Tohoku Univ., Sci. Rep., 2nd ser. (Geol.), v. 54, no. 2, p. 95-139, 6 figs., 8 tables, pls. 7-11, March 30, 1984

Paleogene Foraminifera from Hokkaido, Japan

Part 1. Lithostratigraphy and Biostratigraphy including Description of New Species*

Kunio Kaiho**

ABSTRACT

Foraminiferal assemblages from Paleogene-outcropping areas in Hokkaido, Japan are described, giving a full account of their systematics and stratigraphic distribution. Employing five benthic foraminiferal events which are useful for intra-regional stratigraphic correlation and some other important foraminiferal changes, a sequence of Eocene to lower Oligocene strata is biostratigraphically divided into eight benthic foraminiferal zones. These zones are named, in upward sequence, as follows:

The *Elphidium asanoi-Reophax tappuensis* Assemblage-zone, *Elphidium ishikariense-Bulimina yabei* Assemblage-zone, *Haplophragmoides tanaii-Haplophragmoides subevolutus* Assemblage-zone, *Haplophragmoides umbilicatus-Haplophragmoides subevolutus* Assemblage-zone, *Bulimina schwageri-Haplophragmoides umbilicatus* Assemblage-zone, *Haplophragmoides subevolutus-Cyclammina pacifica* Assemblage-zone, *Bulimina schwageri-Gyroidina yokoyamai* Assemblage-zone, and *Nonion ezoensis-Cyclammina pacifica* Assemblage-zone.

The discovery of nine planktonic foraminiferal species in these Paleogene strata provides a better age determination than that given by previous workers. The major part of the Poronai and Momijiyama Formations in the Yubari area and the Utsunai Formation in the Nakatombetsu area are considered to lie within an Upper Eocene to Lower Oligocene interval.

By means of the distribution of the above-mentioned zones and ages, correlation of Paleogene strata in Hokkaido has been carried out and it is concluded that the "Paleo-Poronai Sea (Kaiho, 1983)" transgressed northward and reached the Tempoku region (northern most region of Japan) during a late Eocene to early Oligocene period. Additionally, radiolarian abundance, lithofacies and benthic foraminifera of the Poronai and Momijiyama Formations in the Yubari area clearly exhibit a southward deepening. Most of the Poronai and Momijiyama Formations are considered to represent outer neritic to bathyal depths on the western continental slope of central Hokkaido. A rapid flourishing of calcareous foraminifera recognized in the vicinity of Eocene/Oligocene boundary in the studied area may have a relation to the rapid deepening of CCD in that time proposed by van Andel and Moore (1974).

In the section of Systematic Paleontology, a total of 142 species and 3 subspecies are described. Of these, 39 species and 1 subspecies are proposed as new to science.

CONTENTS

* This study will be published in two separate parts: Part 2 will discuss problems of stratigraphic correlation of the Paleogene of Hokkaido, and include a systematic treatment of foraminifera. The bibliographic citations in the references include those to be referred to in the second part.

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INTRODUCTION

Marine Paleogene deposits of Hokkaido, Japan, are distributed mainly in the Ishikari, Rumoi, Tempoku and Kushiro coalfields. These Paleogene sediments, ranging in age from Eocene to Oligocene, yield rich molluscan and foraminiferal faunas. These areas include many representative Paleogene sequences which are suitable for the establishment of Paleogene biostratigraphy in Japan.

Benthic foraminiferal studies of some of these sequences have been made by several authors beginning with the work of Yokoyama in 1890. Subsequently, Asano described benthic foraminifera and proposed a zonation using this fossil group (Asano, 1950a, b, c, 1951b, 1952a, 1953b ; Asano and Iwamoto, 1957) and discussed their age and correlation (Asano, 1952a, 1954, 1955, 1961, 1962b, c). Foraminiferal researches based on systematically collected samples, however, are very few (Asano, 1952a, 1962b ; Ujiié and Watanabe, 1960). The present work of Paleogene foraminifera of Hokkaido utilizes more numerous and better preserved specimens than those used by previous authors.

Very little has been studied on Paleogene planktonic foraminifera from Hokkaido, except for those reports by Ujiié and Watanabe (1960) and Maiya et al. (1977). The discovery of nine planktonic foraminiferal species in the present study provides a better age determination than that given by previous workers.

This study aims at describing these foraminiferal faunas and establishing a foraminiferal biostratigraphy of the Paleogene System of Hokkaido. Based upon the foraminiferal sequences observed in individual areas of study, eight benthic foraminiferal zones are proposed and correlation of Paleogene formations in Hokkaido is attempted by means of these zonations. This investigation also attempts to reconstruct paleogeography and paleoenvironment of Hokkaido during Paleogene time. Systematic descriptions of 145 species and subspecies of foraminifera including 40 new speceis and subspecies are given separately in Part 1 and Part 2.

ACKNOWLEDGMENTS

The author expresses his deep gratitude to Professor Yokichi Takayanagi of the Institute of Geology and Paleontology, Faculty of Science, Tohoku University, for his continued guidance, encouragement and critical reading of the manuscript. Deep appreciation is expressed to Professor Tsunemasa Saito of the Department of Earth Sciences, Faculty of Science, Yamagata University, for his suggestion, encouragement and critical reading of the manuscript.

The author is also deeply indebted to the following persons ; Professor Kunihiro Ishizaki of the Institute of Geology and Paleontology, Faculty of Science, Tohoku University, for critically reviewing the manuscript and for his discussion on stratigraphical and paleonotological problems ; Dr. Motoyoshi Oda and Dr. Shiro Hasegawa, also of the same institute and Dr. Toyosaburo Sakai of Utsunomiya University, for their advice on paleontological problems ; Professor Toshimasa Tanai of Hokkaido University, for his kind suggestions ; Professor Yasumochi Matoba of Akita University, for his assistance in the photographic

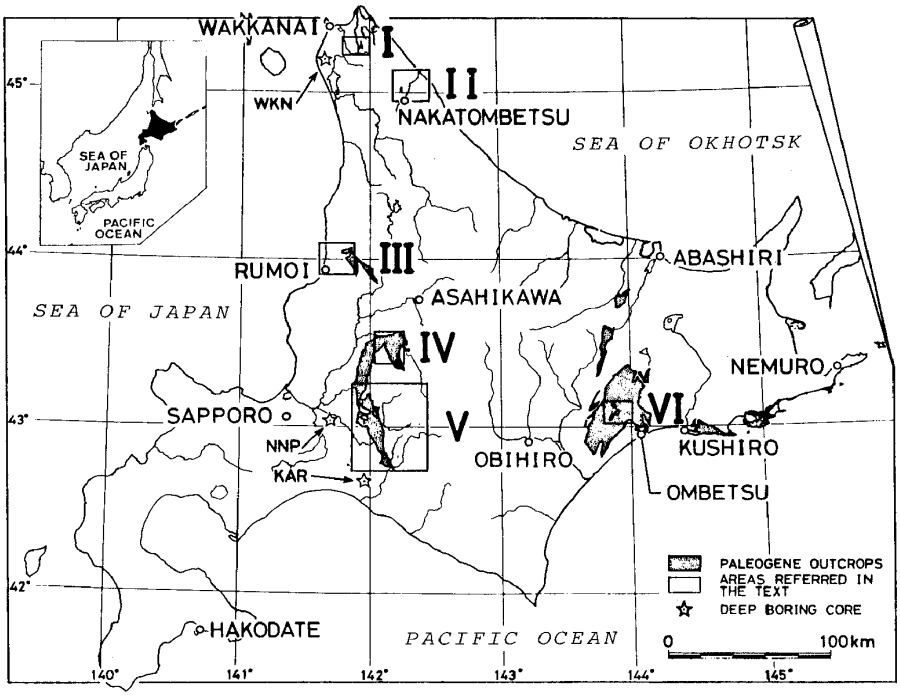
work ; Mr. Koji Takahashi of the Geological Survey of Hokkaido, for his help during field work and for his placement of deep core samples from western Hokkaido at the present author's disposal ; Mr. Hitomaro Honda, Hokusei Consultant Inc. and Mr. Kokitsu Yagi, Hokkaido Tanko-kisen Inc., for their donation of deep core samples from the Yubari coalfield, Hokkaido ; Professor Naoaki Aoki of Tsukuba University, for his assistance in the observation of foraminiferal specimens described by Ujiié and Watanabe (1960) ; Professor Yutaka Honda of Mie University, for his advice on some pertient literature.

LITHOSTRATIGRAPHY

Four major regions were chosen for systematic sampling and studying the distribution of foraminifera in Paleogene strata of Hokkaido. The following notes provide a brief outline of stratigraphy of the regions treated in the present study.

I. Ishikari Region

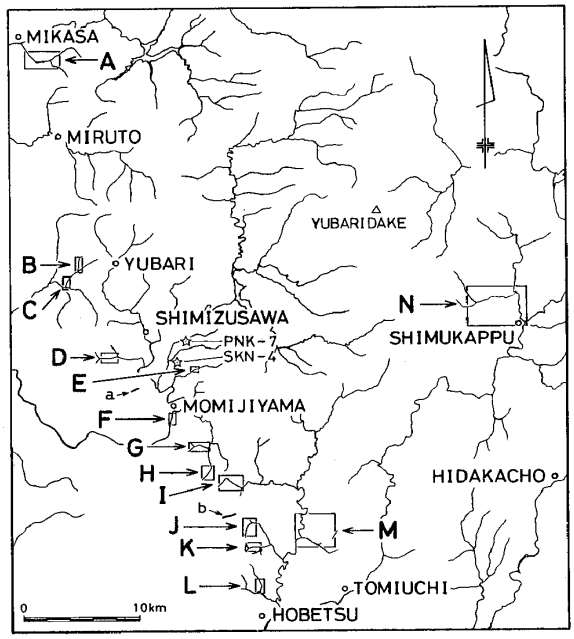
In the Ishikari coalfield situated between the Yubari Mountains in the east and Sapporo in the west, thick Paleogene



I : Wakkanai area
II : Nakatombetsu area
WKN : Wakkanai well
} Tempoku region
III : ——— Rumoi region
IV : Sorachi area
V : Yubari area
NNP : Namporo well
KAR : Karumai well
} Ishikari region
} Central part of Hokkaido
VI : ——— Kushiro region —Eastern part of Hokkaido

Fig. 1. Map showing the distribution of Paleogene deposits in Hokkaido and areas referred in the text.

sediments containing rich fossils are developed (Fig. 1). They are stratigraphically grouped into the Ishikari Group and the Poronai and Momijiyama Formations. These lithostratigraphic names have long been assumed to range in age from Eocene to Oligocene. The Ishikari coalfield is divided into two areas, Sorachi in the north and Yubari (Fig. 2) in the south. The Ishikari Group is mainly developed in the Sorachi area and the Poronai and Momijiyama Formations in the Yubari area. The Poronai Formation rests upon progressively older strata southeastwards from the Paleogene Ishikari Group to the Cretaceous Hakobuchi Group. The Poronai and Momijiyama Formations are unconformably overlain by the middle Miocene Takinoue Formation. A conglomerate unit of several meters in thickness marks the unconformity and is traceable for the whole area (Fig. 3). The majority of the Paleogene System is developed with a NNW-SSE trend between Cretaceous and Neogene sediments in the Yubari area, and along the northern margin of a broad anticline trending generally in a NNE-SSW to N-S direction in the Sorachi area.



