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LATE CRETACEOUS RADIOLARIANS OF THE YUBETSU GROUP, TOKORO BELT, NORTHEAST HOKKAIDO

by

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(with 3 text-figures, 2 tables and 9 plates)

Abstract

The Yubetsu Group represents a Mesozoic sequence constituting the western wing of the Tokoro Belt and occupies the eastern margin of the Central Axial Zone of Hokkaido. Due to the absence of mega-fossils, the age of this group has not been fully known until now. It is mainly made up of very thick Flysch type alternating beds of sandstone and shale, often intercalating conglomerates, pebbly sandstone and shale, acidic tuffs, tuffaceous shales, vari-colored shales, and calcareous nodules. This group shows almost a conformable sequence with an easterly dip and its total thickness is estimated to exceed 14,000 m. A radiolarian biostratigraphic study of all the eight formations of this group reveals that it is entirely Late Cretaceous (Early to Late Campanian) in age. *Lithostrobus* sp. A — *Protoxiphotractus perplexus* assemblage zone is proposed to represent the lower half of this Group assemblage zone is further subdivided into a lower *Spongostaurus* (?) *hokkaidoensis* subzone and an upper *Eusyringium* (?) sp. A subzone. No zonation, however, could be established in the upper half of this group on account of very poor and irregular occurrence of radiolarians, except in some horizons of the Onari Formation. The radiolarian assemblage of the Yubetsu Group is to some extent similar to that of the Uppermost Yezo Group, the Rakichinskaya Series of East Sakhalin, and the Campanian equivalent sequence of California, but there is still some differences in them. It is also less similar to the contemporaneous assemblage of southwestern Japan (Shimanto Group, etc.) and the Tropical Pacific. Yubetsu radiolarian fauna may represent an intermediate latitude population of the northwestern Pacific during Campanian times.

Introduction

The Yubetsu Group is a representative Mesozoic sequence in northeast Hokkaido. This group cropped out in the western wing of the Tokoro Belt, which occupies the eastern margin of the Central Axial Zone of Hokkaido. The Tokoro Belt is composed of three Mesozoic Groups — the Yubetsu, the Nikoro, and the Saroma Groups. The Yubetsu Group consists mainly of alternating beds of sandstone and shale, frequently intercalating conglomerates, acidic tuffs, pebbly sandstone and shale, and so on. The Nikoro Group consists mainly of greenstones of sea mount or abyssal sea floor in origin (Niida et al., 1982; Bamba, 1984), and intercalates bedded chert and limestone. Endo et al. (1959) and Hashimoto (1960) reported stromatoporoids of Torinosu type from the Kunneppu and the Ainonai Limestones of this group, and suggested that the Nikoro Group belonged to the Upper Jurassic or Lower Cretaceous System. Recently, Iwata et al., (1983) and Kiminami et al, (1983) reported Late Jurassic and Early Cretaceous radiolarians respectively from the chert of this group. Kuroda et al. (1964) reported *Aucella (Buchia)* spp. from the Saroma Group consisting of sandstones and shales, and they consider that the Saroma Group also belongs to the Jurassic System. However, Late Cretaceous radiolarians were recently recovered from this group (Iwata

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et al., 1983). In view of their lithological similarity, these three Groups of the Tokoro Belt have been correlated with the Kamui Member of the Hidaka Supergroup, the Yamabe Member of the Sorachi Group, and the Shuyubari Member of the same group in Central Hokkaido (Hashimoto, 1958; Endo et., 1959; Nagao, 1960).

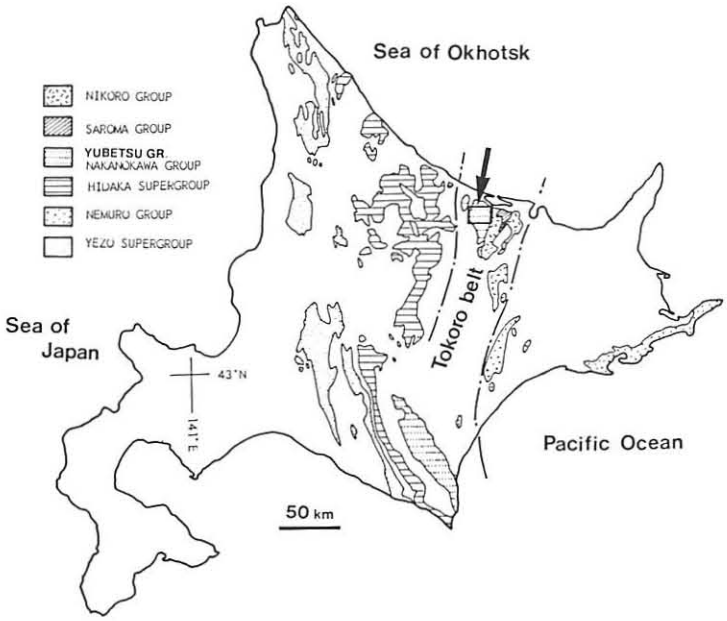
As to the stratigraphic relation of the three groups in the Tokoro Belt, the following different opinions have been put forward. 1) The Yubetsu Group, the Nikoro Group, and the Saroma Groups have conformable relations with each other, the Yubetsu Group being the oldest group among three groups of the Tokoro Belt (Yamada et al., 1963). 2) The Yubetsu Group has a faulted contact with the Nikoro Group, and the former seems to be correlatable with the Saroma Group (Hashimoto, 1952, 1960; Nagao, 1965). However, as stated above, on account of the discovery of Late Jurassic and Early Cretaceous radiolarians from the Nikoro Group (Iwata et al., 1983; Kiminami et al., 1983) and Late Cretaceous radiolarians from the Saroma Group (Iwata et al., 1983), and due to the recognition of an unconformity between the Nikoro and the Saroma Groups (Niida et al., 1982; Research Group of the Tokoro Belt, 1984), the stratigraphic relationship between the Nikoro Group and the Saroma Group should be rectified. Fault contact between the Yubetsu Group and the Nikoro Group has been suggested by Watabe (1982 MS), Niida et al. (1982), and Tajika and Iwata (in prep.).

The name of the "Yubetsu Formation" was first given by Takahashi et al. (1936, a & b) and the "Yubetsu Group" was firstly defined by Hashimoto (1958). A geological survey of this Group was performed by Nagao (1963) and Yamada et al. (1963) in the Nakayubetsu and the Ikutawara regions, respectively. In addition, a sedimentological investigation of this group was carried out by Kiminami et al. (1979) and Kontani et al. (1980). They suggested that the clastic sediments of this group were partly enriched by andesitic volcanic fragments and were supplied from the "Okhotsk Microcontinent" (Hashimoto, 1958; Minato et al., 1965), which existed in the east. Yamada et al. (1963) subdivided the Yubetsu Group into eight formations (Yasukuni, Asahino, Asahitoge, Nisen, Onari, Mizuho, Wakasa, and Nakazono Formations), and they regarded that these formations were overlain conformably with each other. On the other hand, Kimura (1981) suggested a synclinal structure in the Yubetsu Group. Recently, Tajika and Iwata (in prep.) supported the proposal by Yamada et al. (1963) based on the detailed geological investigation of the Yubetsu Group in the eastern terrain of Engaru, where this group is most widely distributed and the entire sequence is available for study. Tajika and Iwata (in prep.) also suggested that the clastic sediments of this group were deposited in a bathyal environment showing sedimentary facies of deep sea fans. The question of the age of the Yubetsu Group has remained unresolved for a long time due to the absence of index megafossils, but recently, Kiminami et al. (1983), for the first time, reported Late Cretaceous radiolarians from the red chert blocks intercalated in the upper part of the Yubetsu Group (Onari Formation), and they suggested that the Yubetsu Group was partly correlatable with the Saroma Group and the Yezo Groups. However, the exact range of the Yubetsu Group has not been fully known yet. Recent advances in radiolarian biostratigraphic studies of the Mesozoic and the Paleozoic sequences or complexes in our country have encouraged reinvestigation of

these sequences of complexes and have contributed greatly to the knowledge of the tectonic and structural evolution of the Japanese Islands during the Mesozoic Era. In this paper, we report the results of a radiolarian biostratigraphic study of the Yubetsu Group in the eastern terrain of Engaru, northeast Hokkaido.

Outline of the geology of the Yubetsu Group

The present field studied covers an area of 17×12 Km^2 in the eastern highlands of Engaru, northeast Hokkaido. Text-fig. 2 shows a simplified geological map and the localities of radiolarian fossils. This region occupies the northern part of the Yubetsu Group. Until recently, no detailed geological investigation of this entire area was undertaken. In this region main part of the Yubetsu Group is extensively distributed, but in a small area of the western part of this field, the Neogene formation unconformably covers the Yubetsu Group. In the eastern margin of this area occurs the Nikoro Group of Late Jurassic to Early Cretaceous age, consisting of greenstones is distributed. Due to poor exposures, one cannot observe direct relations between the Nikoro and the Yubetsu Group, but a fault is suggested between the two. Detailed explanation of the geology, geological structure, sedimentological features of the Yubetsu Group will be presented in another paper currently under preparation, so we only mention the outlines of geology of the Yubetsu Group in this paper.



Text-fig. 1 Distribution of the Cretaceous sedimentary rocks and the Jurassic Nikoro Group in the Central and Eastern Hokkaido, excluding the Sorachi Group (modified from Kiminami et al., 1985). Arrow showing the studied area.

The Yubetsu Group has a general strike trend of NNE-SSW to NE-SW, and generally dips eastward at the angles of 70—90°. In some places there are also beds which dip westward, but they are always overturned, judging from the grading of clastic rocks. Therefore, the Yubetsu Group is regarded to show a homoclinal structure as a whole. The Yubetsu Group consists mainly of Flysch type alternating beds sandstone and shale accompanied by conglomerates (andesite, granites, etc.), pebbly sandstones and shales, acidic tuffs, tuffaceous shales, green and red shales, and a small amount of calcareous and other kinds of nodules. The general sedimentological features of this Group are summarized as follows: 1) grading is easily observable in the clastic sediments; 2) a perfect to sometimes imperfect Bouma sequence is recognized; 3) many "rip-up clasts" are recognized in the coarse sediments; 4) the base of the coarse sediments show sharp scars (small scale of off-scarping and channel structures). These sedimentological features strongly suggest that the major part of Yubetsu Group is made up of clastic sediments which are derived from the gravity flows (Middleton & Hampton, 1973). However, some part of the Group has been known to be transported also by a normal bottom current (Kiminami et al., 1979; Kontani et al., 1980).

