

## **Radiolarian biostratigraphy for transitional facies of chert-clastic sequence of the Taukha terrane in the Koreyskaya River area, Southern Sikhote-Alin, Russia**

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### **ABSTRACT**

Radiolarian biostratigraphic research is done for chert-clastic sequence of the Taukha terrane in the Koreyskaya River area, Far East Russia. Three successive radiolarian assemblages have been distinguished from the lower thrust sheet of the Gorbousha unit; they are the *Xitus gifuensis*, *Stichomitra doliolum* and *Pseudodictyomitra carpatica* assemblages in ascending order. The lower two assemblages are extracted from the cherty part of the section, and the youngest one is from siliceous mudstone and black mudstone. The transitional facies of chert-clastic sequence in the sheet is late Late Tithonian in age. This age is different from that in the second thrust sheet of the Dalnegorsk area which is Late Kimmeridgian to Middle Tithonian. Therefore the approach of the Gorbousha unit-bearing oceanic plate to the subduction zone ranges in age, at least, from Late Kimmeridgian to Berriasian. The difference of age in two different thrust sheets possibly indicates that the duplication of chert-clastic sequences in the Gorbousha unit resulted from successive accretion of oceanic plate.

### **INTRODUCTION**

The Taukha terrane is a fragment of the Early Cretaceous accretionary prism located in the southeastern part of the Sikhote-Alin accretionary system (Fig. 1). It is separated by faults from the Samarka and Zhouravlevka terranes. The Taukha terrane consists of three thrust-bounded tectono-stratigraphic units (called here Erdagou, Gorbousha and Skalistorechenka units in structurally ascending order) which are similar in lithology and structure, but dissimilar in age (Fig. 1). Each unit is composed of chert, limestone, clastic rocks and olistostrome. The chert and limestone gradually change upward into clastic rocks which are accumulated at continental margin, and then the clastic rocks gradually change upward into olistostrome. The olistostromes divide each tectono-stratigraphic unit, and they contain lumps and blocks of chert, limestone and clastic rocks derived from the overlying unit; age of the olistostrome possibly constrains the time of accretion of each unit. According to the youngest age of each unit, the Erdagou unit is youngest and Skalistorechenka unit is oldest. The

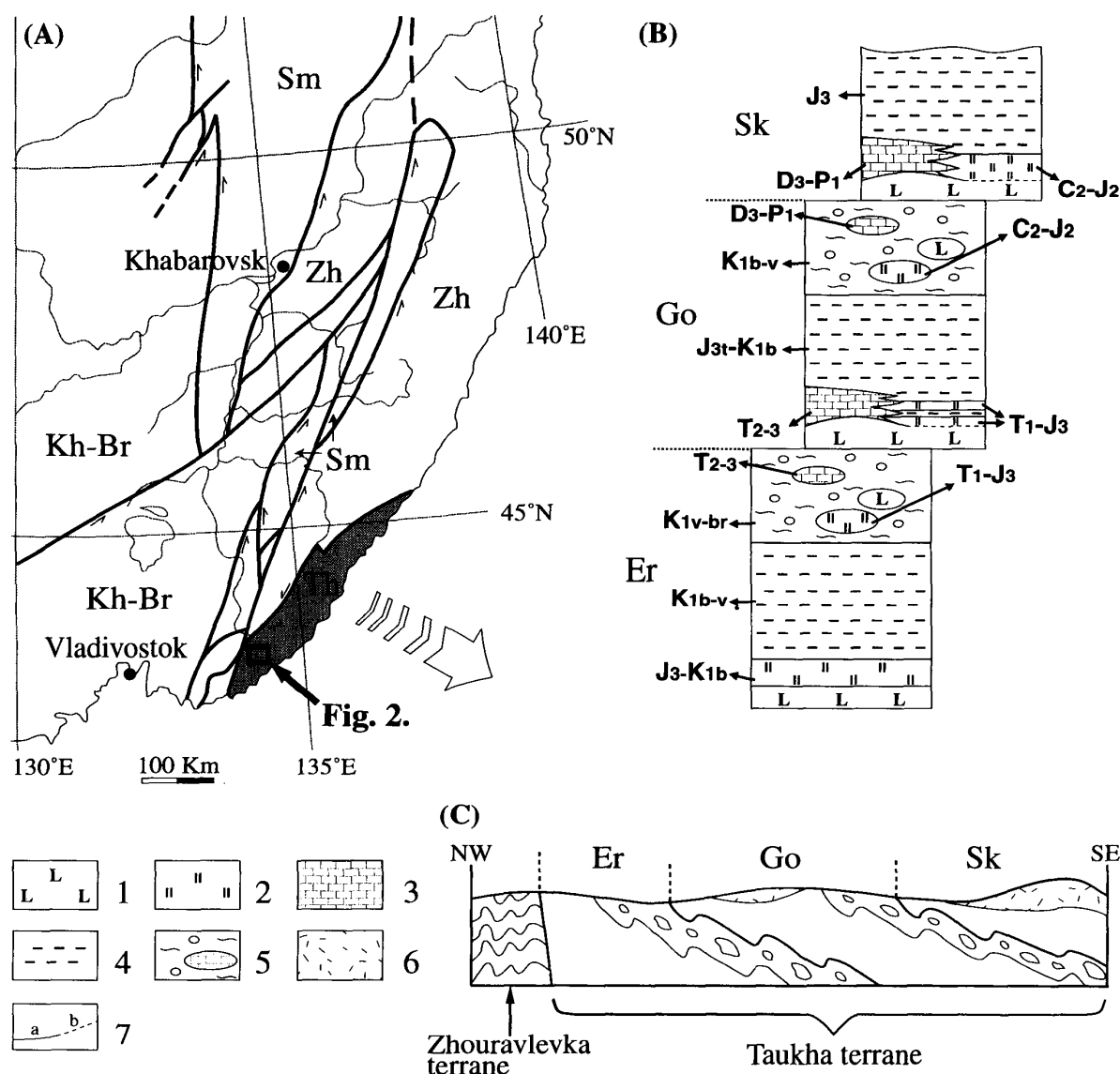


Fig. 1. Tectonic map of the Sikhote-Alin region (A), tectonostratigraphic column (B) and generalized cross-section (C) of the Taukha terrane (after Kemkin and Kemkina, 1999). Kh-Br: Khanka-Bureya superterrane, Sm: Samarka terrane, Zh: Zhouravlevka terrane, Th: Taukha terrane, Er: Erdagou unit, Go: Gorbousha unit, Sk: Skalistorechenka unit. 1: basalt, 2: chert, 3: limestone, 4: turbidite, 5: olistostrome, 6: volcanic rock (Late Cretaceous), 7: character of contact between the lithology; conformable (a) and estimated (b).

Erdagou unit, however, is located at the structurally lowermost part of the Taukha terrane, and the Skalistorechenka unit is at the uppermost part (see Fig. 1).

The Erdagou unit is composed of Middle Jurassic (Callovia) basalt, Late Jurassic to Early Cretaceous (Berriasian) chert and clayey chert (Erdagou suite), and Berriasian to Valanginian turbidite (Silinka suite). The thickness of chert and basalt is about 150 m, whereas that of turbidite is estimated to be 2,500 m (Golozubov and Khanchuk, 1995); the turbidite formations might be tectonically duplicated several times. Gradual change from the chert through siliceous mudstone, mudstone to turbidite is observed

in several localities. The Valanginian to Barremian olistostrome also conformably covers the turbidite. Thickness of the olistostrome varies from 100 to 400 m.

The Gorbousha unit is composed of Middle to Late Triassic limestone (Tetyukha suite) with basal high-titanium alkaline basalt (400 to 500 m in thickness), and Early Triassic to Late Jurassic chert and clayey chert (about 100 m) which gradually change into the Late Tithonian to Berriasian turbidite (Gorbousha suite) and then changes into the Berriasian to Valanginian olistostrome. Thickness of the turbidite formation ranges from 350 to 700 m (Volkhin et al., 1990; Bragin, 1991), whereas that of the olistostrome varies from 100 to 400 m.

The Skalistorechenka unit is composed of Late Devonian to Late Permian limestone (Skalistorechenka suite) associated with high-titanium alkaline basalt (about 400 m) and Carboniferous to Middle Jurassic chert overlapped by Late Jurassic turbidite (Pantovyi Creek suite). The thickness of chert and turbidite is not clear, because they are only fragmentarily exposed.