A : Mikasaporonai River section (PRN)
B, C : Shirirruomappu River sections (SRO and SRR)
D : Kumanosawa section (KUM)
E : Mayachi River section (MYC)
F : Yubari River section (YUB)
G : Satsukizawa section (SKN)
H : Kurukitomarizawa section (SKS)
I : Tsurunosawa section (TUR)
J : Tanakazawa section (SNT)
K : Sekiyuzawa section (SKY)
L : Sumigamanosawa (PKP)
M : Shuttanozawa section (SHT)
N : Pepeshiru River section (PPS)
PNK-7 : Pankemaya-7 well
SKN-4 : Sakinzawa-4 well

Fig. 2. Map showing the location of sections in the Yubari area. ☆ : Deep boring core.

The Ishikari Group consists of alternating beds of nonmarine and shallow marine sediments and is divided into the Noborikawa, Horokabetsu, Yubari, Wakkanabe, Bibai, Akabira, Ikushumbetsu, Hiragishi and Ashibetsu Formations in upward sequence in the Sorachi coalfield. However, the Bibai, Akabira, Hiragishi and Ashibetsu Formations of the Ishikari Group are not distributed in the Yubari area. It is unconformably overlain by thick marine sediments of the Poronai Formation which is conformably overlain by the Momijiyama Formation. The latest unit is confined in its distribution to the central and southern parts of the Yubari area. The stratigraphic sequence of these units in the Ishikari region is summarized as follows in downward sequence.

Stratigraphic Unit *Lithology* *Thickness in meter*

Superjacent unit : Takinoue Formation (TK)*

..... Unconformity .....

**Momijiyama Formation (MJ)

Tuffaceous sandy siltstone intercalated with fine tuff and contains calcareous concretions in the upper part. Volcanic sandstone and dark-gray tuffaceous sandy siltstone in the lower part in the central Yubari area (Jusanmairu Sandstone Member (JS)). Tuffaceous

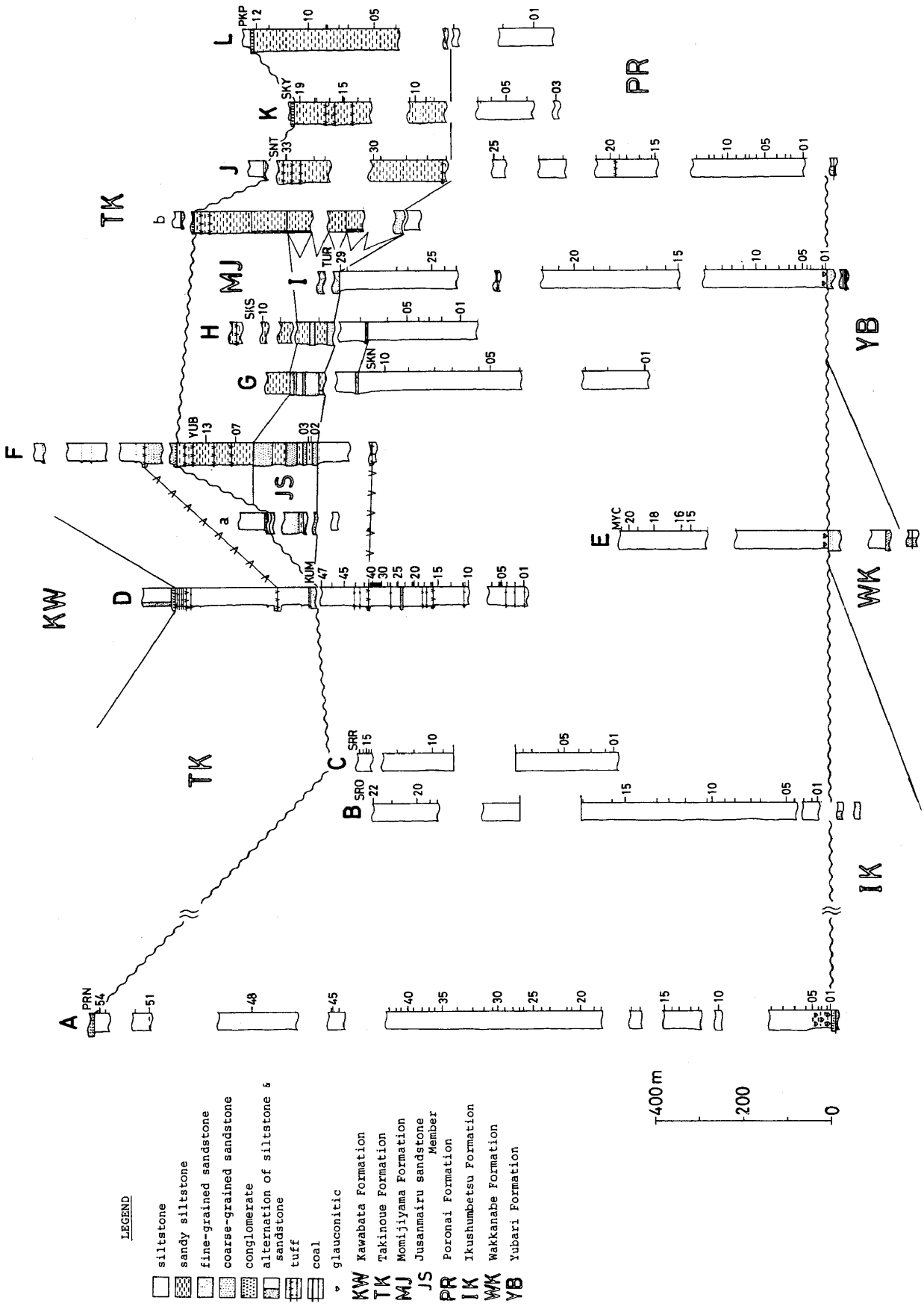


Fig. 3. Columnar sections of the Yubari area. Sampling localities on the columnar sections are also shown.

sandy siltstone, rarely intercalated with tuffaceous sandstone and fine tuff in the lower part of the Momijiyama Formation in the southern Yubari area. 400+

Poronai Formation (PR)

Dark-gray homogeneous massive siltstone with calcareous concretions, and interbedded with 5 cm to 10 cm thick tuffaceous sandstone and sandy tuff in the upper part. Glauconitic sandy siltstone or conglomerate at the base. 850~1,600+

..... Unconformity .....

Ishikari Group

***Ashibetsu Formation (AS)

Massive, gray or pale green, medium to coarse sandstone and dark-gray-to-grayish-black, laminated siltstone intercalating coal seams. 450+

***Hiragishi Formation (HR)

Fine sandstone, sandy siltstone, siltstone and their interbeds. 500

Ikushumbetsu Formation (IK)

Alternating beds of coal and sandstone in the upper part, grayish-black siltstone in the middle part, very thinly bedded to laminated interbeds of greenish gray sandstone and dark-gray siltstone in the lower part of the formation. 750

***Akabira Formation (AK)

Fine sandstone intercalating coal seams in the uppermost part, massive and grayish-black silitstone in the upper part, sandstone in the middle, very thinly bedded to laminated interbeds of blackish-gray siltstone, coaly siltstone and fine sandstone in the lower part of the formation. 400

***Bibai Formation (BB)

Alternating beds of sandstone and siltstone intercalating coal seams. 200

Wakkanabe Formation (WK)

Fine sandstone, dark-gray siltstone and their striped interbeds. 170~260

Yubari Formation (YB)

Alternating beds of sandstone and siltstone with coal seams and coaly siltstone. 200~300

Horokabetsu Formation

Soft dark-gray siltstone intercalated with ironstone layers. 100~200

Noborikawa Formation

Sandstone with siltstone and coal seams. 60~

..... Unconformity .....

Subjacent unit: Hakobuchi Group

*Abbreviations given in parentheses will be used to denote the same formations appearing in text-figures.

**The formation is distributed only in the southern part of the Yubari area.

***The formation is distributed only in the Sorachi coalfield.

Definition and description of a newly revised stratigraphic unit: The type Momijiyama Formation (in the sense of Huzioka, 1941) is herein divided into two members and the lower sandstone-rich sequence is defined as the Jusanmairu Sandstone Member. The type locality of this sandstone member is a riverside cliff along the Yubari River, about 800 m south of Momijiyama. The base of the Jusanmairu Sandstone corresponds to the boundary between a dark gray sandy siltstone of the Poronai Formation and a volcanic sandstone of the Momijiyama Formation. The upper boundary of this member is drawn at the top of another volcanic sandstone layer which is overlain by a thick tuffaceous siltstone of the upper part of the Momijiyama Formation. Lithologic sequence at the type section of the sandstone member is shown in detail in Fig. 3. This member has a tendency to become finer-grained southwards and sandstones disappear to the south of Tanakazawa. Therefore, this member has a restricted distribution in the northern part of the area distributed by the Momijiyama Formation (Fig. 3). Its thickness varies from 0 to 260 meters. In the Yubari River section, it is about 140 meters thick.

Previous papers diverged in the stratigraphic position of the Momijiyama Formation. Some differing points of views are as follows: Some authors assumed the Momijiyama Formation to be a component of either "Kawabata or Poronai Group" (e.g. the former opinion: Tashiro, 1951; Shimogawara and Teshima, 1961; Uchio, 1962; Kanno and Ogawa, 1962, 1963 etc., the later opi-

Table 1. Benthic foraminiferal zones of the Poronai Formation by previous authors (after Ujiié and Watanabe, 1960)

Kamiashibetsu District (Ujiié & Watanabe)	Miruto District (Asano & Iwamoto, 1957)	Ikushunbetsu District (Asano, 1952)		Ikushunbetsu District (Asano, 1953 & 1958b)	Hobetsu District (Asano, 1953)
Plectofrondicularia packardi-Bulimina schwageri Zone	Upper assemblage	*Pl. packaridi* Subzonule	*Bulimina ezoensis* Zonule	*Pl. packardi* Zone	
		Unnamed		*Bulinina ezoensis* Zone	
Poronaia poronaiensis-Ammobaculites akabiraensis Zone	Lower assemblage	Unnamed	*Sigmoidella plummerae* Zonule	*Cornuspiroids oinomikadoi* Zone	
		Planulina poronaiensis Subzonule		*Am. akabiraensis-Nonion sorachiense* Zone	

nion : Huzioka, 1941 ; CCC Sapporo Branch, 1949 ; Ohara, 1966 ; Sagawa, 1970 ; Kaiho, 1979). Others considered it to be an independent unit not related to these groups (e.g. Matsui, 1950 ; Takao, 1952). Based on several lines of lithostratigraphic and foraminiferal evidence, however, the Momijiyama Formation is concluded to overlie conformably the Poronai Formation and to be unconformably overlain by the Takinoue Formation (Kaiho, 1979).

The geology of the Ishikari coalfield has been studied by many workers since the last century. Yabe (1951) assumed that a marine shale of the Poronai Formation is contemporaneous with the Ishikari Group which is largely dominated by brackish to fresh water deposits, although he previously thought that the Poronai Formation has a paraconformable relationship with the Ishikari Group. Asano (1952a, 1954, 1955, 1958a, b, 1962b) supported Yabe's assumption on the basis of foraminiferal zones in the Paleogene strata in the Ishikari coalfield. Later, Ujiié and Watanabe (1960) recognized two benthic foraminiferal zones in the Poronai Formation of the Kamiashibetsu area (Table 1).

