Radiolarian biostratigraphic study of the Hakobuchi Group in the Nakatonbetsu area, north Hokkaido

Keiji IWATA,* Yasushi WATANABE,** and Jun TAJIKA

Abstract: Radiolarian biostratigraphic study of the Hakobuchi Group and the Upper Yezo Group in the Nakatonbetsu area, north Hokkaido, was carried out to establish radiolarian zones of the uppermost Cretaceous System in northern Japan. We have provisionally recognized the following two zones: *Protoxiphotractus perplexus* and *Chlathrocyclos hyronia* zones. The former and the latter indicate early to middle Campanian and middle Campanian to early Maastrichtian, respectively.

INTRODUCTION

During recent years radiolarian biostratigraphic studies of the Mesozoic System have advanced rapidly, particularly by the progress of Deep Sea Drilling Project (DSDP) in the oceans and land–based studies in many countries (Riedel and Sanfilippo, 1974; Foreman, 1968, 1973, 1977, 1978; Pessagno, 1976, 1977 a, b; Baumgartner et al., 1980; De Wever et al., 1979; Yao et al., 1980, 1982; Nakaseko et al., 1979, 1981; Matsuoka, 1983; Mizutani and Koike, 1982; Aita and Okada, 1986; Aita, 1987; Okamura, 1980; Sanfilippo and Riedel, 1985; Taketani, 1982). In terms of the latest Cretaceous System, Foreman (1977) proposed two radiolarian zonations: *Amphipyndax enesseffi* zone indicating early to middle Campanian and *Amphipyndax tylothus* zone indicating late Campanian to early Maastrichtian. These zones were recognized in the Shimanto Group of southwestern Japan (Nakaseko and Nishimura, 1981). On the other hand, Pessagno (1976) who investigated the Great Valley Sequence of California proposed different zonations. In Hokkaido, although radiolarian biostratigraphic study of the Yezo Supergroup has been published by Taketani (1982), fossil zonations and assemblages of the uppermost Cretaceous System have been little understood. In this paper we report the results of radiolarian biostratigraphic study on the Hakobuchi Group in the Nakatonbetsu area where Upper Cretaceous System was deposited without any great time gaps.

I OUTLINE OF GEOLOGY OF THE CRETACEOUS SYSTEM IN THE NAKATONBETSU AREA

Fig. 1 shows simplified geological maps and an index map of the investigated area. The Nakatonbetsu area is situated at a lowland, surrounded by the Kitami Highland in the east and the Teshio Highland in the west. The Kitami Highland consists of pre–Tertiary Hidaka Supergroup and overlying Miocene volcanic rocks. On the other hand, the Teshio Highland

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Fig. 1 Simplified geological maps for the Hakobuchi Group and the Upper Yezo Group in the Nakatobetsu area. An index map of the investigated area is shown by an arrow.
consists of the late Jurassic to early Cretaceous Sorachi Group and the Cretaceous Lower Yezo Group, Middle Yezo Group, Upper Yezo Group and Hakobuchi Group. Upper Cretaceous System in the Nakatono-betsu area is mainly exposed along the Heitaro River and the Utsunai River (tributaries of the Tonbetsu River). The Tertiary System named the Utsunai Formation is distributed in the northwestern part of this area. It consists of shale, glauconitic sandstone, and a coal seam two meters thick is intercalated in the upper part of this formation. Coquina (Shelly) limestone is also included in the upper part. The Utsunai Formation rests unconformably on the Cretaceous Hakobuchi Group. Tanaka (1960) correlated this formation with the Poronai Formation accumulated during the late Eocene or early Oligocene (Kaiho, 1984).