It should be noted that the Gorbousha unit is characterized by several-times duplications of chert-clastic sequences in a single section, forming piled thrust sheets with same lithostratigraphic sequence. Four-times duplications of chert-clastic sequences are commonly observed in several areas of the Taukha terrane (Volkhin et al., 1990; Bragin, 1991; Golozubov et al., 1992; Kemkin et al., 1997; Kemkin and Kemkina, 1998). The detailed age of each thrust sheet is, however, not yet known, and it makes difficult to understand the internal structure of the Taukha terrane. In this paper, the thrust sheets are called Slice 1 to Slice 4 in structurally ascending order, and we focus the radiolarian age of transitional facies of chert-clastic sequences. Lithological change from chert to overlying siliceous mudstone indicates the pelagic to hemipelagic environmental change and landward approach of the oceanic plate (Matsuda and Isozaki, 1991). The age of siliceous mudstone of the chert-clastic sequences is regarded as the key for comparison of different accretionary complexes (Matsuoka, 1994) and different units in a single accretionary complex (Wakita, 1988; Matsuoka et al., 1998). It also makes clear the age trend in a single unit of an accretionary complex (Matsuoka, 1984). Recently we have done the detailed radiolarian biostratigraphic research for transitional facies of chert-clastic sequence in the Koreyskaya River area, and we present the results of the research in this paper.

## REGIONAL GEOLOGICAL SETTING

In the Koreyskaya River area, the Taukha terrane is composed of three different rock units: Erdagou unit, Gorbousha unit and Taukha suite (Fig. 2; Kemkin, 1996).

The structurally lowermost unit is composed of olistostrome. According to the ages and composition of olistoliths described below, this olistostrome is regarded as the uppermost part of the Erdagou unit. This olistostrome is a chaotic formation which is composed of lumps and blocks of different lithologies and ages embedded in a siltstone and shale matrix. The size of olistoliths varies from several millimeters to several tens of meters. The olistoliths show diverse shapes from isometric, elongated, lens-like to irregular. In some cases the amount of olistoliths makes up 35–40 % of total rock volume. Late Permian limestone, Triassic sandstone and siltstone, Triassic

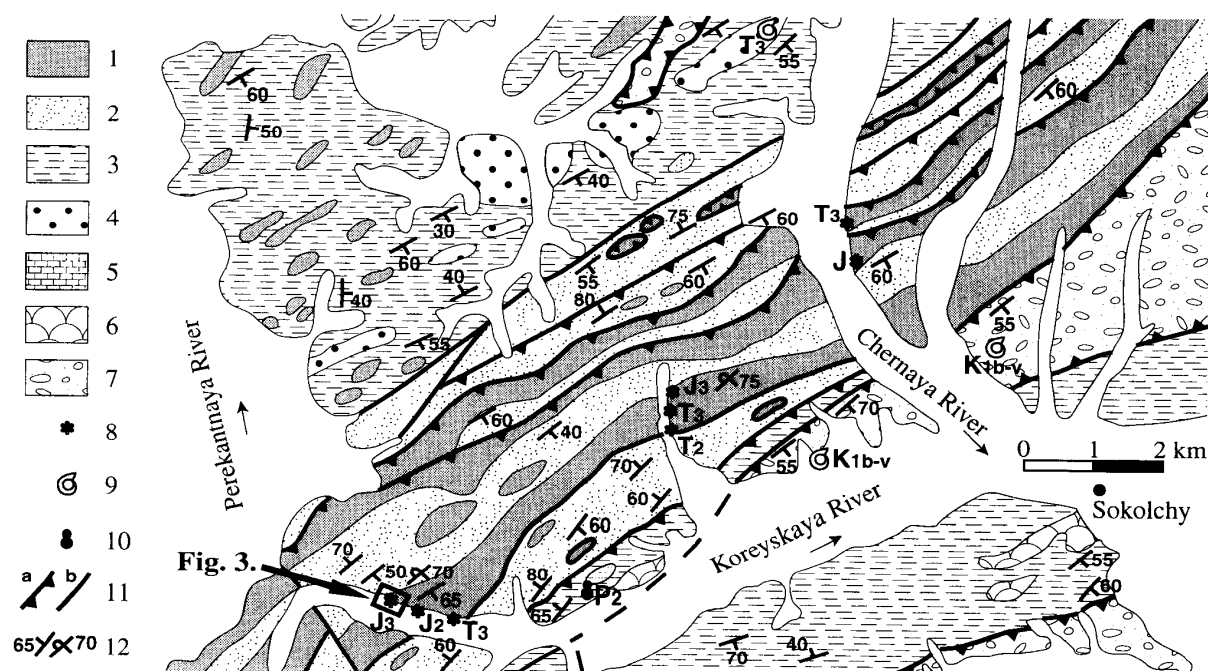


Fig. 2. Geological map of the Koreyskaya River area.  
 1: Triassic – Jurassic chert and clayey chert, 2: late Late Tithonian – Early Cretaceous (Berriasian ?) turbidite, 3: Valanginian – Barremian olistostrome, 4: Triassic sandstone and siltstone, 5: Permian limestone, 6: basalt, 7: Berriasian – Valanginian conglomerate, sandstone and siltstone, 8-10: locality of fossils (8: radiolarians, 9: macrofauna, 10: foraminifera), 11: faults; thrust (a) and strike-slip fault (b), 12: strike and dip of strata; normal (left) and overturned (right).

and Jurassic chert, Late Jurassic siliceous mudstone, Early Cretaceous (?) siltstone and sandstone, and basalt of unknown age were distinguished as the olistoliths (Kemkin, 1996). The matrix of olistostrome is slightly sorted siltstone. Thickness of the olistostrome varies from 10 to 200 m.

The olistostrome is tectonically overlain by chert-clastic sequences belonging to the Gorbousha unit. In the Koreyskaya River area the chert-clastic sequences of the Gorbousha unit are duplicated twice, although four times duplications are observed in other areas of the Taukha terrane. Lower part of these slices is composed of red to yellowish-red and greenish-gray bedded chert and clayey chert. The bedded chert formation is composed of chert beds which vary in thickness from 1.5 to 5 cm, rarely to 10 cm, and thin (1–3 mm) clay beds between the chert. Disharmonic small-scale folds and microfaults are developed in the chert formations. The total thickness of a complete chert formation is about 100 m, although same formations repeatedly exposed three to five times (Kemkin et al., 1997; Kametaka et al., 1997). The chert formation conformably and gradually changes into clastic rocks. Siliceous mudstone lies immediately on the chert, and it changes into thin flat-bedded siltstone. The siltstone is covered with alternating beds of siltstone and sandstone, then they are covered with massive medium- to coarse-grained sandstone. Thickness of the clastic rocks is 300–350 m. According to the radiolarian fossils, the chert is Early Triassic to Late Jurassic in age, and the clastic rocks are late Late Tithonian to Berriasian (Kemkin,

