Jour. Fac. Sci., Hokkaido Univ., Ser. IV
vol. 22, no. 3, Feb., 1989, pp. 425-452.

RADIOLARIAN BIOSTRATIGRAPHIC STUDY OF THE PRE-TERTIARY SYSTEM AROUND THE KAMIKAWA BASIN, CENTRAL HOKKAIDO, JAPAN

by

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(with 9 text-figures, 2 tables and 8 plates)

Abstract

A re-investigation on the pre-Tertiary System that lies within the Kamikawa Basin, central Hokkaido, was carried out from a radiolarian biostratigraphic point of view. As a result, Tosshozan Formation and the Toma Formation, which have been previously included in the Sorachi Group and regarded as Triassic and Permian-Triassic sequences respectively, are now seen to consist of olistostromes of the Early Cretaceous age (Berriasian ?-Valanginian in the former formation and Barremian to Aptian in the latter formation). The Toma Formation in particular includes many exotic blocks of various geological ages: middle Permian and late Triassic limestones, late Triassic chert, late Jurassic chert and limestones, siliceous shales or acidic tuffs of Early Cretaceous, and sandstones and greenstones. The matrix of this formation consists of pebbly shale which is strongly sheared. A similar oliststrome belt of early Cretaceous age extends from the western flank of the southern Hidaka Belt to Sakhalin and seems to represent a convergent zone along the Eurasian plate margin during the early Cretaceous time. Additionally, we have found that the Takasu and the Kaimei Formations in the studied region belong to the Middle Yezo Supergroup, while the Hidaka Supergroup is here represented by the Aibetsu Formation belonging to the late Cretaceous sequence. Consequently, we proposed a revision of stratigraphy of the Pippu — Toma regions.

Introduction

Pre-Tertiary Systems are widely distributed in the Axial Belt of Hokkaido (Text-Fig. 1). Recently, re-investigations of these pre-Tertiary Systems have been urgently undertaken in order to understand the global tectonic development around northern Japan during the Mesozoic age. The Axial Belt of Hokkaido is divided into various tectonic belts — the Sorachi-Yezo Belt, the Hidaka Western Belt, the Hidaka Belt, and the Tokoro Belt. Pre-Tertiary Systems are distributed in a complicated manner in each belt. Until the last few years, scholars believed that both the "Sorachi Group" in the Sorachi-Yezo Belt and the Hidaka Western Belt and the Hidaka Supergroup in the Hidaka Belt are pre-Cretaceous geosynclinal deposits which accumulated in the basins more or less occupying their present positions in the central part of Hokkaido. (Minato et al., 1965). It was thought that limestones, cherts, and greenstones ("Schalstein"),

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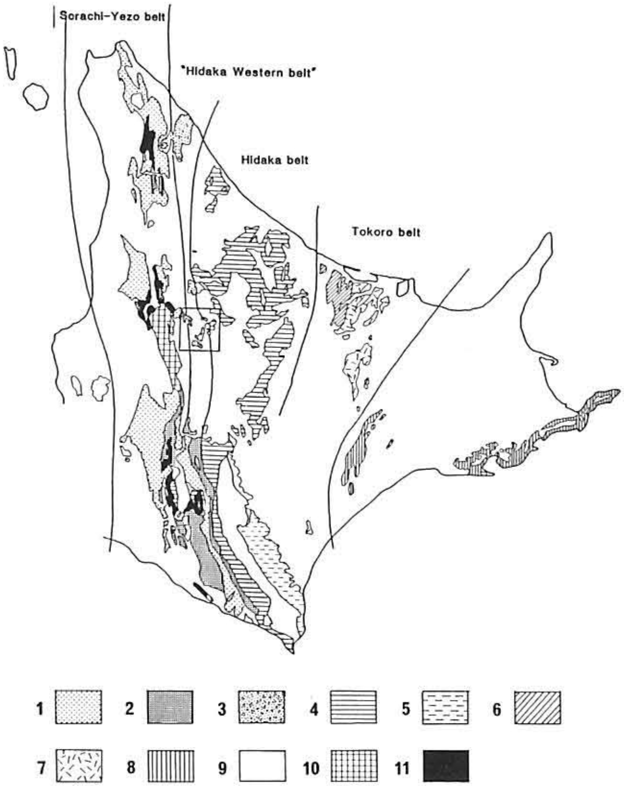


Text-fig. 1 Distribution of the Mesozoic Systems in the Axial zone of Hokkaido and the structural subdivision. A rectangle space showing the studied area.
1: Yezo Supergroup, 2: Sorachi Group, 3: Hidaka Supergroup in the "Hidaka Western Belt", 4: Hidaka Supergroup, 5: Nakanogawa Group, 6: Yubetsu Group, 7: Nikoro Group, 8: Nemuro Group, 9: Hidaka metamorphic rocks, 10: Kamuikotan metamorphic rocks, 11: serpentinite

which were intercalated in the Sorachi Group, Nikoro Group, and the Hidaka Supergroup, were either autochtonous sediments or the products of initial volcanic activity within the geosynclines. Hashimoto et al., (1975) reported the presence of Permian fusulinids and Triassic conodonts respectively in several limestone blocks in the Toma Formation and insisted that the Toma Formation belonged to the Sorachi Group and that the accumulation of the Sorachi geosynclinal deposits had occurred since the late Paleozoic time. And they thought that the Hidaka Supergroup overlay the Sorachi Group concordantly. Kontani and Sakai (1978), on the other hand, pointed out that the Sorachi Group in the Sorachi-Yezo Belt had accumulated during the late Jurassic-early Cretaceous while the "Sorachi Group" in the Hidaka Western Belt had accumulated during the Permian and the Triassic age. However, recent discoveries of Cretaceous radiolarians in the Hidaka Supergroup and other pre-Tertiary Systems in the Axial Belt of Hokkaido (Iwata et al., 1983; Tajika & Iwata, 1983; Kiminami et al., 1983; Ishizuka et al., 1984; Kiminami et al., 1986; Iwata and Kato, 1986) have cast a doubt on the previously held pre-Cretaceous geosynclinal theory (e.g., Minato et al., 1965; Hashimoto et al., 1975). The Hidaka Supergroup, which is widely distributed in the Hidaka Belt, has recently been regarded as Cretaceous accretionary complexes formed at the eastern margin of the Eurasian Plate (Kimura, 1985; Kiminami et al., 1986).

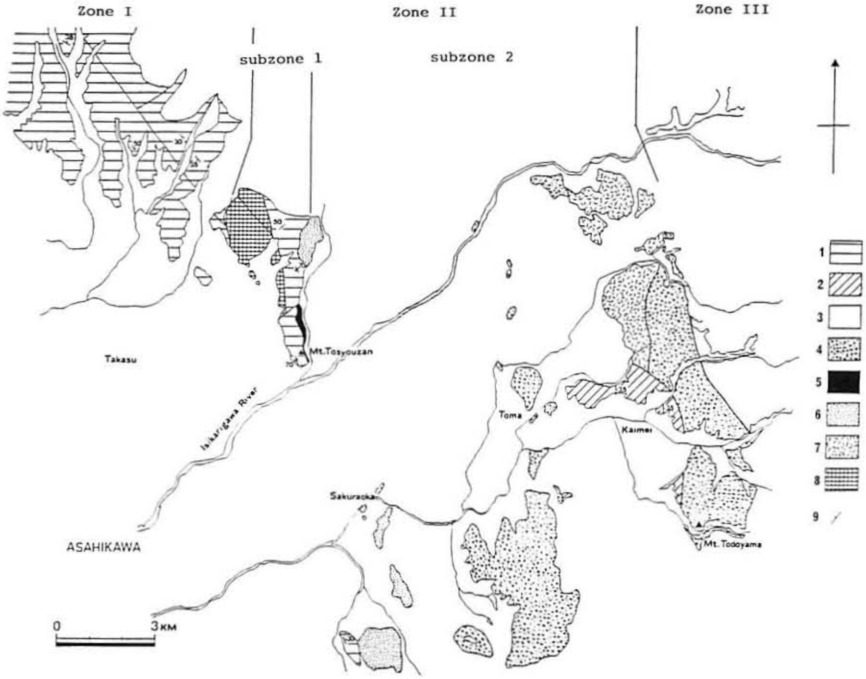
In this paper we should like to report the results of a radiolarian biostratigraphic investigation of the pre-Tertiary Systems around the Kamikawa Basin, where the oldest strata in the Axial Belt of Hokkaido is believed to have been exposed. The aim of this study is to examine the validity of the stratigraphic relationship among the pre-Tertiary Systems in the study region by means of the identification of these microfossils which occur most abundantly in each formation.

Outline of geology

The region studied occupies an area of about $30 \times 15 Km^2$, and is situated more or less in the central part of Hokkaido (Text-Fig. 1). This region is geographically included within the Kamikawa Basin, and the pre-Tertiary Systems are distributed on hills or monadnocks within this basin. The pre-Tertiary Systems of this region just touch all three belts — the Sorachi Belt, the Hidaka Western Belt, and the Hidaka Belt. Based our decision on lithological and structural differences, we have, for convenience, separated the pre-Tertiary Systems of this region into three zones (Text-Fig. 2).

Zone I

This zone is situated at the western part of the study region, and the pre-Tertiary Systems are mainly distributed in the hills north of Takasu Town. This zone falls within the Sorachi-Yezo Belt. Only deposits of the Yezo Supergroup can be found in this zone. Along the western edge of the Zone I, we can find the Kamuikotan metamorphic rocks composed of pelitic schists and serpentinites. We were unable, however, to examine the structural relation between the Yezo Supergroup and the Kamuikotan metamorphic rocks because of weathering. Suzuki (1957) divided the Cretaceous System found in this region into Lower and Upper Cretaceous Systems, basing his dicision on the occurrence of the following fossils — *Orbitolina discoidea* var. *ezoensis* and *Propeamussium couperi* var. *yubarensis*, respectively. Since Suzuki (1957), there have been reports of *Orbitolina* limestone in the middle stream of the Chiraiwenbetsu River; but we were unable to find any examples of this limestone. *Orbitolina discoidea* is known to belong to the Lower Miyakoan Series (Aptian-Albian) (Hanzawa, 1962). Suzuki (1957) considered that the *Orbitolina* bearing horizon of the Cretaceous System could be assigned to the Lower Yezo Supergroup, while the *Propeamussium* bearing horizon belonged to the Upper Yezo Supergroup. He believed that the Lower and the Upper Yezo Supergroups were in fault contact with each other. According to Suzuki, there was no Middle Yezo Supergroup in this region. We ourselves, however, have found no significant lithological differences in the Yezo Supergroup throughout the



Text-fig. 2 Simplified geological map of the studied region.
1: Takasu Formation, 2: Kaimei Formation, 3: Aibetsu Formation, 4: Toma Formation, 5: Tosshozan Formation, 6: Sankakuyama green rocks, 7: Byobuyama green rocks, 8: Kitoushiyama green rocks, 9: strike, (faults illustrated with solid lines.)

region surveyed. Kato (1986 MS) re-named the Yezo Supergroup the Takasu Formation. The Takasu Formation exposes itself in a typical manner along the Chiraiwenbetsu River and the Haishubetsu River. This formation consists mainly of black or dark grey shale, and often intercalates alternating beds of sandstone and shale, glauconite bearing sandy shale, and acidic tuffs. There are two fault systems, one of a NW-SE and the other of NE-SW direction. The strike of this formation on the southern side of the NW-SE fault lies between N 20°W — N 70°W and its homoclinal structure dips in an eastward direction. The strike on the western side of the NE — SW fault lies around NS — N 10°W and it dips 80°E — 90°E. The strike on the eastern side of the NE-SW fault lies between N 30°W — N 50°W and dips 30°W — 60°W. The total thickness of this formation cannot be measured on account of faulting, but it probably exceeds 2,000m.