Teshima (1955, 1958, 1961, 1962, 1967), on the basis of his study of molluscan fossils and other megafossils from the Poronai Formation in the Ishikari coalfield, concluded that nine megafossil zones, A to I, are recognizable in this formation and are widely traceable within the region except for the northern part where the upper three zones are absent. Then, Matsuno et al. (1964) subdivided the A zone into the A zone proper and the A0 zone consisting of sandy siltstone because the A zone of higher stratigraphic level is largely represented by a shale facies. Furthermore, they recognized three subdivisions of B zone, B0, B1 and B2, and two subdivisions of C zone, C1 and C2, in the Mikasaporonai River section.

II. Rumoi Region

Thirty-three samples from a single section herein treated cover the Shimokine and type Tappu Formations exposed along the Soshubetsu River, a tributary of the Obirashibe River, about 20 km northeast of Rumoi. The Paleogene sequence in the Soshubetsu River section is as follows in downward sequence :

Stratigraphic unit *Lithology* *Thickness in meter*

Superjacent unit: Neiraku Formation (NR)
..... Unconformity .....
Tappu Formation(TP)
Massive, dark-gray siltstone. 500
Shimokine Formation (SN)
Striped interbeds of tuffaceous silty very fine sandstone and thin coal seams in the uppermost part of the formation (so-called "Toranokawa bed"). In the remainder of the formation, fine sandstone, silty very fine sandstone and sandy siltstone. 590
..... Unconformity .....
Uryu Group
Obira Formation (OB)
Alternating beds of fine to medium sandstone and dark-gray siltstone intercalating with thick sandstone and coal seams. 650+
..... Unconformity .....
Subjacent unit: Upper Yezo Group

The boundary between the Shimokine and Tappu Formations is marked by the disappearance of coaly fragments in upward sequence. A benthic foraminiferal fauna from the same section was already described by Asano (1956).

III. Tempoku Region

This region includes the Nakatombetsu and Wakkanai areas and Wakkanai well.

1. Nakatombetsu Area

Marine Paleogene sediments known as the Utsunai Formation are distributed only in the Utsunai River basin and forms a basin structure with a N–S trending synclinal axis, surrounded by Upper Cretaceous strata. This formation overlies unconformably a siltstone facies of the Hakobuchi Group and is overlain by alluvial deposits. The Utsunai Formation is divided into two lithofacies. The lower facies about 300 m thick consists principally of a soft siltstone with intercalations of glauconitic silty-sandstone in the middle and calcareous concretions in the middle and upper parts. The upper facies about 300 m thick is composed of a hard tuffaceous sandy siltstone intercalated with glauconitic sandstone layers at the base as well as in the lower part, and coal beds at the top. The upper facies of the formation is a regressive facies. Such stratigraphic changes in lithofacies from non-volcanic siltstone in the lower to tuffaceous and coarser-grained sediments in the upper is similar to those observed in the sequence from the Poronai to Momijiyama Formations, except for the intercalations of glauconitic sandstone in the former.

Eight benthic foraminiferal species were already described from the Utsunai River section by Asano (1953b).

2. Wakkanai Area

The Magaribuchi Formation, which occupies the northernmost area of the marine Paleogene basins of Japan, extends from its type locality along the Uruya River northwards to the Cape Soya. Many tectonic features such as folds and faults divide its distribution into many small areas. In and around the type locality, the Magaribuchi Formation is divided into two parts; the lower half consisting of siltstone and tuffaceous fine sandstone with a pebbly conglomerate at the base and glauconite at the top, and the upper half comprising pumice tuff and tuffaceous siltstone.

3. Wakkanai Well

This well is located to the southwest of the Wakkanai area (Fig. 1). It penetrated the "Poronai Group" showing a characteristic coarsening upward lithofacies change (The Committee of the Mining Industry Development of Hokkaido, 1979). A similar change in lithology occurs also in the Poronai and Momijiyama Formations of the Yubari area.

IV. Kushiro Region

The Kushiro coalfield situated in the southeastern part of Hokkaido consists of thick Paleogene sediments yielding

abundant fossils. The geology of the Kushiro coalfield was summarized by Mabuti (1962) and Matsui (1962). The Kushiro region as treated in this paper represents the western part of the Kushiro coalfield (Fig. 1) and covers the drainage areas along the middle and upper courses of the Ombetsu River, Ombetsu-machi, and those of the Charo River, Shiranuka-machi, Shiranuka-gun, Hokkaido. Stratigraphy of this region was studied by the present writer (Kaiho, 1977 MS). Sediments of the region are grouped into the Urahoro and Ombetsu Groups of probable Late Eocene to Early Oligocene age and the Kawaruppu Formation of Late Paleocene to early Middle Eocene age. The former two groups are treated herein.

The Urahoro Group, which comprises the following four (in the west) or six (in the east) formations, displays a cyclic change in sedimentary environments, namely, fresh water→brackish water→shallow marine→brackish or fresh water deposits. The transgression which deposited the Urahoro Group culminated at about the middle of the Shitakara Formation. The Urahoro Group is unconformably ovelain by thick marine sediments of the Ombetsu Group. The Ombetsu Group is composed of the Omagari, Charo and Nuibetsu Formations. The stratigraphic sequence of the Paleogene sediments is summarized as follows in downward sequence.

Stratigraphic unit *Lithology* *Thickness in meter*

Superjacent unit: Kamicharo Formation (KC)

..... Unconformity .....

Ombetsu Group

Nuibetsu Formation (NB)

Alternation of grayish black tuffaceous sandstone and hard tuffaceous siltstone intercalated with a thick andesitic tuff breccia in the upper part. Massive dark-gray siltstone intercalated with grayish black tuffaceous sandstone and with calcareous concretions in the lower part. In the western part of the Kushiro region, the former lithofacies occurs only in the uppermost part. 175～900

Charo Formation (CH)

Massive dark-gray siltstone occasionally intercalated with fine tuffaceous sandstone and calcareous concretions. A glauconitic fine sandstone bed in the lower part. 130～500

Omagari Formation (OM)

Light greenish gray bedded fine to very fine sandstone with calcareous concretions. Partly pebbly conglomerate at the base. 25～170

..... Unconformity .....

Urahoro Group

Shakubetsu Formation (SB)

Sandstone and conglomerate, intercalated with siltstone and coal seams in the western part of the region. Sandstone, siltstone and coaly siltstone, intercalated with coal seams in the eastern part of the region. 35～370

Shitakara Formation (SK)

Sandstone and conglomerate intercalated with sandy siltstone in the western part of the region. The sequence in the eastern part of the region can be divided into three parts as follows: Massive fine to medium sandstone intercalated with granular and pebbly conglomerate in the upper part (SKY), siltstone and sandy siltstone in the middle part (SKM) and medium to coarse sandstone intercalated with granular and pebbly conglomerate in the lower part of the formation (SKL). 70～300

Yubetsu Formation (YB)

Dark-gray siltstone and very fine to fine sandstone intercalated with coal seams and coaly siltstone in the western part. The sequence in the eastern part of the region can be divided into two parts as follows: Bedded dark-gray siltstone with very fine sandstone in the upper part (Soun siltstone Member), fine to medium coaly sandstone and gray or dark-gray siltstone intercalated with coal, coaly siltstone and conglomerate in the lower part (Yubetsu coal-bearing Member). 100～530

Rushin Formation (western part of the region)

Conglomerate intercalated with sandstone and siltstone. 310～430

Tenneru Formation (eastern part of the region)

Conglomerate and sandstone intercalated with siltstone. This formation is correlative with the Rushin Formation. 290

Harutori Formation (eastern part)

Alternating beds of sandstone and siltstone

intercalated with coal seams. 25~50
Beppo Formation (eastern part)
Cobbly to pebbly conglomerate intercalated with coarse to medium sandstone. 25~
..... Unconformity .....
Subjacent unit: Kawaruppu Formation of the Nemuro Group

There is a marked difference in lithofacies between the western and eastern parts of the region. The Urahoro Group is generally composed of coarser-grained sediments in the western part than the eastern part. On the contrary, the Charo and Nuibetsu Formations have less frequent sandstone intercalations in the western area than the eastern area. The composition of sandstone suggests that the Urahoro Group contains much more sediments derived from granitic rocks in the eastern part than the western area (Kaiho, 1977 MS). Asano (1955, 1962b) reported 17 species of foraminifera from the Ombetsu Group and the Shitakara Formation and attempted a correlation between the Kushiro and Ishikari coalfields.

FORAMINIFERAL BIOSTRATIGRAPHY

I. Method of Study

A detailed geological survey was undertaken in the Kushiro region (Kaiho, 1977 MS) and the central part of the Yubari area (Kaiho, 1979 MS) for systematic samplings. In other areas, however, type sections or typical sequences of formation were chosen for taking foraminiferal samples. A total of about 600 samples were used for foraminiferal study. Samples were in principle taken at a stratigraphic interval of 10 to 20 m in each section, although intervals may vary depending on conditions of outcrops and suitability of materials for extracting foraminifera. All the sample localities and their stratigraphic positions are shown in Part 2. Bore-hole samples from the Yubari area and Karumai, Namporo and Wakkanai localities were placed at the present author's disposal by the Hokkaido Tanko-kisen Inc. and Geological Survey of Hokkaido, respectively.

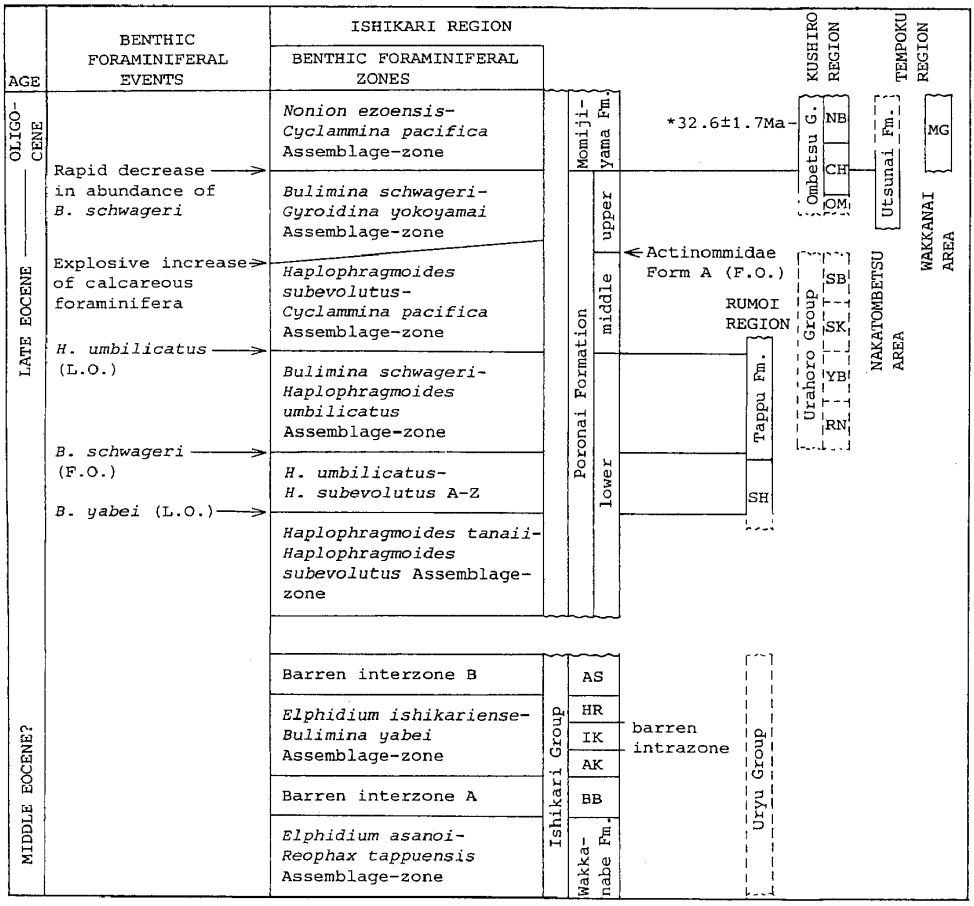
In the laboratory each sample having 80, 100 or 160 g. dry weight was disaggregated with the use of sodium sulphate solution and naphtha solution for rock maceration (Maiya and Inoue, 1973), wet sieved through a 200 mesh screen and dried again. Processed samples were then divided by a sample splitter into aliquot parts. In many cases, more than 200 foraminiferal specimens were picked with the use of a binocular microscope from one aliquot part of the washed residues. When samples contained planktonic species, entire washed residues were examined to pick up all the planktonic specimens.