The Yubetsu Group in this area can be subdivided lithologically into eight Formations, Toyosato and Yasukuni, Asahino, Kamibaro, Onari, Mizuho, Wakasa, and Nakazono Formations in ascending order. The name of these formations basically follow Yamada et al. (1963), but we proposed two new formations (Toyosato and Kamibaro Formations). In the following lines we briefly describe the lithological features of all these formations.

Toyosato Formation (Abbreviation; TY)

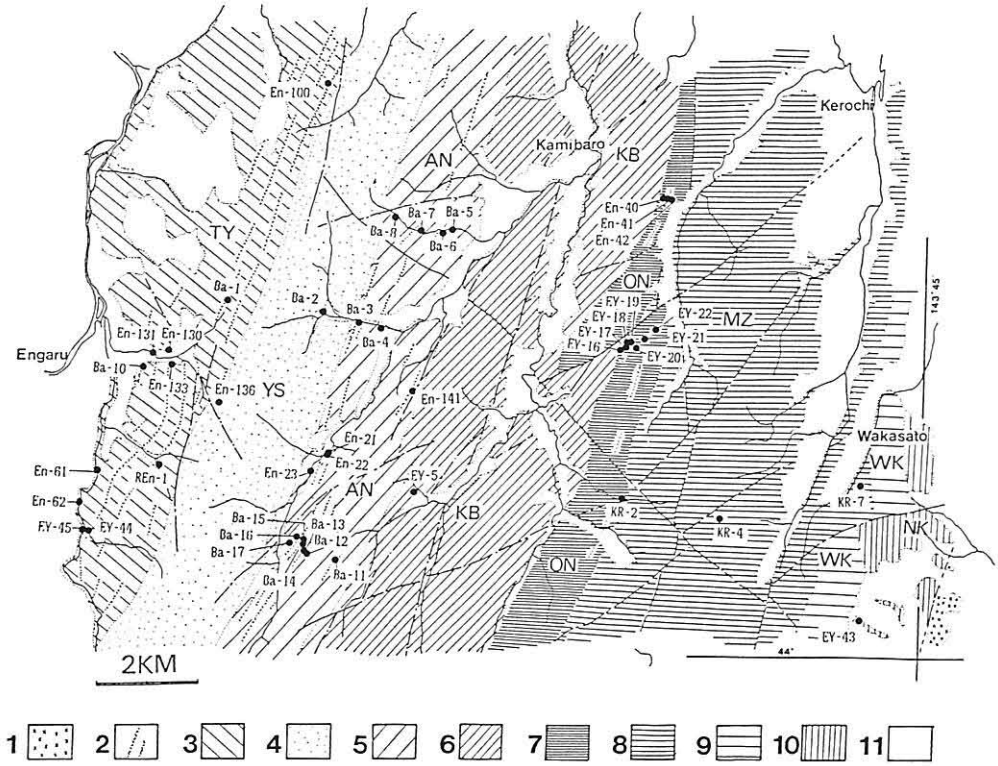
The lower Member of this formation consists mainly of greenish to gray sandstone and sandstone predominating sandy Flysch. Thin conglomerate beds are often intercalated. The upper Member of this formation consists of shaly Flysch and intercalates four or five vari-colored shales (pale green, grayish green, dusky red or purple shales, partly siliceous shales), acidic tuffs and tuffaceous shales. Total thickness is estimated to be about 2,000 m.

Yasukuni Formation (YS)

This formation consists mainly of massive sandstone and sandy-Flysch, and intercalates pebbly sandstone. It rarely contains acidic tuffs. This formation becomes thinner and finer toward the north of this region. The lower Member of this formation is represented by sandy Flysch. Total thickness is 1,600 m.

Asahino Formation (AN)

The lower part of this formation is comprises of shaly Flysch, and the upper one consists of sandy Flysch. Very frequently, vari-colored shales of ten centimeters to several meters in thickness are intercalating. Total thickness is 1,400 m.



Text-fig. 2 Simplified geological map of the Yubetsu Group in the eastern terrain of Engaru. Solid circles showing sample locations. 1) Nikoro Group, 2)—10); Yubetsu Group; 2) "varicolored shales", 3) Toyosato Formation (TY), 4) Yasukuni F. (YS), 5) Asahino F. (AN), 6) Kamibaro F. (KB), 7) Onari F. (ON), 8) Mizuho F. (MZ), 9) Wakasa F. (WK), 10) Nakazono F. (NK), 11) Tertiary & Quarternary.

Kamibaro Formation (KB)

Relatively thick sandstone is developed in the lower and the upper part of this formation. The middle part of this formation consists of shaly Flysch. This formation includes the Asahitoge Formation and the Nisen Formation by Yamada et al. (1963). In the present area we could not distinguish two formations on account of poor-exposure. Total thickness is about 2,300 m.

Onari Formation (ON)

This formation consists mainly of shale, and intercalates a small amount of shaly Flysch, acidic tuffs, vari-colored shales, tuffaceous shales, and a small amount of calcareous nodules. This formation often includes slump blocks of sandstone. Yamada et al. (1963) stated that this formation included red chert in the Ikutawara region, which lies in the southern proximity of the present field. Total thickness is about 1,000 m.

Mizuho Formation (MZ)

This formation consists mainly of normal Flysch and shaly Flysch. In the upper part of the formation sandy Flysch predominates. This formation sometimes has intercalations of conglomerates and pebbly sandstones of several tens of meters in thickness. Lebenspuren (*Paleodictyon* spp., etc.) have been observed in the clastic sediments of this formation. Total thickness is 4,000 m.

Wakasa Formation (WK)

This formation consists of thick sandstone and pebbly sandstone, partly intercalates shaly Flysch. However, thick sandstone pinches out toward the north, and sediments become finer in the same direction. Total thickness is 800 m.

Nakazono Formation (NK)

This formation consists of normal Flysch and shaly Flysch. Its total thickness is more than 1,000 m. However, the upper limit of this formation is unknown on account of the fault between the greenstone of the Nikoro Group and the upper most part of the Nakazono Formation.

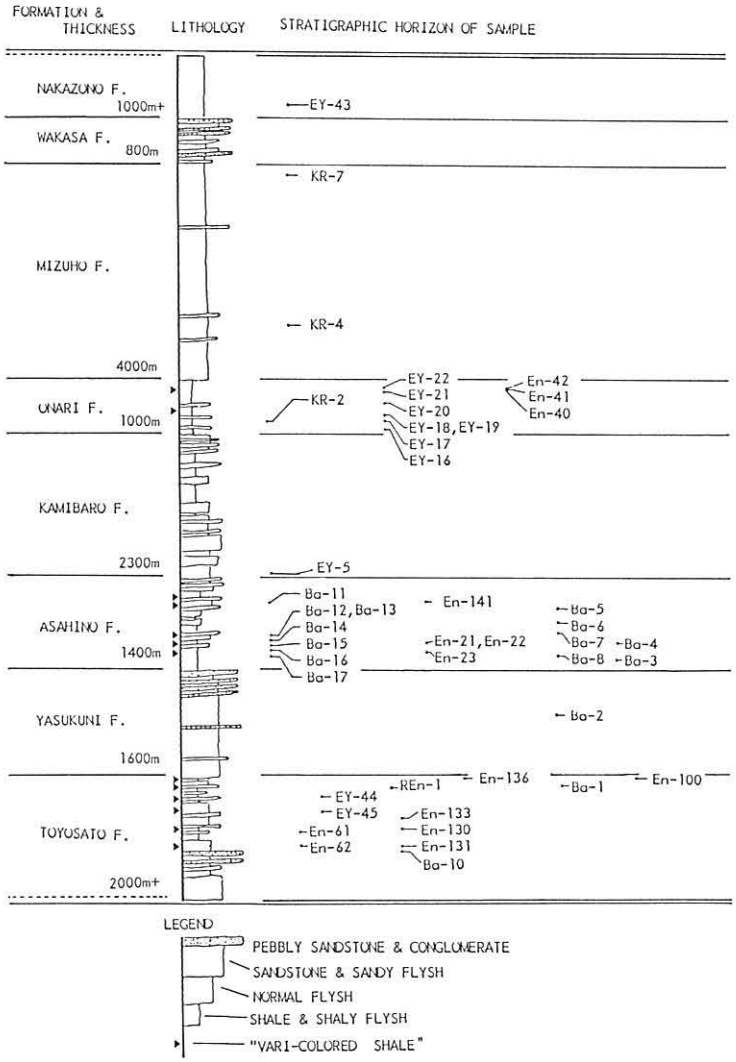
Stratigraphic distribution and zonation of radiolarians in the Yubetsu Group

Stratigraphic distribution

Radiolarians were obtained from more than 40 localities throughout the eight formations of the Yubetsu Group in the studied area. Text-fig. 2 shows the major localities of radiolarian fossils of the Yubetsu Group in the eastern terrain of Engaru. Megafossils were not obtained in this field. In spite of enormous thickness of this Group, radiolarians were confined mainly in a few formations such as the Toyosato, Asahino, and Onari Formations. The other Formations yielded only a small quantity of radiolarians. Benthonic foraminifers co-occurred in the Onari, Asahino, and Toyosato Formations. A small amount of diatoms and sponge spicules, also, occurred along with radiolarians in some cases. Calcareous nodules and black shales generally yielded only a small quantity of radiolarians, while varicolored shales or siliceous shales from several horizons of this group (See simplified geological column in Text-fig. 3) yielded abundant, well-preserved radiolarians.