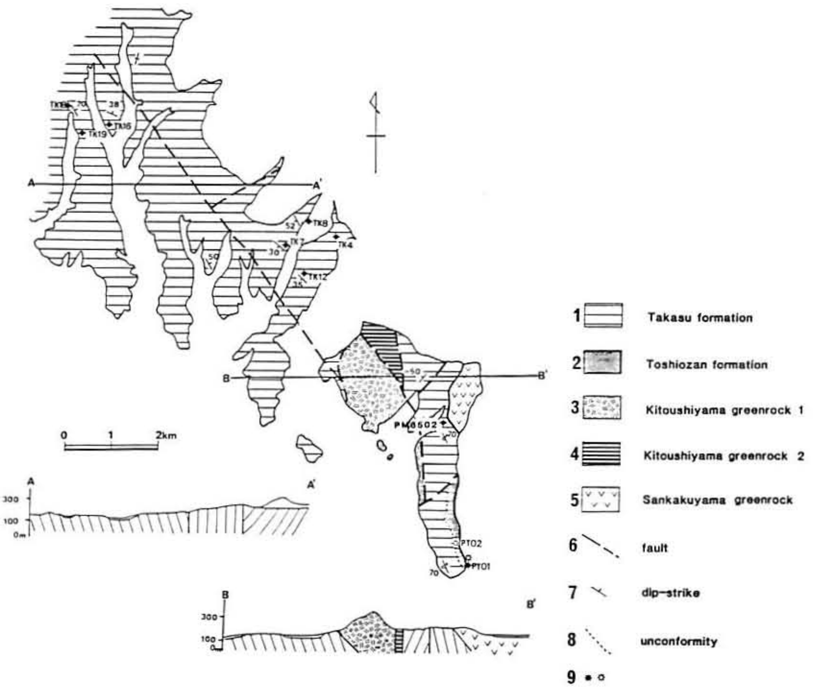
Zone II

This zone occupies the central part of the study area, and the major concern of this study was concentrated in this zone. The zone ranges from the vicinity of Mt. Kitoushi to Mt. Todoyama, and falls within the Hidaka Western Belt (Text-Fig. 2). The pre-

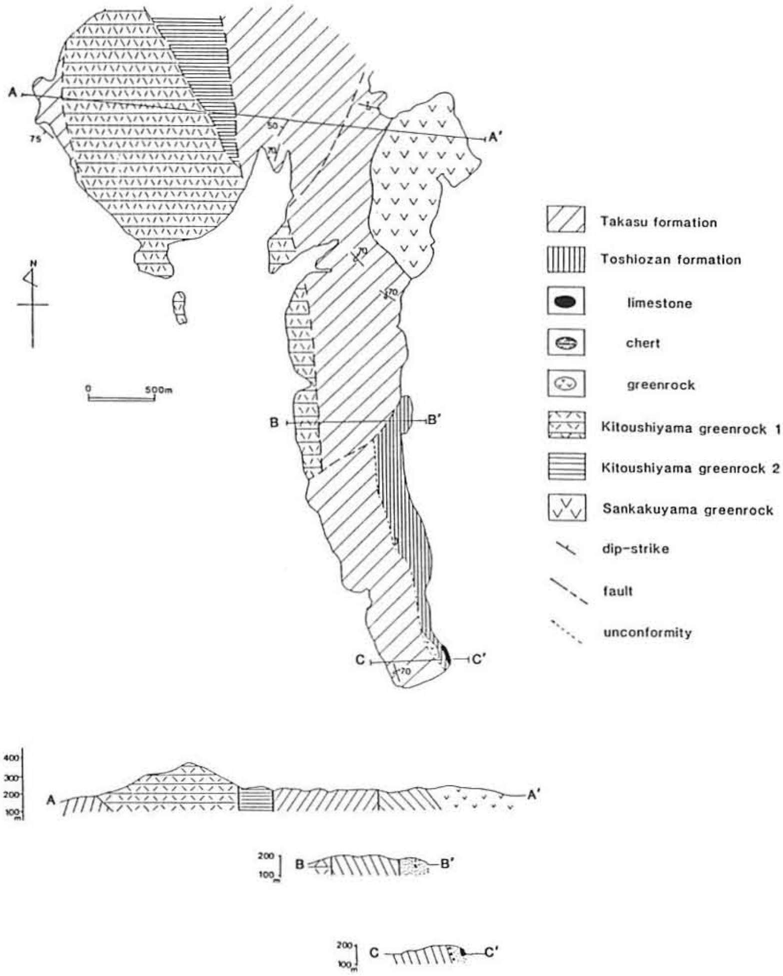
Tertiary System is here arranged in a complicated manner. It assumes a Schuppen structure caused by many thrusts developed among them and serpentinites intrude along these faults, especially in the eastern part of the zone (Kato et al., 1986). We summarize the geological features of the pre-Tertiary Systems of this zone, and we separate it into two subzones — subzone (1) and (2).

Subzone (1) Pippu — Tosshozan district

An enlarged simplified geological map is given in Text-Figs. 2-4. Suzuki (1957) included the whole of the pre-Tertiary Systems in this area within the "Hidaka Group". He distinguished four units — H_1: Schalstein; H_2: sandy tuffaceous breccia; H_3: black slate; H_4: weathered Schalstein. He did not suggest the age of the "Hidaka Group", and he placed H_1 at the base of the Hidaka Group. Later, Hashimoto (1952) placed the pre-Tertiary Systems of this region in the Sorachi Group. Igo et al. (1974) have reported Triassic conodonts (*Neogondolella polygnathiformis*) in the limestone exposed at the southern end of the Pippu-Tosshozan area (Text-Fig. 4; See Plate 7, Figs. 4-6), and included the pre-Tertiary Systems of this area within the Sorachi Group partly because of the Triassic System and correlated it to the Sambosan Group in the southwest Japan. However, Ishizuka et al. (1984) have recently discovered early Cretaceous radiolarians in the siliceous shale surrounding the Triassic limestone and have



Text-fig. 3 Simplified geological map of the Takasu — Pippu area. Black circles showing localities of radiolarian fossils from shale. Open circles showing locations of radiolarians from chert blocks.



Text-fig. 4 Geological map of the Pippu region.

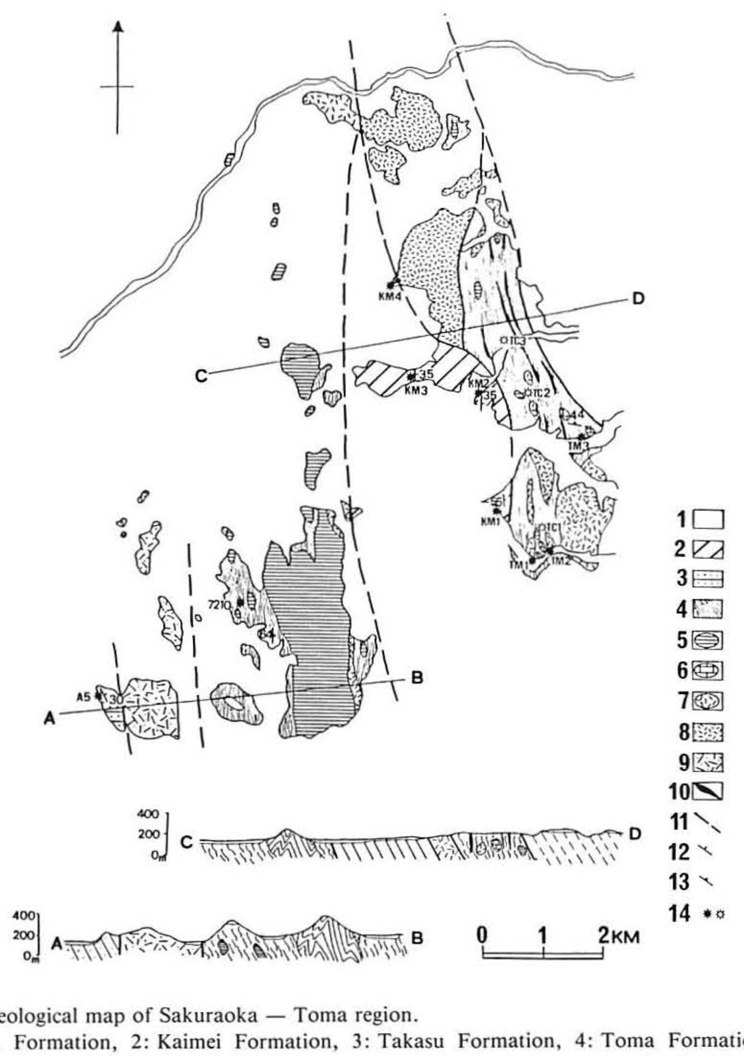
suggested that this limestone is an exotic block of the early Cretaceous System. Kato (1986 MS) has subdivided the pre-Tertiary Systems of this region into the following several stratigraphic units — Kitoushiyama and Sankakuyama greenstones, Tosshozan Formation, and the Takasu Formation (Yezo Supergroup). Kitoushiyama greenstone consists of basaltic pillow lavas and volcanic sandstone. Sankakuyama greenstone consists of altered basalt. The Tosshozan Formation is distributed only at the southern end of the studied region. This formation consists of acidic tuffs, siliceous shales, and intercalates micritic limestones, cherts, and lenticular basaltic pillow lavas. The total thickness of this formation is estimated to be 180m. We have also recognized the same conodont species as Igo et al. (1974) (Plate 7, Fig. 4). Kato (1986 MS) showed that this conodont bearing limestone was enclosed in the acidic tuffs in the form of an olistolith.

And he suggested that this formation was created in an olistostromal fashion near the trench. The Yezo Supergroup of this region, which was formerly included in the Hidaka Group (Suzuki, 1957) or the Sorachi Group (Igo et al., 1974), consists mainly of black shales, intercalating thin beds of acidic tuffs, alternating beds of sandstone and shale. Bouma sequence can be observed at the northern part of this region. This formation has a strike of N10°W — N45°W and dips eastward at angles of 10—30°. The basal part of this formation consists of conglomerates or acidic tuffs, limestones, cherts, siliceous shales, hyaloclastites, which have been possibly derived from the underlying Tosshozan Formation. There is, therefore, a possible unconformity between the Tosshozan Formation and the Yezo Supergroup. Since this Yezo Supergroup can be regarded as the eastern extension of the Takasu Formation, we deal with it here as a part of the Takasu Formation.

