* predominate among the numerous radiolarians of this assemblage. Some spumellarians such as *Tritrabs*, *Emiluvia* and *Pantanellium* are also found. The geological age of the assemblage is presumed to be late Kimmeridgian to middle Tithonian. The lower age boundary corresponds to the first appearance of *Xitus gifuensis* (Baumgartner *et al.*, 1995). The upper boundary is restricted by the lower boundary of the upper assemblage. The assemblage is correlated with that of the *Pseudodictyomitra primitiva* zone (Matsuoka, 1995) and also contains some species which are similar to *Pseudodictyomitra nuda* and *Pseudodictyomitra leptocnica*.

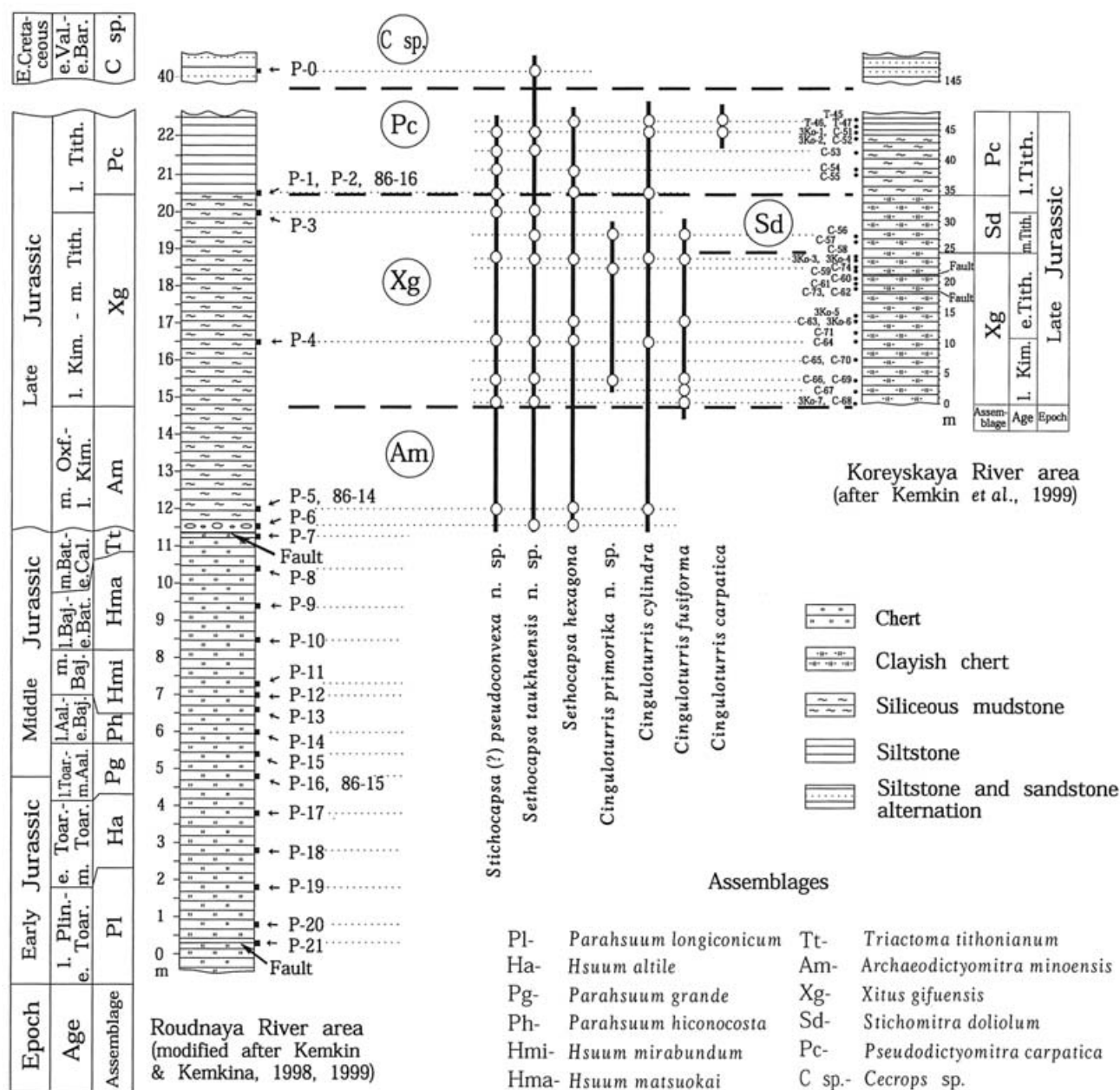


Figure 2. Lithological-stratigraphic column and radiolarian assemblages of chert-clastic sequences of the Gorbousha Unit and stratigraphic range of new radiolarian species.

The *Pseudodictyomitra carpatica* assemblage was found in black mudstones (samples P-1, P-2, 86-16) very close to the contact with green cherty mudstones. The assemblage is represented by numerous and diverse radiolarians correlated to the end of the Jurassic and the beginning of the Cretaceous time. Nassellarians such as *Pseudodictyomitra*, *Archaeodictyomitra*, *Xitus*, *Thanarla* and *Sethocapsa* are predominant. Spumellarians such as *Tritrabs*, *Emiluvia*,

Pantanellium and others are also contained therein. The age of the assemblage is late Tithonian. The lower age boundary corresponds to the first appearance of *Pseudodictyomitra carpatica* (Matsuoka, 1992, 1995). The upper boundary is determined by the last appearance of *Archaeodictyomitra minoensis*, *Ristola altissima* and *Protunuma japonicus* (Baumgartner et al., 1995). This assemblage also contains some species similar to *Pseudodictyomitra nuda* and *Pseudodictyo-*

mitra leptaconica. The assemblage is comparable in age with that of the lower part of the *Pseudodictyomitra carpatica* zone (Matsuoka, 1995) established in Japan.

The *Cecrops* sp. assemblage was distinguished in the black mudstones (sample P-0) that are 40 m above the horizon P-1 of the section. The assemblage is characterized by diverse and abundant radiolarian species. Most of them have a wide age interval. However, the presence of *Cecrops* sp. and *Stichocapsa* ex gr. *altiformina* allows us to determine the age as early Valanginian to early Barremian (Baumgartner *et al.*, 1995). This assemblage is comparable in age with that of the *Cecrops septemporatus* zone and the lower part of the *Acanthocircus carinatus* zone (Matsuoka, 1995).