Toyosato Formation

The lower Member of this formation seldom yielded radiolarians, with the exception of a few ill-preserved spumellarians. On the other hand, vari-colored shales intercalated in the upper Member yielded well-preserved radiolarians (Localities: Ba-10, En-131, 132, 133, En-62, R-En-1, En-32, En-100, etc.). The following radiolarian species were identified: *Cornutella californica, Lithatractus pusillus, Spongostaurus* (?) *hokkaidoensis, Lithostrobus* sp. A & B, *Spongosaturnalis spinifer, Protoxiphotrac-*



Text-fig. 3 Schematic columnar section of the Yubetsu Group and the stratigralphic horizons of sampling points.

tus perplexus, Orbiculiforma monticelloensis, O. sp. A, *Theocalyptra* cf. *limbata, Clathrocyclas* cf. *diceros, Eucyrtidium* sp. A, *Crucella espartoensis, C.* spp, *Patulibrachium* spp., etc, (Pl. 7-9). Besides these radiolarians, *Dictyomitra multicostata, Rhopalosyringium magnificum, Orbiculiforma quadrata* etc were associated. Among these radiolarians, *Lithostrobus* sp. A, *Orbiculiforma* sp. A, *Eucyrtidium* sp. A were more abundant but *Spongostaurus* (?) *hokkaidoensis* are very common in the lower part of this Member. Taketani (1982) suggested that *Spongostaurus* (?) *hokkaidoensis* probably occurred only in the early Campanian portion

(Chinomigawa Formation), based on his elaborata biostratigraphic study of the Yezo Group in central Hokkaido. And Pessagno (1976) reported that *Protoxiphotractus perplexus* was restricted to the early Campanian portion of the Great Valley Sequence. Therefore, the Toyosato Formation is considered to be Upper Cretaceous (Early Campanian) in age.

Yasukuni Formation

No radiolarians have been found as yet from the lower Member of this formaiton. Dark greenish gray shale of the upper Member of this formation (Loc. Ba-2) yielded a small amount of *Lithostrobus* sp. A, *Eucyrtidium* sp. A, *Bathropyramis campbelli, Orbiculiforma* cf. *monticelloensis, Cornutella californica*, and *Archaeodictyomitra* spp., etc.

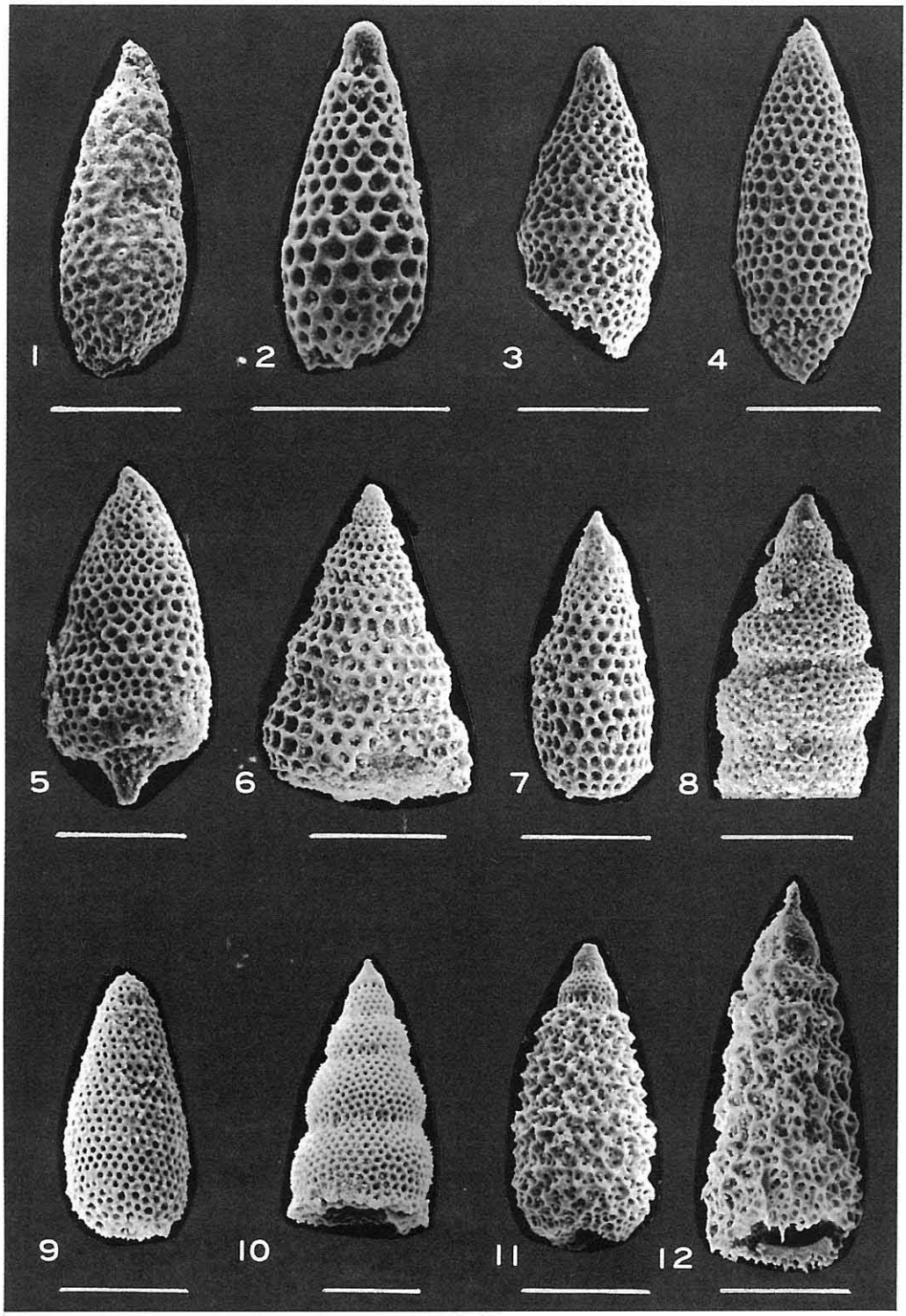
Asahino Formation

Vari-colored shales (partly silicified) intercalated in this formation yielded relatively well preserved radiolarians from Locs., Ba-8, Ba-11, 12, 13, 14, 15, 16, 17, Ba-5, 6, 7, and EY-14. *Protoxiphotractus perplexus, Lithostrobus* sp. A, *Eucyrtidium* sp. A, *Orbiculiforma* cf. *monticelloensis, O.* sp. A, *Bathropyramis campbelli, Eusyringium* (?) sp. A, *Lithatractus pusillus*, etc were identified (Pl. 6). Among these radiolarian species, *Eusyringium* (?) sp. A is most characteristic. Until now, this species was not reported from other Formations of the Yubetsu Group. Thus, *Eusyringium* (?) sp. A seems to be a good zone marker for this Formation. This species has been known from the Rakichinskaya Series of East Sakhalin (Zamoida, 1972). From this series, *Inocaramus (Sphenoceramus) schmidtii, Mesopachydiscus* sp., *Gaudryceras* sp., were reported by Sasa et al. (1935). Therefore, the Rakichinskaya Series includes the Middle Campanian. However, it is not precisely determined whether the Asahino Formation belonged to the middle Campanian or not, because no mega-fossils have been found from the Asahino Formation. A few tests of *Protoxiphotractus perplexus* may show that at least a part of the Asahino Formation belongs to the Lower Campanian.

Explanation of Plate 1

All figures are scanning electron micrographs. Scale 100 μm. Fig. 1: Mizuho Formation, Loc. KP-4, Figs. 2-12: Onari Formation., Loc. EY-19.

Fig. 1 *Amphipyndax* cf. *stocki* (Campbell & Clark)
Fig. 2 *Amphipyndax stocki* (Campbell & Clark)
Fig. 3 *Amphipyndax* cf. *stocki* (Campbell & Clark)
Fig. 4 *Stichomitra livermorellensis* Foreman
Fig. 5 *Stichomitra* sp.
Fig. 6 *Stichomitra* aff. *communis* Squinabol
Fig. 7 *Stichomitra campi* Foreman
Fig. 8 *Amphipyndax plousios* Foreman
Fig. 9 *Stichomitra* aff. *campi* Foreman
Fig. 10 *Stichomitra* sp.
Fig. 11 *Xitus* (?) sp. A
Fig. 12 *Xitus* (?) sp. B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Kamibaro Formation

This formation seldom yielded radiolarians. Black shale of Loc. EY-5 yielded a small amount of *Cryptamphorella sphaerica, Gongylothorax verbeeki, Amphipyndax stocki*, and *Phaseliforma* spp., (Pl. 5, figs. 11-12).