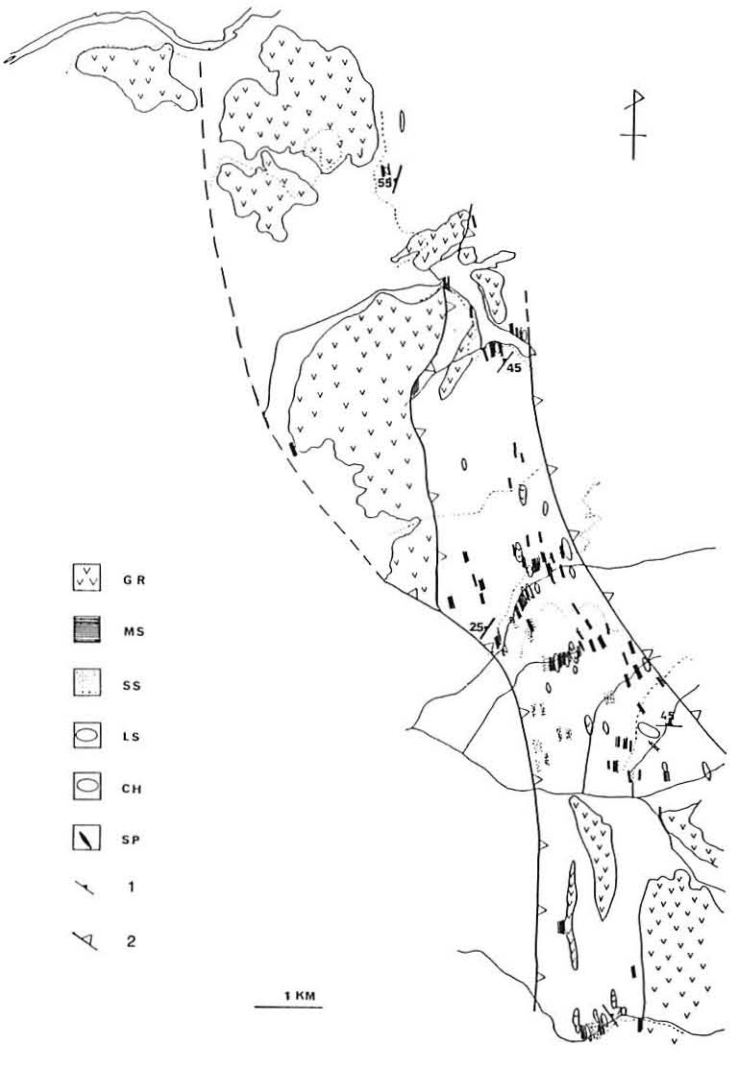
Subzone (2) Sakuraoka and Toma district

This area covers the eastern part of Asahikawa City (Sakuraoka) and most of Toma Town. The pre-Tertiary Systems of this subzone belong to the Hidaka Western Belt. Both Fujiwara et al. (1964) and Suzuki et al. (1966) divided the pre-Tertiary Systems into two formations — the Toma and Kaimei Formations. They treated the Kaimei Formation as an undivided Yezo Supergroup, and suggested that this formation might be correlated to the Middle Yezo Supergroup, judging from its lithological appearance. And they subdivided the Toma Formation, in which greenstones predominate, into the two members — the Lower and Upper Members. The Lower Member of the Toma Formation is distributed in the western part of this region, especially around Sakuraoka, while the Upper Member is distributed in the eastern part of this region, especially in the Kaimei and Todoyama areas. Since they made their assignments, the Kaimei Formation has been considered to be sandwiched between the two members of the Toma Formation as a consequence of faulting. Fujiwara et al. (1964) and Suzuki et al. (1966) included the Toma Formation within the Hidaka Supergroup, and considered that this formation was created during the initial volcanic activity of the Hidaka Orogeny. Further, they suggested that the Toma Formation was pre-Cretaceous (probably Jurassic) in age. Hashimoto et al. (1975) discovered Permian fusulinids (*Nankinella* sp., *Reichelina* sp., etc.) and Triassic conodonts (*Neogondolella polygnathiformis)* (See Plate 7, Fig. 7) respectively in different small limestone blocks included in the Toma Formation of the Todoyama area. We have now in addition found the following foraminifers: *Reichelina* cf. *cribroseptata, Nodosaria* cf. *shekhanica, Dagmarita* cf. *chanakchiensis, Sphaelurina* sp., *Hemigordius* sp., *Agathammina* sp. (identified by Prof. Okimura of Hiroshima University) and a coral *Waagenophyllum* sp. (identified by Prof. Kato of Hokkaido University) from the same Permian limestone block. This limestone is considered to be middle to late Permian in age. Hashimoto et al. (1975), basing their assessment on these fossils, insisted, however, that the Toma Formation belonged to the Permo-Triassic System. They believed that the Toma Formation rested concordantly on the Kaimei Formation. If this were true, the Kaimei Formation would be the oldest stratum in this region. Hashimoto et al.

(1975) have also insisted that the Aibetsu Formation lies concordantly on the Toma Formation. However, Kato (1984 MS) and Kato et al. (1986), basing their assessment on a detailed geological survey and micropaleontological study of the pre-Tertiary Systems in the Toma area, have reached a quite different conclusion from Hashimoto et al. (1975). Kato et al. (1986) have renamed the Upper Member of the Toma Formation of Suzuki et al. (1966) as the Toma Complex. They have also clarified that the Toma Complex was characterized by chaotic mixtures of greenstones, cherts, limestones, acidic tuffs, siliceous shales, sandstones in an intensely foliated pebbly shale. In the present paper, we treat the Toma Complex as the Toma Formation. Text-Fig. 5 gives



Text-fig. 5 Geological map of Sakuraoka — Toma region.
1: Aibetsu Formation, 2: Kaimei Formation, 3: Takasu Formation, 4: Toma Formation, 5: chert blocks, 6: limestone blocks, 7: blocks of green stones, 8: Byobuyama green rocks, 9: Sakuraoka green rocks, 10: serpentinite, 11: faults, 12: strike, 13: foliation, 14: localities of radiolarians. black circle — from shale matrix, open circle — chert blocks.



Text-fig. 6 Lithological map within the Toma Formation of the Kaimei — Todoyama region. GR: greenstones, MS: mudstone, SS: sandstone, LS: limestone, CH: chert, SP: serpentinite, 1 : foliation, 2 : thrust.

a simplified geological map of this area. In the western part of this area, there is a narrow greenstone belt, which is composed of Sakuraoka and Sankakuyama greenstone members and lithologically consists of intensely altered or mylonitized basalt and hyaloclastite. Banno et al. (1963) have reported pumpellyite from Sakuraoka greenstone member, and suggested that the metamorphic effect of Kamuikotan Belt extends over the whole region. These greenstones are in fault contact with the Yezo Supergroup and the Toma Formation. As Kato (1986 MS) and Kato et al. (1986) have already pointed out, the Toma Formation in the Sakuraoka and the Kaimei-Todoyama area is characterized by a chaotic mixture of greenstones, cherts, limestones, sandstones, acidic tuffs, and siliceous shales in a pebbly shale matrix. Both Permian and Triassic limestones were regarded as exotic blocks (Kato et al., 1986). The matrix of this formation has generally suffered from an intense shearing, and the cleavages of pebbly shale do not show any particular orientations. Blocks of cherts, limestones, and greenstones are often deformed and broken into pieces. At the same time, many thrusts can be observed within this formation and on its boundary with the Kaimei Formation or greenstones. All the thrusts show a common westward vergence. Furthermore, serpentinite intrude along the faults. The exact thickness of the Toma Formation cannot be measured on account of many faults. The Kaimei Formation, which was treated as an undivided Cretaceous System by Suzuki et al. (1966) and regarded as the oldest strata by Hashimoto et al. (1975), consists mainly of black to greyish shale and intercalates thin beds of sandstone and acidic tuff. It also includes small calcareous nodules. This formation has a strike of N10°W — N30°W, and dips eastward with angles of 30 — 40°E. The thickness of this formation is estimated to be about 1,500m.

Zone III

This zone occupies the most easterly part of the study region and lies within the Hidaka Belt. Only the Aibetsu Formation is distributed in this zone. The Aibetsu Formation has a strike of NS-NNW and dips 50°E. This formation consists mainly of alternating beds of sandstone and shale, often intercalating small recrystallized limestones and cherts as exotic blocks. Judging from the grading texture of sandstone of this formation, we can suppose that the original sequence of this formation was the way up (overturned) (Kato, 1986 MS; Iwata and Kato, 1986). Dolerite and basalt predominate in the lower part of this formation, while in its upper part lithic wacke is found in abundance (Kato and Iwata, 1987). Suzuki et al. (1966) correlated the Aibetsu Formation to the Kamui Group of the Hidaka Supergroup in the southern Hidaka Belt. Hashimoto et al. (1975) regarded that this formation overlies concordantly the Toma Formation, which they believed to be a Permo Triassic System. But Kato et al. (1986) has revealed that Aibetsu Formation is in fault contact with the Toma Formation. At the same time, Iwata and Kato (1986) reported late Cretaceous radiolarians from the uppermost part of the Aibetsu Formation.

Radiolarian biostratigraphic study of the pre-Tertiary Systems around the Kamikawa Basin

In the section we describe the results of a radiolarian biostratigraphic study of the pre-Tertiary Systems of the studied region in the following order — (a) the Tosshozan Formation, (b) the Toma Formation, and (c) the Yezo Supergroup and its related formations. As we have already described them in an earlier paper (Iwata and Kato, 1986), we omit the radiolarian assemblages of the Aibetsu Formation from this paper.

(a): Radiolarians of the Tosshozan Formation

Well-preserved radiolarians were obtained from siliceous shale and acidic tuff taken from this formation (Loc. PT-01) (Text-Fig. 3 & 7). The following radiolarian species were found: *Mirifusus mediodilatatus, Lithocampe chenodes, Ristola boesii, Ristola cretacea, Acaeniotyle umbilicata, Sphaerostylus lanceola, Dibolachras apletopora* (Plate 1), *Thanarla conica, Archaeodictyomitra apiarum, Stichocapsa cribata, Sethocapsa* cf. *cetia, Sethocapsa* cf. *kaminogoensis* (Plate 2), *Novixitus weylli, Williriedellum* cf. *carpaticum, Emiluvia* cf. *hopsoni* (Plate 3), *Parvicingula* spp., *Archaeospongoprunum* spp., *Dictyomitra* spp. Among these radiolarian species, *Ristola cretacea* is thought by Baumgartner (1984) to range from Berriasian to Valanginian, while it is claimed that *Lithocampe chenodes* ranges from Berriasian to Barremian (Aita and Okada., 1986), *Sethocapsa kaminogoensis* ranges from Berriasian to Valanginian (Aita and Okada., 1986), *Emiluvia hopsoni* ranges from Tithonian to Berriasian (Baumgartner, 1984), and *Thanarla conica* ranges from Valanginian to Aptian (Pessagno, 1977a). Ishizuka et al. (1984) have reported *Thanarla conica, Ristola boesii* in the siliceous shale of this formation, and have suggested that this formation is most probably Valanginian in age. Considering our results and those of Ishizuka et al. (1984), we judge that the Tosshozan Formation seems to range from Berriasian (?) to Valanginian in origin. Ishizuka et al. (1984) were the first to suggest that the Upper Triassic limestone which yielded Carnian conodonts (Igo et al., 1974; See Plate 7, figs. 4-6) seems to be an exotic block of the Tosshozan Formation. As we have already noted, this limestone is present in the acidic tuff of this formation in the form of an olistolith. Consequently, we support the proposal made by Ishizuka et al. (1984).