In the Koreyskaya River area, three successive Late Jurassic radiolarian assemblages have been distinguished from the chert-clastic sequence of the Gorbousha Unit exposed along the bank of the Koreyskaya River (Kemkin *et al.*, 1999). They are the *Xitus gifuensis*, *Stichomitra doliolum* and *Pseudodictyomitra carpatica* assemblages. The age of each assemblage and the stratigraphical position of each sample of the section are also shown in Figure 2. The species composition and age assignment of the assemblages are as follows:

The *Xitus gifuensis* assemblage was extracted from the greenish grey clayish cherts (samples 3Ko-3, 3Ko-4, 3Ko-5, 3Ko-6, 3Ko-7, C-58, C-61, C-63, C-64, C-65, C-66, C-67, C-68, C-69, C-70, C-71, C-74). This assemblage contains numerous well preserved radiolarian faunas which are characterized by rich species diversity. They are *Archaeodictyomitra*, *Cinguloturris*, *Hsuum*, *Parvicingula*, *Pseudodictyomitra*, *Sethocapsa*, *Spongocapsula*, *Stichocapsa*, *Stichomitra*, *Thanarla*, *Xitus*, *Wrangellium* and others. The geological age of the assemblage is presumed to be late Kimmeridgian to early Tithonian. The lower age boundary corresponds to the first appearance of *Xitus gifuensis*, *Archaeodictyomitra excellens*, *Obesacapsula verbana* and *Sethocapsa horokanaiensis* (Mizutani, 1981; Kawabata, 1988; Baumgartner *et al.*, 1995). The upper boundary is restricted by the last appearance of such species as *Eucyrtidiellum ptyctum*, *Parvicingula dhimenaensis*, *Sethocapsa funatoensis*, *Wrangellium okamurai*, *Triactoma blakei* and *Tritrabs exotica*. This boundary corresponds to the early Tithonian (Pessagno, 1977; Mizutani, 1981; Aita, 1987; Baumgartner *et al.*, 1995). The assemblage is correlated with the upper part of the *Hsuum maxwelli* zone and the lower part of the *Pseudodictyomitra primitiva* zone (Matsuoka, 1995).

The *Stichomitra doliolum* assemblage was found in the identical greenish-grey clayish chert (sample C-

56). The assemblage is represented by numerous and diverse well preserved radiolarians related to the end of Jurassic and the beginning of Cretaceous time. Nassellarians such as *Pseudodictyomitra*, *Cinguloturris*, *Parvicingula*, *Archaeodictyomitra*, *Xitus*, *Thanarla*, *Stichocapsa*, *Stichomitra* and *Sethocapsa* are predominant. The assemblage also contains spumellarians such as *Tritrabs* and *Emiluvia*. The range of the assemblage is middle Tithonian to early late Tithonian. The lower age boundary is based on the absence of characteristic species of the early Tithonian (see *Xitus gifuensis* assemblage), as well as the presence of *Stichomitra doliolum*, the first appearance of which is described from the middle Tithonian (Aita and Okada, 1986). The upper age boundary is controlled by the lower boundary of the next assemblage, as well as by the last appearance of *Ristola altissima*, which corresponds to early late Tithonian (Baumgartner *et al.*, 1995). The assemblage is comparable in age with that of the *Pseudodictyomitra primitiva* zone (Matsuoka, 1995).

The *Pseudodictyomitra carpatica* assemblage was revealed in greenish-grey siliceous mudstone and black mudstone (samples T-45, T-46, 3Ko-1, 3Ko-2, C-51, C-53, C-54). Abundant well preserved radiolarians of the latest Jurassic to earliest Cretaceous were extracted from these samples. Representatives of nassellarians such as *Archaeodictyomitra*, *Cinguloturris*, *Eucyrtidiellum*, *Hsuum*, *Parvicingula*, *Pseudodictyomitra*, *Sethocapsa*, *Stichocapsa*, *Stichomitra*, *Thanarla*, *Wrangellium*, *Xitus* and others are predominant among them. The geological age of the assemblage is late late Tithonian. The lower age boundary is accepted according to the first appearance of *Pseudodictyomitra carpatica* and corresponds to late late Tithonian (Matsuoka, 1992). The upper boundary is determined by the last appearance of *Archaeodictyomitra minoensis*, *Spongocapsula perampla*, *Protunuma japonicus*, *Eucyrtidiellum pyramis* and *Sethocapsa yahazuensis* (Mizutani, 1981; Matsuoka and Yao, 1985; Aita, 1987; Baumgartner *et al.*, 1995). The assemblage is correlated with the lower part of the *Pseudodictyomitra carpatica* zone (Matsuoka, 1995).

Systematic paleontology

Three new species are described and compared with co-occurring species of the same genera.