Upper Cretaceous System in this study area was first called the Tonbetsu Group by Imanishi (1953), and later Matsumoto et al. (1980) redefined it as the Hakobuchi Group. The Hakobuchi Group in this area strikes N–S or NNW–SSE, presenting a semi-basin structure with a fold NNW plunging axis (Fig. 1). Igi (1959) subdivided late Cretaceous sedimentary rocks of this area into four formations (H1–H4), and Tanaka (1960) subdivided it into five (H1–H5). On the other hand, Osanai et al. (1963) subdivided it into two formations; the Kotobuki Formation (Lower part of the Hakobuchi Group) and the Heitarozawa Formation (Upper part of the Hakobuchi Group), followed by Matsushita et al. (1967). Matsumoto et al. (1980) demonstrated that the Hakobuchi Group was deposited through Campanian to late Maastrichtian age without any great time gap and the sediments were finer and thicker than those of the Hokibuchi Group of the Ishikari coal field in central Hokkaido. Based on detailed molluscan biostratigraphic studies, they subdivided the Late Cretaceous deposit of this area into five formations (A to E formations) (Matsumoto et al., 1980). In this paper we followed the subdivision by Matsumoto et al. (1980). Table 1 shows a correlation of formations by several authors. Here we describe simply the lithology of the Hakobuchi Group in the area. Fig. 3

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<td>Upper Yezo Gr.</td>
<td>Kotobuki Fm.</td>
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Table 1 Correlation of formation subdivision by several authors.
shows stratigraphic columns of the Hakobuchi Group of the studied area.

A Formation

This formation consists mainly of black or dark grey mudstone, and includes sporadically marl nodules. The upper part of the formation changes into fine sandstone, and alternating beds of sandstone and shale. MATSUMOTO et al. (1980) reported the occurrence of Sphenoceramus orientalis, Inoceramus balticus, Anapachydiscus naumanni. This formation is assignable to early Campanian in age. The thickness of this formation exceeds 900 M.

B Formation

This formation consists of sandstone and dark grey siltstone, "Mud-eating sandstone" is present in the basal part of this formation. This formation yields Sphenoceramus schmidtii and Baculites rex and is assignable to middle to late Campanian in age. The thickness of the formation is ca. 600 M.

C Formation

This formation consists of fine to medium-sized sandstone and grey siltstone, and yields Inoceramus shikotanensis (MATSUMOTO et al., 1980). This formation is assignable to early Maastrichtian. The thickness of this formation is ca. 400 M.

D Formation

This formation consists mainly of glauconitic sandstone and intercalates thin beds of sandy siltstone. This formation yields Inoceramus hetonaianus (MATSUMOTO et al., 1980) and is assignable to late Maastrichtian in age. Although MATSUMOTO et al. (1980) subdivided this formation into two members (D1 and D2), we could not distinguish the lithological difference between them. Thus, we deal D1 and D2 formations as one unit (D Formation). This thickness of this formation is measured ca. 280 M.

E Formation

This formation is exposed along the Utsunai River and this Heitarozawa. This formation consists mainly of glauconitic sandstone intercalating thin beds of sandy siltstone and green mudstone. MATSUMOTO et al. (1980) reported the occurrence of Inoceramus aff. hetonaianus and I. awajiensis from this formation. Instead, we discovered bivalve fossils (Acila sp.) from the mudstone of this formation. This formation is presumed to be late Maastrichtian. MATSUMOTO et al. (1980) subdivided this formation into two members (E1 and E2). The thickness of the formation attains more than 800 M. Reporting Paleocene planktonic foraminifers from the uppermost part of this formation, YASUDA (1986) separated Paleogene System from this formation as the Utsunaigawa Formation. Paleocene Utsunaigawa Formation is cropping out sporadically along the Utsunai River and Kumanosawa River (Fig. 5). On account of ill-exposure, we could not ascertain the stratigraphic relationship between the Utsunaigawa Formation and the Cretaceous portion of the Hakobuchi Group. Probably the Hakobuchi Group and the Paleocene Utsunaigawa Formation are in fault contact with each other.
II RADIOLARIAN BIOSTRATIGRAPHIC STUDY OF THE HAKOBUCHI GROUP AND THE UPPERMOST YEZO GROUP IN THE NAKATONBETSU AREA

Mudstone and siltstone samples of the Hakobuchi Group and the uppermost part of the Upper Yezo Group were collected in the sections along the Heitaro River, Utsunaigawa River,

Fig. 2 Sample localities of radiolarian fossils.
Fig. 3 Stratigraphic columns of the Hakobuchi Group along the Heitaro (-zawa) River and the Utsunai River. Subdivision of formation by Matsumoto et al. (1980) is shown by capitals.
drag roads of Heitarozawa, Shoyo and Kunizuka. Localities of the samples are shown in Fig. 2. Mudstone samples were immersed in 5% hydrofluoric solution and individuals of radiolarians were extracted. They were identified under the scanning electron microscope. List of radiolarians and range chart throughout A to E formations and the Utsunaigawa Formation is shown in Table 2.