Both benthic and planktonic specimens were then identified. Their frequencies are listed by the species, except for those badly broken and/or poorly preserved, which were counted together and listed under the category of "miscellaneous" in the distribution charts to be published in Part 2 of the present report. Percentages of agglutinated, calcareous porcelaneous and calcareous hyaline foraminifera were then calculated for each sample.

In the present study, the type specimens described by Asano (1949, 1951b, 1952a, 1953b, 1958b, 1962b), Ujiié and Watanabe (1960), Takayanagi (1960) and Saito's collections of planktonic foraminifera of DSDP were examined for identification and comparison purposes of specimens studied.

II. Benthic Foraminiferal Events

Five benthic foraminiferal events were recognized in the Paleogene System of Hokkaido on the basis of first and last



* : Potassium-argon methed after Shibata and Tanai, 1982

F.O. : First occurrence	NB : Nuibetsu Formation
L.O. : Last occurrence	CH : Charo Formation
AS : Ashibetsu Formation	OM : Omagari Formation
HR : Hiragishi Formation	SB : Shakubetsu Formation
IK : Ikushumbetsu Formation	SK : Shitakara Formation
AK : Akabira Formation	YB : Yubetsu Formation
BB : Bibai Formation	RN : Rushin Formation
SH : Shimokine Formation	MG : Magaribuchi Formation

Fig. 4. Correlation of the Paleogene sequences of Hokkaido based on the proposed benthic foraminiferal events and zones.

occurrences of species which occur relatively continuously (Fig. 4). These five benthic foraminiferal events are useful for intra-regional stratigraphic correlation. Details of these events and their relation to occurrences of planktonic species are as follows beginning with the oldest :

1. Last occurrence of *Bulimina yabei* Asano and Murata

Bulimina yabei occurs in marine formations of the Ishikari Group (the Wakkanabe, Akabira and Hiragishi Formations) and the basal parts of both the Poronai Formation of the Ishikari region and the Shimokine Formation of the Rumoi region.

2. First occurrence of *Bulimina sch-*

wageri Yokoyama

The Poronai Formation can be divided into three parts, lower, middle and upper parts as follows: The top of the lower part is defined by the last occurrence of *Haplophragmoides umbilicatus* and the top of the middle part by the first occurrence of Actinommiidae Form A (Radiolaria) (Fig. 4).

Bulimina schwageri explosively appears in the lower parts of the Poronai Formation of the Yubari area and the Tappu Formation of the Rumoi region.

3. Last occurrence of *Haplophragmoi-*

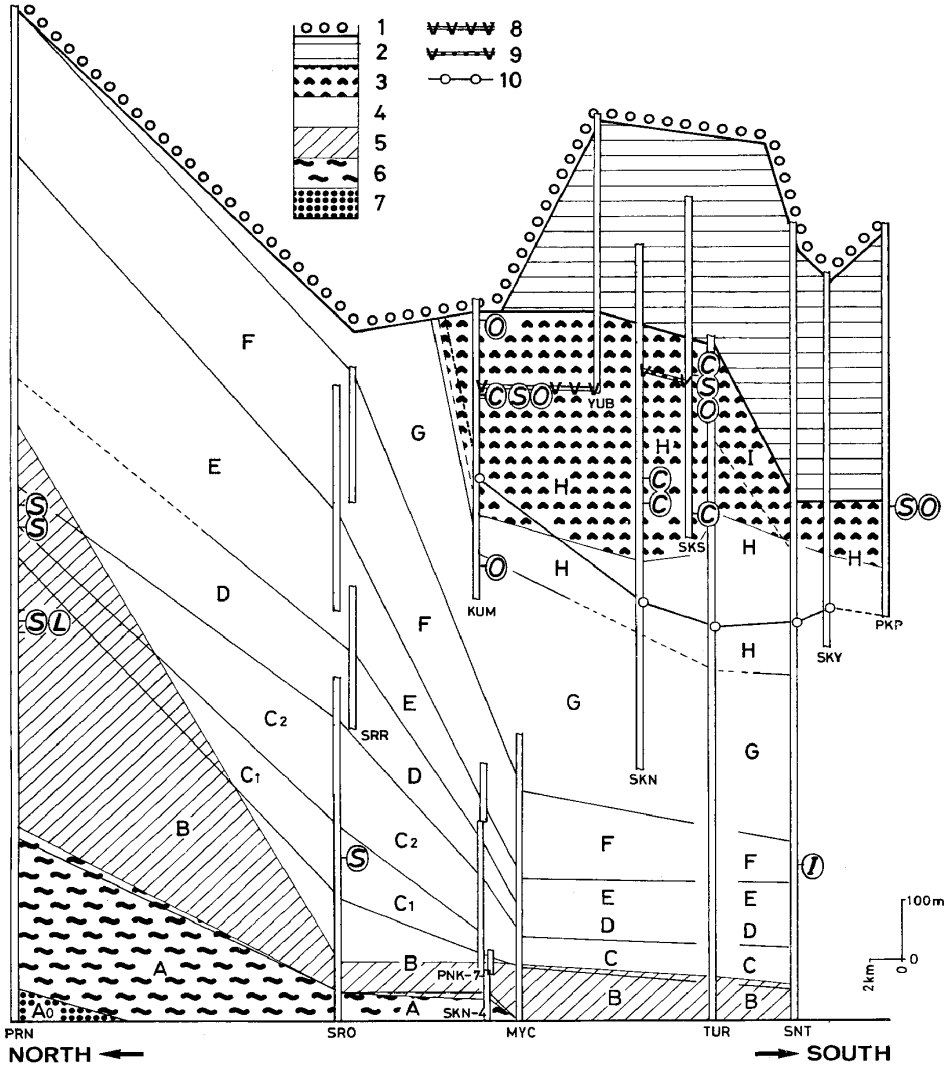


Fig. 5. Stratigraphic and geographic distribution of megafossil and benthic foraminiferal zones and planktonic foraminifera of the Poronai Formation in the Yubari area. 1: Takinoue Formation 2: *Nonion ezoensis-Cyclammina pacifica* Assemblage-zone (Momijiyama Formation) 3: *Bulimina schwageri-Gyroidina yokoyamai* Assemblage-zone 4: *Haplophragmoides subevolutus-Cyclammina pacifica* Assemblage-zone 5: *Bulimina schwageri-Haplophragmoides umbilicatus* Assemblage-zone 6: *Haplophragmoides umbilicatus-Haplophragmoides subevolutus* Assemblage-zone 7: *Haplophragmoides tanaii-Haplophragmoides subevolutus* Assemblage-zone 3-7: Poronai Formation 8: tuff 9: tuffaceous sandstone 10: First occurrence of Actinommidae Form A (Radiolaria) A0, A, B, ····· I: Megafossil zone ©: *Chiloguembelina cubensis* ①: *Globorotalia insolita* ⑤: *Globorotaloides suteri* ⓛ: *Subbotina* cf. *linaperta* ⓞ: *Subbotina* cf. *oregonensis* PRN, SRO, KUM, ------PKP: Sections (see Fig. 2)

des umbilicatus Kaiho, n. sp.

This event occurs at the top of the lower part of the Poronai Formation in the Yubari area and in the upper part of the Tappu Formation in the Rumoi region. *H. umbilicatus* is the only species which becomes extinct within an interval between the A and H megafossil zones in the Poronai Formation with the exception of *A. akabiraensis*, although within its stratigraphic range its occurrence is relatively continuous. Above the last occurrence level of *H. umbilicatus*, which marks the boundary between the lower and middle parts of the Poronai Formation, a continuous presence of Radiolaria is noted throughout the Yubari area.

4. Explosive increase of calcareous foraminifera

Calcareous forms increase their abundance explosively near the boundary between the middle and upper parts of the Poronai Formation in the Yubari area. The occurrence of planktonic species *Chiloguembelina cubensis* (Palmer) is restricted within an interval between the present and the next foraminiferal events in Hokkaido. The present event occurs near the first occurrence of radiolarian Actinommidae Form A, but horizons representing these two microfossils intersects with each other (Fig. 5).

5. Rapid decrease in abundance of *Bulimina schwageri* Yokoyama

Bulimina schwageri rapidly decreases its abundance at the top of the Poronai Formation in the Yubari area, in the middle parts of both the Utsunai Formation of the Nakatombetsu area and the Charo Formation of the Kushiro region. The last occurrence of Actinommidae Form A was recognized at the same horizon as in the Yubari area.

III. Description of Benthic Foraminiferal Zones

Paleogene formations of Hokkaido may be subdivided biostratigraphically into eight assemblage-zones based on benthic foraminifera (Fig. 4). The International Stratigraphic Guide (International Subcommission on stratigraphic classification, 1976), defines both the assemblage-zone and barren zone. The above-mentioned five benthic foraminiferal events and some other important foraminiferal changes occurring in the Ishikari region serve to establish eight benthic foraminiferal zones. The definition, remarks, reference section, distribution and age of each zone are noted in the foregoing lines (Figs. 4, 5, 6). Stratigraphic and geographic positions of these reference sections are given in Figs. 2 and 3.

1. *Elphidium asanoi-Reophax tappuensis* Assemblage-zone

Definition : This assemblage-zone is marked by the joint occurrence of *Elphidium asanoi* Kaiho, n. sp. and *Reophax tappuensis* Asano.

Remarks : An assemblage consisting of *E. asanoi*, *R. tappuensis*, *Pseudonodosaria shitakaraensis* Kaiho, n. sp. and *Bulimina yabei* characterizes this zone. This assemblage shows a low species diversity. *Elphidium asanoi* is restricted to the Wakkanabe Formation and is very abundant, forming almost a monospecific assemblage in siltstone facies. *R. tappuensis* is dominant in sandy siltstone facies.