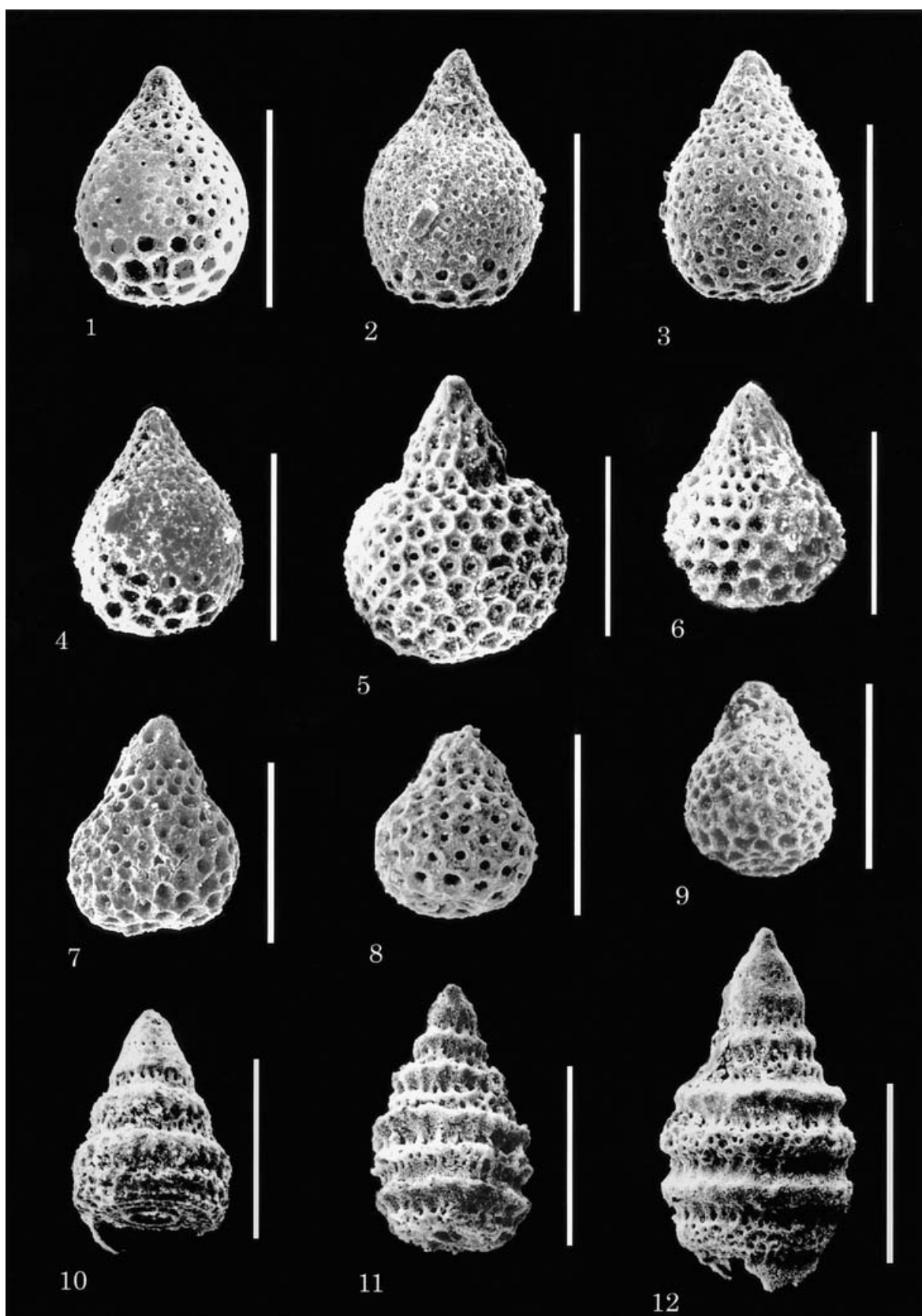
Subclass Radiolaria

Order Nassellaria

Family Theoperidae

Genus ***Stichocapsa*** Haeckel, 1881

Stichocapsa Haeckel, 1881, p. 439



Type species.—*Stichocapsa jaspidea* Rüst, 1885

***Stichocapsa* (?) *pseudoconvexa* sp. nov.**

Figure 3.1–3.4

Tricolocapsa sp. nov.; Kemkin *et al.*, 1997, pl. 5, fig. 6.

Sethocapsa sp. nov.; Kemkin *et al.*, 1999, fig. 6.46.

Holotype.—0341-09 – C-51

Definition.—Shell is probably of four segments, lacking strictures. It is composed of two parts. Upper part of shell regularly and gradually increases in width, with segmental partitions only slightly visible outside. Cephalis spherical, small and poreless, without apical horn. Thorax subcylindrical with sparsely displaced small circular pores. Abdomen trapezoidal also with sparsely displaced small circular pores. Post-abdominal segment globe-shaped, covered by sparse circular pores. The terminal portion of the test is closed, with 2–3 circular rows of large circular pores. The diameter of these pores is 3–5 times bigger than of the other pores.

Remarks.—Shell consists of upper conical and lower globose parts as well as whole genus, but it lacks apparent distal aperture. Therefore it is questionable that this form belongs to *Stichocapsa*. However, since its outline and surface are similar to *Stichocapsa convexa* Yao, this form is tentatively described as *Stichocapsa*. *Stichocapsa* (?) *pseudoconvexa* n. sp. is very similar to *Stichocapsa convexa* Yao by having almost the same shape and a smooth surface, but it differs from the latter by possessing a smaller cephalis and thorax chambers, and by having 2–3 circular rows of large circular pores in the terminal portion of the test.

Etymology.—*Stichocapsa* (?) *pseudoconvexa* means false (or mistaken) *Stichocapsa convexa* Yao.

Measurements (in μm).—(based on 5 specimens)

Height: 120–146

Max. width: 86–108

Type locality.—Right bank of Koreyskaya River, Gorbousha Unit of the Taukha Terrane, Sikhote-Alin, Russia.

Occurrence.—*Archaeodictyomitra minoensis*, *Xitus gifuensis*, *Stichomitra doliolum* and *Pseudodictyomitra carpatica* assemblages (middle Oxfordian to late

Tithonian).

Family Sethocapsidae

Genus ***Sethocapsa*** Haeckel, 1881

Sethocapsa Haeckel, 1881, p. 433

Type species.—*Sethocapsa cometa* (Pantaneli); Rüst, 1885; Subsequent designation by Foreman, 1973.

***Sethocapsa hexagona* Hori, 1999**

Figure 3.5

Sethocapsa sp.; Aita and Okada, 1986, pl. 5, fig. 13.

Sethocapsa hexagona Hori, 1999, p. 74–75, Fig. 6.12–6.16, Fig. 11.1a, b.

Occurrence.—*Archaeodictyomitra minoensis*, *Xitus gifuensis*, *Stichomitra doliolum* and *Pseudodictyomitra carpatica* assemblages (middle Oxfordian to late Tithonian).

***Sethocapsa taukhaensis* sp. nov.**

Figure 3.6–3.9

Sethocapsa sp.; Kemkin *et al.*, 1997, pl. 6, fig. 6.

Holotype.—0377-06 – C-58

Definition.—Shell pear-shaped, probably of four segments as for all other species of the genus. Upper part of shell conical, regularly and gradually increases in width, with segmental partitions only slightly visible outside. Cephalis is subspherical, small, poreless, without apical horn. Thorax and abdomen are trapezoidal, with sparsely displaced small circular pores. Fourth chamber closed, globose and much larger than first three segments. Pores of the fourth segment circular and have hexagonal or pentagonal pore frames. Terminal portion of the test has 1–2 circular rows of large circular pores, diameters of which are 2–3 times larger than of the other pores.

Remarks.—*Sethocapsa taukhaensis* n. sp. is similar to *Sethocapsa hexagona* Hori, but differs from it by having a much smaller test, by lacking a stricture between the first three segments and the fourth segment, and also by having smaller-sized pores on the whole.

◆ **Figure 3.** Late Jurassic radiolarians from chert-clastic sequence of the Gorbousha Unit.

Scanning electron photomicrographs. All markers are 100 μm .