Onari Formation

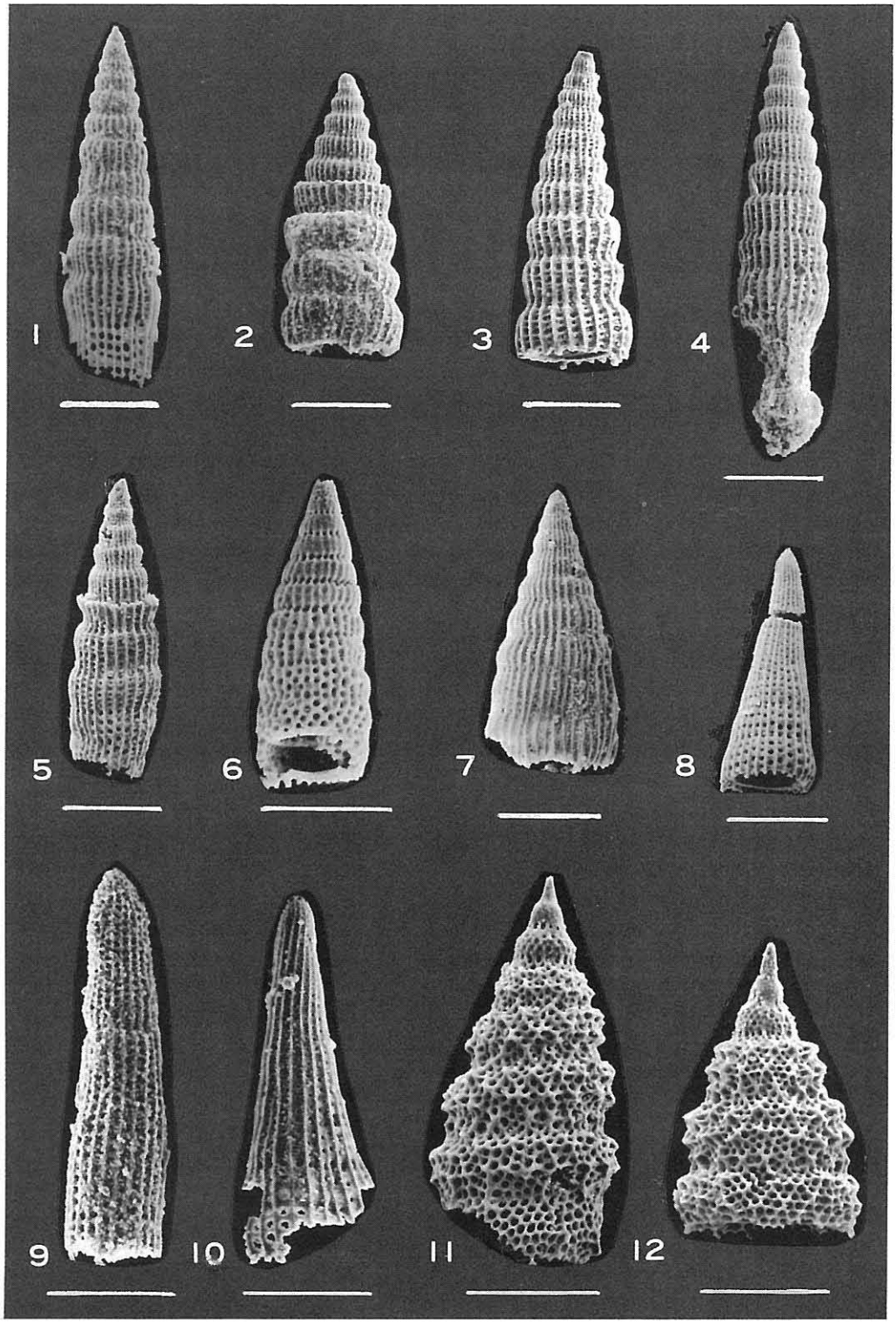
Black shales predominated in this formation, but vari-colored shales intercalated in a few horizons yielded abundant well-preserved radiolarians. The following species were obtained from Locs. EY-16, 17, 18, 19, 20, 21, En-40, 41, 42, KR-2, etc. *Amphipyndax plousios, A. stocki, Stichomitra* cf. *campi, S. livermorellensis, Xitus* (?) *asymbatos, Dictyomitra multicostata, D. crassispina, D.* cf. *andersoni, Mita regina, Bisphaerocephalina* (?) sp. A & B, *Crucella espartoensis, C.* cf. *aster, Phaseliforma* cf. *laxa, Orbiculiforma sacramentoensis, Conocaryomma universa, Clathrocyclas hyronia, Gongylothorax verbeeki, Cryptamphorella sphaerica*, etc (Pl. 1-5). However, *Lithostrobus* sp. A, *Protoxiphotractus perplexus, Eusyringium* (?) sp. A, *Orbiculiforma* sp. A do not occur. Among these radiolarians, *Mita regina, Orbiculiforma sacramentoensis, Xitus* (?) *asymbatos, Phaseliforma laxa, Amphipyndax plousios, Stichomitra livermorellensis*, etc., are common in the Late Campanian radiolarian assemblage of California reported by Campbell and Clark (1944), Foreman (1968), and Pessagno (1976). This formation, therefore, can be assigned approximately to the Upper Campanian (probably *Phaseliforma carinata* subzone of Pessagno, 1976).

Kiminami et al. (1983) reported Late Cretaceous radiolarians of Late Albian to Early Cenomanian in age (e. g. *Thanarla elegantissima, T.* aff. *veneta*, etc.) from the red chert blocks intercalated within the Onari Formation of the Ikutawara region, just south of the present research area. This chert does not extend into our area under investigation. Further, we have found *Dictyomitra multicostata, Xitus* (?) *asymbatos, Phaseliforma* cf. *laxa,* etc., from red and green shales in the vicinity of the red chert blocks reported by Kiminami et al. (1983). Consequently, we assume that red chert, which yielded Late Albian to Early Cenomanian radiolarians, may be exotic blocks within the Onari Formation.

Explanation of Plate 2

Fig. 1-12: Onari Formation., Loc. EY-19.

Fig. 1 *Dictyomitra multicostata* Zittel
Fig. 2 *Dictyomitra* cf. *multicostata* Zittel
Fig. 3 *Dictyomitra* aff. *multicostata* Zittel
Fig. 4 *Dictyomitra crassispina* (Squinabol)
Fig. 5 *Dictyomitra* cf. *andersoni* Foreman
Fig. 6 *Pseudodictyomitra* sp.
Fig. 7 *Archaeodictyomitra* sp.
Fig. 8 *Mita* cf. *regina* (Campbell & Clark)
Fig. 9 *Mita regina* (Campbell & Clark)
Fig. 10 *Archaeodictyomitra* sp.
Fig. 11 *Xitus* (?) *asymbatos* Foreman
Fig. 12 *Xitus* (?) *asymbatos* Foreman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Mizuho Formation

This formation is characterized by thick rhythmical alternating beds of black shale and sandstone, and yields a small amount of ill-preserved radiolarians such as *Cryptamphorella sphaerica, Dictyomitra* spp., *Amphipyndax* cf. *stocki, A.* spp. *Stichomitra* spp., which were obtained from black shale of Locs. KR-4 and KR-7 (Pl. 1, fig. 1). Black shale of KR-7 accompanied several individuals of reworked Lower Cretaceous radiolarians such as *Thanarla conica* and *Novixitus* spp.

Wakasa Formation

No radiolarians have been obtained from this formation.

Nakazono Formation

This formation seldom yielded radiolarians. Only one location (EY-43) yielded a few individuals of ill-preserved *Amphipyndax* spp. and *Stichomitra* spp. The Nakazono Formation of the type locality in the Ikutawara region also yielded very few radiolarians.

The above-mentioned three formations overlying the Onari Formation, in spite of their great thicknesses, yielded very few radiolarians and no index marker species. Therefore, we could not decide the exact age of these three Formations and the upper limit of the Yubetsu Group. Based on the remnant Amphipyndacids, the uppermost part of the Yubetsu Group (Nakazono Formation) may belong to the Uppermost Campanian or Lower Maastrichtian.

Radiolarian zonation of the Yubetsu Group

Stratigraphic distribution of radiolarians of the Yubetsu Group was summarized in Table 1. As already stated in the foregoing chapter, several species were known to be stratigraphically limited. *Spongostaurus* (?) *hokkaidoensis, Lithostrobus* sp. A, *Eucyrtidium* sp. A, *Protoxiphotractus perplexus, Orbiculiforma* sp. A, etc ranged through the Toyosato Formation to the Asahino Formation. *Eusyringium* (?) sp.A occurred only in the Asahino Formation. From above-memtioned results, we provisionally propose a *Lithostrobus* sp. A — *Protoxiphotractus perplexus* assemblage zone, which covers approximately the lower half of the Yubetsu Group. Furthermore, this zone can be subdivided into two subzones; i.e., lower *Spongostaurus* (?) *hokkaidoensis* subzone and upper *Eusyringium* (?) sp. A subzone. On the other hand, we find it difficult to

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Explanation of Plate 3

Fig. 1-11: Onari Formation, Loc. EY-19.

Fig. 1 *Xitus* (?) sp. C
Fig. 2 *Xitus* (?) sp. D
Fig. 3 *Xitus* (?) sp. B
Fig. 4 *Theocampe* (?) sp.
Fig. 5 *Bathropyramis campbelli* Taketani
Fig. 6 *Cornutella californica* Campbell & Clark
Fig. 7 *Cornutella* (?) sp.
Fig. 8 *Plectopyramis* (?) sp.
Fig. 9 *Clathrocyclas hyronia* Foreman
Fig. 10 *Clathrocyclas hyronia* Foreman
Fig. 11 *Spongosaturnalis* sp.

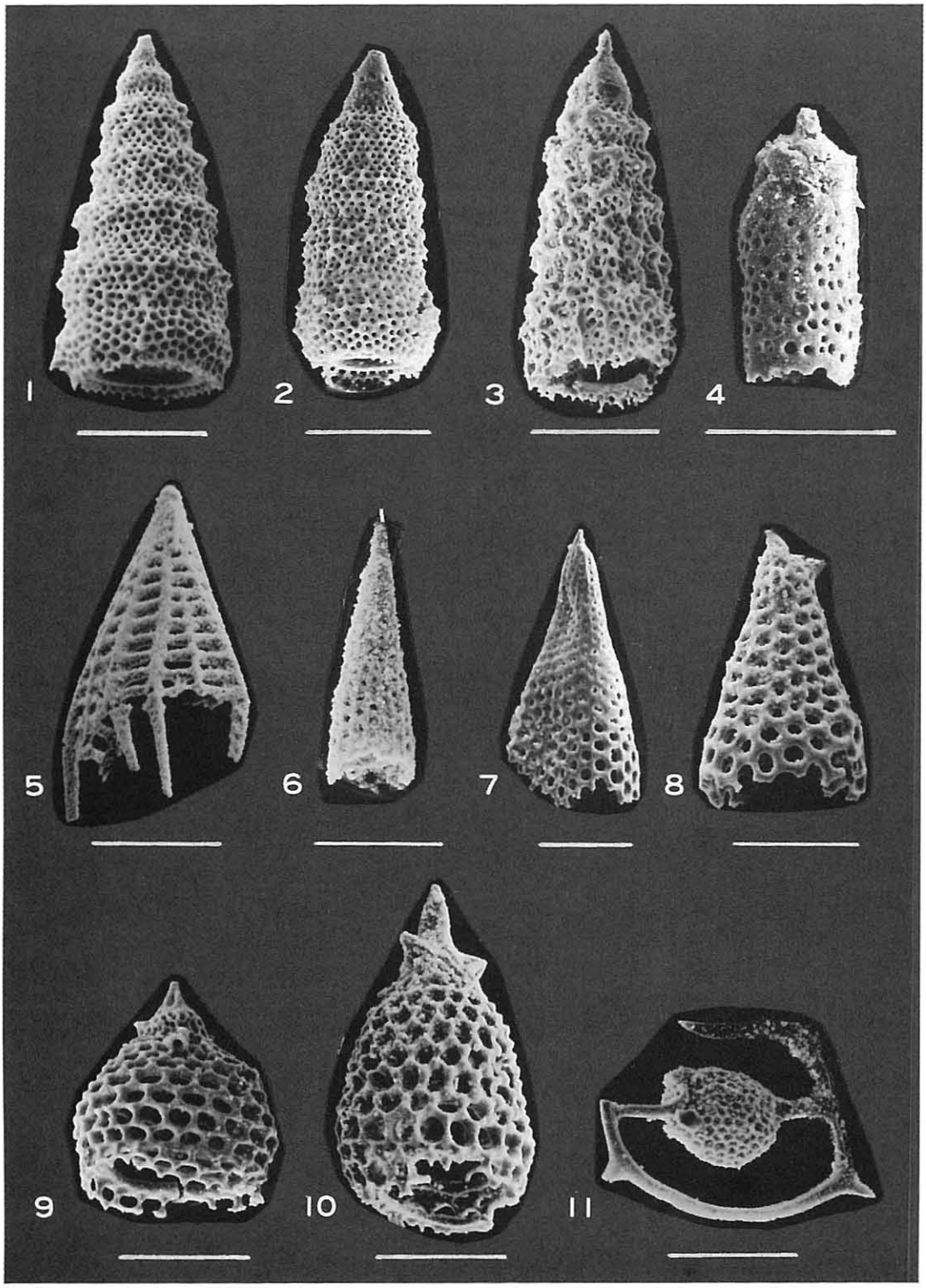
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Table 1

Stratigraphic distribution and abundance of Radiolaria in the Yubetsu Group in the eastern terrain of Engaru. Letter symbols showing abundance of radiolarians are as follows; rare (r), less than 5% of the total species; common (c), 5 to 15%; abundant (a), more than 15%.