Reference section : Wakkanabe Formation along the Pankemaya-7-well.

2. Barren interzone A

The barren interzone A corresponds to the Bibai Formation.

3. *Elphidium ishikariense-Bulimina yabei* Assemblage-zone

Definition : This assemblage-zone is marked by the occurrence of *Elphidium ishikariense* Kaiho, n. sp. and *Bulimina yabei*.

Remarks : This zone intercalates a barren intrazone which covers all of the Ikushumbetsu Formation and possibly

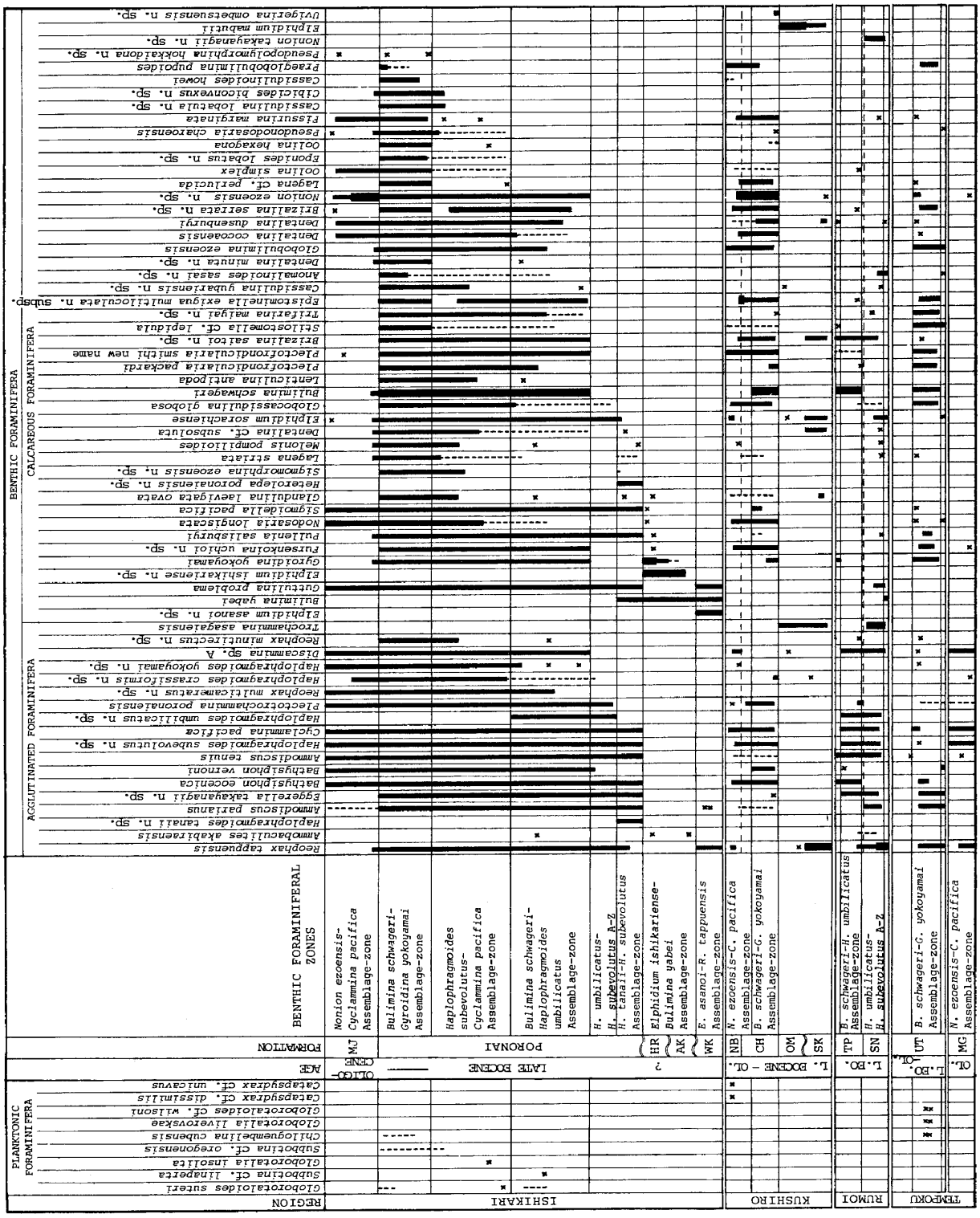


Fig. 6. Stratigraphic distribution of important foraminifera of Hokkaido, Japan.

some of the adjacent formations. The subjacent and superjacent formations have a similar assemblage composed of *E. ishikariense*, *B. yabei* and *Gyroidina yokoyamai*.

Reference sections: Akabira Formation along the Tanzan River; Hiragishi Formation along the Pankeriyaushi River.

4. Barren interzone B

The barren interzone B encompassing the Ashibetsu Formation.

5. *Haplophragmoides tanaii-Haplophragmoides subevolutus* Assemblage-zone

Definition: The present zone represents a body of strata characterized by the joint occurrence of *Haplophragmoides tanaii* Kaiho, n. sp. and *H. subevolutus* Kaiho, n. sp.

Remarks: Abundant species are *H. tanaii* and *H. subevolutus*. *H. tanaii* and *Heterolepa poronaiensis* Kaiho, n. sp. are restricted to this assemblage-zone, which is also marked by the first occurrence of *Ammodiscus parianus* Hedberg, *Eggerella takayanagii* Kaiho, n. sp., *Bathysiphon eocenica* Cushman and Hanna, *Ammodiscus tenuis* Brady, *H. subevolutus*, *Cyclammina pacifica* Beck, *Sigmomorphina ezoensis* Kaiho, n. sp., *Lagena striata* (d'Orbigny), *Melonis pompilioides* (Fichtel and Moll) and *Dentalina* cf. *subsoluta* (Cushman). This assemblage-zone corresponds to the megafossil zone A0.

Reference section: The basal part of the Poronai Formation along the Mikasaporonai River.

6. *Haplophragmoides umbilicatus-Haplophragmoides subevolutus* Assemblage-zone

Definition: This zone is marked by the occurrence of *Haplophragmoides umbilicatus* and *H. subevolutus* and corresponds to an interval from the last occurrence of *Bulimina yabei* to the first occurrence of *B. schwageri*.

Remarks: *H. umbilicatus* first occurs at or near the base of this zone, and is generally common throughout this zone. *H. subevolutus* is a common element, persisting from the subjacent zone. This zone is also characterized by the dominance of *C. pacifica*. *Plectotrochammina poronaiensis* (Asano) and *Globocassidulina globosa* (Hantken) first occur in this zone. Stratigraphically, this zone is almost identical with the megafossil zone A.

Reference section: The lower part of the Poronai Formation along the Mikasaporonai River.

Distribution: The lower part of the Poronai Formation in the northern and central parts of the Yubari area; the upper part of the Shimokine Formation and the basal part of the Tappu Formation along the Soshubetsu River section in the Rumoi region.

7. *Bulimina schwageri-Haplophragmoides umbilicatus* Assemblage-zone

Definition: This zone represents a body of strata characterized by the joint occurrence of *Bulimina schwageri* and *Haplophragmoides umbilicatus*.

Remarks: In the Yubari area, many other species have their first occurrences in this zone. These are: *Haplophragmoides yokoyamai* Kaiho, n. sp., *Plectofrondicularia packardi* Cushman and Schenck, *P. smithi* Kaiho, new name, *Brizalina saitoi* Kaiho, n. sp., *Trifarina maiyai* Kaiho, n. sp., *Anomalinoides sasai* Kaiho, n. sp., *Globobulimina ezoensis* (Yokoyama), *Dentalina dusenburyi* Beck, *Brizalina serrata* Kaiho, n. sp., *Nonion ezoensis* Kaiho, n. sp., etc. (Fig. 6). *B. schwageri* rapidly becomes abundant at the base of the zone, although other species occur sporadically near the base. *B. schwageri* is so abundant throughout this zone that the zone is most easily and widely recognizable. The top of this zone lies within the megafossil zone D in the Mikasaporonai River section and within the megafossil zone B in the Shirirruomappu River

section. In the southern section, the top of this zone is mostly identical with the top of megafossil zone B. Planktonic foraminifera found in this zone are *Globorotaloides suteri* Bolli and *Subbotina* cf. *linaperta* (Finlay).

Reference section : The lower part of the Poronai Formation along the Mikasaporonai River.

Distribution : The lower part of the Poronai Formation in the Yubari area; the middle part of the Tappu Formation in the Soshubetsuzawa section of the Rumoi region.

Age : Middle to Late Eocene

8. *Haplophragmoides subevolutus-Cyclammina pacifica* Assemblage-zone

Definition : The last occurrence of *Haplophragmoides umbilicatus* defines the base of this zone and its top marked by the biohorizon were calcareous foraminifera rapidly flourish.

Remarks : This zone is characterized by the dominance of such agglutinated foraminifera as *Haplophragmoides subevolutus*, *Cyclammina pacifica*, etc., a general low diversity of foraminiferal species and the absence of *H. umbilicatus*. The last mentioned is replaced by *Haplophragmoides crassiformis* Kaiho, n. sp. Planktonic foraminifera found in this zone are *Globorotalia insolita* Jenkins and *Subbotina* cf. *oregonensis* McKeel and Lipps.

Reference section : The middle part and the lower portion of the upper part of the Poronai Formation along the Tsurunosawa.

Distribution : The middle part and the lower portion of the upper part of the Poronai Formation in the Yubari area; the upper part of the Tappu Formation along the Soshubetsu River in the Rumoi region.

Age : Late Eocene

9. *Bulimina schwageri-Gyroidina yokoyamai* Assemblage-zone

Definition : The zonal base is defined by the biohorizon where calcareous forms rapidly flourished and its top by the biohorizon where the frequency of *Bulimina schwageri* rapidly declines.

Remarks : This assemblage is characterized by a comparatively high diversity and the dominance of calcareous hyaline foraminifera. Common species throughout this zone are *B. schwageri*, *G. yokoyamai*, and *H. subevolutus*. *Praeglobobulimina pupoides* d'Orbigny and *Cassidulinoides howei* Cushman first occur in this zone, although they are extremely rare. The last occurrence of *B. saitoi* Kaiho, n. sp. is an approximate guide to the top of this zone. Many other species also last occur at or near the top of this zone in the Yubari area, for example, *Eggerella takayanagii*, *Fursenkoina uchioi* Kaiho, n. sp., *Sigmomorphina ezoensis*, *Plectofrondicularia packardi*, *Trifarina maiyai*, *Anomalinoides sasai*, *Cassidulina lobatula* Kaiho, n. sp., *P. pupoides*, etc. (Fig. 6). These species are, however, not useful as markers for the top of this zone in the Kushiro region with the exception of *P. packardi*. Planktonic foraminifera occurring in this zone are *Chiloguembelina cubensis* (Palmer), *Globorotaloides suteri* and *Subbotina* cf. *oregonensis*.

Reference section : The upper part and the upper portion of the middle part of the Poronai Formation along the Kumanosawa.