Table 2 Stratigraphic distribution of representative radiolarian species in the Hakobuchi Group and the Uppermost Yezo Group (including the Paleocene Utsunaigawa Formation).
Sample localities are partly omitted.

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<th>Species</th>
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<th>B Formation</th>
<th>C Formation</th>
<th>D Formation</th>
<th>E Formation</th>
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A Formation

The following radiolarians were obtained from A Formation (Localities are shown in Fig. 2 and 3); *Amphipyndax stocki*, A. sp., *Archaeodictymitra lamellicostata*, *Archaeostrongylus salum*, *Artostrobium urna*, *Bathypyrampus campbelli*, *Cortinata californica*, *Dictyomitra densicostata*, *D. koslova*, *D. urakawaensis*, *Phaseliforma spp.*, *Patulibrachium sp.*, *Protoxiphotractus perplexus*, *Pseudoutophacus florescensis*, *P. lentillacus*, *Rhopalosyngium magnificum*, *Spongostaurus (?) hokkaidoensis*, *Stichomitra campi*, *S. communis*, *Xitus takayanagii* (Plate 2). Among these radiolarians *Protoxiphotractus perplexus* occurs successively throughout this formation. *Pseudoutophacus florescensis* and *P. lentillacus* occurs commonly. *Spongostaurus (?) hokkaidoensis* occurs in the lower and middle horizon of the formation, but in the uppermost part this species is absent.

B Formation

The following species were obtained from this formation (Localities are shown in Figs. 2 and 3); *Amphipyndax stocki*, *Archaeodictymitra lamellicostata*, *Bathypyrampus campbelli*, *Cortinata californica*, *Chlathrocycas hyronia*, *Diacanthocapsa ovoidea*, D. sp., *Dictyomitra densicostata*, *D. urakawaensis*, *D. multicostata*, *Phaseliforma cf. laxa*, *Stichomitra livermorensis*, *Tholodiscus fresnoensis*, (Plate 3). Among these radiolarians *Chlathrocycas hyronia* appears from the base of this formation and occurs commonly throughout this formation. *Diacanthocapsa ovoidea* also appears from this formation.

C Formation

The following species were obtained from this formation (Localities are shown in Figs. 2 and 3); *Amphipyndax stocki*, *Bathypyrampus campbelli*, *Chlathrocycas hyronia*, *Cortinata californica*, *Diacanthocapsa ovoidea*, *D. carpocanoides*, D. cf. *umbilicata*, *Dictyomitra densicostata*, *D. multicostata*, *Phaseliforma cf. laxa*, *Orculiforma renillaformis*, *Tholodiscus fresnoensis* (Plate 4 and 5). In this formation *Chlathrocycas hyronia* occurs commonly.

D Formation

The following species were obtained from this formation (Localities are shown in Figs. 2 and 3); *Amphipyndax stocki*, *Archaeodictymitra lamellicostata*, *A. riedeli*, *Bathypyrampus campbelli*, *Dictyomitra rhadina*, *Lithostrobus sp.*, *Stichomitra campi* (Plate 5). *Chlathrocycas hyronia* is not found from this formation. *Dictyomitra rhadina* appears first from this formation, but its occurrence is sporadical.

E Formation

This formation yields a very small amount of radiolarians (Localities are shown in Figs. 2 and 3). The following species are sporadically present in this formation; *Amphipyndax stocki*, *Dictyomitra rhadina*, *Hemicryptocapsa polyhedra* (Plate 5).