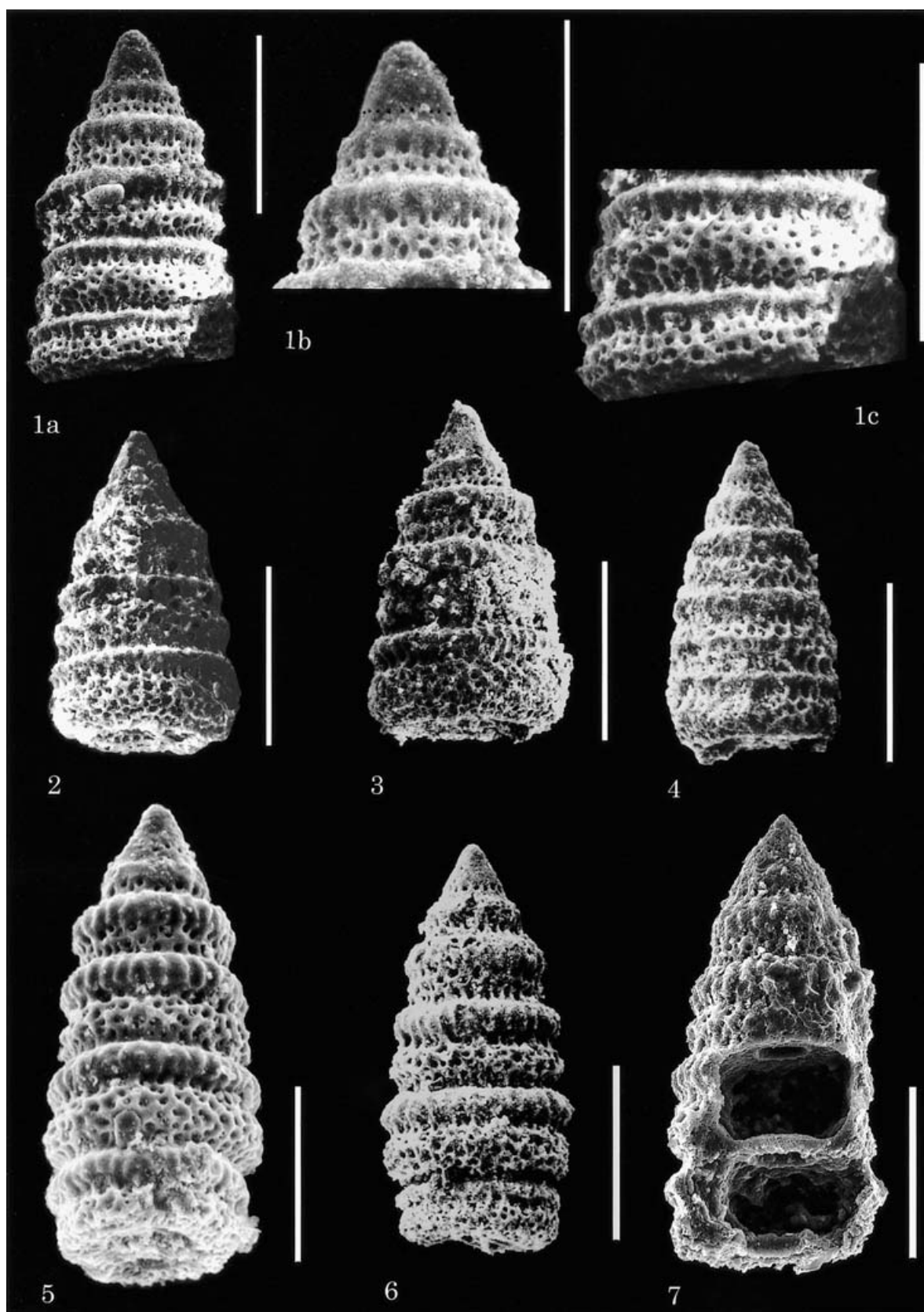
1–4. *Stichocapsa* (?) *pseudoconvexa* sp. nov. (1 – C-51, holotype; 2 – P-3; 3 – P-4; 4 – 86-16)

5. *Sethocapsa hexagona* Hori (C-54)

6–9. *Sethocapsa taukhaensis* sp. nov. (6 – C-58, holotype; 7 – P-3, 8 – P-6; 9 – C-56)

10. *Cinguloturris carpatica* Dumitrica (C-51)

11, 12. *Cinguloturris fusiforma* Hori (11 – C-69; 12 – C-56)



Etymology.—The species name is derived from the Taukha Terrane of the Sikhote-Alin region, Far East of Russia.

Measurements (in μm).—(based on 5 specimens)

Height: 103–127

Max. width: 83–103

Type locality.—Right bank of Koreyskaya River, Gorbousha Unit of the Taukha Terrane, Sikhote-Alin, Russia.

Occurrence.—*Archaeodictyomitra minoensis*, *Xitus gifuensis*, *Stichomitra doliolum*, *Pseudodictyomitra carpatica* and *Cecrops* sp. assemblages (middle Oxfordian to early Barremian).

Family Parvicingulidae

Genus ***Cinguloturris*** Dumitrica in Dumitrica and Mello, 1982

Cinguloturris Dumitrica; Dumitrica and Mello, 1982, p. 22.

Type species.—*Cinguloturris carpatica* Dumitrica; Dumitrica and Mello, 1982.

Cinguloturris carpatica Dumitrica in Dumitrica and Mello, 1982

Figure 3.10

Theoperidae gen. et sp. indet. I; Aita, 1982, pl. 2, fig. 18.
Theoperid gen. et sp. indet.; Aoki and Tashiro, 1982, pl. 2, fig. 9.
Cinguloturris carpatica Dumitrica; Dumitrica and Mello, 1982, p. 23, pl. 4, figs. 7–11; Yao, 1984, pl. 2, fig. 28; Aita, 1985, fig. 7.12; Ishida, 1985, pl. 4, figs. 13, 14; Matsuoka and Yao, 1985, pl. 2, fig. 13; Tanaka *et al.*, 1985, pl. 1, fig. 12; Matsuoka, 1986, pl. 2, fig. 16, pl. 3, fig. 11; Matsuoka and Yao, 1986, pl. 2, fig. 14; Aita, 1987, p. 64, pl. 10, fig. 12; Wakita, 1988, pl. 5, fig. 8; Kato and Iwata, 1989, pl. 5, fig. 5, pl. 6, fig. 10; Matsuoka and Oji, 1990, pl. 1, fig. 7; Yao, 1990, pl. 4, fig. 11; Ishida and Hashimoto, 1991, p. 46, pl. 4, fig. 16; Matsuoka, 1992, pl. 4, fig. 1; Kashiwagi and Yao, 1993, pl. 2, fig. 4; Sashida *et al.*, 1993, fig. 6.7; Gorican, 1994, p. 64, pl. 23, figs. 1, 6–11; Kemkin and Rudenko, 1994, p. 1118, pl. 1, figs. 2, 5–8; Baumgartner *et al.*, 1995, p. 142, pl. 3193, figs. 1, 2, 4–6 (not 3); Ohba and Adachi, 1995, pl. 3, fig. 10; Kemkin, 1996a, pl. 1, figs. 1, 2, 5; Sashida and Uematsu, 1996, p. 65, fig. 4.11; Shen *et al.*, 1996, pl. 2, fig. 11; Nishizono *et al.*, 1997, pl. 2, fig. 13; Ishida and Hashimoto, 1997, pl. 2, fig. 5; Takashima *et al.*, 1997, fig. 5.10; Yang and Matsuoka, 1997, pl. 3, fig. 9; Zyabrev and Matsuoka, 1999, pl. 1, fig. 11; Hori, 1999, p. 91, fig. 9.1.