YUBETSU GROUP																										
Toyosato F.						Yasukuni F.	Asahino F.							Kamibaro F.	Onari F.							Mizuho F.		Wakasa F.	Nakazono F.	FORMATIONS
Ba-10	En-62 En-131	En-61 En-130	EY-45 En-133	EY-44	R-En-1	Ba-2	Ba-17	Ba-16 En-23	Ba-15 En-22	Ba-14 En-21	Ba-13	Ba-12	Ba-11 En-141	EY-5	EY-16	EY-17	EY-18	EY-19	EY-20 En-40	EY-21 En-41	EY-22 En-42	KR-4	KR-7	Barren	EY-43	SAMPLES SPECIES
	r				r											r		r								*Amphipyndax alamedaensis* Campbell & Clark
																		r								*A. plousios* Foreman
	r				r								r			r		c	c			r	r			*A. stocki* (Campbell & Clark)
														r	r	r	r	c	r	r	r		r		r	*A.* cf. *stocki* (Campbell & Clark)
	r				r	r							r	r		r	r	r	r							*Archaeodictyomitra* spp.
r	c	c	r		c	r	c	c	c	c	r	r	r		r	r	r	c	c							*Bathropyramis campbelli* Taketani
																		c	r							*Bisphaerocephalina* (?) sp. A
																		c								*B.* (?) sp. B
							r	r					r					r								*Botryocyrtis* spp.
					c		r					r	r													*Clathrocyclas* cf. *diceros* Foreman
																		c								*C. hyronia* Foreman
																		r								*Conocaryomma universa* (Pessagno)
	r				c	r	r											r								*Cornutella californica* (Campbell & Clark)
												r						r								*Cromyomma* (?) *nodosa* Pessagno
																		r								*Crucella* cf. *aster* (Lipman)
													r					r								*C. espartoensis* Pessagno
	r																	r	r							*C.* spp.
														r				r								*Cryptamphorella sphaerica* (White)
	r	r	r		r									r												*Diacanthocapsa* cf. *ancus* (Foreman)
	r	r			r													r								*D.* cf. *ovoidea* Dumitrica
																		r								*Dictyomitra* cf. *andersoni* Foreman
		r																a	c							*D. crassispina* (Squinabol)
		r											r					c								*D.* cf. *multicostata* Zittel
																		c								*D.* spp.
	c	c		c	c	r	r				r	c	r													*Eucyrtidium* sp. A
					r							r	r													*E.* sp. B
							r	c	c	c			r													*Eusyringium* (?) sp. A
								r	r	r																*E.* (?) sp. B
														r				r								*Gongylothorax verbeeki* (Tan Sin Hok)
						r		r			r		r					c								*Lithatractus pusillus* (Campbell & Clark)
								c			r		r		r			r								*Lithomespilus* cf. *mendosa* (Krashenikov)
																		r								*Lithomitra* spp.
r	c	c	c	c	c	r	c	r	r	r	r	c	c	r												*Lithostrobus* sp. A
				r	r							r														*L.* sp. B
																		c								*Mita regina* (Campbell & Clark)
c	c		r	r	r	r		r	r	r			r			r		r								*Orbiculiforma monticelloensis* Pessagno
r	c	c											r					r								*O.* cf. *quadrata* Pessagno
																		r								*O. sacramentoensis* Pessagno
c	c	c	c		r	r	c	c	r	c			r													*O.* sp. A
													r					r								*Patulibrachium* spp.
																										Peripyramis spp.
	r				r													c	r							*Phaseliforma* cf. *laxa* Pessagno
													r	r			r	a	c	r	r	r	r			*P.* spp.
	r				c													c	r							*Praestylosphaera hastatus* Empson-Morin
	r				r		r						c													*Protoxiphotractus perplexus* Pessagno
	r												r													*P.* spp.
																		r								*Pseudodictyomitra* spp.
					r																					*Rhopalosyringium magnificum* Campbell & Clark
	r				c																					*Spongosaturnalis spinifer* Campbell & Clark
													r					r								*S.* spp.
																										Spongostaurus (?) *hokkaidoensis* Taketani
r	a	c	c										r					r								*Spongotripus morenoensis* Campbell & Clark
																		c				r			r	*Spongurus* spp.
																		r								*Stylosphaera* cf. *goruna* Sanfilippo & Riedel
															r	r	r	c	r	r	r					*S.* spp.
																		r								*Staurodictya* spp.
																		r								*Stichomitra* cf. *communis* Squinabol
	r	r											r					c								*S. livermorellensis* Foreman
																r	r	c								*S. campi* Foreman
																		r								*Theocampe* spp.
																										Theocalyptra cf. *limbata* Lipman
	r	r			c								c		r	r	r	c	c							*Xitus* (?) *asymbatos* Forman
													r					c								*X.* (?) sp. A
																		r								*X.* (?) sp. B
																		r								*X.* (?) sp. C
																		r								*X.* (?) sp. D

Explanation of Plate 4

Fig. 1-12: Onari Formation, Loc. EY-19.

Fig. 1 *Bisphaerocephalina* (?) sp. A

Fig. 2 *Bisphaerocephalina* (?) sp. A

Fig. 3 *Bisphaerocephalina* (?) sp. B

Fig. 4 Hagiastrid gen. et sp. indet.

Fig. 5 *Phaseliforma* sp.

Fig. 6 *Phaseliforma* sp.

Fig. 7 *Phaseliforma* cf. *laxa* Pessagno

Fig. 8 *Diacanthocapsa* cf. *ancus* (Foreman)

Fig. 9 *Stylosphaera* sp.

Fig. 10 *Stylosphaera* sp.

Fig. 11 *Stylosphaera* sp.

Fig. 12 *Stylosphaera* sp.