Radiolarians from a chert block of the Tosshozan Formation

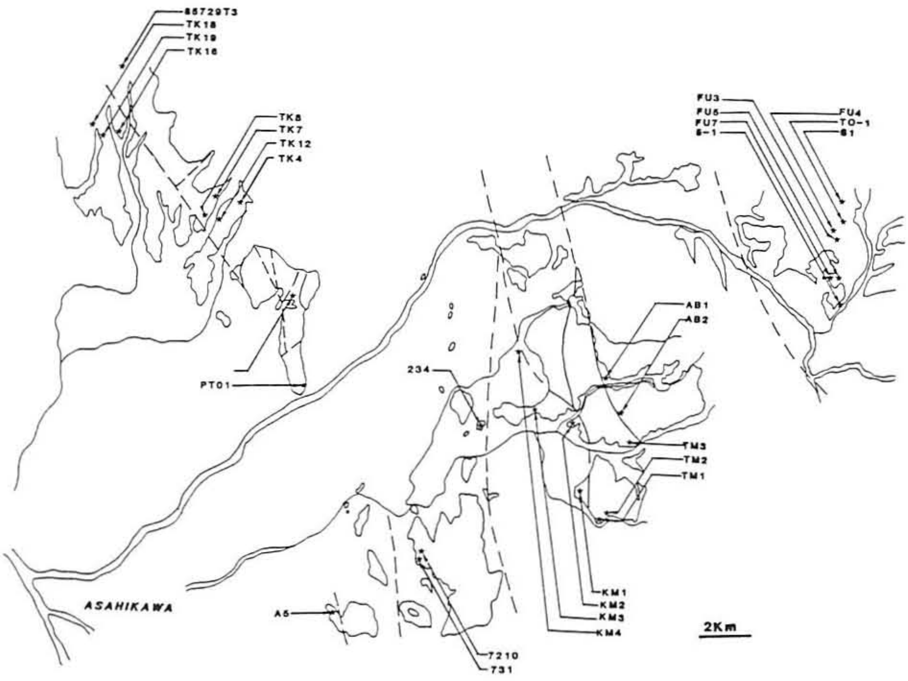
Many small chert blocks are embedded in this formation. A chert block at the peak of Mt. Tosshozan is the largest (about 4m in diameter) (Text-Fig. 3, Loc. PT-02). This chert is white in colour and suffers from weathering. It yeilded only a small number of radiolarians. The following species were included: *Stichocapsa himedaruma, Emiluvia* sp, *Pantanellium* spp., *Napora* spp., *Sethocapsa* spp., *Tricolocapsa* spp. Among them *Stichocapsa himedaruma* is known to exist in the Upper Jurassic Irazuyama Formation of southwest Japan (Aita, 1985). On account of the small quantity of radiolarians, the accurate age of this chert could not be determined, but we consider it to be late Jurassic in age. This chert and other small cherts, as well as Triassic limestone, are considered to be olistoliths of the Tosshozan Formation.

(b): Radiolarians of the Toma Formation

This formation consists of a mixture of many kinds of cherts, limestones, greenstones, siliceous shales, acidic tuffs, in a sheared pebbly shale matrix. Radiolarians of different geological ages were obtained from the chert blocks and shale matrices.

(i) Radiolarians from the shale matrices of the Toma Formation

Radiolarians were obtained from the black shales of Locs. 7210, TM 1, TM 2 (Text-Fig. 7). A list of the radiolarians of the shale matrices of this formation is shown in



Text-fig. 7 Locality map of radiolarians in the studied region.

Table 1. Among these radiolarians, *Archaeodictyomitra lacrimula* is known to range from late Barremian to middle Aptian (Schaaf, 1981; Kito, 1987). *Eucyrtis micropora* is known to range from Valanginian to early Aptian (Foreman, 1975). The matrix of the Toma Formation (both in the Sakuraoka and the Kaimei-Todoyama areas) is therefore considered to be early Cretaceous (approximately Barremian to Aptian) in age.

(ii) Radiolarians of chert blocks in the Toma Formation

Cherts of various sizes and colours of the Toma Formation yielded radiolarians of different ages. The localities of chert blocks are shown in Text-Fig. 5 & 6. TC-1 is a white chert that alternates with pink limestone. This chert is 10m in diameter. The following radiolarians were obtained: *Perispyridium tamanense, Cinguloturris carpatica, Dibolachras* cf. *apletopora, Podocapsa* cf. *guembeli, Mirifusus mediodilatatus* (Plate

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Explanation of Plate 1

Tosshozan Formation. Loc. PT-01. Scales 100μm.

Fig. 1 *Mirifusus mediodilatatus* (Rust)
Fig. 2 *Parvicingula* sp.
Fig. 3 *Lithocampe chenodes* Renz
Fig. 4 *Ristola boesii* (Parona)
Fig. 5 *Parvicingula* (?) sp.
Fig. 6 *Ristola cretacea* (Baumgartner)
Fig. 7 *Xitus* sp.
Fig. 8 *Archicapsa* (?) sp.
Fig. 9 *Acaeniotyle umbilicata* (Rust)
Fig. 10 *Sphaerostylus lanceola* (Parona)
Fig. 11 *Dibolachras apletopora* Foreman
Fig. 12 *Archaeospongoprunum* sp.

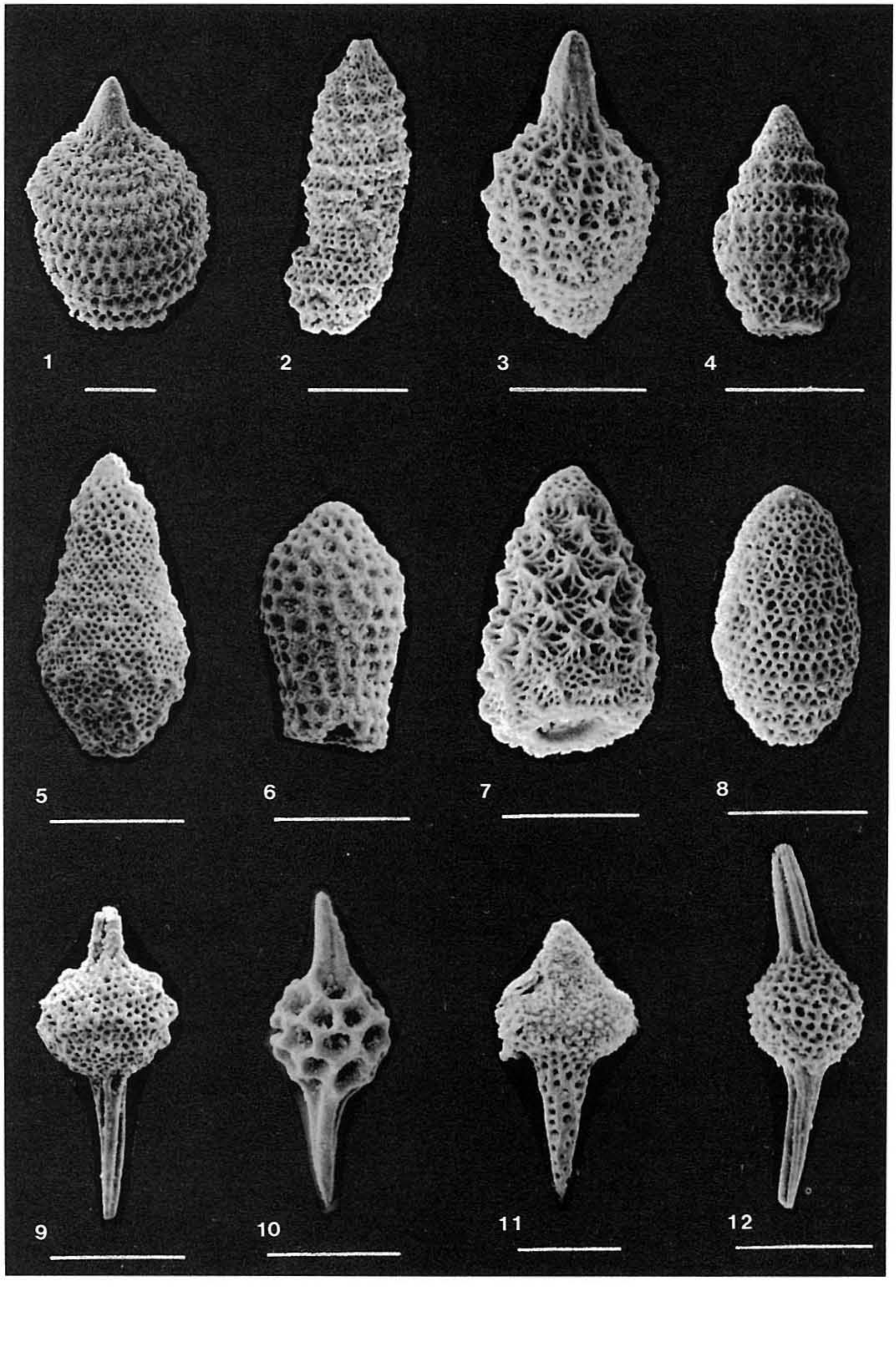

Table 1 Radiolarians occurred in the shale matrices of the Toma Formation.