Distribution : The upper part and the upper portion of the middle part of the Poronai Formation in the Yubari area; the lower part of the Charo Formation along the Satombetsu River section in the Kushiro region; the lower part of the Utsunai Formation along the Utsunai River section in the Nakatombetsu area.

Age : Late Eocene to Early Oligocene

10. *Nonion ezoensis-Cyclammina pacifica* Assemblage-zone

Definition : The zonal base is defined by a rapid decrease in the abundance of

Bulimina schwageri. Its top is not defined herein, because this is the youngest zone recognized in the present study.
Remarks: Numerous long-ranging species which continue from the underlying zone characterize the assemblage of this zone. This assemblage is dominated by *Nonion ezoensis* and a few agglutinated forms including *Cyclammina pacifica*, *Haplophragmoides subevolutus*, *Discammina* sp. A, and *Bathysiphon eocenica*. *Plectofrondicularia smithi* is the only species of this genus that ranges into this zone. The geographic extent of this assemblage-zone corresponds to the aerial distribution of a tuff-bearing or tuffaceous rock facies.
Reference section: The Momijiyama Formation along the Yubari River.
Distribution: Momijiyama Formation in the Yubari area; the upper part of the Charo Formation and the Nuibetsu Formation along the Satombetsu River section in the Kushiro region; the Magaribuchi Formation along the Tatsuniushinai River, Nitatoromanai River and Uruya River sections in the Wakkanai area.
Age: Early Oligocene

AGE AND CORRELATION

I. Previous Age Determination

1. Ishikari Region

1) Poronai Group

In 1890 Yokoyama first reported several foraminiferal species from Poronai of the Ishikari region as Cretaceous forms. Subsequently, Asano (1950 a) proved the provenance of these forms to be from the Paleogene Poronai Formation.

Asano (1952a) correlated the Poronai Formation with the Refugian Stage of California by benthic foraminifera. Takeda (1953) correlated it by molluscan fossils with the lower Oligocene Blakeley Formation. Recently, Warren and Newell (1981) pointed out the likelihood of discovering *G. insolita* from the Blakeley Formation, a species which is characteristic of Refugian sediments of the Pacific Northwest. Kobayashi (1957) correlated it with the Ashiya Group in Kyushu, Japan, by occurrence of *Aturia yokoyamai* Nagao and concluded that the Poronai Formation is Oligocene in age. After that, Ujiié and Watanabe (1960) correlated this formation in Kamiashibetsu, Sorachi area, with the Narizian of California by means of benthic foraminifera. They also reported *Globigerina* cf. *linaperta* Finlay from Kamiashibetsu.

Asano (1962 b) demonstrated the ages of the Momijiyama and Poronai Formations as follows: The Asagai and Shimokine Formations, which are correlative with the Momijiyama Formation by means of benthic faraminifera, are in turn equated with the Iojima Formation of Kyushu. This Iojima Formation yields planktonic foraminifera assignable to the *Globigerina ampliapertura* zone. The *G. ampliapertura* Zone of Trinidad was correlated with the Lattorfian by Bolli (1959), Stainforth (1960) and Jenkins (1960). Therefore, the Momijiyama, Shimokine and Asagai Formations are all considered to be of the Lattorfian Stage. Consequently, the underlying Poronai Formation is likely to be of Eocene age. The occurrence of *Globigerina linaperta* in the Poronai Formation upholds this age assignment. Meanwhile, Kanno (1971) studied molluscan fauna from the southern Alaska, and resultantly correlated the Poronai Formation with the Poul Creek Formation, considering their age to be Oligocene. There is thus a discrepancy between the molluscan workers and foraminiferal workers in relation to the age of the Poronai Formation; the former

hold the Oligocene and the latter the Eocene.

2) Ishikari Group

The age of the Ishikari Group has mainly been determined by plant remains. The Ikushumbetsu Formation was assigned to the late Eocene by Endo (1931) on the basis of floral assemblages with a close resemblance to those of the upper Eocene of Alaska. However, Oishi and Huzioka (1943) made an objection to his opinion. On the other hand, Asano (1962b) considered, by means of benthic foraminifera, that the Ishikari Group is of Eocene age. As above mentioned, Kanno (1971) correlated the Ishikari Group with the Poul Creek Formation in southern Alaska, and considered its age to be Eocene.

2. Rumoi Region

Asano (1962b) considered that the Shimokine Formation is correlative with the Lattorfian Stage for the reason mentioned above; this is consistent with the occurrence of the Priabonian *Amynodon* from the subjacent Numata Formation, the uppermost part of the Uryu Group.

3. Kushiro Region

Tanai (1970) used the evidence provided by a paleobotanical comparison of four Hokkaido floras with Paleogene floras of western North America to establish their ages as follows; the Harutori flora to the Early Oligocene, the Tenneru to the late Early Oligocene, and the Yubetsu and Shakubetsu to the Middle to Late Oligocene (probably Middle Oligocene). Recently, Sawamura and Otowa (1979) reported a silicoflagellate flora from the Nuibetsu Formation which represents the Upper Oligocene *Naviculopsis biapiculata* zone.

II. Age Assignment based on Planktonic Foraminifera

The Paleogene foramitions in Hokkaido can be dated by a few but important planktonic foaminifera newly discovered in this study. Planktonic foraminifera such as *Globorotaloides suteri* Bolli, *Subbotina* cf. *linaperta* (Finlay) and *Globorotalia insolita* Jenkins were found, although sparse, from the Poronai Formation (Figs. 5, 6). The presence of *Globorotalia insolita* in the middle part of the Poronai Formation leads to a correlation of this sequence with the *Globigerina linaperta* zone of Jenkins (1965) in New Zealand because *G. insolita* is restricted to the upper part of the *Globigerina linaperta* zone, which was considered to be of Late Eocene age. This species was also recorded from the *G. insolita* zone in the eastern equatorial Pacific by Jenkins and Orr (1972) and from the Refugian Stage of the U.S. Pacific Northwest. The *G. insolita* zone was considered to be correlative with the Upper Eocene Zone P. 17 of Blow (1969).

According to Blow (1979), *Subbotina linaperta* (= *G. linaperta*) last occurs in Zone P. 16 (*Subbotina* cf. *linaperta* occurs from the megafossil zone B2, lower part of the Poronai Formation in the Mikasaporonai River section). *Globorotaloides suteri* Bolli, which ranges from zone P. 13 to N. 8 of Blow (1969), is comparatively common in the middle part of the Poronai Formation of the Yubari area. According to these facts, the lower and middle parts of the Poronai Formation are considered to be within the Middle to Upper Eocene Zone P. 13 to P. 17, namely, Bartonian to Priabonian of the European stage (Berggren et al., 1984 in press).

Chiloguembelina cubensis (Palmer) first occurs within the upper part of the Poronai Formation and characterizes this part of the formation of the central Yubari area (Figs. 5, 6). It commonly occurs in Oligocene sediments, but the lower range of this species down to late Eocene is an unsettled question. *Subbotina* cf. *oregonensis* occurring in the middle and upper parts of the Poronai

Formation (Figs. 5, 6) is previously recorded only from the Upper Eocene of the type locality in Oregon, but its full range has yet to be determined. An age assignment of the middle part of the Poronai Formation to the Late Eocene may lead to a probable placement of the upper part of the Poronai Formation in the vicinity of the Eocene/Oligocene boundary. The superjacent Momijiyama Formation may be Oligocene in age, but its precise age cannot be determined.

Planktonic species were found for the first time from the Utsunai Formation; they are *Globorotalia liverovskae* (Bykova), *Chiloguembelina cubensis*, *Globorotaloides* cf. *wilsoni* (Cole) and *Globigerina* sp. (Fig. 6). These planktonic forms are confined to the lower part of the formation. *Globorotalia liverovskae* was reported by Subbotina (1953) from the "*Bolivina* zone" and the "zone of small globigerina" of northern Caucasus as *Globigerina postcretacea* Mjatlyuk and *G. liverovskae* was considered to range from upper Eocene to lower Oligocene. This species was originally reported from the Lower Oligocene of Kazakhstan by Bykova (1960, inaccessible, *fide* Cat. Foram.). *Globorotaloides wilsoni* was also reported from the middle Eocene to lower Oligocene of North and South America (Cole, 1927; Stainforth, 1948; McKeel and Lipps, 1975; Poore and Brab, 1977). The occurrence of *Chiloguembelina cubensis* from the Utsunai Formation is consistent with the estimated age based on *G. liverovskae* and *G. wilsoni*. As a result, the lower part of the Utsunai Formation is considered to be of late Eocene to early Oligocene age (Matsumoto et al., 1981).

In the Kushiro region, *Catapsydrax* cf. *unicavus* Bolli, Loeblich and Tappan and *Catapsydrax* cf. *dissimilis* (Cushman and Bermúdez) occur from the middle part of the Nuibetsu Formation (Fig. 6). These two forms, however, have a long range from Zone P. 13 to N. 6 (Blow, 1969), Middle Eocene to Early Miocene (Stainforth et. al., 1975). Thus, these species cannot give precise age of the sediments. According to Shibata and Tanai (1982), the K-Ar age of andesite in the middle part of the type Nuibetsu Formation is 32.6 ± 1.7 Ma, indicating the Early Oligocene. This age assignment does not contradict with that of the present study; the Momijiyama Formation, which is correlated with the Nuibetsu Formation by means of benthic foraminifera, is probably early Oligocene in age.

SYSTEMATIC DESCRIPTION OF NEW SPECIES

Descriptions of 40 new species and subspecies plus one new name are given in this chapter. The scheme of suprageneric classification used herein is the one proposed by Loeblich and Tappan (1964, 1974, 1981). Detailed descriptions of localities of these new species and subspecies will appear in Part 2 of the present report. The type specimens of all the new species and subspecies are deposited in the collections of the Institute of Geology and Paleontology (IGPS), Tohoku University, Sendai, Japan.

Order Foraminiferida Eichwald, 1830
Suborder Textulariina Delage and Hérouard, 1896
Superfamily Lituolacea de Blainville, 1825
Family Hormosinidae Haeckel, 1894
Subfamily Hormosininae Haeckel, 1894
Genus *Reophax* Montfort, 1808

Reophax minutirectus Kaiho, n. sp.

Pl. 7, fig. 1

Description: Test free, small, narrow, elongate, laterally somewhat compressed, uniserial and rectilinear, later portion

with roughly parallel, somewhat lobulate margins; several chambers, somewhat inflated, early ones broader than height, increasing slowly, somewhat irregularly in size as added, final chambers of nearly equal breadth and height; sutures distinct, depressed, perpendicular to axis of test; wall finely agglutinated, surface roughly finished; aperture terminal, rounded, on a slightly raised mound.
Type and dimensions: Holotype, IGPS 98010, length 0.53 mm, maximum breadth 0.16 mm, sample PRN24, Poronai Formation.
Remarks: This species resembles *R. scottii* Chaster but is distinct in the chamber shape and longer test. It closely resembles *R. kuklerensis* Conkin from the upper Mississippian of Perry County, Indiana, but differs in having somewhat more lobulate chambers, depressed sutures and coarser wall texture.
Occurrence in study area: Ranges from the *B. schwageri-H. umbilicatus* Assemblage-zone to the *B. schwageri-G. yokoyamai* Assemblage-zone.