III RADIOLARIANS OF THE REGOSAWA FORMATION AND THE UTSUNAIGAWA FORMATION

During this study the authors have also investigated radiolarians of the Regosawa Formation underlying the uppermost part of the Upper Yezo Group (A Formation) in order to understand a successive stratigraphic distribution of radiolarians of the Hakobuchi Group and the Upper Yezo Group. Moreover, we have studied on the radiolarians of the Utsunaigawa
Fig. 4 Geological map of the Yezo Supergroup around Kamitobetsu (modified from IGI, 1959 and OSAKA et al., 1963). Solid circles with numbers show localities of radiolarians from the Regosawa Formation.

Fig. 5 Distribution of the Paleocene Utsunaigawa Formation and the Oligocene-Eocene Utsunai Formation (YASUDA, 1987). Solid circles show localities of Paleogene radiolarians.
Formation in which Yasuda (1987) found the Paleocene foraminifers.

**Radiolarians of the Regosawa Formation**

This formation is distributed ca. 12 km south of the center of Nakatonbetsu Town (Figs. 4 and 5). Loc. 87070301 yielded abundant well preserved radiolarians. The following species were included; *Alievium gallowayi*, *Amphipyndax stocki*, *Archaeodictyomitra riedeli*, *Archaeospongopruma triplum*, *Bathopyramis campbelli*, *Cornutella californica*, *Crucella sp.*, *Dictyomitra formosa*, *D. multicornata*, *D. koslovaee*, *Lithatanaxis pessillis*, *Oribuciforma quadrata*, *Paronaella sp.*, *Praeconocaryomma universa*, *Pseudoaulophacus floresensis*, *P. lenticulatus*, *Stichomitria asymbatos*, *S. spp.*, *Xitus spp.*, (Plate 1).

Among these radiolarians *Oribuciforma quadrata*, *Alievium gallowayi*, and *Dictyomitra formosa* are known as index species for Santonian (Pessagno, 1976; Taketani, 1982). Thus, the Regosawa Formation is safely assignable to Santonian in age.

**Radiolarians of the Utsunaigawa Formation**

This formation yields a very small amount of radiolarians from Locs. 87092004 and 87092005; Fig. 5). The following species are sporadically present in this formation; *Amphipyndax stocki*, *Dictyomitra sp.*, *Stichomitria sp.*, *Cryptamphorella (?)* sp. Paleocene index species such as *Amphisphaera spinulosa* (= *Stylolophera goruna*), *Lithocampe (?)* granulata and *Buryella tetradica* were not obtained from this formation.

Table 3  Correlation of radiolarian zonations of the late Cretaceous System by several authors.

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<td><em>Amphipyndax tyloctus</em></td>
<td>A. <em>tyloctus</em></td>
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Summarizing the above-cited stratigraphic distribution of radiolarians of the Hakobuchi Group and the uppermost Yezo Supergroup, it can be said that A Formation is characterized by the occurrence of *Protoxiphobractus perplexus*, and that B and C Formations are featured by the occurrence of *Chlorthrocyclus hyronia*. Characteristic species available for stratigraphic markers could not be found from D and E Formations. We propose provisionally the following radiolarian zonation for the Latest Cretaceous System (Table 3): *Protoxiphobractus perplexus* zone that indicates early to middle Campanian, and *Chlorthrocyclus hyronia* zone that indicates middle Campanian to early Maastrichtian in age.