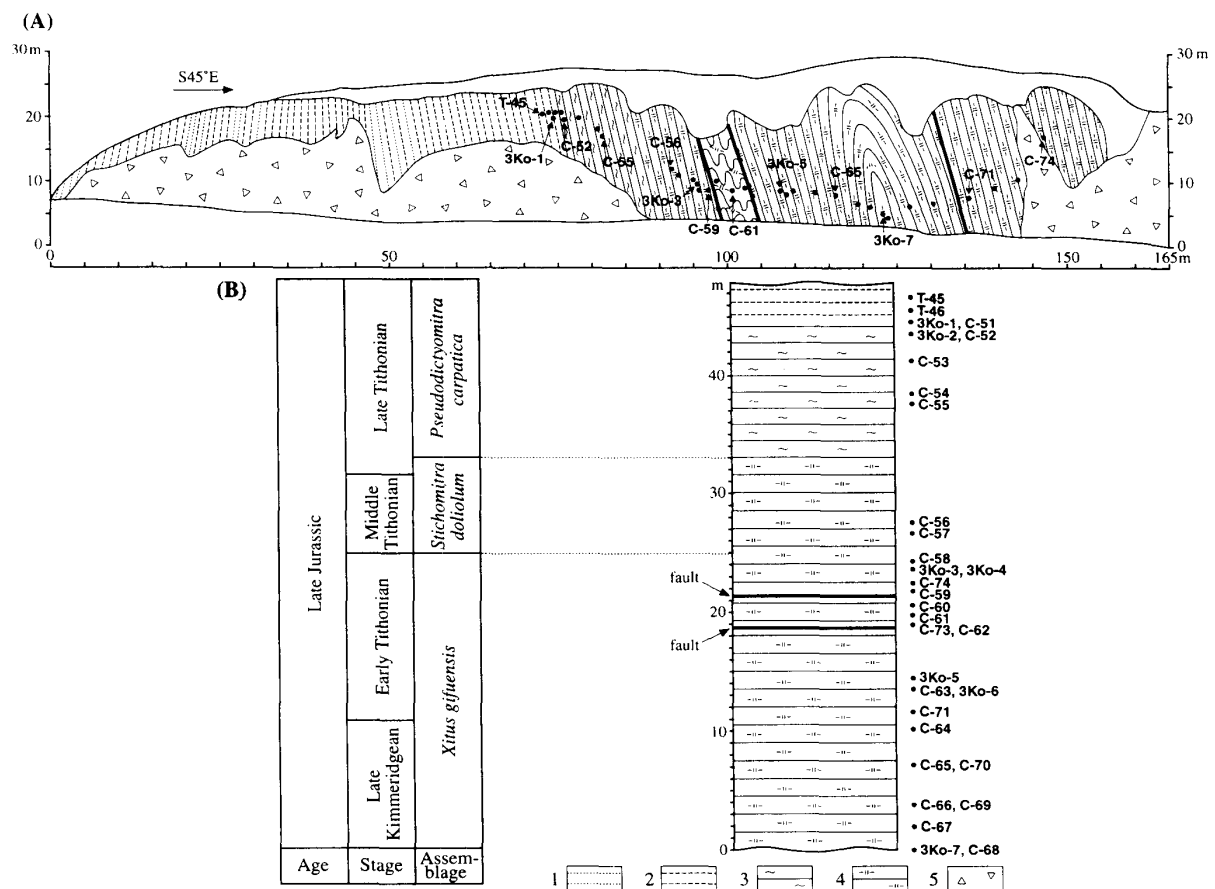


Fig. 3. Sketch map of bank outcrop along the Koreyskaya River (A) and stratigraphic column with allocated radiolarian assemblages (B).

1996; Kametaka et al., 1997).

The Berriasian to Valanginian clastic rocks (Taukha suite) are thrust over the Erdagou and Gorbousha units. The Taukha suite is composed of thinly bedded, fine- to coarse-grained sandstone and siltstone, with interlayers of conglomerate in the lower part. The Taukha suite yields abundant Berriasian to Valanginian flora and fauna (Bersenev 1969). We compare this formation to forearc basin sediments deposited under shallow-marine (shelf) conditions synchronously with the trench-fill turbidite of the Gorbousha unit.

## RADIOLARIAN ASSEMBLAGES

Detailed biostratigraphic research for the transitional facies of the chert-clastic sequence in Slice 1 was carried out on the exposure along the left bank of the Koreyskaya River (Fig. 3). In this exposure the chert-clastic sequence is folded to form an overturned anticline having NE-SW trending axis. The folded formations have NE-SW strike dipping to SE. The results of radiolarian studies show that the uppermost cherty layer (greenish gray clayey chert), siliceous mudstone (also greenish-gray in color) and lowermost clastic layer (black mudstone) are Late Jurassic in age, and three successive radiolarian assemblages have been distinguished (see Table 1 and



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Figs. 4–6). The lower two assemblages are extracted from the cherty part of the section, and the last one is found from the siliceous mudstone and black mudstone. Brief descriptions of the radiolarian assemblages are given below in ascending order.

### 1. *Xitus gifuensis* assemblage

Radiolarians of the *Xitus gifuensis* assemblage are extracted from the greenish gray clayey chert (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 and C-74). This assemblage contains well-preserved radiolarian fauna which is characterized by rich species diversity (Fig. 4 and Table 1); they are *Archaeodictyomitra*, *Cinguloturris*, *Hsuum*, *Parvicingula*, *Pseudodictyomitra*, *Sethocapsa*, *Spongocapsula*, *Stichocapsa*, *Stichomitra*, *Thanarla*, *Xitus*, *Wrangellium* and others. The age range of this assemblage is assumed to be Late Kimmeridgian to Early Tithonian. The lower boundary of this assemblage zone corresponds to the first appearance of *Xitus gifuensis* Mizutani, *Archaeodictyomitra excellens* (Tan), *Obesacapsula verbana* (Parona) and *Sethocapsa horokanaiensis* Kawabata (Mizutani, 1981; Kawabata, 1988; Baumgartner et al., 1995). The upper boundary is restricted by the last appearance of such species as *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo), *Parvicingula dhimenaensis* Baumgartner, *Sethocapsa funatoensis* Aita, *Wrangellium okamurai* (Mizutani), *Triactoma blakei* (Pessagno), *Tritrabs exotica* (Pessagno). This boundary corresponds to the Early Tithonian (Pessagno, 1977; Mizutani, 1981; Aita, 1987; Baumgartner et al., 1995). This assemblage is correlated with the upper part of the *Hsuum maxwelli* zone, and the lower part of the *Pseudodictyomitra primitiva* zone (Matsuoka, 1995). It should be noted that this assemblage contains *Stichocapsa altiforamina* Tumanda which was reported from the Valanginian to Barremian formation of the Esashi Mountain area, Hokkaido, Japan (Tumanda, 1989). This new finding allows us to extend the biostratigraphic range of this species down to, at least, the Late Kimmeridgian.

### 2. *Stichomitra doliolum* assemblage

Radiolarians of the *Stichomitra doliolum* assemblage are found in the greenish gray clayey chert (samples C-56). The assemblage is represented by numerous and diverse well-preserved radiolarians characteristic to the end of Jurassic and beginning of Cretaceous time (Fig. 5 and Table 1). Nassellarians such as *Pseudodictyomitra*, *Cinguloturris*, *Parvicingula*, *Archaeodictyomitra*, *Xitus*, *Thanarla*, *Stichocapsa*, *Stichomitra*, *Sethocapsa* are predominant. Spumellarians such as *Tritrabs* and *Emiluvia* are also contained. The range of this assemblage zone is Middle Tithonian to early Late Tithonian. The lower boundary is defined by the extinction of characteristic species of Early Tithonian age (see *Xitus gifuensis* assemblage) and the first appearance of *Stichomitra doliolum* Aita which was described from the Middle Tithonian formation of the Irazu Mountain area, Shikoku, Japan by Aita and Okada (1986). The upper boundary is defined by the lower boundary of the overlying *Pseudodictyomitra carpatica* assemblage, as well as the last appearance of *Ristola altissima* (Rüst) which corresponds to the early Late Tithonian (Baumgartner et al., 1995). This assemblage is correlated with the upper part of the *Pseudodictyomitra primitiva* zone (Matsuoka, 1995). This assemblage also contains *Stichocapsa altiforamina* Tumanda.