Species \ Localities	7210	731	234	TM1	TM2	TM3
Acaeniotyle umblicata	●					
Alievium sp.						●
Archaeodictyomtra apiara		●			●	
A. lacrimula	●	●			●	
Crucella sp.						●
Eucyrtis micropora	●	●			●	
E. tenuis		●				
Parvicingula boesii					●	
Holocryptocanium barbui	●			●		●
Praeconcaryoma spp.					●	●
Sethocapsa spp.	●				●	
Sphaerostylus lanceola group		●				
Stichomitra sp.						●
Thanarla conica	●	●		●	●	●
Xitus cf. *alievi*				●		
Xitus sp.					●	

5), *Vallupus hopsoni* (Plate 6). Among these radiolarians, *Perispyridium tamanense* has been reported from the late Jurassic (Kimmeridgian to Tithonian) of California by Pessagno (1977b) and Pessagno et al. (1984), while *Vallupus hopsoni* is known to be restricted to the Tithonian age (Pessagno et al., 1984). *Cinguloturris carpatica* is reported from the Oxfordian (Aita, 1985) and the Tithonian (Matsuoka and Yao, 1985). We therefore consider the age of TC-1 to be late Jurassic (approximately Tithonian). TC-2 is a red stratified chert exposed in the Shimizusawa region. This chert included the following radiolarians: *Mirifusus mediodilatatus, Acaeniotyle umbilicata, Eucyrtis micropora, Ristola boesii, Thanarla conica, Hemicryptocapsa* cf. *capita, Sphaerostylus lanceola.* Among these radiolarians, *Mirifusus mediodilatatus* is known to range from the Oxfordian to early Hauterivian (Baumgartner et al., 1980), while *Eucyrtis micropora* is known to range from Valanginian to early Aptian (Foreman, 1975). We therefore consider the age of TC-2 to be approximately Valanginian. Besides TC-2, siliceous shales which occurred as boulders midway between the Permian and the

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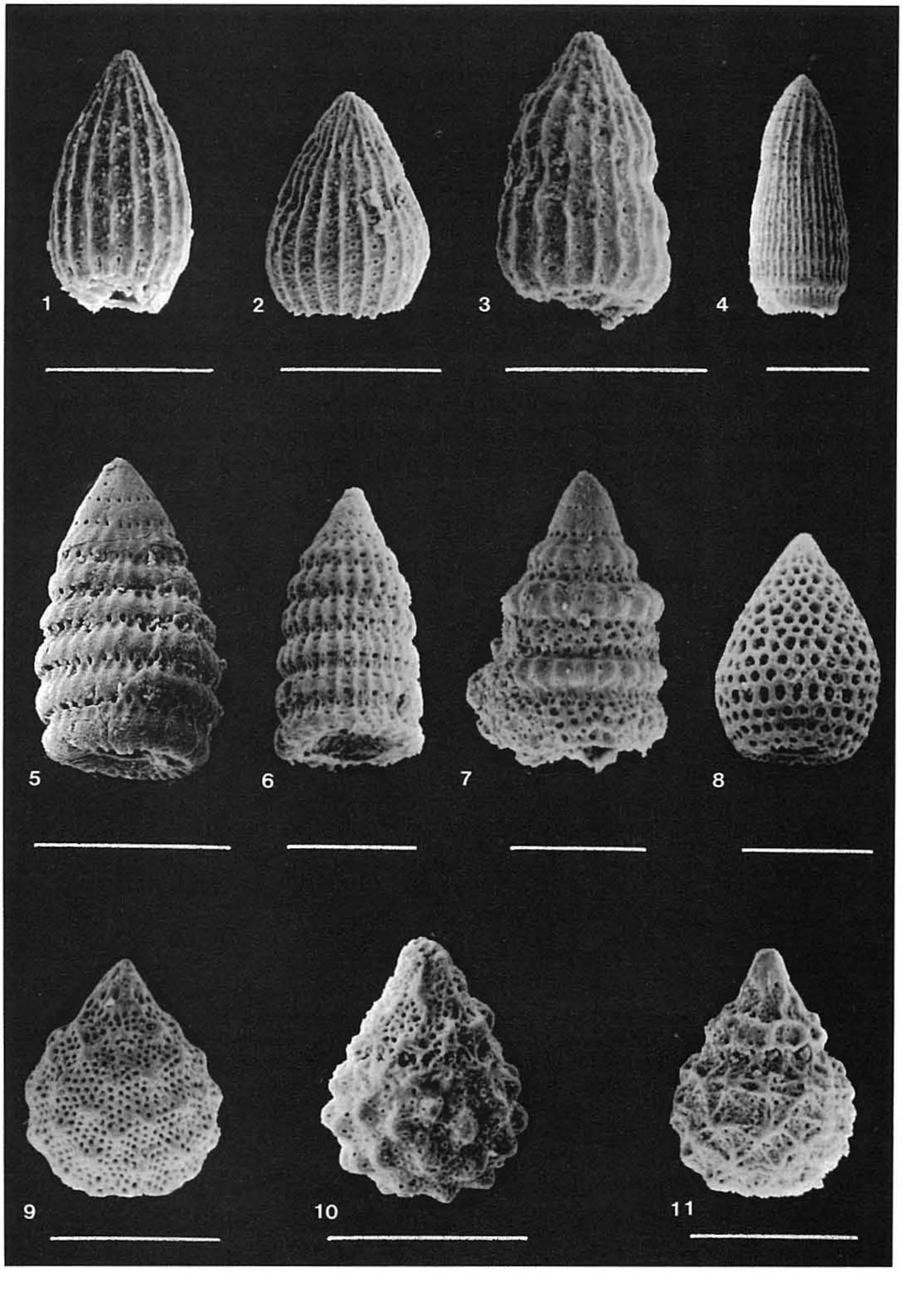
Explanation of Plate 2

Tosshozan Formation. Loc. PT-01. Scales 100μm.

Fig. 1 *Thanarla conica* (Aliev)
Fig. 2 *Thanarla conica* (Aliev)
Fig. 3 *Archaeodictyomitra* sp.
Fig. 4 *Archaeodictyomitra apiara* (Rust)
Fig. 5 *Pseudodictyomitra* sp.
Fig. 6 *Dictyomitra* sp.
Fig. 7 *Cinguloturris* sp.
Fig. 8 *Stichocapsa cribata* Hinde
Fig. 9 *Sethocapsa* aff. *cetia* Foreman
Fig. 10 *Sethocapsa* cf. *kaminogoensis* Aita
Fig. 11 *Sethocapsa* sp.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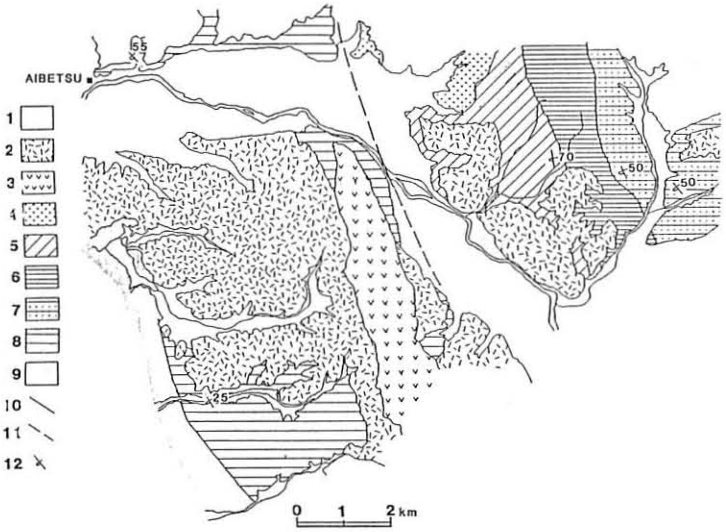
Triassic limestones at the Todoyama yielded similar radiolarian assemblages as TC-2. TC-3 is a black or amber-coloured chert exposed in the road-cut of the Kumanosawa region of the Kaimei area. This chert block is 50m in diameter, has suffered extensively from weathering, and is folded. A small number of radiolarian species of the following were present: *Capnodoce anapetes, Tripocyclia* cf. *acythus, Betraccium* cf. *deweveri* (Plate 7, Figs. 1-3). *Capnodoce anapetes* has been reported from the Upper Triassic Systems (Carnian — Norian) of Greece and Turkey (DeWever et al., 1979). We therefore consider TC-3 to be late Triassic (Carnian to Norian) in age. Amber-coloured chert boulders in the neighbourhood of the Triassic limestone in the todoyama area yielded also a small number of conodonts (See Plate 7, Fig. 8). This chert is probably Triassic in age. TC-4 and TC-5 are stratified red cherts which alternate with limestone. TC-4 has now been excavated and cropped from a quarry at Sakuraoka. TC-5 is distributed at Mt. Kuroiwa and has a great thickness of more than several hundreds of meters. A northern part of this chert extends over Mt. Toma, Mt. Shogun, Mt. Oyako. In spite of great thickness of these cherts, the number of radiolarians was very small, and ill-preserved. *Ristola boesii, Pantanellium* spp., *Crucella* spp., *Sethocapsa* spp.,



Text-fig. 8 Geological map of the Aibetsu area (referred from Kato & Iwata, 1987).
1: Terrace deposits, 2: Antaroma welded tuff, 3: Higashiyama lava, 4: Tokusei Formation, 5-7: Koshiji Formation (5: Ka member, 6: Kb member, 6: Kb member, 7: Kc member), 8: Aibetsu Formation, 9: Toma Formation, 10: faults, 11: estimated faults, 12: dip and strike.

Explanation of Plate 3

Tosshozan Formation. Loc. PT-01. Scales 100μm.

Fig. 1 *Sethocapsa* sp.
Fig. 2 *Xitus* (?) sp.
Fig. 3 *Novixitus weyli* Schmidt-Effing
Fig. 4 *Stichocapsa* sp.
Fig. 5 *Williriedellum* cf. *carpaticum* Dumitrica
Fig. 6 *Dictyomitra* sp.
Fig. 7 *Eusyringium* (?) sp.
Fig. 8 *Praeconocaryomma* sp.
Fig. 9 *Emiluvia* sp.
Fig. 10 *Emiluvia* cf. *hopsoni* Pessagno