Dictyomitra sp. B; Ishida, 1983, pl. 5, figs. 3, 4.

Unnamed multicyrtoid nassellarian; Yamamoto, 1983, pl. 1, fig. 10.

Cinguloturris sp. aff. *C. carpatica* Dumitrica; Yao, 1984, pl. 3, fig. 19.
Cinguloturris sp. cf. *C. carpatica* Dumitrica; Tanaka *et al.*, 1985, pl. 1, fig. 7; Kurimoto, 1989, pl. 1, fig. 17.

Occurrence.—*Pseudodictyomitra carpatica* assemblage (late Tithonian).

Cinguloturris cylindra Kemkin and Rudenko, 1993

Figure 4.5–4.7

Unnamed multicyrtoid nassellarian; Adachi, 1982, pl. 2, fig. 9.
Cinguloturris sp.; Wakita, 1987, pl. 1, fig. 8; Kato and Iwata, 1989, pl. 2, fig. 7.
Cinguloturris sp. aff. *C. carpatica* Dumitrica; Wakita, 1988, pl. 6, fig. 14; Sashida *et al.*, 1993, fig. 6.8, 6.9.
Cinguloturris carpatica Dumitrica; ?Yasuda, 1989, pl. 1, fig. 14.
Cinguloturris sp. cf. *C. carpatica* Dumitrica; Kemkin *et al.*, 1992, p. 33, pl. 2, fig. 3.
Cinguloturris cylindra Kemkin and Rudenko, 1993, p. 116, pl. 2, figs. 3, 9–15; Kemkin and Rudenko, 1994, p. 1116, pl. 1, figs. 3, 9–15; Baumgartner *et al.*, 1995, p. 144, pl. 6101, figs. 1–4; Kemkin, 1996a, pl. 3, fig. 11; Dumitrica *et al.*, 1997, p. 69, pl. 14, fig. 16; Kemkin *et al.*, 1997, pl. 3, fig. 9, pl. 4, fig. 11, pl. 6, fig. 3; Hori, 1998, pl. 2, fig. 12; Hori, 1999, p. 91–93, fig. 9.2; Kemkin *et al.*, 1999, fig. 4.8, 4.9, fig. 5.9; Matsuoka *et al.*, 2002, fig. 6.7.
Cinguloturris sp. A; Gorican, 1994, p. 64, pl. 23, figs. 3–5.
Cinguloturris arabica Jud, 1994, p. 69, pl. 5, figs. 15, 16.

Occurrence.—*Archaeodictyomitra minoensis*, *Xitus gifuensis*, *Stichomitra doliolum* and *Pseudodictyomitra carpatica* assemblages (middle Oxfordian to late Tithonian).

Cinguloturris fusiforma Hori, 1999

Figure 3.11, 3.12

Unnamed multicyrtoid nassellarian; Adachi, 1982, pl. 2, figs. 8, 10.
Cinguloturris carpatica Dumitrica; Kishida and Hisada, 1986, fig. 2.12; Kawabata, 1988, pl. 2, fig. 10; Tamba Belt Research Group, 1990, pl. 2, fig. 16; Sashida *et al.*, 1993, fig. 6.6.
Cinguloturris sp. A; Kemkin and Rudenko, 1994, p. 1118, pl. 1, fig. 6.
Cinguloturris sp.; Hori, 1998, pl. 2, fig. 13.
Cinguloturris fusiforma Hori, 1999, p. 93, fig. 9.3–9.6, fig. 11.6.
Cinguloturris sp. nov.; Kemkin *et al.*, 1999, fig. 5.10.

Occurrence.—*Xitus gifuensis* and *Stichomitra doliolum* assemblages (late Kimmeridgian to middle Tithonian).

Cinguloturris primorika sp. nov.

Figure 4.1–4.3

Cinguloturris carpatica Dumitrica; Baumgartner *et al.*, 1995, p. 142–

Figure 4. Late Jurassic radiolarians from chert-clastic sequence of the Gorbousha Unit.

Scanning electron photomicrographs. All markers are 100 μm .

1–3. *Cinguloturris primorika* sp. nov. (1 – C-69, holotype; 2 – C-56; 3 – C-74)

4. *Cinguloturris* sp. aff. *C. primorika* sp. nov. (C-56)

5–7. *Cinguloturris cylindra* Kemkin and Rudenko (5 – T-47; 6 – C-58; 7 – Be-9 from the fourth right tributary of Benevka River)

143, pl. 3193, fig. 3; ?Matsuoka, 1992, pl. 3, fig. 2; Hori, 1998, pl. 2, fig. 11.

Holotype.—0409-02 – C-69

Definition.—Multisegmented conical test as with all other species of the genus. The number of segments is seven or more. The diameter of the segments increases rapidly from the proximal to the distal portion of the test. Cephalis subspherical, smooth, poreless and without apical horn. Thorax also smooth, poreless and trapezoidal. Thorax and abdomen are separated from one another by a single row of small circular pores. Each post-thoracic segment begins with a narrow, inflated, poreless and slightly costate circumferential ridge. The remaining segment wall is covered with a thick spongy meshwork with irregularly arranged pores. The ratio of height between ridge and spongy meshwork is 1:3–1:5. Meshed portion of segment wall and ridge are separated from one another by a single row of larger pores.

Remarks.—*Cinguloturris primorika* n. sp. differs from *Cinguloturris cylindra* Kemkin and Rudenko and *Cinguloturris fusiforma* Hori by possessing a distinct conical shell shape. From *Cinguloturris carpatica* Dumitrica it differs by having very narrow, slightly costate circumferential ridges.