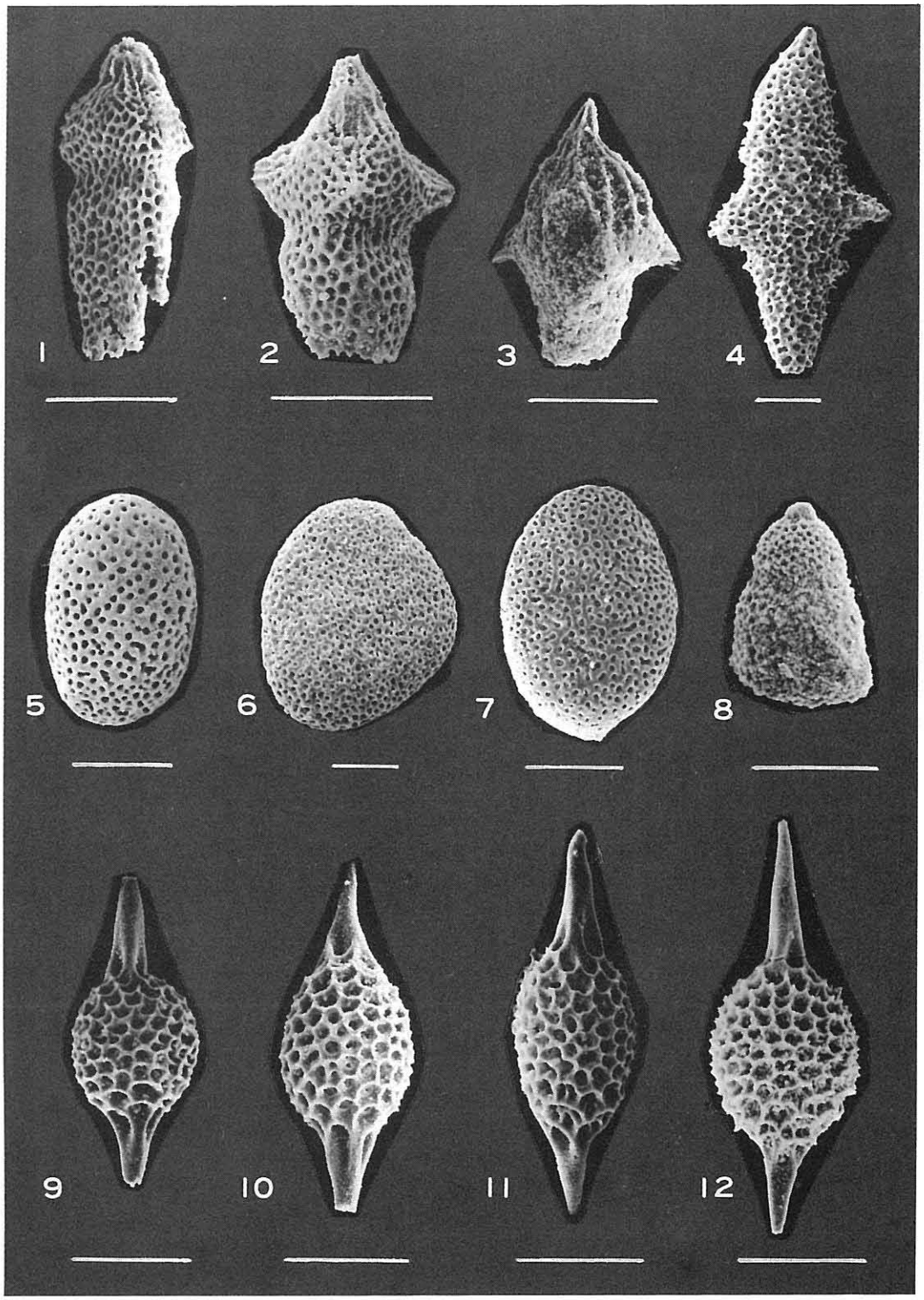
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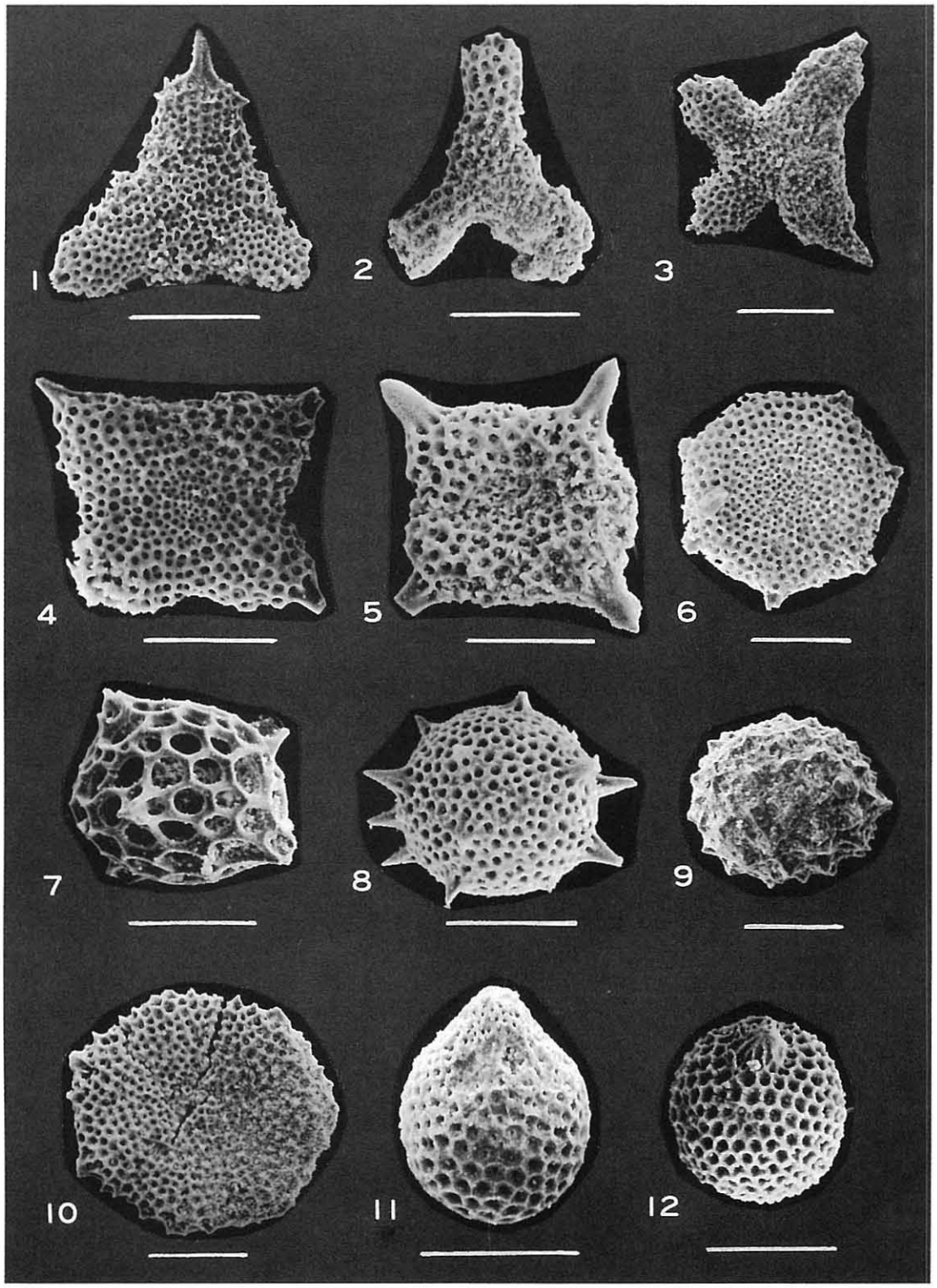
Table 2 Correlation of the proposed zonation with the zones of earlier authors.

	Pessagno (1976)	Riedel & Sanfilippo (1974), Foreman (1977)	Taketani (1982)	Iwata & Tajika (this report)	Formations
Upper Cretaceous					
Maastr.	*Orbiculiforma renillaeformis* Z.	*Amphipyndax tylotus* Z.		?	Nakazono F.
Campanian	*Patulibrachium dickinsoni* Z.	*A. enessefji* Z.		*Bisphaerocephalina* (?) sp. A *Orbiculiforma sacramentoensis* *Phaseliforma* cf. *laxa* *Xitus* (?) *asymbatos* etc.	Wakasa F. Mizuho F. Onari F. Kamibaro F.
	Phaseliforma carinata subz.				
	Patulibrachium lawsoni subz.				
	Protoxiphotractus perplexus subz.			*Lithostrobus* sp. A — *Protoxiphotractus perplexus* assemblage Z.	Asahino F.
	Crucella espartoensis Z.				
			Spongostaurus (?) *hokkaidoensis* Z.	*Eusyringium* (?) sp. A subz.	Yasukuni F.
				Spongostaurus (?) *hokkaidoensis* subz.	Toyosato F.
Santonian	*Alievium gallowayi* Z.	*Artostrobium urna* Z.	*Orbiculiforma quadrata* Z.		

Explanation of Plate 5

Figs. 1-10: Onari Formation, Loc. EY-19; Figs. 11-12: Kamibaro Formation, Loc. EY-5

Fig. 1 *Spongotripus morellensis* Campbell & Clark
Fig. 2 *Patulibrachium* sp.
Fig. 3 *Crucella espartoensis* Pessagno
Fig. 4 Crucella cf. *aster* (Lipman)
Fig. 5 *Orbiculiforma* cf. *quadrata* Pessagno
Fig. 6 *Orbiculiforma sacramentoensis* Pessagno
Fig. 7 *Cromyomma* (?) cf. *nodosa* Pessagno
Fig. 8 *Cromyomma* (?) sp.
Fig. 9 *Conocaryomma universa* (Pessagno)
Fig. 10 *Orbiculiforma sacramentoensis* Pessagno
Fig. 11 *Cryptamphorella sphaerica* (White)
Fig. 12 *Gongylothorax verbeeki* (Tan Sin Hok)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establish any radiolarian zonation in the upper half of the Yubetsu Group, because occurrence of stratigraphically useful radiolarians is restricted to very limited horizons. Hence, we propose only one zonation from the results of the present biostratigraphic study. *Lithostrobus* sp. A — *Protoxiphotractus perplexus* assemblage zone is assignable to Pessagno's *Crucella espartoensis* zone (especially *Protoxiphotractus perplexus* subzone) and *Amphipyndax enesseffi* zone of Riedel & Sanfilippo (1974) and Foreman (1968). However, *Amphipyndax enesseffi* and *A. tylotus* have not yet been obtained from the Yubetsu Group.

Discussion

The results of the present radiolarian biostratigraphic study of the Yubetsu Group, which has long been called the Unknown Mesozoic System in Hokkaido, have revealed that this group belonged to Late Cretaceous (Early to Late Campanian) in age. However, its upper limit could not precisely be determined on account of very few radiolarians being present. Kiminami et al. (1983) reported radiolarians of Late Albian to Early Cenomanian in age from the chert blocks intercalated within the Onari Formation. But as already stated in the foregoing chapters, this chert is considered to be an exotic block within the Onari Formation. Besides, small chert block intercalated in the Toyosato Formation yielded radiolarians of Upper Jurassic age (Iwata, unpublished). This chert can also be considered to be an olistolith. However, throughout the whole profile of the Yubetsu Group, such olistoliths are not common. In this paper we provisionally proposed *Lithostrobus* sp. A — *Protoxiphotractus perplexus* assemblage zone. This assemblage zone was subdivided into two subzones such as *Spongostaurus* (?) *hokkaidoensis* subzone (lower) and *Eusyringium* (?) sp. A subzone (upper). *Lithostrobus* sp. A — *Protoxiphotractus perplexus* assemblage zone is partly assignable to Pessagno's *Crucella espartoensis* zone (i.e., *Protoxiphotractus perplexus* subzone) and to *Amphipyndax enesseffi* zone proposed by Riedel & Sanfilippo (1974) and Foreman (1977). The lower half of *Lithostrobus* sp. A — *Protoxiphotractus perplexus* assemblage zone may also be partly correlated to *Spongostaurus* (?) *hokkaidoensis* zone, which was provisionally established by Taketani (1982).

The radiolarian assemblage of the lower horizons of the Yubetsu Group (Toyosato and Yasukuni Formations) is somewhat similar to that of the uppermost Yezo Group