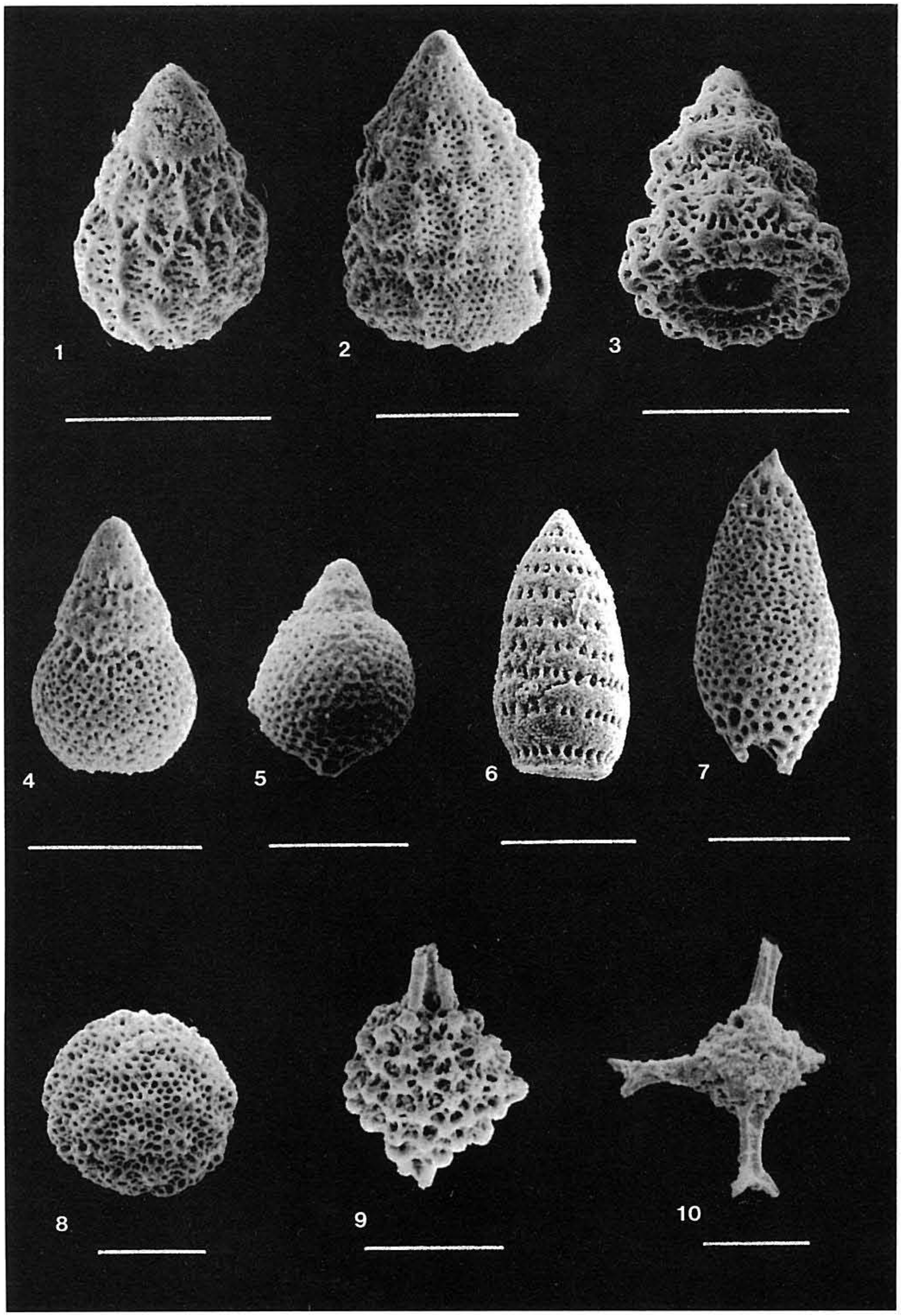

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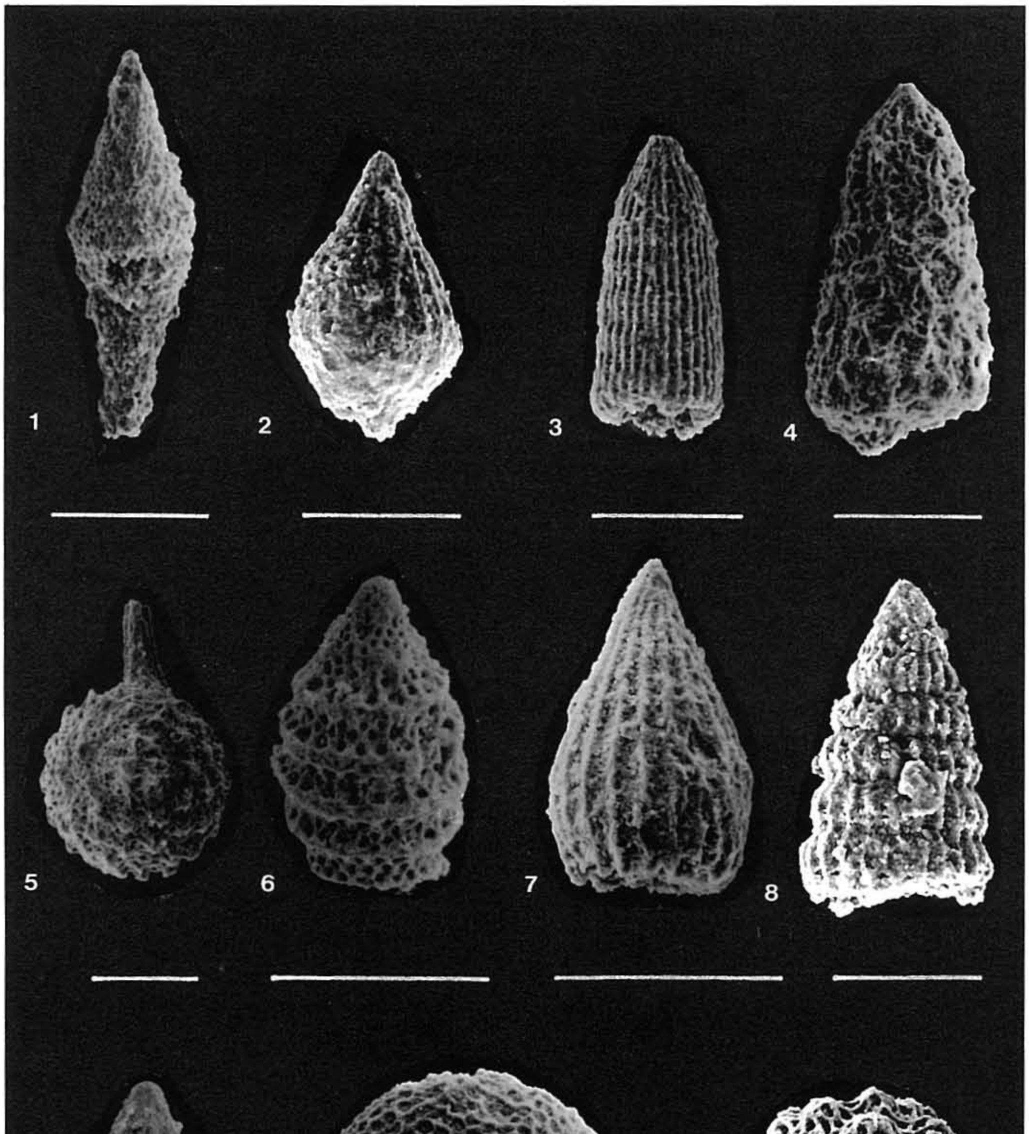
Table 2 Radiolarians of the Takasu and the Kaimei Formations.

Species \ Localities	TK-4	TK-7	TK-8	TK-12	TK-16	TK-18	TK-19	85729T-3	A-5	KM-1	KM-2	KM-3	KM-4	PM6502
Thanarla veneta	●		●			●	●		●	●	●	●		
T. elegantissima			●			●	●			●	●	●		
Diacanthocapsa euganea	●									●	●	●		
Stichomitra asymbatos	●													
S.s communis	●		●		●					●	●	●	●	●
S. sp.									●				●	
Pseudodictyomitra pseudomacrocephala			●	●						●	●	●		
P. cf. *nakasekoi*										●		●		
P. spp.										●	●			
Holocryptocanium barbui	●		●	●						●	●	●		
H. geysersense										●	●			
Eusyringium spinosum			●		●					●	●	●		●
Novixitus weyli			●							●	●	●		●
N. spp.												●		
Spongocapsula (?) *zamoraensis*	●				●							●		
Praeconocaryomma spp.										●	●			
Amphipyndax ellipticus											●	●		
A. stocki	●		●		●	●	●			●	●	●		
A. cf. *conicus*												●		
Mita regina			●											
M. sp.										●		●		
Archaeodictyomitra spp.	●	●						●	●					●
Sethocapsa simplex					●		●							●
S. spp.												●		
Squinabollum fossilis					●									
Dictyomitra urakawaensis														●
D. spp.			●								●	●		
Crucella sp.										●	●	●		
Hemicrytocapsa cf. *polyhedra*													●	

Explanation of Plate 4

Toma Formation. Radiolarians from black shale matrix. Scales 100μm.

Fig. 1 *Eucyrtis micropora* (Squinabol); Loc. 7210.
Fig. 2 *Archaeodictyomitra* cf. *lacrimula* (Foreman); Loc. 7210.
Fig. 3 *Archaeodictyomitra* sp. Loc. 7210.
Fig. 4 *Xitus* cf. *alievi* (Foreman); Loc. TM-2.
Fig. 5 *Acaeniotyle umbilicata* (Rust); Loc. 7210.
Fig. 6 *Ristola boesii* (Parona); Loc. 7210.
Fig. 7 *Thanarla conica* (Aliev); Loc. TM-2.
Fig. 8 *Dictyomitra* sp.; Loc. 7210.
Fig. 9 *Sethocapsa* sp.; Loc. 7210.
Fig. 10 *Holocryptocanium barbui* Dumitrica; Loc. TM-1.
Fig. 11 *Praeconocaryomma* sp.; TM-2.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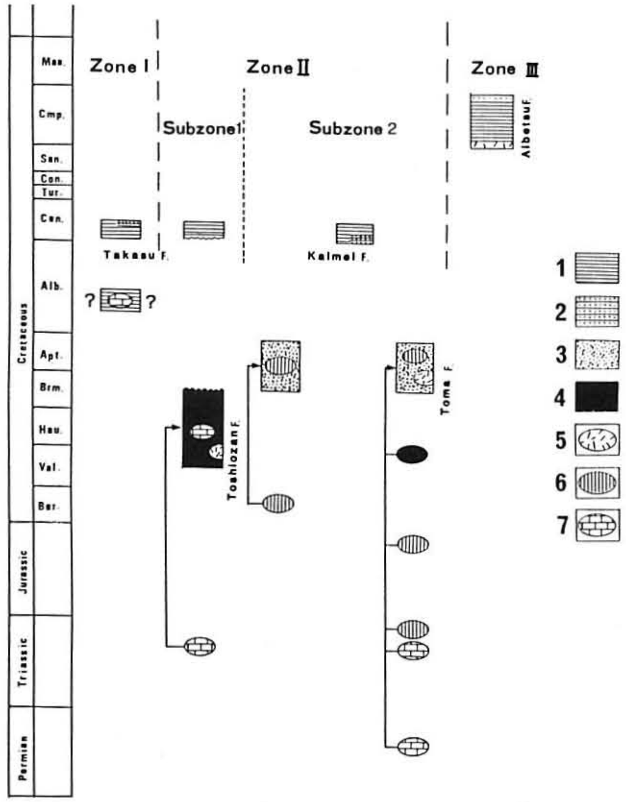
Stichocapsa spp. were obtained from TC-4 and TC-5. We were unable to determine the exact age of either chert block. These cherts seem to be late Jurassic or early Cretaceous in age.