Etymology.—The species name is derived from Primorye area, southern part of the Far East of Russia.

Measurements (in μm).—(based on 6 specimens)

Height: 166–186

Max. width: 103–120

Type locality.—Right bank of Koreyskaya River, Gorbousha Unit of the Taukha Terrane, Sikhote-Alin, Russia.

Occurrence.—*Xitus gifuensis* and *Stichomitra doliolum* assemblages (late Kimmeridgian to middle Tithonian).

Cinguloturris sp. aff. *C. primorika* sp. nov.

Figure 4.4

Remarks.—*Cinguloturris* sp. aff. *C. primorika* n. sp. differs from *Cinguloturris primorika* n. sp. by having less prominent circumferential ridges.

Occurrence.—*Stichomitra doliolum* assemblage (middle Tithonian).

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References

- Adachi, M., 1982: Some considerations on the *Mirifusus baileyi* assemblage in the Mino terrain, central Japan. In Nakaseko, K. ed., *Proceedings of the First Japanese Radiolarian Symposium. News of Osaka Micropaleontologists, Special Volume*, no. 5, p. 211–225. (in Japanese with English abstract)
- Aita, Y., 1982: Jurassic radiolarian biostratigraphy in Irazuyama district, Kochi Prefecture, Japan – a preliminary report –. In Nakaseko, K. ed., *Proceedings of the First Japanese Radiolarian Symposium. News of Osaka Micropaleontologists, Special Volume*, no. 5, p. 255–270. (in Japanese with English abstract)
- Aita, Y., 1985: Jurassic radiolarian biostratigraphy of the Irazuyama Formation (Takano Section), Shikoku, Japan. *Scientific and Technical Reports of the Mining College, Akita University*, no. 6, p. 33–41. (in Japanese with English abstract)
- Aita, Y., 1987: Middle Jurassic to Lower Cretaceous radiolarian biostratigraphy of Shikoku with reference to selected section in Lombardy Basin and Sicily. *Science Reports of the Tohoku University, Second Series (Geology)*, vol. 58, no 1, p. 1–91.
- Aita, Y. and Okada, H., 1986: Radiolarians and calcareous nannofossils from the uppermost Jurassic and Lower Cretaceous strata of Japan and Tethyan regions. *Micropaleontology*, vol. 32, no. 2, p. 97–128.
- Aoki, T. and Tashiro, M., 1982: A stratigraphical study of the Cretaceous Shimanto Belt (the “Doganaro” and Uwagumi Formations) at Uwagumi, Kagami-machi, Kami-gun, Kochi Prefecture, Shikoku. *Research Reports of the Kochi University*, vol. 31, p. 1–39.
- Baumgartner, P. O., O'Dogherty, L., Gorican, S., Dumitrica-Jud, R., Dumitrica, P., Pillevuit, A., Urquhart, E., Matsuoka, A., Danelian, T., Bartolini, A., Carter, E. S., De Wever, P., Kito, N., Marcucci, M. and Steiger, T., 1995: Radiolarian catalogue and systematics of Middle Jurassic to Early Cretaceous Tethyan genera and species. In Baumgartner, P. O., O'Dogherty, L., Gorican, S., Urquhart, E., Pillevuit, A. and De Wever, P. eds., *Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: Occurrences, Systematics, Biochronology. Mémoires de Géologie (Lausanne)*, no. 23, p. 37–685.
- Bragin, N. U., 1991: Radiolarians and Lower Mesozoic deposits of the East of the USSR. Nauka, Moscow, 125 p. (in Russian)
- Dumitrica, P., Immenhauser, A. and Dumitrica-Jud, R., 1997: Mesozoic radiolarian biostratigraphy from Masirah Ophiolite, Sultanate of Oman – Part I: Middle Triassic, uppermost Jurassic and lower Cretaceous spumellarians and multisegmented nassellarians –. *Bulletin of the*