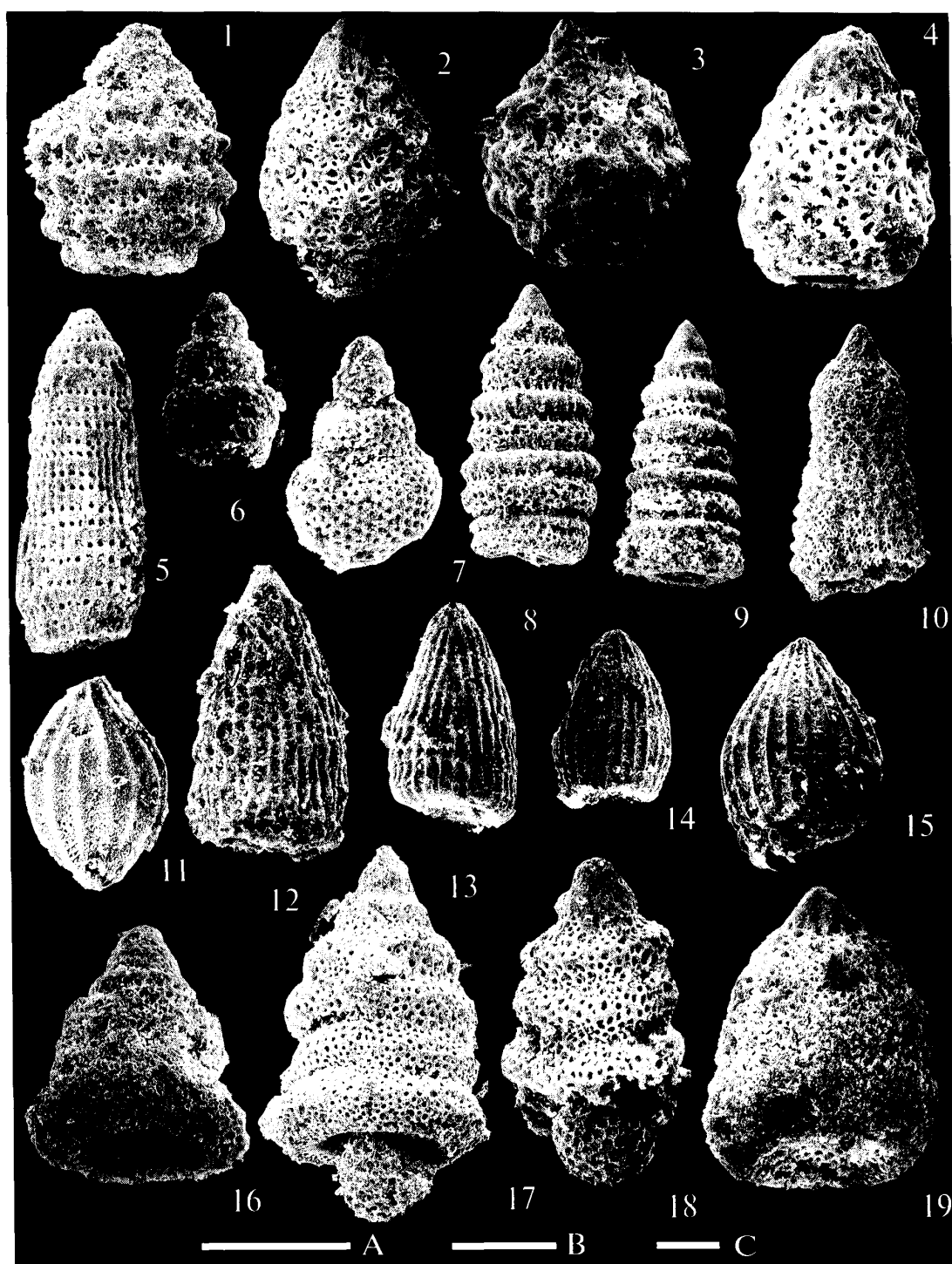


Fig. 4. Scanning electron photomicrographs of radiolarians of the *Xitus gifuensis* assemblage (Late Kimmeridgian – Early Tithonian). All scale bars indicate 100  $\mu$ m. A: 1, 3-7, 11-15, 21, 22, 24-33, 36-40, 43-45, 47-57, 59. B: 2, 8, 9, 16-20, 23, 42, 46, 58. C: 10, 34, 35, 41. 1-3. *Xitus gifuensis* Mizutani (1 – C-74; 2, 3 – C-69). 4. *Xitus* aff. *gifuensis* Mizutani (C-58). 5. *Archaeodictyomitra excellens* (Tan) (C-61). 6. *Obesacapsula verbana* (Parona) (C-63). 7. *Sethocapsa horokanaiensis* Kawabata (C-61). 8-9. *Cinguloturris cylindra* Kemkin and Rudenko (C-58). 10. *Ristola altissima* (Rüst) (C-69). 11. *Protunuma japonicus* Matsuoka and Yao (C-58). 12-13. *Archaeodictyomitra* ex gr. *vulgaris* Pessagno (12 – C-58; 13 – C-69). 14-15. *Thanarla brouweri* (Tan) (14 – C-58; 15 – C-63). 16-18. *Spongocapsula perampla* (Rüst) (16 – C-58; 17 – C-74; 18 – C-58). 19. *Spongocapsula obesa* Jud (C-64).

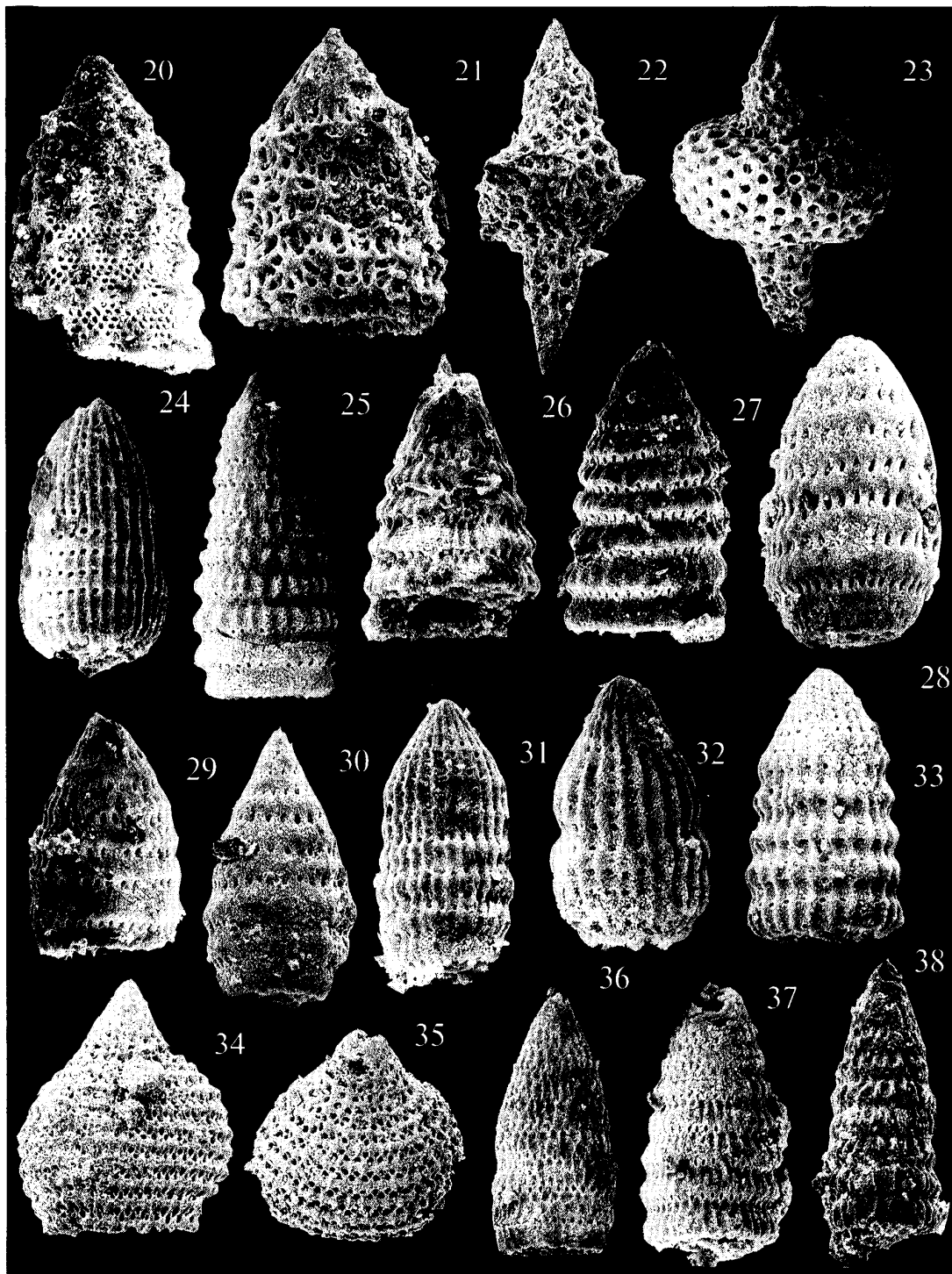


Fig. 4. (continued). 20. *Xitus spicularius* (Aliev) (C-58). 21. *Xitus* cf. *plenus* Pessagno (C-63). 22. *Podobursa* aff. *triacantha* (Fischli) (C-58). 23. *Podobursa triacantha* (Fischli) (C-69). 24. *Archaeodictyomitra apiarium* (Rüst) (C-69). 25-27. *Pseudodictyomitra* ex gr. *leptoconica* (Foreman) (25 – C-58; 26-27 – C-63). 28-30. *Pseudodictyomitra* ex gr. *nuda* Schaaf (28-29 – C-63; 30 – C-69). 31-33. *Archaeodictyomitra minoensis* (Mizutani) (31, 33 – C-58; 32 – C-63). 34-35. *Mirifusus diana minor* Baumgartner (34 – C-74; 35 – C-71). 36-37. *Pseudodictyomitra primitiva* Matsuoka and Yao (36 – C-68; 37 – C-61). 38. *Pseudodictyomitra lodogaensis* Pessagno (C-63).