(iii) Radiolarians from the Takasu Formation and the Kaimei Formation

The Takasu Formation and the Kaimei Formation yielded abundant radiolarians, and their assemblages were very similar between the two formations. The localities of the radiolarians from the two formations are shown in Text-Fig. 5 and 7, and a list of radiolarians is given in Table 2. The following species predominated: *Holocryptocanium barbui, Holocryptocanium geysersense, Amphipyndax stocki, Pseudodictyomitra*

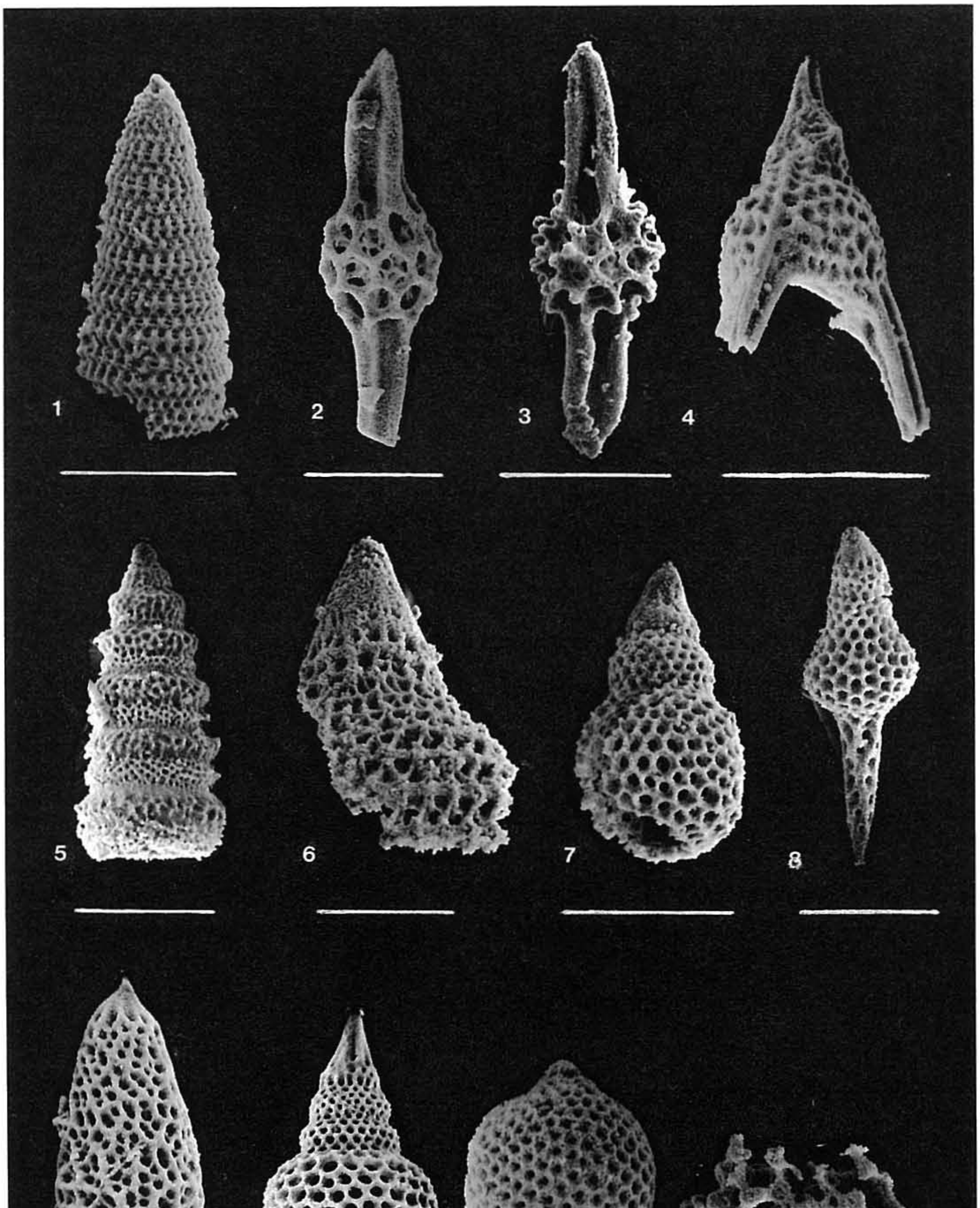


Text-fig. 9 Revised stratigraphy of the pre-Tertiary System in the Pippu-Toma region. Encircled symbols show exotic blocks.

Explanation of Plate 5

Radiolarians from chert block (TC-1) of the Toma Formation. Scales $100\mu m$.

Fig. 1 *Ristola* sp.
Fig. 2 *Pantanellium* sp.
Fig. 3 *Pachyoncus* (?) sp.
Fig. 4 *Napora* sp.
Fig. 5 *Cinguloturris carpatica* Dumitrica
Fig. 6 *Mirifusus mediodilatatus* (Rust)
Fig. 7 *Sethocapsa* sp.
Fig. 8 *Dibolachras* cf. *apletopora* Foreman
Fig. 9 *Hsuum* (?) sp.
Fig. 10 *Podocapsa* cf. *guembeli* Rust
Fig. 11 *Zhamoidellum* sp.
Fig. 12 *Perispyridium tamanense* Pessagno & Blome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pseudomacrocephala, Pseudodictyomitra cf. *nakasekoi, Spongocapsula* (?) *zamoraensis, Stichomitra communis, Diacanthocapsa euganea, Thanarla elegantissima,* and *Thanarla veneta* (Plate 8). These radiolarian assemblages were very similar to the assemblage of *Diacanthocapsa euganea — Thanarla elegantissima* found by Taketani (1982), which ranges from late Albian to early Cenomanian. According to Pessagno (1976), *Thanarla elegantissima* and *Pseudodictyomitra pseudomacrocephala* are known to be restricted to the early Cenomanian. Consequently, the Takasu and the Kaimei Formations are revealed to be Upper Cretaceous and can therefore be corresponding to the Middle Yezo Supergroup.

(c): Revision of the stratigraphy of the pre-Tertiary Systems

As we have mentioned in earlier sections, we have obtained different results of the stratigraphic relation of the pre-Tertiary Systems in the studied region from those obtained by previous authors (Suzuki, 1957; Fujiware et al., 1964; Suzuki et al., 1966; Igo et al., 1974; Hashimoto et al., 1975). By including the results of Ishizuka et al., (1984), Kato et al., (1986), Iwata and Kato (1986), and Kato and Iwata (1987), we propose a revision of the stratigraphy in Text-Fig. 9. In this figure, the exotic blocks are shown with encircled symbols.

Discussion

This study revises the stratigraphy and reassigns the accumulation of the pre-Tertiary System which extends over the Sorachi-Yezo Belt, the Hidaka Western Belt, and the Hidaka Belt around Kamikawa. The Tosshozan and the Toma Formations, which have been thought to be Triassic and Permo-Triassic System by Hashimoto et al. (1975), are now shown to be the early Cretaceous in age (Berriasian? — Valanginian in the Tosshozan Formation and Barremian to Aptian in the Toma Formation). These formation include exotic blocks ranging from the Permian to the early Cretaceous exclusively. As the Tosshozan and the Toma Formations are now considered to be broken formations, a geosyncline concept to these formations can no longer be accepted. Several scholars have recently made advances in geologic and biostratigraphic studies of the "Hidaka Supergroup" in the Hidaka Western Belt (Ezaki, 1984; Kiminami et al., 1986; Kato and Iwata, 1986; Sakai and Kanie, 1986; Sakamoto et al., 1987; Kiyokawa et al., 1987). According to these studies, most of these pre-Tertiary Systems are now seen to be characterized by the presence of similar olistostromes of the early Cretaceous period. The occurrence of such olistostromes is expected to extend

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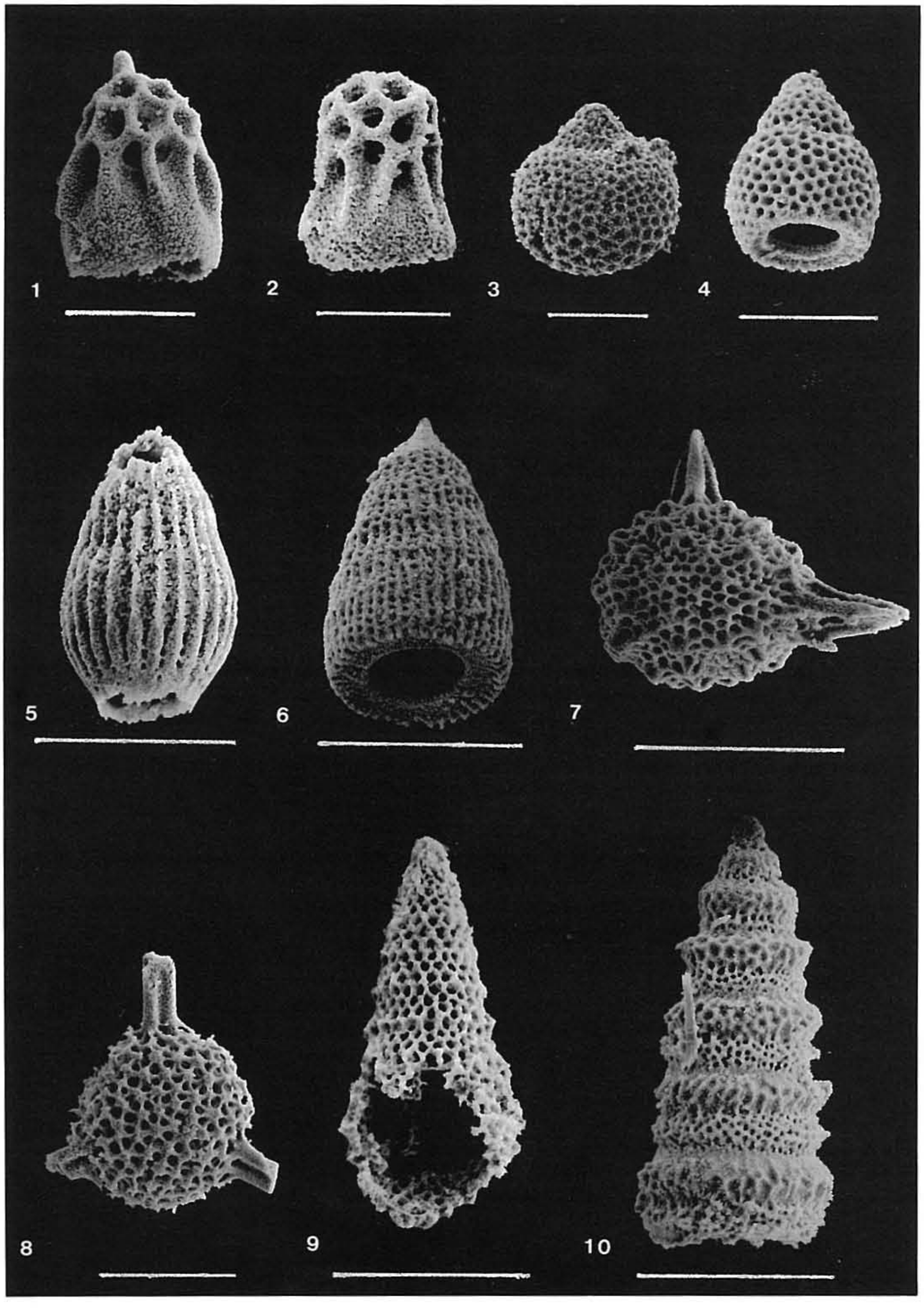
Explanation of Plate 6

Radiolarians from chert block (TC-1) of the Toma Formation. Scales 100μm.

Fig. 1 *Vallupus hopsoni* Pessagno & Blome
Fig. 2 *Vallupus hopsoni* Pessagno & Blome
Fig. 3 *Zhamoidellum* sp.
Fig. 4 *Stichomitra* sp.
Fig. 5 *Archaeodictyomitra* sp.
Fig. 6 *Parahsuum* (?) sp.
Fig. 7 *Acaeniotyle* sp.
Fig. 8 *Tripocyclia* cf. *jonesi* Pessagno
Fig. 9 *Milax* (?) sp.
Fig. 10 *Cinguloturris carpatica* Dumitrica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into Sakhalin Island (Richter and Bragin, 1985). These olistostromes are distributed on the eastern side (that is, on the oceanic side) of the Yezo fore-arc basin, and consist of a mixture of terrigeneous clastics and oceanic materials or fragments of oceanic crust (greenstones, cherts, and limestones). Such mixing of oceanic and terrestrial materials seems to have occurred initially in the vicinity of the trench regions in the eastern margin of the Eurasian Plate during the early Cretaceous (Valanginian — Barremian).