- National Museum of Natural Science, no. 9, p. 1–106.
- Dumitrica, P. and Mello, J., 1982: On the age of the Meliata Group and the Silica Nappe radiolarites. *Geologicke Prace*, vol. 77, no. 8, p. 17–28.
- Foreman, P.H., 1973: Radiolaria from DSDP Leg. 20. In Heezen, B. C., MacGregor, I. D. et al., *Initial Reports of the Deep Sea Drilling Project*, vol. 20, p. 249–305. U. S. Govt. Printing Office, Washington, D.C.
- Golozubov, V.V. and Khanchuk, A.I., 1995: Taukha and Zhuravlevka Terranes (South Sikhote-Alin) – fragments of Early Cretaceous Asia continental margin. *Tikhookeanskaya Geologiya*, vol. 14, no. 2, p. 13–26. (in Russian)
- Gorican, S., 1994: Jurassic and Cretaceous radiolarian biostratigraphy and sedimentary evolution of the Budva Zone (Dinarides, Montenegro). *Mémoires de Géologie (Lausanne)*, no. 18, p. 1–177.
- Haeckel, E., 1881: Entwurf eines Radiolarien-Systems auf Grund von Studien der Challenger-Radiolarien. *Jenaische Zeitschrift für Naturwissenschaft*, vol. 15, p. 418–472.
- Hori, N., 1998: Latest Jurassic radiolarians from the Odaira area in the Torinoko Block, Yamizo Mountains, and its paleobiogeographic significance – a consideration on the spatio-temporal distribution of the *Vallupus* territory –. *Journal of the Geological Society of Japan*, vol. 104, no. 4, p. 233–242. (in Japanese with English abstract)
- Hori, N., 1999: Latest Jurassic radiolarians from the northeastern part of the Torinoko Block, Yamizo Mountains, central Japan. *Science Reports of the Institute of Geoscience, University of Tsukuba, Section B (Geological Sciences)*, vol. 20, p. 47–114.
- Ishida, K., 1983: Stratigraphy and radiolarian assemblages of the Triassic and Jurassic siliceous sedimentary rocks in Konose Valley, Tokushima Prefecture, Southwest Japan. – Studies of the South Zone of the Chichibu Belt in Shikoku, Part IV –. *Journal of Science, University of Tokushima*, vol. 16, p. 111–141. (in Japanese with English abstract)
- Ishida, K., 1985: Radiolarian and conodont ages of the sedimentary bodies and their spatial arrangement in the South Zone of the Chichibu Belt in Tokushima Prefecture. – Studies of the South Zone of the Chichibu Belt in Shikoku, Part V –. *Journal of Science, University of Tokushima*, vol. 18, p. 27–81. (in Japanese with English abstract)
- Ishida, K. and Hashimoto, H., 1991: Radiolarian assemblages from the Lower Cretaceous formations of the Chichibu Terrane in eastern Shikoku and their ammonite ages. *Journal of Science, University of Tokushima*, vol. 25, p. 23–67. (in Japanese with English abstract)
- Ishida, K. and Hashimoto, H., 1997: Mesozoic and Paleozoic radiolarians from the chert pebbles and fine clastics of the Ryoseki and Monobegawa Groups in East Shikoku. In Yao, A. ed., *Proceedings of the Fifth Radiolarian Symposium. News of Osaka Micropaleontologists, Special Volume*, no. 10, p. 217–235. (in Japanese with English abstract)
- Jud, R., 1994: Biochronology and systematics of Early Cretaceous Radiolaria of the western Tethys. *Mémoires de Géologie (Lausanne)*, no. 19, p. 1–147.
- Kashiwagi, K. and Yao, A., 1993: Jurassic to Early Cretaceous radiolarians from the Yuasa area in western Kii Peninsula, Southwest Japan and its significance. In Aita, Y., Ishiga, H., Kito, N., Kuwahara, K., Matsuoka, A., Nishimura, A., Sakai, T., Sashida, K. and Sugano, K. eds., *Proceedings of the Fourth Radiolarian Symposium. News of Osaka Micropaleontologists, Special Volume*, no. 9, p. 177–189. (in Japanese with English abstract)
- Kato, Y. and Iwata, K., 1989: Radiolarian biostratigraphic study of the pre-Tertiary system around the Kamikawa Basin, central Hokkaido, Japan. *Journal of the Faculty of Science, Hokkaido University, Series 4 (Geology and Mineralogy)*, vol. 22, no. 3, p. 425–452.
- Kawabata, K., 1988: New species of latest Jurassic and earliest Cretaceous radiolarians from the Sorachi Group in Hokkaido, Japan. *Bulletin of the Osaka Museum of Natural History*, no. 43, p. 1–13.
- Kemkin, I.V., 1996a: New data on the geology and age of the Koreyskaya River area (South Sikhote-Alin). *The Island Arc*, vol. 5, p. 130–139.
- Kemkin, I.V., 1996b: Tectono-stratigraphy of the Perekatnaya-Chernaya Rivers area (southern Sikhote-Alin). *Stratigraphy and Geological Correlation*, vol. 4, no. 2, p. 91–101.
- Kemkin, I.V., Kametaka, M. and Kojima, S., 1999: Radiolarian biostratigraphy for transitional facies of chert-clastic sequence of the Taukha terrane in the Koreyskaya River area, Southern Sikhote-Alin, Russia. *Journal of Earth and Planetary Sciences, Nagoya University*, vol. 46, p. 29–47.
- Kemkin, I.V. and Kemkina, R.A., 1998: Jurassic-Early Cretaceous biostratigraphy of chert-terigenous deposits of Dalnegorsk Ores district (South Sikhote-Alin). *Tikhookeanskaya Geologiya*, vol. 17, no. 1, p. 59–76. (in Russian)
- Kemkin, I.V. and Kemkina, R.A., 1999: Radiolarian biostratigraphy of the Jurassic-Early Cretaceous chert-clastic sequence in the Taukha Terrane (South Sikhote-Alin, Russia). *Geodiversitas*, vol. 21, no. 4, p. 675–685.
- Kemkin, I.V. and Kemkina, R.A., 2000: Taukha terrane of Southern Sikhote-Alin: structure and conditions of formation. *Geotectonika*, no. 5, p. 71–79. (in Russian).
- Kemkin, I.V. and Khanchuk, A.I., 1994: First data on the Early Cretaceous accretionary complex in the Chernaya River basin, Southern Sikhote-Alin. *Geology of the Pacific Ocean*, vol. 10, p. 183–188.
- Kemkin, I.V. and Rudenko, V.S., 1993: New representatives of *Cinguloturris* genus (radiolarians) in the Mesozoic deposits of the Sikhote-Alin. *Tikhookeanskaya Geologiya*, no. 6, p. 110–121. (in Russian)
- Kemkin, I.V. and Rudenko, V.S., 1994: New species of the *Cinguloturris* (radiolarians) genus in the Sikhote-Alin Mesozoic deposits. *Geology of the Pacific Ocean*, vol. 10, p. 1115–1128.
- Kemkin, I.V., Rudenko, V.S. and Kojima, S., 1992: Early Cretaceous radiolarians from the Chernaya River area, southern Sikhote-Alin. *Bulletin of Nagoya University, Furukawa Museum*, no. 8, p. 27–35.
- Kemkin, I.V., Rudenko, V.S. and Taketani, Y., 1997: Some Jurassic and Early Cretaceous radiolarians from chert-terigenous sequence of the Taukha Terrane, southern Sikhote-Alin. *Memoirs of the Geological Society of Japan*, no. 48, p. 163–175.
- Kishida, Y. and Hisada, K., 1986: Radiolarian assemblages of the Sambosan Belt in the western part of the Kanto Mountains, central Japan. In Ichikawa, K. ed., *Recent progress of research on radiolarians and radiolarian terranes of Japan. News of Osaka Micropaleontologists, Special Volume*, no. 7, p. 25–34. (in Japanese with English abstract)
- Kurimoto, C., 1989: Microfossils from the Gozaishoyama dis-