IV DISCUSSION

In this study it has become clear that the latest Cretaceous System can be subdivided into two radiolarian zones; lower Campanian *Protoxiphobractus perplexus* zone and middle Campanian *Chlorthrocyclus hyronia* zone. Foreman (1977) established *Amphipyndax enesseffi* zone (early to middle Campanian) and *Amphipyndax tylotus* zone (middle Campanian to early Maastrichtian). In our field, however, *Amphipyndax enesseffi* does not occur at all, and so was the case with *Amphipyndax tylotus*. Therefore we cannot correlate accurately our zonation with two zones of Foreman (1977). Pessagno (1976) proposed that *Protoxiphobractus perplexus* and *Patulibrachium lawsonii* subzones (*Crucella espartoensis* zone) indicate early to middle Campanian, and that *Phaseliforma carinata* subzone and *Patulibrachium dickinsonii* zone indicate late Campanian. He also suggested that *Orbiculiforma renillaeformis* indicated Maastrichtian. In our study *Protoxiphobractus perplexus* zone was proved to indicate early to middle Campanian, while *Chlorthrocyclus hyronia* zone is at the moment provisional one. Vishnevskaya (1986) stated that *Amphipyndax enesseffi* zone indicates early to middle Campanian, and *Chlorthrocyclus diceros* zone indicates early Campanian to early Maastrichtian. She also stated that *Bathropyramis sanjoaquinensis* zone indicated late Maastrichtian to Danian (early Paleocene). These zones cannot be applied to our studied area, because the above-cited species are not present in the investigated area. Radiolarians of the Utsunaigawa Formation seem to be survivors from the Maastrichtian. There may be a time gap between the Hakobuchi Group and the Utsunaigawa Formation. Further studies in other areas will be necessary to understand the transitional faunal change throughout K-T boundary.

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北海道北部—中頓別地域における
函淵層群の放散虫生層序学的研究

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要 旨

道北の中頓別地域に発達する函淵層群は、著しい堆積間隔もなく白亜紀後期のカンパン世からマーストリヒト世にわたりほぼ連続した層序を示す。道央地域の函淵層群にくらべ、細粒の堆積物から構成される。筆者らは、北日本の白亜紀末期の放散虫化石帯および同化石群集の地史的変遷過程を明らかにする目的で、本地域の函淵層群の地質調査ならびに放散虫生層序学的研究を行なった。その結果、カンパン世早期から中期のProtoxiphotactus perplexus 帯とカンパン世後期からマーストリヒト世にかけてのChlathrocyclus hyronia 帯の2つの化石帯を確立設定し、他の研究者によって提唱されている化石分帯との比較検討を行なった。また、古第三紀早期の宇津内川層の化石についても報告した。

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EXPLANATION OF PLATES

Plate 1
Radiolarians of the Regosawa Formation (Loc. 87070301). All figures are scanning electron micrographs. Scale bars are 100 μm long.
Fig. 1: Archaeospongioprum triangulum PESSAGNO
Fig. 2: Pseudoaulophacus floresensis PESSAGNO
Fig. 3: Pseudoaulophacus lenticulatus PESSAGNO
Fig. 4: Aliivum gallowayi PESSAGNO
Fig. 5: Dicyomynta formosa SQUINABOL
Fig. 6: Dicyomynta cf. koslovae FOREMAN
Fig. 7: Archaeodicyomynta sp.
Fig. 8: Archaeodicyomynta riedeli TAKETANI
Fig. 9: Stichomitra asymbatos FOREMAN
Fig. 10: Amphipyndax cf. stocki FOREMAN
Fig. 11: Amphipyndax sp.
Fig. 12: Xitus sp.
Fig. 13: Orbuculiforma quadrata PESSAGNO
Fig. 14: Crucella sp.
Fig. 15: Praeconocorymyena univera PESSAGNO
Fig. 16: Paronaella sp.

Plate 2
Radiolarians from A Formation of the Hakobuchi Group. Scale bars are 100 μm long. Figs. 1–3, 5–7, 9–15 are derived from Loc. 86092002, and Figs. 4, 8, and 16 are from Loc. 86092806.
Fig. 1: Dicyomitra koslovae FOREMAN
Fig. 2: Dicyomynta cf. urakawaensis PESSAGNO
Fig. 3: Rhopatosyngeium magnificum CAMPBELL and CLARK
Fig. 4: Archaeospongioprum saurini PESSAGNO
Fig. 5: Protodipteractus perplexus PESSAGNO
Fig. 6: Stichomitra communis SQUINABOL
Fig. 7: Xitus takayanagii TAKETANI
Fig. 8: Xitus sp.
Fig. 9: Stichomitra campi (CAMPBELL and CLARK)
Fig. 10: Patulibrachium sp.
Fig. 11: Pseudoaulophacus floresensis PESSAGNO
Fig. 12: Pseudoaulophacus floresensis (WHITE)
Fig. 13: Spongostaurus (?) hokkaidoensis TAKETANI
Fig. 14: Pseucliforma cf. lewa PESSAGNO
Fig. 15: Artostrobium urna FOREMAN
Fig. 16: Napora sp.