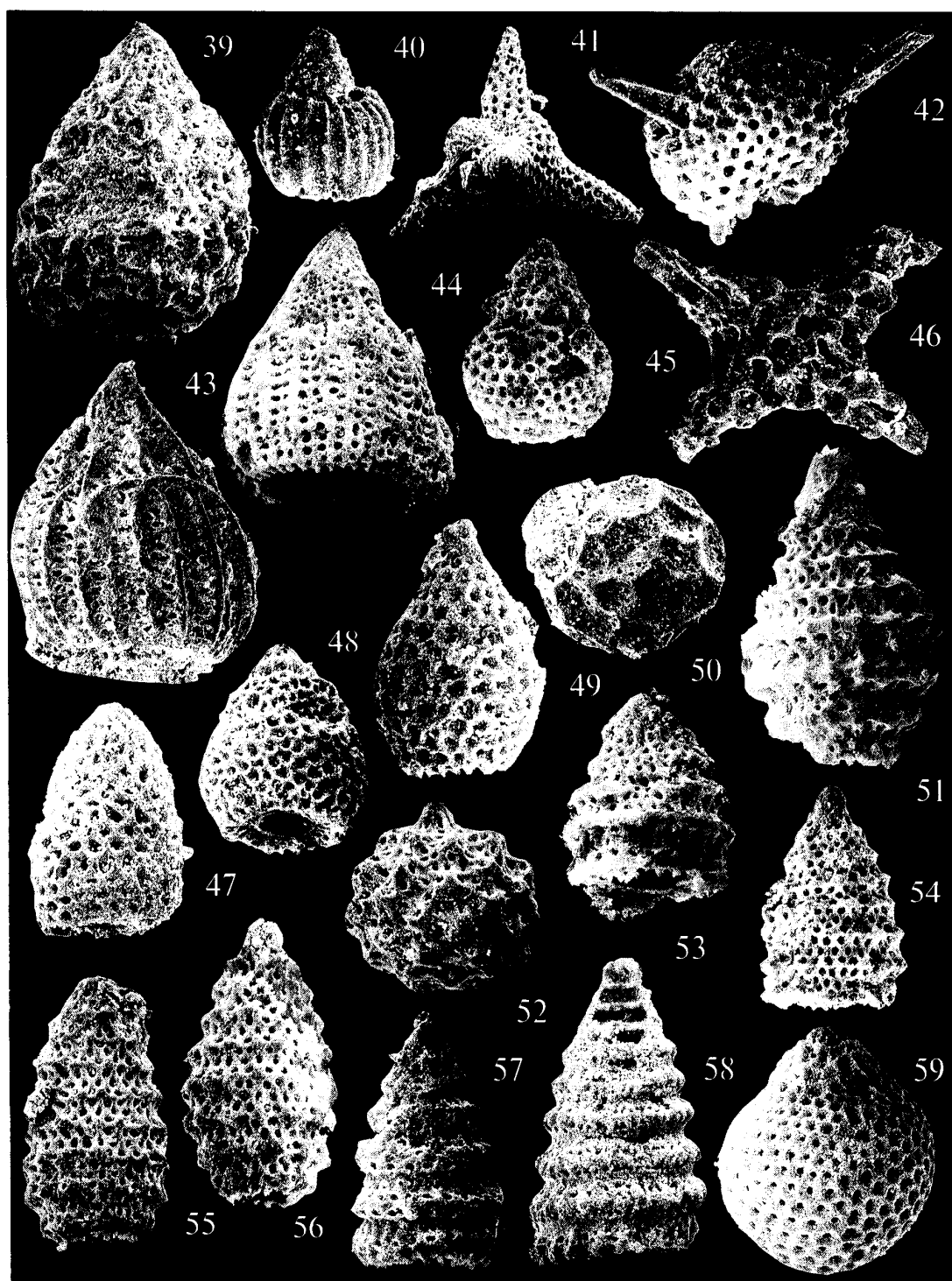


Fig. 4. (continued). 39. *Stichocapsa altiforamina* Tumanda (C-69). 40. *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) (C-68). 41. *Podocapsa amphitreptera* Foreman (C-58). 42. *Triactoma blakei* (Pessagno) (C-69). 43. *Hsuum* sp. nov. (C-70). 44. *Nassellaria* gen. et. sp. indet. (C-69). 45. *Sethocapsa subcrassitestata* Aita (C-58). 46. *Emiluvia* sp. (C-58). 47. *Stichomitra* ex gr. *mediocris* (Tan) (C-74). 48. *Stichomitra japonica* (Nakaseko and Nishimura) (C-58). 49. *Stichocapsa* ex gr. *cribata* Hinde (C-69). 50. *Williriedellum crystallinum* Dumitrica (C-58). 51. *Parvicingula mashitaensis* Mizutani (C-69). 52. *Sethocapsa funatoensis* Aita (C-58). 53. *Parvicingula boesii* gr. (Parona) (C-68). 54-56. *Parvicingula dhimenaensis* Baumgartner (54, 56 – C-69; 55 – C-58). 57-58. *Wrangellium okamurai* (Mizutani) (C-69). 59. *Zhamoidellum ovum* Dumitrica (C-58).