Reophax multicameratus Kaiho, n. sp.

Pl. 7, figs. 2 a, b

Description: Test free, large, elongate, laterally compressed, uniserial, nearly straight or arcuate; up to 11 chambers, inflated in later portion, increasing slowly in size as added, broader than height; sutures distinct, depressed; wall finely agglutinated to moderately coarse grained, surface somewhat smooth; aperture terminal, rounded, on an indistinct or very slightly broad neck.
Type and dimensions: Holotype, IGPS 98011, length 2.96 mm, maximum breadth 0.71 mm, maximum thickness 0.31 mm, sample SRO09, Poronai Formation.
Remarks: This species differs from a Recent species, *Reophax ammobaculites* Hofker, from the Albatross Station, off the Philippine Islands, in having a finer wall texture and indistinct neck.
Occurrence in study area: Ranges from the *B. schwageri-H. umbilicatus* Assemblage-zone to the *N. ezoensis-C. pacifica* Assemblage-zone.

Family Lituolidae de Blainville, 1825
Subfamily Haplophragmoidinae Maync, 1952
Genus *Haplophragmoides* Cushman, 1910
Haplophragmoides crassiformis Kaiho, n. sp.

Pl. 7, figs. 3 a, b

Description: Test free, large, planispiral and involute, biumbilicate, with small umbilici, peripheral margin rounded, peripheral outline lobulate; five to six chambers in final whorl, somewhat inflated, cuneate in side view; sutures somewhat depressed, radial, with a slightly sinuate appearance; wall rather coarsely agglutinated, surface rather roughly finished; aperture equatorial, a low interiomarginal arch.
Type and dimensions: Holotype, IGPS 98015, maximum diameter 1.30 mm, minimum diameter 0.94 mm, thickness 0.75 mm (range of maximum diameter 1.1 to 1.6 mm), sample SRR11, Poronai Formation.
Remarks: This species has a smaller test with fewer chambers and lesser amount of cement than *H. grandiformis* Cushman.
Occurrence in study area: Ranges from the uppermost part of the *H. umbilicatus-H. subevolutus* Assemblage-zone to the lower part of the *N. ezoensis-C. pacifica* Assemblage-zone

Haplophragmoides subevolutus Kaiho, n. sp.

Pl. 7, figs. 7 a, b

cf. *Cribrostomoides cretacea* Cushman and Hanna. Ujiié and Watanabe, 1960, p. 127, 128, pl. 1, figs. 3-5.

Description: Test free, planispiral, partly evolute, biumbilicate, commonly two whorls visible on both sides, nearly parallel in side view, peripheral margin rounded, peripheral outline commonly slightly lobulate; nine to 14 chambers in the final whorl, slightly inflated, increasing slowly in size as added, much lower than thickness and width; sutures straight to slightly sinuate, radial, slightly depressed; wall finely agglutinated, surface smoothly finished; aperture equatorial, a low interiomarginal arch.

Type and dimensions: Holotype, IGPS 98017, maximum diameter 1.32 mm, minimum diameter 1.21 mm, thickness 0.62 mm, sample PRN02, Poronai Formation.

Remarks: This species differs from *Haplophragmoides canariensis* (d'Orbigny) in having a partially evolute test, and shows an intermediate character between *Haplophragmoides* and *Trochamminoides*. It differs from *H. wilsoni* Smith in its larger and comparatively thinner test.

Occurrence in study area: This is one of the most dominant species from the upper Eocene to the Oligocene of Hokkaido. Ranges from the *H. tanaii-H. subevolutus* Assemblage-zone to the *N. ezoensis-C. pacifica* Assemblage-zone.

Haplophragmoides tanaii Kaiho, n. sp.

Pl. 7, figs. 5a, b

Description: Test free, compressed, planispiral and involute, biumbilicate, peripheral margin subacute to somewhat rounded, peripheral outline lobulate; seven to six chambers in final whorl, commonly seven, slightly inflated, increasing rather rapidly in size as added; sutures straight, radial, somewhat depressed; wall coarsely agglutinated, surface rather roughly finished; aperture an interiomarginal equatorial arch.

Type and dimensions: Holotype, IGPS 98018, maximum diameter 0.94 mm, minimum diameter 0.70 mm, thickness 0.32 mm, sample PRN02, Poronai Formation.

Remarks: In comparison with *H. umbilicatus* n. sp., the present species shows a narrow umbilicus, coarse wall texture and rapidly increasing chambers in size as added.

This species is named in honor of Prof. Toshimasa Tanai of Hokkaido University, who has contributed to the Paleogene stratigraphy of Hokkaido.

Occurrence in study area: This is a characteristic fossil of the *H. tanaii-H. subevolutus* Assemblage-zone.

Haplophragmoides umbilicatus Kaiho, n. sp.

Pl. 7, figs. 6 a, b

Description: Test free, planispiral, partly evolute, biumbilicate, commonly two whorls visible on both sides, penultimate whorl occupying approximately one fifth the diameter of test, peripheral margin rounded or subrounded, peripheral outline lobulate; six to nine chambers in final whorl, slightly inflated, increasing gradually in size as added; sutures distinct, straight, radial, somewhat depressed; wall moderately coarsely agglutinated, surface rather smoothly finished; aperture an interiomarginal equatorial arch.

Type and dimensions: Holotype, IGPS 98019, maximum diameter 0.96 mm, minimum diameter 0.79 mm, thickness 0.43 mm (range of maximum diameter 0.80 to 1.19 mm, thickness 0.27 to 0.32 mm), sample PRN08, Poronai Formation.

Remarks: This species differs from *H. yokoyamai* in having a wider and open umbilicus on both sides. It has a more compressed test than *H. langsdalensis* Applin.

Occurrence in study area: This species is a good marker fossil for the lower part

of the Poronai Formation and its correlatives. Ranges from the *H. umbilicatus-H. subevolutus* Assemblage-zone to the *B. schwageri-H. umbilicatus* Assemblage-zone.

Haplophragmoides yokoyamai Kaiho, n. sp.

Pl. 7, figs. 4 a, b

Description: Test free, planispiral and involute, biumbilicate, peripheral margin subrounded, peripheral outline lobulate; five to six chambers in final whorl, somewhat inflated, cuneate in side view, increasing gradually in size as added; sutures distinct, depressed, radial; wall finely agglutinated, surface smoothly finished; aperture an interiomarginal equatorial arch.

Type and dimensions: Holotype, IGPS 98020, maximum diameter 0.77 mm (range of maximum diameter 0.5 to 0.8 mm), minimum diameter 0.70 mm, thickness 0.30 mm, sample KUM39, Poronai Formation.

Remarks: The shape and arrangement of chambers of this species resemble those of *Haplophragmium horridum* Grzybowski from the lower to middle Eocene of Poland and *Haplophragmoides tryssa* Loeblich and Tappan from the Jurassic of South Dakota. It differs from the former in being smaller in size and having a finely finished wall surface, and from the latter in being much larger in size and having more slowly increasing chambers in size as added.

This species is named in honor of the late Prof. Matajiro Yokoyama in recognition of his pioneer works on the foraminifera of the Poronai Formation.

Occurrence in study area: Ranges from the *B. schwageri-H. umbilicatus* Assemblage-zone to the *N. ezoensis-C. pacifica* Assemblage-zone.

Family Ataxophragmiidae Schwager, 1877
Subfamily Globotextulariinae Cushman, 1927
Genus *Eggerella* Cushman, 1933

Eggerella takayanagii Kaiho, n. sp.

Pl. 7, figs. 8 a-c

Description: Test free, elongate, flaring, very early whorls usually indistinct but approximately four chambers in a whorl, remainder of test triserial, tapering regularly to a sharp posterior point, composed of up to six whorls; chambers low and broad, somewhat inflated in early portion, increasing regularly in size as added, subglobular, strongly inflated in last whorl; sutures depressed; wall finely agglutinated, surface rather smooth; aperture an arch, open in a deeply excavated umbilicus at junction of three chambers.

Type and dimensions: Holotype, IGPS 98036, length 0.52 mm, maximum breadth 0.33 mm, minimum breadth 0.28 mm, sample UTN09, Utsunai Formation.

Remarks; Most specimens are compressed due to secondary deformation. Some undeformed specimens are pyritized. It differs from *Eggerella advena* (Cushman), *emend.* Loeblich and Tappan and *E. arctica* Höglund (both from the Recent) in having regularly increasing breadth of test. It has a much smaller test and a more angular initial point than those of *Vernenilina propinqua* Brady from the Recent of the South and North Atlantic.

The specific name is given in honor of Prof. Yokichi Takayanagi of Tohoku University of Japan in recognition of his works on foraminifera.

Occurrence in study area: Ranges from the *H. tanaii-H. subevolutus* Assemblage-zone to the *B. schwageri-G. yokoyamai* Assemblage-zone.

Subfamily Valvulininae Berthelin, 1880
Genus *Martinottiella* Cushman, 1933
Martinottiella crassa Kaiho, n. sp.

Pl. 7, figs. 9-10 b

Description: Test free, large, elongate, somewhat compressed, comparatively stout, ovate in transverse section; early chambers trochospirally arranged in two or three whorls, later becoming biserial in one or two pairs, then uniserial; early trochospiral to biserial portion inflated; uniserial portion occupying more than half the length of test; chambers inflated, broader than height, increasing rapidly in size as added; sutures depressed, oblique in early portion, later becoming right angle to test axis; wall coarsely agglutinated, surface somewhat roughly finished; aperture terminal, ovate.
Type and dimensions: Holotype, figs. 10 a, b, IGPS 98040, length 1.15 mm, maximum breadth 0.55 mm, thickness 0.37 mm, sample TUR04; figs. 9, IGPS 98041, length 1.22 mm, maximum breadth 0.70 mm, thickness 0.40 mm, sample SNT01. Both from Poronai Formation.
Remarks: No species similar to the present one has been described. It differs from *Schenckiella suteri* Cushman and Stainforth in having more inflated chambers and the uniserial stage whose breadth increasing more rapidly.
Occurrence in study area: A few specimens from the lower part of the Poronai Formation.

Martinottiella rectidelicata
Kaiho, n. sp.

Pl. 7, figs. 11 a, b

Description: Test free, narrow, elongate, cylindrical, rounded to oval in tangential section, earliest portion quadriserial, followed by triserial to biserial stages, later becoming uniserial, uniserial portion occupying more than half the length of test in adult specimens; chambers low, inflated; sutures depressed, wall finely agglutinated, surface smoothly finished; aperture terminal, with a distinct lip, semilunar, at end of a slender short neck.
Type and dimensions: Holotype, IGPS 98042, length 0.79 mm, maximum diameter 0.21 mm, minimum diameter 0.17 mm, sample PKP03, Poronai Formation.
Remarks: The present specimens are somewhat compressed by secondary deformation. This species is related to a Neogene form *M. communis* (d'Orbigny), but differs from it in having comparatively low and inflated chambers. It has a much smaller test with a shorter uniserial portion, more inflated chambers and a more slender neck than those of *M. primaeva* (Cushman), an Recent species from the Albatross station near Borneo. It resembles *Listerella anconensis* Coryell and Embich decribed from the upper Eocene Tranquilla Shale of Panama, but *M. rectidelicata* possesses four chambers to a whorl in the spiral stage instead of five chambers. It also resembles *Listerella nodulosa* (Cushman) var. *glabrata* Cushman from the Upper Tertiary of Georges Bank off New England coast.
Occurrence in study area: Several specimens from a single sample (PKP03) of the Poronai Formation.