- trict in the southwestern part of the Mino Terrane, central Japan. *Bulletin of the Geological Survey of Japan*, vol. 40, no. 2, p. 55–64. (in Japanese with English abstract)
- Matsuoka, A., 1986: *Tricolocapsa yaoi* Assemblage (Late Jurassic radiolarians) from the Togano Group in Shikoku, Southwest Japan. *Journal of Geosciences, Osaka City University*, vol. 29, art. 4, p. 101–115.
- Matsuoka, A., 1992: Jurassic and Early Cretaceous radiolarians from Leg. 129, Sites 800 and 801, western Pacific Ocean. In Larson, R. L., Lancelot, Y. et al., *Proceedings of the Ocean Drilling Program, Scientific Results*, vol. 129, p. 203–220. College Station, TX (Ocean Drilling Program).
- Matsuoka, A., 1995: Jurassic and Lower Cretaceous radiolarian zonation in Japan and in the western Pacific. *The Island Arc*, vol. 4, p. 140–153.
- Matsuoka, A. and Oji, T., 1990: Middle Jurassic radiolarian fossils from the Magisawa Formation in the Taro Belt, North Kitakami Mountains. *Journal of the Geological Society of Japan*, vol. 96, no. 3, p. 239–241. (in Japanese)
- Matsuoka, A., Yang, Q., Kobayashi, K., Takei, M., Nagahashi, T., Zeng, Q. and Wang, Y., 2002: Jurassic-Cretaceous radiolarian biostratigraphy and sedimentary environments of the Ceno-Tethys: records from the Xialu Chert in the Yarlung-Zangbo Suture Zone, southern Tibet. *Journal of Asian Earth Sciences*, vol. 20, p. 277–287.
- Matsuoka, A. and Yao, A., 1985: Latest Jurassic radiolarians from the Torinosu Group in Southwest Japan. *Journal of Geosciences, Osaka City University*, vol. 28, art. 5, p. 125–145.
- Matsuoka, A. and Yao, A., 1986: A newly proposed radiolarian zonation for the Jurassic of Japan. *Marine Micropaleontology*, vol. 11, nos. 1–3, p. 91–106.
- Mizutani, S., 1981: A Jurassic formation in the Hida-Kanayama area, Central Japan. *Bulletin of the Mizunami Fossil Museum*, no. 8, p. 147–190.
- Nishizono, Y., Sato, T. and Murata, M., 1997: A revised radiolarian zonation for the South Belt of the Chichibu terrane, western Kyushu, Southwest Japan. *Marine Micropaleontology*, vol. 30, nos. 1–3, p. 117–138.
- Ohba, H. and Adachi, M., 1995: Permian, Triassic and Jurassic radiolarians from Omura and Ogura Islands in the eastern part of the Shima Peninsula, Southwest Japan. *Journal of Earth and Planetary Sciences, Nagoya University*, vol. 42, p. 55–67.
- Pessagno, E. A., Jr., 1977: Upper Jurassic Radiolaria and radiolarian biostratigraphy of the California Coast Ranges. *Micropaleontology*, vol. 23, no. 1, p. 56–113.
- Rüst, D., 1885: Beiträge zur Kenntniss der fossilen Radiolarien aus Gesteinen des Jura. *Palaeontographica*, vol. 31, ser. 3, p. 269–321.
- Sashida, K., Igo, H. and Sato, T., 1993: Late Jurassic radiolarians from the Yamizo Mountains. *Annual Report of the Institute of Geoscience, University of Tsukuba*, no. 19, p. 33–42.
- Sashida, K. and Uematsu, H., 1996: Late Jurassic radiolarians from the Torinosu-type limestone embedded in the Early Cretaceous Hinodani Formation of the northern Shimanto Terrane, Shikoku, Japan. *Science Reports of the Institute of Geoscience, University of Tsukuba, Section B (Geological Sciences)*, vol. 17, p. 39–69.
- Shen, G., Ujiie, H. and Sashida, K., 1996: Off-scraped Permian-Jurassic bedded chert thrust on Jurassic-early Cretaceous accretionary prism: Radiolarian evidence from Ie Island, central Ryukyu Island Arc. *The Island Arc*, vol. 5, p. 156–165.
- Takashima, R., Suzuki, N., Koike, T. and Saito, T., 1997: Reexamination of the unconformity proposed at the boundary between the Lower and Middle Yezo Groups in the Soshubetsu area, Hokkaido, and its geological significance – reevaluation of the intra-Yezo disturbance –. *Journal of the Geological Society of Japan*, vol. 103, no. 5, p. 489–492. (in Japanese)
- Tamba Belt Research Group, 1990: Paleozoic and Mesozoic systems in the Tamba Belt (Part 7) – The Type I Suite in the southern part of Natasho Village, Onyu-gun, Fukui Prefecture –. *Earth Science (Chikyū Kagaku)*, vol. 44, no. 2, p. 77–90. (in Japanese with English abstract)
- Tanaka, H., Fujita, H., Miyamoto, T. and Hase, A., 1985: Late Jurassic radiolarian fossils from the Shinkai Formation developed to the south of Mt. Haidate, Oita Prefecture, Kyushu. *Journal of the Geological Society of Japan*, vol. 91, no. 8, p. 569–571. (in Japanese)
- Volokhin, Y. G., Burii, G. I., Rudenko, V. S. and Filippov, A. N., 1990: Triassic cherty formation of the South Sikhote-Alin. *Izvestiya Akademii Nauk SSSR, Geologicheskaya Seriya*, no. 4, p. 45–57. (in Russian)
- Wakita, K., 1987: The occurrence of Latest Jurassic-Earliest Cretaceous radiolarians at the Hida-Kanayama area in the Mino Terrane, central Japan. *Journal of the Geological Society of Japan*, vol. 93, no. 6, p. 441–443. (in Japanese)
- Wakita, K., 1988: Early Cretaceous melange in the Hida-Kanayama area, central Japan. *Bulletin of the Geological Survey of Japan*, vol. 39, no. 6, p. 367–421.
- Yamamoto, H., 1983: Occurrence of late Jurassic radiolarians of the *Mirifusus baileyi* Assemblage from Neo Village, Gifu Prefecture, central Japan. *Journal of the Geological Society of Japan*, vol. 89, no. 10, p. 595–596. (in Japanese)
- Yang, Q. and Matsuoka, A., 1997: A composition study on Upper Jurassic radiolarian biostratigraphy of the Taman Formation, east-central Mexico and the ODP Site 801B Section, west Pacific. *Science Reports of Niigata University, Series E (Geology and Mineralogy)*, no. 12, p. 29–49.
- Yao, A., 1984: Subdivision of the Mesozoic complex in Kii-Yura area, southwest Japan and its bearing on the Mesozoic basin development in the southern Chichibu terrane. *Journal of Geosciences, Osaka City University*, vol. 27, art. 2, p. 41–103.
- Yao, A., 1990: Triassic and Jurassic radiolarians. In Ichikawa, K., Mizutani, S., Hara, I., Hada, S. and Yao, A., eds., *Pre-Cretaceous Terranes of Japan*, p. 329–345. IGCP Project no. 224.
- Yasuda, M., 1989: Equivalents to the Torinosu Group of the Chichibu Belt in the southeastern part of the Kanto Mountains, central Japan – lithology and radiolarian biostratigraphy –. *Journal of the Geological Society of Japan*, vol. 95, no. 6, p. 463–478. (in Japanese with English abstract)
- Zyabrev, S. and Matsuoka, A., 1999: Late Jurassic (Tithonian) radiolarians from a clastic unit of the Khabarovsk complex (Russian Far East): Significance for subduction accretion timing and terrane correlation. *The Island Arc*, vol. 8, p. 30–37.