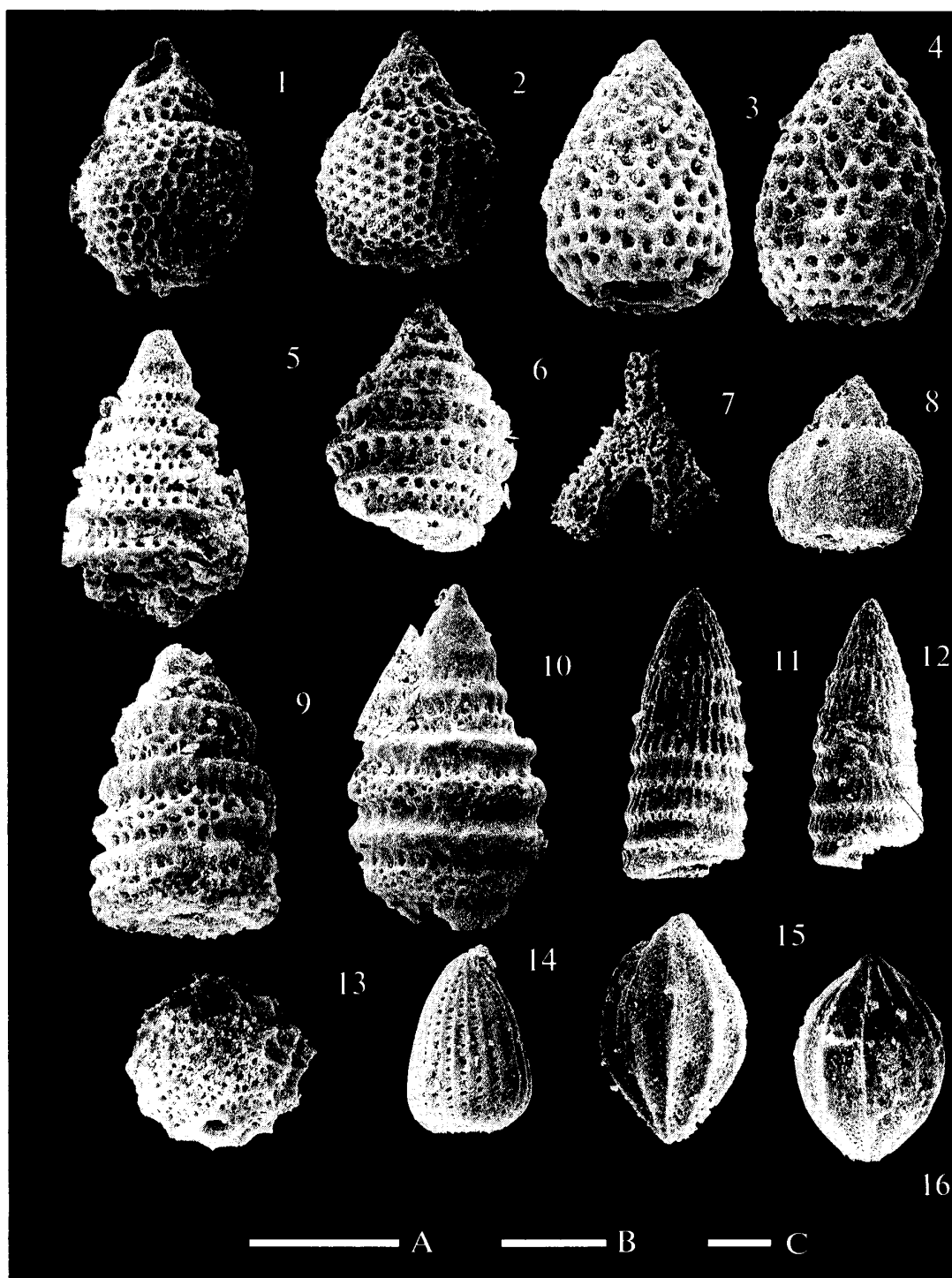


Fig. 5. Scanning electron photomicrographs of radiolarians of the *Stichomitra doliolum* assemblage (Middle Tithonian – early Late Tithonian). All scale bars indicate 100  $\mu\text{m}$ . A: 1-16, 18-21, 23, 25-32. B: 17, 22, 33. C: 24. 1-2. *Stichomitra doliolum* Aita (C-56). 3-4. *Stichocapsa* ex gr. *cribata* Hinde (C-56). 5. *Parvicingula* aff. *mashitaensis* Mizutani (C-56). 6. *Parvicingula boesii* gr. (Parona) (C-56). 7. *Deviatus diamphidius* (Foreman) (C-56). 8. *Eucyrtidiellum pyramis* (Aita) (C-56). 9. *Cinguloturris cylindra* Kemkin and Rudenko (C-56). 10. *Cinguloturris* sp. nov. (C-56). 11-12. *Pseudodictyomitra primitiva* Matsuoka and Yao (C-56). 13. *Williriedellum crystallinum* Dumitrica (C-56). 14. *Thanarla brouweri* (Tan) (C-56). 15-16. *Protunuma japonicus* Matsuoka and Yao (C-56).

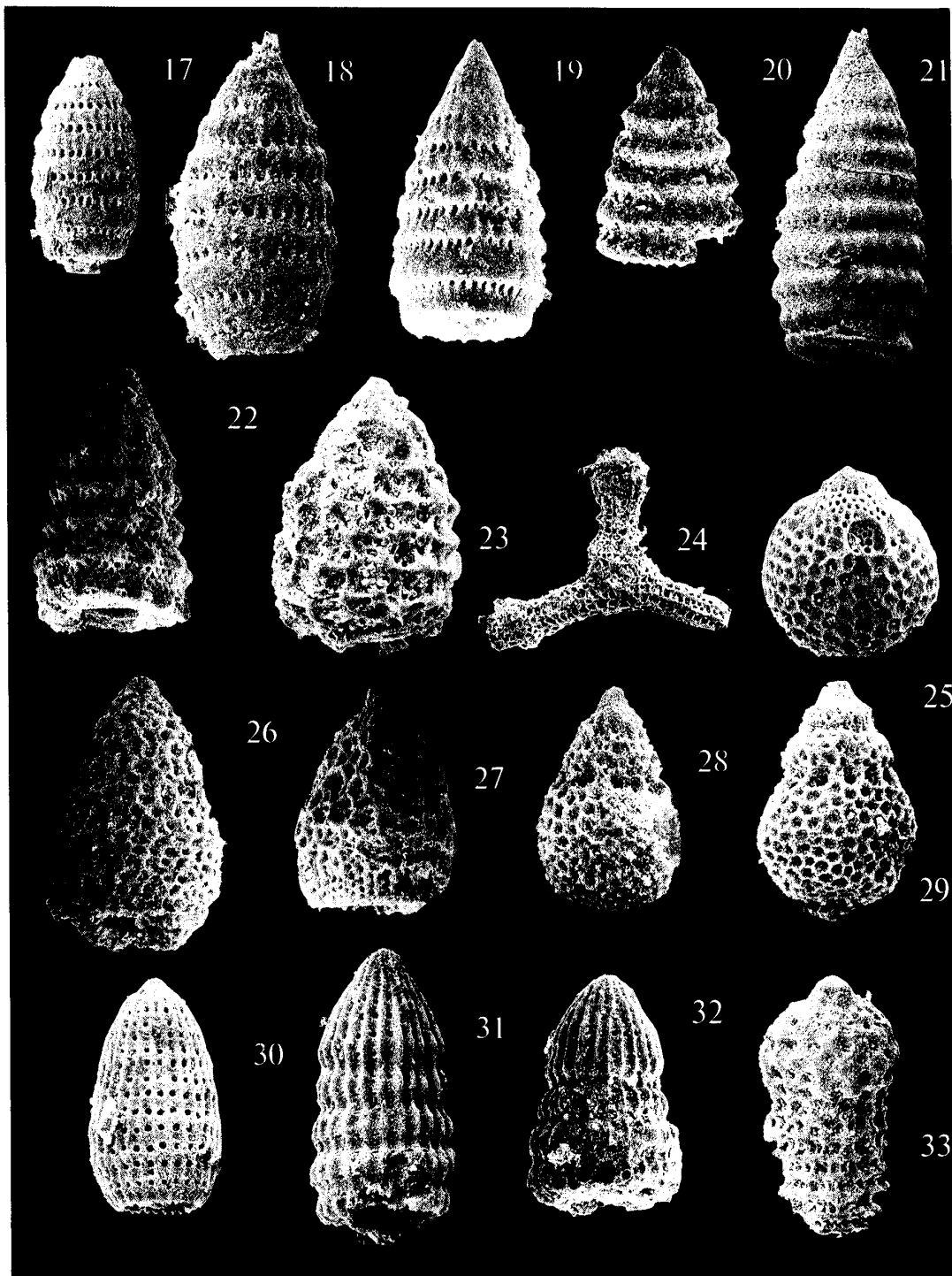


Fig. 5. (continued). 17-18. *Pseudodictyomitra* ex gr. *nuda* Schaaf (C-56). 19-21. *Pseudodictyomitra* ex gr. *leptoconica* (Foreman) (C-56). 22. *Xitus spicularius* (Aliev) (C-56). 23. *Xitus gifuensis* Mizutani (C-56). 24. *Tritrabs* sp. (C-56). 25. *Zhamoidellum ovum* Dumitrica (C-56). 26. *Stichomitra* ex gr. *mediocris* (Tan) (C-56). 27. *Stichocapsa altiforamina* Tumanda (C-56). 28-29. *Sethocapsa subcrassitestata* Aita (C-56). 30. *Archaeodictyomitra* ex gr. *apiarium* (Rüst) (C-56). 31-32. *Archaeodictyomitra minoensis* (Mizutani) (C-56). 33. *Ristola altissima* (Rüst) (C-56).