Acknowledgements

We should like to acknowledge the continuing guidance and encouragement of Profs. S. Uozumi and K. Nakamura of Hokkaido University. We are grateful to Prof. M. Kato of Hokkaido University, Prof. Y. Okimura of Hiroshima University, and Prof. S. Sakagami of Chiba University for their identification of corals, foraminifers, and bryozoans. We also wish to thank Prof. K. Nakaseko and Miss. A. Nishimura of Osaka University for their help with the identification of the radiolarian fossils. We are indebted to Mr. J. Tajika of Geological Survey of Hokkaido for his assistance during the field survey. Thanks are due to Mr. M. Hirama, Misses. Y. Igarashi & A. Tanisawa during the laboratory work. This work was financially supported by a Grant-in-Aid from the Japanese Ministry of Education (Leader: Prof. S. Uozumi, No. 630209).

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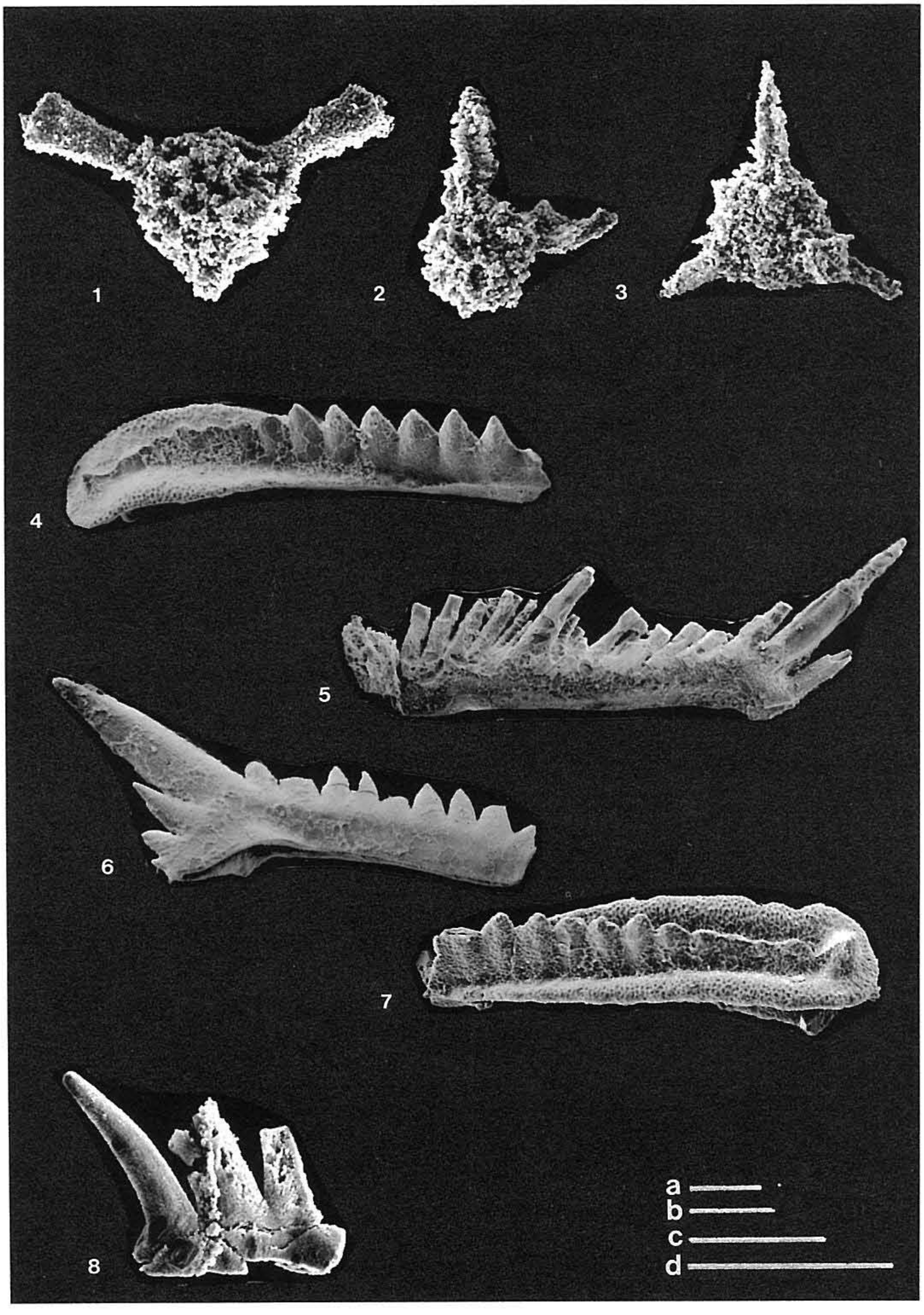
Explanation of Plate 7

Radiolarians and conodonts from exotic blocks of the Tosshozan Formation and the Toma Formation. Figs. 1-3; Radiolarians from TC-3 (amber coloured chert) of Kumanosawa, Kaimei area. Toma Formation. Figs. 4-6; Conodonts from Pippu-Tosshozan Limestone, Tosshozan Formation. Fig. 7; Conodont from Todoyama Limestones (Ls-C & Ls-D), Toma Formation. Fig. 8; Conodont from amber coloured chart boulder of Todoyama area (Toma Formation). Scales 100μm.

Fig. 1 *Capnodoce anapetes* DeWever
Fig. 2 *Betraccium* cf. *deweveri* Pessagno & Blome
Fig. 3 *Tripocyclia* cf. *acythus* DeWever
Fig. 4 *Neogondolella polygnathiformis* (Budurov & Stepanov)
Fig. 5 *Neohindeodella* sp.
Fig. 6 *Ozarcodina* (?) sp.
Fig. 7 *Neogondolella polygnathiformis* (Budurov & Stepanov)
Fig. 8 *Prioniodina* sp.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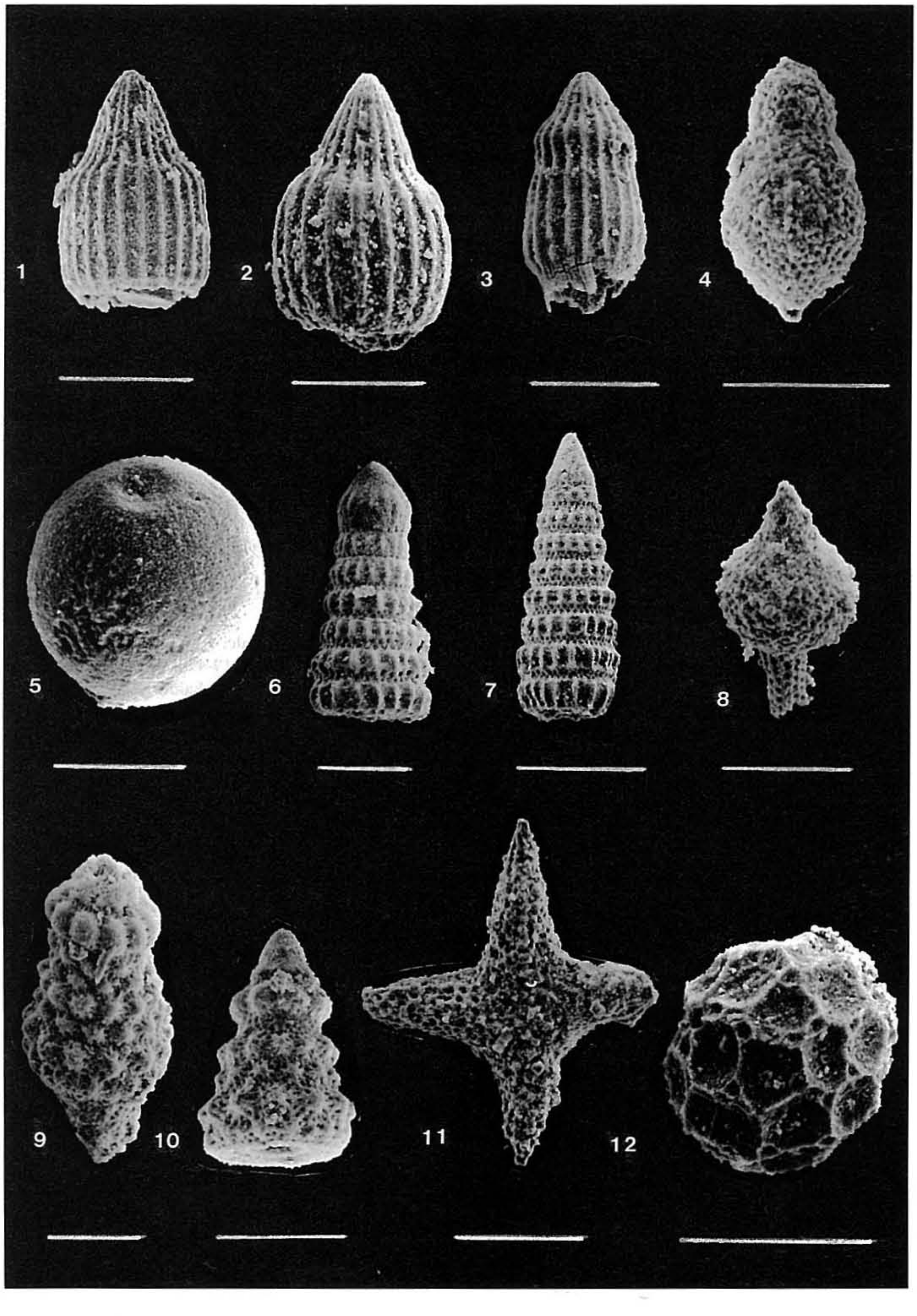
Explanation of Plate 8

Radiolarians from the Kaimei Formation. Scales 100μm.

Fig. 1 *Thanarla elegantissima* (Cita), Loc. KM-2.
Fig. 2 *Thanarla pulchra* (Squinabol), Loc. KM-3.
Fig. 3 *Thanarla veneta* (Squinabol), Loc. KM-2.
Fig. 4 *Diacanthocapsa euganea* Squinabol, Loc. KM-3.
Fig. 5 *Holocryptocanium barbui* Dumitrica, Loc. KM-1.
Fig. 6 *Pseudodictyomitra pseudomacrocephala* Squinabol, Loc. KM-1.
Fig. 7 *Pseudodictyomitra* sp., Loc. KM-1.
Fig. 8 *Eusyringium spinosum* Squinabol, Loc. KM-2.
Fig. 9 *Novixitus weyli* Schmidt-Effing, Loc. KM-3.
Fig. 10 *Novixitus* sp., Loc. KM-3.
Fig. 11 *Crucella* sp., Loc. KM-2.
Fig. 12 *Hemicryptocapsa* cf. *polyhedra* Dumitrica, Loc. KM-4.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(Manuscript received on Oct. 27, 1988; and accepted on Nov. 30, 1988).