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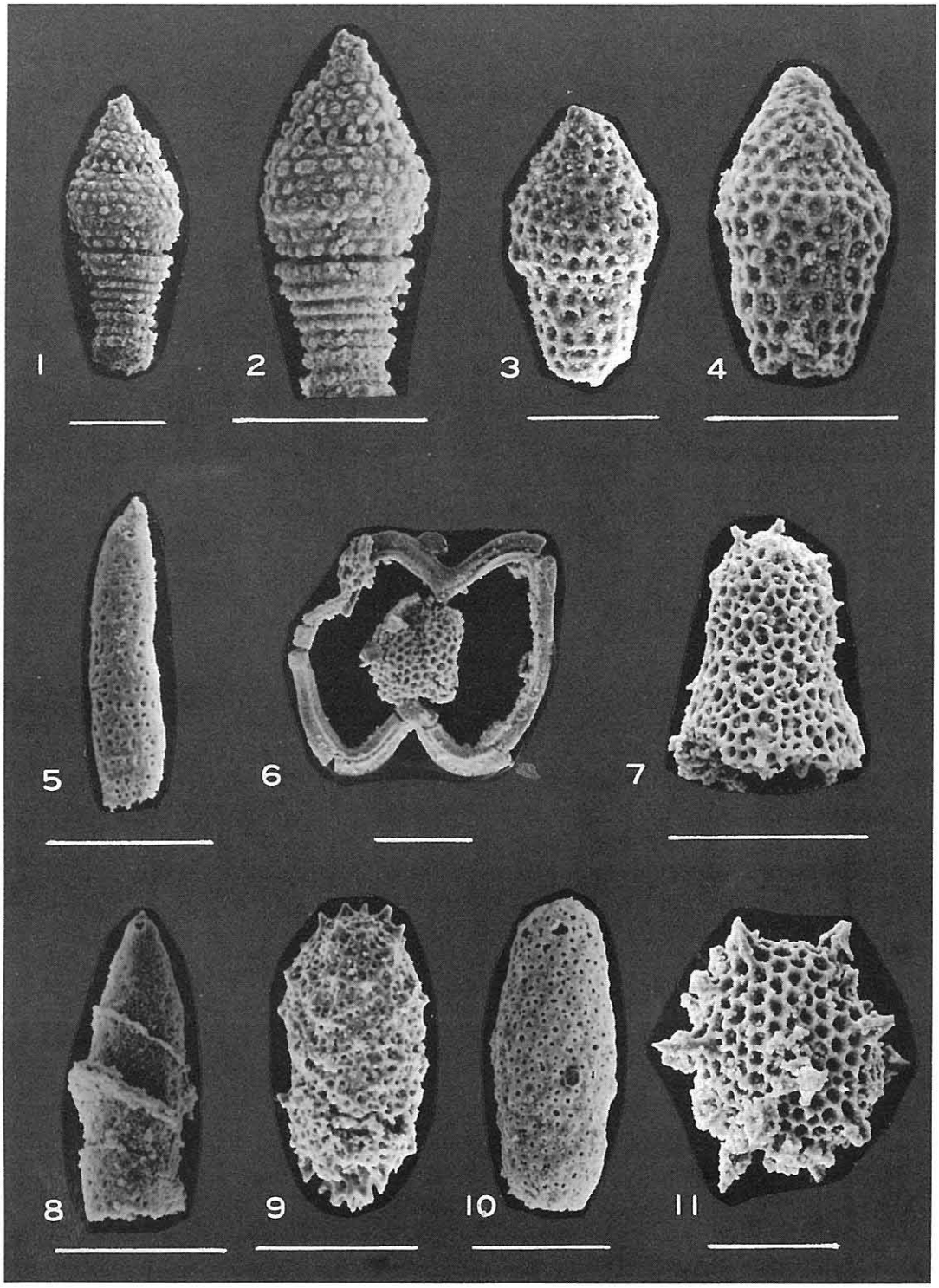
Explanation of Plate 6

All figures are of radiolarians derived from the Asahino Formation. Figs. 1-2: Loc. En-21; Figs. 3-4: Loc. Ba-5; Figs. 5-9: Loc. Ba-11; Figs. 10-11: Loc. Ba-8.

Fig. 1 *Eusyringium* (?) sp. A Zamoida (inner mould)
Fig. 2 *Eusyringium* (?) sp. A Zamoida (inner mould)
Fig. 3 *Eusyringium* (?) sp. A Zamoida
Fig. 4 *Eusyringium* (?) sp. A Zamoida
Fig. 5 *Eucyrtidium* sp.
Fig. 6 *Spongosaturnalis* sp.
Fig. 7 *Botryocyrtis* sp.
Fig. 8 *Eucyrtidium* sp.
Fig. 9 *Spongodiscus* sp.
Fig. 10 *Spongodiscus* (?) sp.
Fig. 11 *Stylospongia* (?) sp.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(Chinomigawa Formation) reported by Taketani (1982). Moreover, the radiolarian assemblage of the Onari Formation resembles the Late Campanian radiolarian assemblage of California reported by Campbell & Clark (1944), Foreman (1968), and Pessagno (1976). On the other hand, with the exception of some cosmopolitan species, the radiolarian assemblage of the Yubetsu Group, as a whole, has less similarity to the Campanian equivalent assemblages of southwestern Japan (Simanto Group, etc.) reported by Nakaseko et al. (1979), Nakaseko & Nishimura (1981), Okamura (1980), Mizutani et al. (1982), Matsuyama et al. (1982), Yamauchi (1982), and Okamura et al. (1984), and Pacific Ocean fauna reported by Empson-Morin (1981). Furthermore, the radiolarian assemblage of the Yubetsu Group may be regarded as being closely related to the Rakichinskaya fauna of East Sakhalin described by Zamoida (1972). However, Rakichinskaya fauna has a smaller number of species compared to the Yubetsu fauna.

Recently, Empson-Morin (1984) discussed the depth and the latitude distribution and paleoecology of the Campanian radiolarians of the Tropical and the Subtropical regions. With reference to her results, the radiolarian fauna of the Yubetsu Group may belong to her intermediate latitude population. This tendency will be made clearer by considering the equivalent radiolarian faunas of the Hidaka Supergroup, which is distributed in the west of the present area and represents approximately contemporaneous deposits showing a different sedimentary environment (Tajika, 1982; Tajika & Iwata, 1983, in prep.). We will leave the paleoecological implications of this radiolarian assemblage to a future report. At any rate, the radiolarian assemblage of the Yubetsu Group may show a representative fauna of Upper Cretaceous (Campanian) of the northwest Pacific region.

Our reinvestigation of the Saroma Group in the eastern block of the Tokoro Belt suggests that this Group is partly contemporaneous with the Yubetsu Group (Iwata & Tajika, unpublished). A part of the upper horizon of the Yubetsu and Saroma Groups is contemporaneous with the lowest Member of the Nemuro Group in southeastern Hokkaido. Our preliminary radiolarian biostratigraphic study of the Hidaka Supergroup revealed that some parts of this group were also contemporaneous with the Yubetsu Group, and that many exotic blocks of Upper Triassic, Upper Jurassic, Lower

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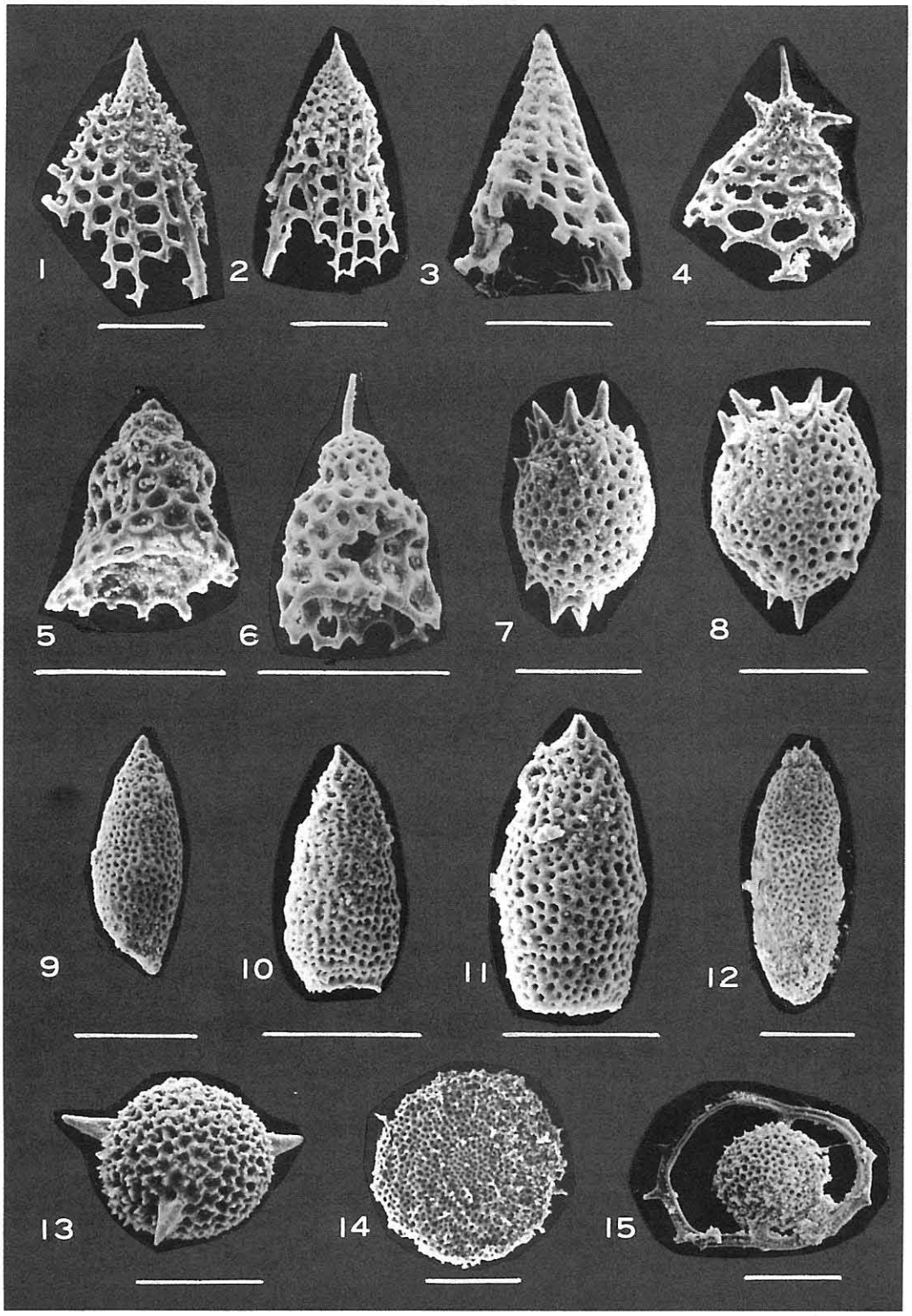
Explanation of Plate 7

Figs. 1-15: Toyosato Formation. Loc. R-En-1.

Fig. 1 *Peripyramis* sp.
Fig. 2 *Peripyramis* sp.
Fig. 3 *Bathropyramis campbelli* Taketani
Fig. 4 *Clathrocyclas* cf. *diceros* Foreman
Fig. 5 *Theocalyptra* cf. *limbata* Lipman
Fig. 6 *Theocalyptra* cf. *limbata* Lipman
Fig. 7 *Lithomespilus* cf. *mendosa* (Krashenikov)
Fig. 8 *Lithomespilus* cf. *mendosa* (Krashenikov)
Fig. 9 *Eucyrtidium* sp. B
Fig. 10 *Eucyrtidium* sp. A
Fig. 11 *Eucyrtidium* sp. A
Fig. 12 *Eucyrtidium* (?) sp.
Fig. 13 *Actinomma* (?) sp.
Fig. 14 *Stylodictya* sp.
Fig. 15 *Spongosaturnalis spinifer* Campbell & Clark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Cretaceous in ages were included in places (Iwata et al., 1983; Tajika & Iwata, 1983). These facts suggests new aspects for consideration on the geological development of Hokkaido during the Mesozoic. According to a recent plate tectonic interpretation of the Mesozoic complexes of the Tokoro Belt and the Hidaka Belt, these complexes are considered to represent the fore-arc basin, and partly the eastward subduction complex (Komatsu et al., 1982; Kontani et al., 1982; Kiminami et al., 1983, 1 & b; Kiminami, 1984; Kiminami et al., 1985). Such eastward "subduction", if it actually occurred, may have persisted during the Late Cretaceous (Campanian). Much more work should be done in order to understand the tectonic development of the Axial Zone of Hokkaido. The great amount of clastic sediments of the Yubetsu Group is considered to reflect a rapid sedimentation (with a rate of more than one thousand meter per Ma), and this may be related to the abrupt disintegration of the "Okhotsk Microcontinent" of volcanic island nature that persisted during the late Cretaceous.