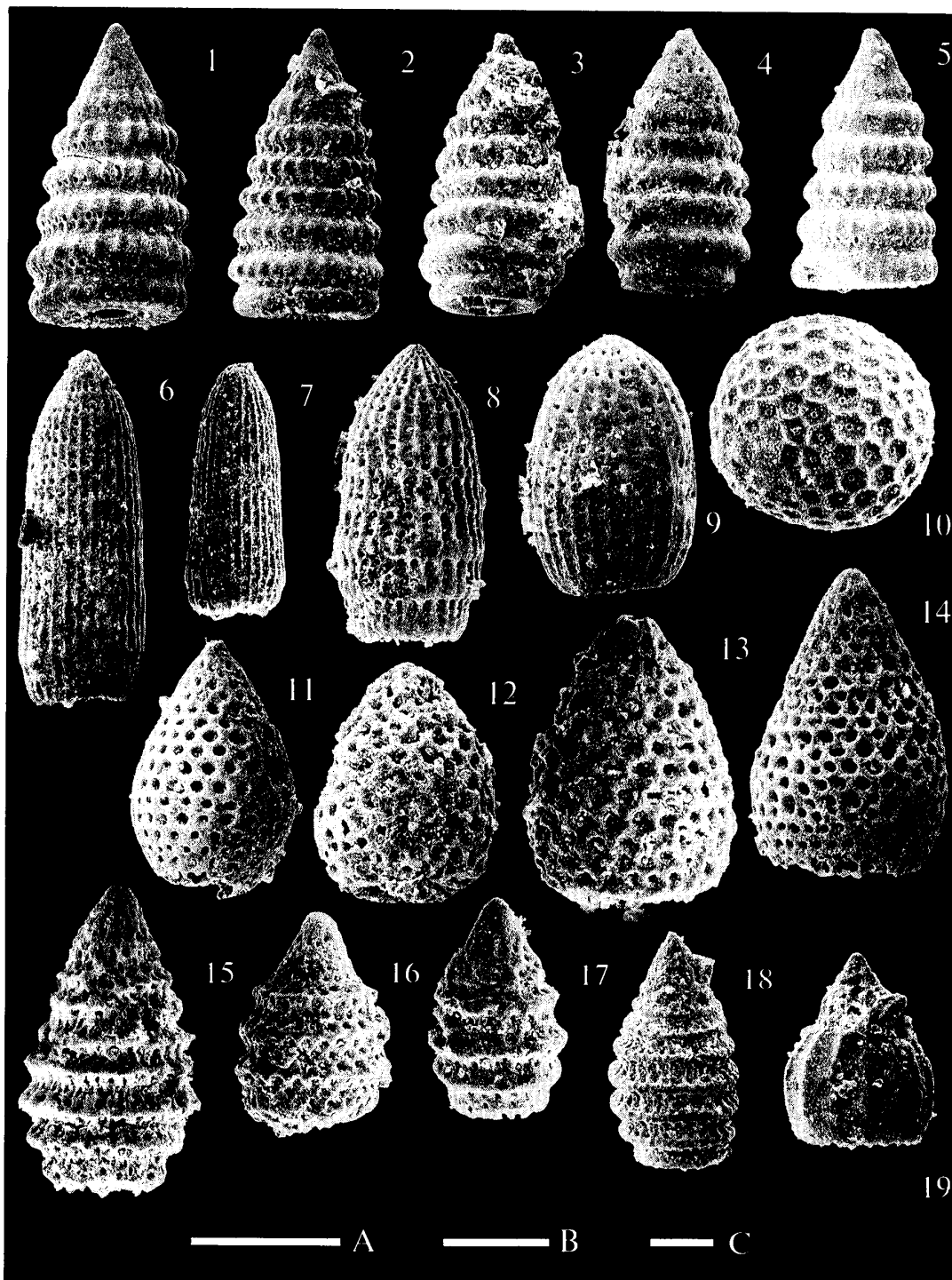


Fig. 6. Scanning electron photomicrographs of radiolarians of the *Pseudodictyomitra carpatica* assemblage (late Late Tithonian). All scale bars indicate 100  $\mu\text{m}$ . A: 1-6, 8-10, 12-17, 19-24, 27-31, 33-40, 42-48, 50-54, 56. B: 7, 11, 18, 25, 26, 32, 41, 49, 55. 1-5. *Pseudodictyomitra carpatica* (Loznyi) (1, 2, 4, 5 – C-54; 3 – C-51). 6-7. *Archaeodictyomitra excellens* (Tan) (6 – C-54; 7 – C-51). 8. *Archaeodictyomitra* ex gr. *apiarium* (Rüst) (C-51). 9. *Archaeodictyomitra apiarium* (Rüst) (C-51). 10. *Holocryptocanium barbui* Dumitrica (C-51). 11. *Stichocapsa cribata* Hinde (C-51). 12-14. *Stichocapsa* ex gr. *cribata* Hinde (12, 13 – C-51; 14 – C-54). 15-17. *Parvicingula boesii* gr. (Parona) (15 – C-54; 16, 17 – C-51). 18. *Parvicingula mashitaensis* Mizutani (C-51). 19. *Eucyrtidiellum pyramis* (Aita) (C-51).



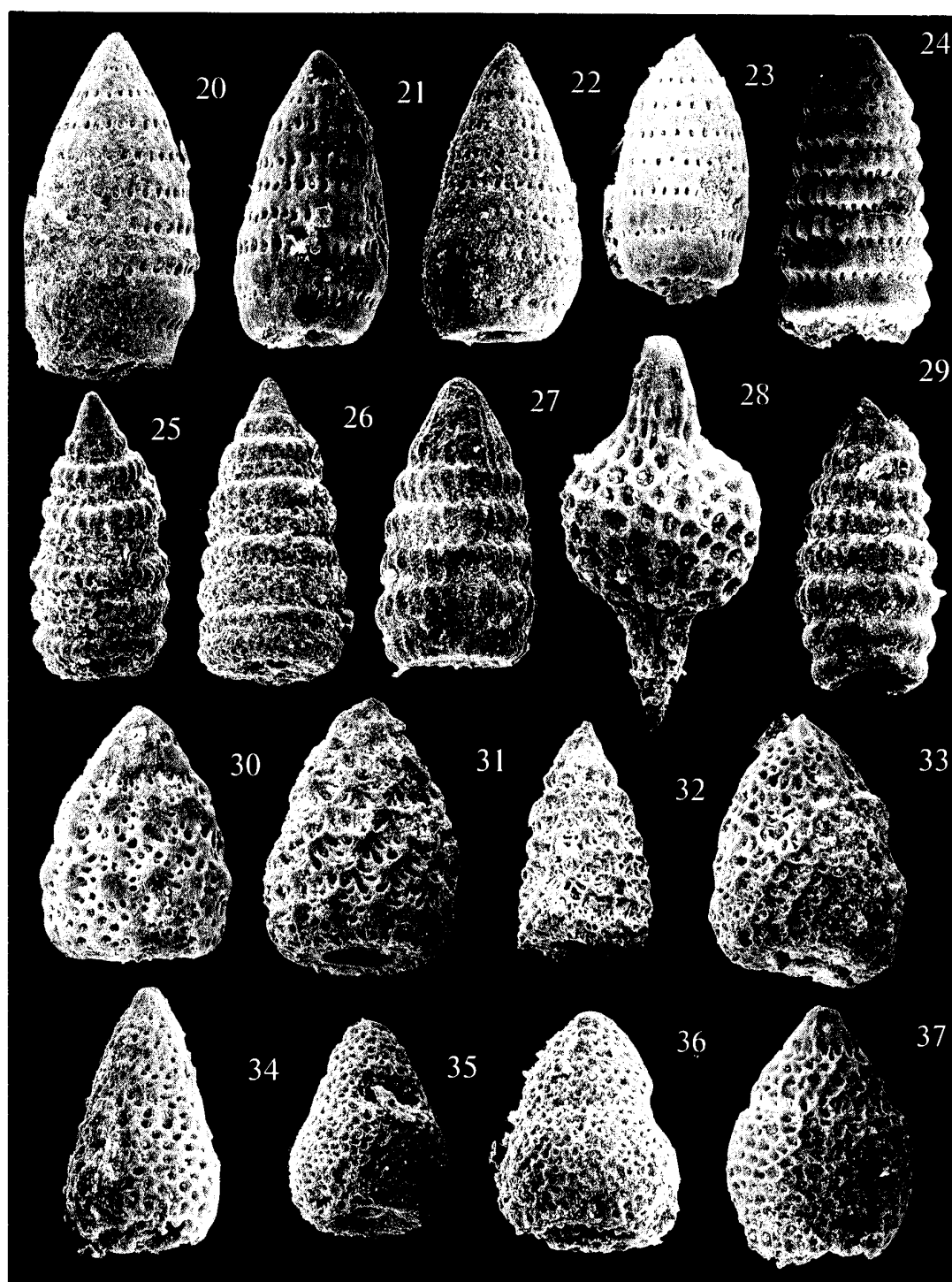


Fig. 6. (continued). 20-23. *Pseudodictyomitra* ex gr. *nuda* Schaaf (20, 22 – C-51; 21 – C-54; 23 – C-53). 24. *Pseudodictyomitra* ex gr. *leptoconica* (Foreman) (C-54). 25-26. *Cinguloturris cylindra* Kemkin and Rudenko (C-51). 27. *Wrangellium* sp. nov. (C-51). 28. *Podobursa triacantha* (Fischli) (C-51). 29. *Pseudodictyomitra lodogaensis* Pessagno (C-51). 30-31. *Xitus gifuensis* Mizutani (C-54). 32. *Xitus spicularius* (Aliev) (C-51). 33. *Xitus* cf. *plenus* Pessagno (C-54). 34. *Stichomitra* ex gr. *mediocris* (Tan) (C-51). 35-36. *Stichomitra japonica* (Nakaseko and Nishimura) (35 – C-54; 36 – C-51). 37. *Stichomitra* ex gr. *japonica* (Nakaseko and Nishimura) (C-54).