Plate 3
Radiolarians from B Formation of the Hokobuchi Group. Scale bars are 100 μm long. Figs. 1–3, 5–7, 9–12, 14–15 are from Loc. 86092101, and Figs. 4, 8, 13, 16, are from Loc. 86092806.
Fig. 1: Cornutella californica FOREMAN
Fig. 2: Amphipyndax stocki FOREMAN
Fig. 3: Amphipyndax sp.
Fig. 4: Archaeodicyomynta lamellicostata FOREMAN
Fig. 5: Dicyomynta urakawaensis TAKETANI
Fig. 6: Dicyomynta sp.
Fig. 7: Dicyomynta sp.
Fig. 8: Dicyomynta densicostata PESSAGNO
Fig. 9: Chlathrocylaca hyronia FOREMAN
Fig. 10: Diacanthocapsa ovoides DUMITRICA
Plate 4
Radiolarians from C Formation of the Hokobuchi Group. Scale bars are 100 \( \mu m \) long. Loc. 86092201.
Fig. 1 : *Chlathrocyclas kyronia* FOREMAN
Fig. 2 : *Bathypyramis campbelli* TAKETANI
Fig. 3 : *Cornutella cretacea* TAKETANI
Fig. 4 : *Foremanina cf. schona* EMPSON-MORIN
Fig. 5 : *Phaseliforma cf. laza* PESSAGNO
Fig. 6 : *Orbiculiforma renitlaformis* PESSAGNO
Fig. 7 : *Orbiculiforma cf. renitlaformis* PESSAGNO
Fig. 8 : *Lithattractus pussillus* (CAMPBELL and CLARK)
Fig. 9 : *Diacanthocapsa ovoidea* DUMITRICA
Fig.10 : *Diacanthocapsa ovoidea* DUMITRICA
Fig.11 : *Diacanthocapsa carpocanoides* DUMITRICA
Fig.12 : *Dictyomitra urakawaensis* TAKETANI
Fig.13 : *Amphipyndax stocki* FOREMAN
Fig.14 : *Pseudodictyomitra* sp.
Fig.15 : *Dictyomitra urakawaensis* TAKETANI
Fig.16 : *Tholodiscus fresnoensis* FOREMAN

Plate 5
Radiolarians from C, D, E Formations of the Hakobuchi Group and the Paleocene Utsunaigawa Formation. Scale bars are 100 \( \mu m \) long. Figs. 1–4 (C Formation ; Loc. 86092201), Figs. 5–8 (D Formation ; Loc. 87070605), and Figs. 9–12 (E Formation ; Loc. 87070515), Figs. 13–16 are radiolarians from the Utsunaigawa Formation (Loc. 87092505).
Fig. 1 : *Dictyomitra radiina* FOREMAN
Fig. 2 : *Dictyomitra radiina* FOREMAN
Fig. 3 : *Dictyomitra* sp.
Fig. 4 : *Diacanthocapsa cf. umbilicata* DUMITRICA
Fig. 5 : *Lithostrous* sp.
Fig. 6 : *Archaeodictyomitra riedeli* TAKETANI
Fig. 7 : *Stichomitra* sp.
Fig. 8 : *Amphipyndax* sp.
Fig. 9 : *Cryptamphorella* sp.
Fig. 10 : *Cryptamphorella* sp.
Fig. 11 : *Cryptamphorella* sp.
Fig. 12 : *Cryptamphorella* (?) sp.
Fig.13 : *Hemicryptocapsa polyhedra* DUMITRICA
Fig.14 : *Dictyomitra* sp.
Fig.15 : *Pseudodictyomitra* sp.
Fig.16 : *Dictyomitra* sp.