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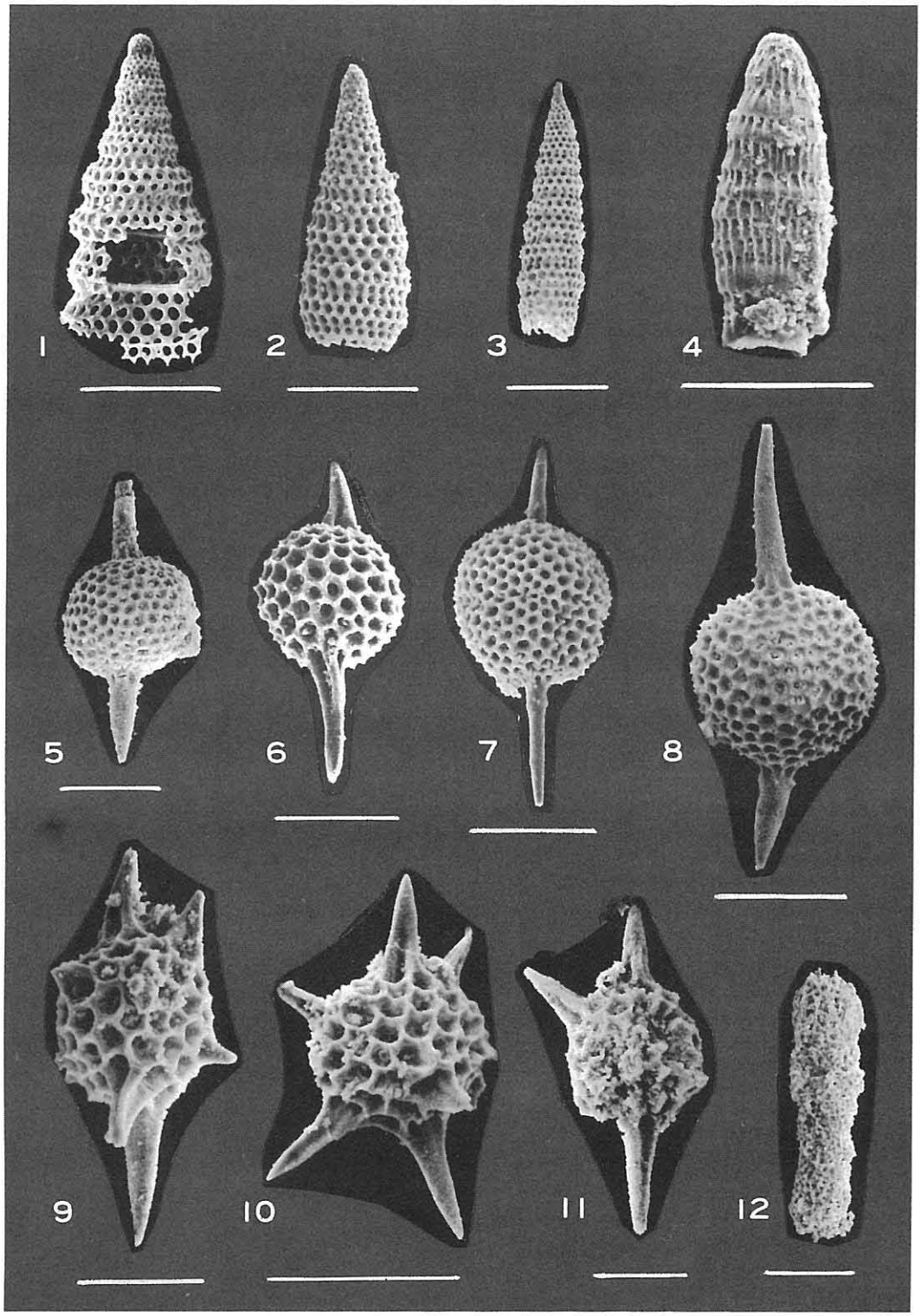
Explanation of Plate 8

Radiolarians from the Toyosato Formation.

Fig. 1, Figs. 4-12: Loc. R-En-1; Figs. 2-3: Loc. En-131.

Fig. 1 *Stichomitra* sp.
Fig. 2 *Lithostrobus* sp. A
Fig. 3 *Lithostrobus* sp. B
Fig. 4 *Lithomitra* sp.
Fig. 5 *Praestylosphaera hastatus* (Campbell & Clark)
Fig. 6 *Stylosphaera* sp.
Fig. 7 *Praestylosphaera hastatus* (Campbell & Clark)
Fig. 8 *Lithatractus pusillus* (Campbell & Clark)
Fig. 9 *Stylosphaera* cf. *goruna* Sanfilippo & Riedel
Fig. 10 *Stylosphaera* cf. *goruna* Sanfilippo & Riedel
Fig. 11 *Stylosphaera* cf. *goruna* Sanfilippo & Riedel
Fig. 12 *Spongurus* sp.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Explanation of Plate 9

Radiolarians from the Toyosato Formation.

Figs. 1-2, Figs. 4-9: Loc. En-131; Fig. 3: Loc. R-En-1; Figs. 10-11: Loc. Ba-10.

Fig. 1 *Spongostaurus* (?) *hokkaidoensis* Taketani

Fig. 2 *Stichomitra* cf. *communis* Squinabol

Fig. 3 Actinomid gen. et sp. indet.

Fig. 4 *Protoxiphotractus perplexus* Pessagno

Fig. 5 *Phaseliforma* sp.

Fig. 6 *Patulibrachium* sp.

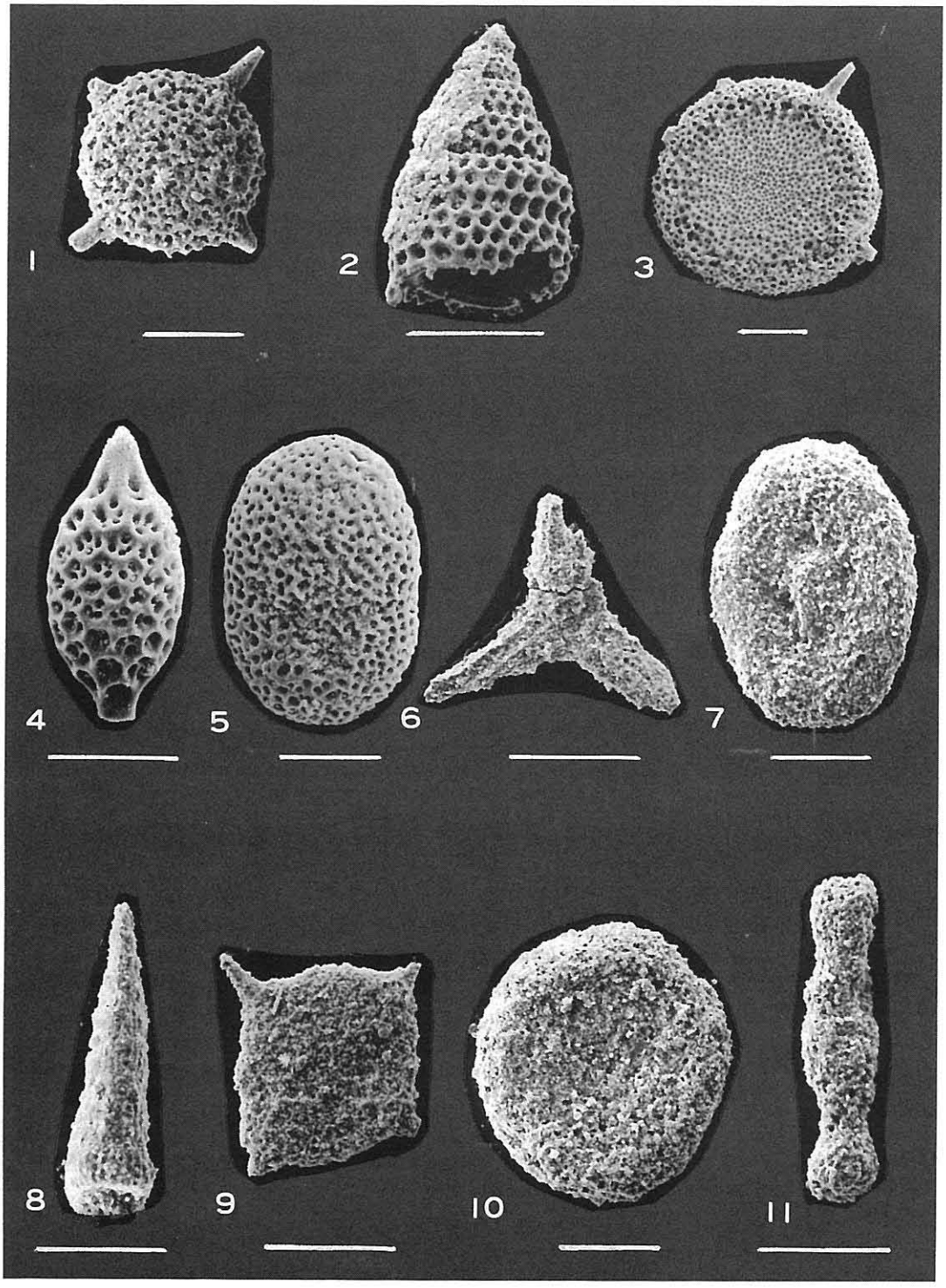
Fig. 7 *Orbiculiforma* sp. A

Fig. 8 *Archaeodictyomitra* sp.

Fig. 9 *Spongostaurus* (?) *hokkaidoensis* Taketani

Fig. 10 *Orbiculiforma monticelloensis* Pessagno

Fig. 11 *Spongurus* sp.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