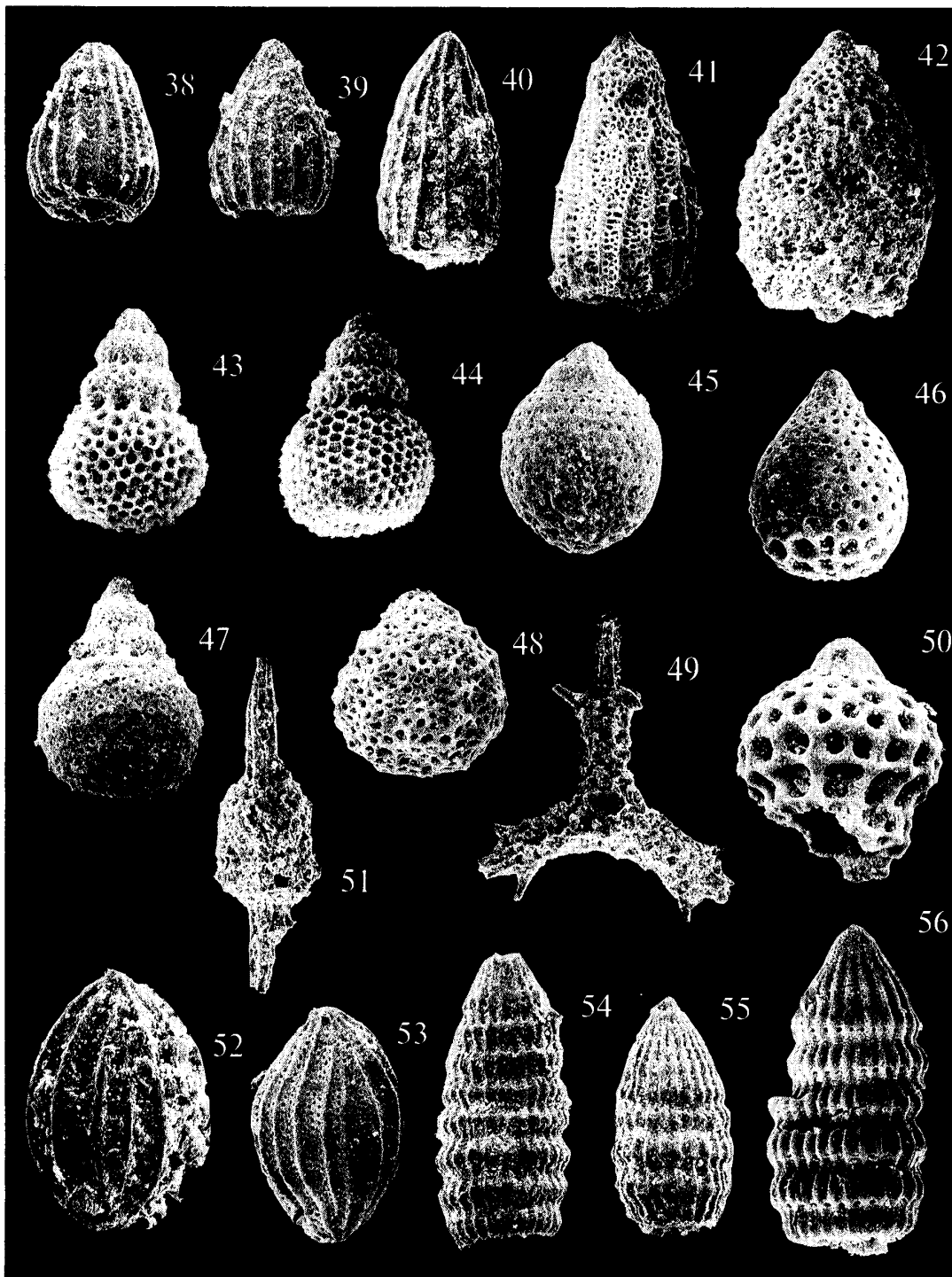


Fig. 6. (continued). 38-39. *Thanarla brouweri* (Tan) (C-51). 40. *Archaeodictyomitra* ex gr. *vulgaris* Pessagno (C-51). 41. *Hsuum cuestaense* Pessagno (C-51). 42. *Stichocapsa altiforamina* Tumanda (C-54). 43-44. *Sethocapsa horokanaiensis* Kawabata (C-54). 45-46. *Sethocapsa* sp. nov. (C-51). 47. *Sethocapsa subcrassitestata* Aita (C-54). 48. *Sethocapsa* aff. *yahazuensis* Aita (C-51). 49. *Paronaella* sp. (C-51). 50. *Ristola cretacea* (Baumgartner) (C-51). 51. *Archaeospongoprunum imlayi* Pessagno (C-51). 52-53. *Protunuma japonicus* Matsuoka and Yao (52 - C-51; 53 - C-54). 54-56. *Archaeodictyomitra minoensis* (Mizutani) (54 - C-53; 55 - C-51; 56 - C-54).



### 3. *Pseudodictyomitra carpatica* assemblage

Radiolarians of the *Pseudodictyomitra carpatica* assemblage are extracted from greenish gray siliceous mudstone and black mudstone (samples T-45, T-46, 3Ko-1, 3Ko-2, C-51, C-53 and C-54). Abundant well-preserved latest Jurassic to earliest Cretaceous radiolarians were found from these samples (Fig. 6 and Table 1). The representatives of Nassellarians such as *Archaeodictyomitra*, *Cinguloturris*, *Eucyrtidiellum*, *Hsuum*, *Parvicingula*, *Pseudodictyomitra*, *Sethocapsa*, *Stichocapsa*, *Stichomitra*, *Thanarla*, *Wrangellium*, *Xitus* and others are predominant. This assemblage is late Late Tithonian in age. The lower boundary of this assemblage zone is defined by the first appearance of *Pseudodictyomitra carpatica* (Lozyniak), and is in the late Late Tithonian in age (Matsuoka, 1992). The upper boundary is determined by the last appearance of *Archaeodictyomitra minoensis* (Mizutani), *Spongocapsula perampla* (Rüst), *Protunuma japonicus* Matsuoka and Yao, *Eucyrtidiellum pyramis* (Aita) and *Sethocapsa yahazuensis* Aita (Mizutani, 1981; Matsuoka and Yao, 1985; Aita, 1987; Baumgartner et al., 1995). This assemblage zone is correlated with the lower part of the *Pseudodictyomitra carpatica* zone (Matsuoka, 1995). *Stichocapsa altiforamina* Tumanda also occurs in this assemblage. This assemblage contains *Archaeodictyomitra elliptica* Vishnevskaya and *Parvicingula omgoniensis* Vishnevskaya which were reported from the Middle Jurassic (Bajocian to Bathonian) formation of Omgon range, Kamchatka by Vishnevskaya et al. (1998). These new findings allow us to extend the biostratigraphic range of these species up to, at least, Early Cretaceous (Berriasian).

## DISCUSSION

Above-mentioned radiolarian analysis indicates that the age of transitional facies in Slice 1 of the Gorbousha unit at the Koreyskaya River area corresponds to the late Late Tithonian which is fixed by the *Pseudodictyomitra carpatica* assemblage established in siliceous mudstone. Thus, the oceanic plate having Slice 1 at the Koreyskaya River area had approached to the subduction zone at the end of Late Tithonian. On the other hand, previous biostratigraphic research in the Dalnegorsk area (Kemkin and Kemkina, 1998) indicates that the transitional facies of chert-clastic sequence in Slice 2 of the Gorbousha unit are Late Kimmeridgian to Middle Tithonian in age. The *Pseudodictyomitra carpatica* assemblage in Slice 2 in the Dalnegorsk area is found from black mudstone which conformably covers the siliceous mudstone. It indicates that the approach of the Gorbousha unit-bearing oceanic plate to the subduction zone ranges in age, at least, from Late Kimmeridgian to Berriasian.

Similar duplication structures can be found in modern accretionary prisms formed along the convergent plate margins (Von Huene et al., 1982; Ogawa, 1985; Kaiko II Research Group, 1987), and in the accretionary complexes on land (Matsuoka, 1984). These structures are formed by duplexing and underplating at subduction zones during the continuous accretion process (Matsuda and Isozaki, 1991). The difference of age in two areas indicates that the duplication of chert-clastic sequences in the Gorbousha unit resulted from successive accretion of oceanic plate, and not indicates that the thrusts synchronously formed with the folds.

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