Suborder Lagenina Delage and Hérouard, 1896
Superfamily Nodosariacea Ehrenberg, 1838
Family Nodosariidae Ehrenberg, 1838
Subfamily Nodosariinae Ehrenberg, 1838
Genus *Dentalina* Risso, 1826
Dentalina minuta Kaiho, n. sp.

Pl. 7, figs. 12, 13

Description: Test free, elongate, slightly arcuate, rounded in transverse section; chambers more inflated on outer side of arch, mid-portion most inflated;

chambers about twice as long as broad; sutures strongly and broadly depressed; wall calcareous, finely perforate, surface smooth; aperture on protruding apex, not central, near inner side of arch.
Type and dimensions: Holotype, fig. 13, IGPS 98052, length 1.00 mm, maximum diameter 0.22 mm; paratype, fig. 12, IGPS 98053, length 0.52 mm, maximum diameter 0.15 mm. Both from sample KUM14, Poronai Formation.
Remarks: The present species is similar to *Dentalina reussi* Neugeboren from the Neogene of the Vienna Basin, but is distinguished from the latter in the shape of chambers being more inflated on the outer side.
Occurrence in study area: Ranges from the *B. schwageri-H. umbilicatus* Assemblage-zone to the *N. ezoensis-C. pacifica* Assemblage-zone.

Genus *Lenticulina* Lamarck, 1804
Lenticulina ishikariensis Kaiho, n. sp.

Pl. 7, figs. 14a, b

Description: Test free, small, Planispiral and involute, sides flattened, peripheral outline elliptical, peripheral margin angular, weakly keeled; chambers about seven in final whorl, not inflated, increasing rapidly in size as added; umbo small, flush, skewed towards apertural face; sutures curved, flush with surface; wall calcareous, hyaline, surface smooth; aperture radiate, at the slightly protruding peripheral angle.
Type and dimensions: Holotype, IGPS 98064, maximum diameter 0.57 mm, minimum diameter 0.41 mm, thickness through center 0.21 mm, sample SKS07, Poronai Formation.
Remarks: This species differs from *Lenticulina obirashibensis* Takayanagi from the Upper Cretaceous of Hokkaido in having a more ovate test with a narrower keel. No umbo is present in juvenile forms.
Occurrence in study area: Ranges from the *B. schwageri-G. yokoyamai* Assemblage-zone to the *N. ezoensis-C. pacifica* Assemblage-zone.

Genus *Pseudonodosaria* Boomgaart, 1949
Pseudonodosaria shitakaraensis Kaiho, n. sp.

Pl. 8, figs. 1a, b

Pseudoglandulina obtusissima (Reuss). Yoshida, 1957, p. 64, text-figs. 3-9.

Description: Test free, elongate, uniserial, widest at about one fourth the test length from gradually tapering apertural end; chambers up to five, fairly overlapping, last chamber occupying approximately one half the length of test; sutures distinct, perpendicular to test axis, flush with surface; wall calcareous, hyaline, surface smooth; aperture terminal, radiate; apertural end not protruding.
Type and dimensions: Holotype, IGPS 98069, length 1.26 mm, maximum diameter 0.66 mm, minimum diameter 0.52 mm, sample NIB14, Shitakara Formation.
Remarks: This species has a compressed test which may have resulted from secondary deformation. It differs from *Rectoglandulina netrona* Tappan from the Albian, Topagoruk Formation in northern Alaska in having a less protruding apertural end and a much larger test.
Previous record in Hokkaido: Shitakara Formation of Kombumori, Kushiro, eastern Hokkaido (Yoshida, *loc. cit.*).
Occurrence in study area: Common in the Shitakara Formation, a few in the Wakkanabe Formation, rare in the basal part of the Utsunai Formation.

Genus *Saracenaria* Defrance in de Blainville, 1824
Saracenaria ujiiei Kaiho n. sp.

Pl. 7, figs. 15a-c

Description: Test free, early portion

close coiled, later tending to uncoil, fusiform in edge view; several chambers increasing rapidly in size as added, triangular in transverse section, with subacute angles and two sides being longer than breadth of face, last chamber extending backward to proloculus; sutures distinct, flush with surface, curved in early portion, later somewhat sigmoidal; wall calcareous, finely perforate, surface smooth; aperture radiate, at the protruding peripheral angle.

Type and dimensions: Holotype, IGPS 98070, length 0.98 mm, breadth of side 0.5 mm, breadth of apertural face 0.45 mm, sample KUM13, Poronai Formation.

Remarks: This species resembles *Saracenaria colei* Srinivasan from the Upper Eocene, Kaiatan and Runangan Stages of New Zealand in general outline, but differs in having a more slender test with fewer number of chambers which increase more rapidly in size, non-keeled peripheral edge, and non-limbate and sigmoidal sutures. It differs from *Saracenaria trigonata* (Plummer) from the Paleocene Midway Formation of Texas, in having non-carinate peripheral margin and more rapidly enlarging chamber.

This species is named after Prof. Hiroshi Ujiié of Ryukyu University in recognition of his work on Paleogene foraminifera of the Sorachi area.

Occurrence in study area: Rare in the Poronai and Momijiyama Formations.

Subfamily Plectofrondicularriinae Cushman, 1927
Genus *Plectofrondicularia* Liebus, 1902
Plectofrondicularia delicatula Kaiho, n. sp.

Pl. 8, fig. 2

Description: Test free, flattened, elongate, rather narrow, tapering gradually to round aboral end, periphery acute, keeled; proloculus sub-spherical, biserial chambers followed by numerous broad, low, strongly equitant uniserial ones; sutures distinct, strongly limbate, flush with surface; wall calcareous, finely perforate, surface smooth except for earlier portion ornamented with a few short weak longitudinal costae; aperture indistinct in specimens available.

Type and dimensions: Holotype, IGPS 98072, length 1.44 mm, maximum breadth 0.58 mm, maximum thickness 0.06 mm, sample SKS06, Poronai Formation.

Remarks: This new species comes from only one locality. It closely resembles *P. miocenica* Cushman from the Miocene of San Luis Obispo County, California, U.S.A., but differs in having more strongly equitant chambers, its sutures being flush with surface, and weaker costae. This new species has a more rounded and broad aboral end than *P. smithi* Kaiho, new name.

Occurrence in study area: Only found in the Poronai Formation of the Kurukitomarizawa section in the central part of the Yubari area.

Plectofrondicularia smithi Kaiho, new name

Pl. 8, figs. 3, 4

Plectofrondicularia gracilis Smith, 1956, p. 93, Pl. 12, figs. 2-5; Asano, 1958b, p. 49, text-figs. 5, 6; Fairchild, Wesendunk and Weaver, 1969, p. 47, Pl. 9, fig. 11.

Types: Hypotype, fig. 3, IGPS 98076; hypotype, fig. 4, IGPS 98077. Both from sample SRO10, Poronai Formation.

Remarks: The name *P. gracilis*, which has been used by many authors is preoccupied by the Middle or Lower Eocene *P. gracilis* Rey from northern Morocco. The present writer here proposes a new name, *smithi*, for Smith's species and fully accepts the species criteria given by Smith for his species. It is characterized by its narrow and very much compressed

test with very strongly equitant chambers and narrow continuous, longitudinal costae.
Previous record in Hokkaido: Poronai Formation (Asano, *loc. cit.*).
Occurrence in study area: Ranges from the *B. schwageri-H. umbilicatus* Assemblage-zone to the *N. ezoensis-C. pacifica* Assemblage-zone. It is the only species of *Plectofrondicularia* occurring in the *N. ezoensis-C. pacifica* Assemblage-zone.

Family Polymorphinidae d'Orbigny, 1839
Subfamily Polymorphininae d'Orbigny, 1839
Genus *Guttulina* d'Orbigny in de la Sagra, 1938
Guttulina takayanagii Kaiho, n. sp.

Pl. 8, figs. 5a-d

Description: Test free, elongate-ovate in outline, somewhat compressed, narrow, greatest breadth about the middle, periphery rounded, aboral end narrowly rounded, apertural end acute; chambers quinqueloculine in arrangement, about six, elongate, slightly inflated in later portion, somewhat removed from aboral end; sutures oblique, flush with surface in early portion, slightly depressed in later portion; wall calcareous, finely perforate, surface smooth; aperture terminal, radiate.
Type and dimensions: Holotype, IGPS 98083, length 0.60 mm, breadth 0.30 mm, thickness 0.22 mm, sample SNT08, Poronai Formation.
Remarks: This species has a slender test and less inflated chambers than those of *G. problema* (d'Orbigny). It differs from *G. stavensis* Bandy from the Middle Eocene Lisbon Formation of Alabama in having not a pointed but rounded aboral end.

This species is named in honor of Prof. Yokichi Takayanagi, in recognition of his works on foraminifera.

Occurrence in study area: Ranges from the *H. tanaii-H. subevolutus* Assemblage-zone to the *B. schwageri-G. yokoyamai* Assemblage-zone.

Genus *Pseudopolymorphina* Cushman and Ozawa, 1928
Pseudopolymorphina hokkaidoana Kaiho, n. sp.

Pl. 8, figs. 8a-c

Description: Test free, elongate, roughly fusiform in outline, somewhat compressed, aboral end rounded, apertural end subacute; chambers comprising up to six, proloculus large, rounded, succeeding chambers ovate in transverse section, early chambers much embracing, arranged in a quinqueloculine manner, each succeeding chamber further removed from aboral end, later becoming biserial; sutures strongly oblique, depressed; wall calcareous, finely perforate, surface, smooth; aperture terminal, radiate.
Type and dimensions: Holotype, IGPS 98085, length 1.00 mm, breadth 0.42 mm, thickness 0.32 mm, sample KUM43, Poronai Formation.
Remarks: This species has less elongate, broader chambers than those of *P. allani* Hornibrook from the lower Oligocene of New Zealand. It differs from *P. tasmanica* Parr and Collins from the lower Miocene of Australia in having less overlapping chambers in early portion and a more projecting aperture.
Occurrence in study area: Ranges from the *B. schwageri-G. yokoyamai* Assemblage-zone to the *N. ezoensis-C. pacifica* Assemblage-zone.

Genus *Sigmomorphina* Cushman and Ozawa, 1928
Sigmomorphina ezoensis Kaiho, n. sp.

Pl. 8, figs. 6a-7b, 9a-d

Description: Test free, large, oval (in young) to oblong (in adult), compressed,

	holotype in figs. 9a-d	paratype in figs. 7a-b	paratype in figs. 6a-d
IGPS no.	98088	98089	98090
Sample no.	KUM 47	SNT 12	SNT12
Formation	Poronai	Poronai	Poronai
Length	1.59 mm	1.38 mm	1.85 mm
Breadth	1.11 mm	1.14 mm	1.28 mm
Thickness	0.66 mm	0.37 mm	0.72 mm

rounded at the base, periphery somewhat angulate, broadest near the middle, rounded-rhomboid in transverse section; chambers elongate, more or less inflated, arranged in a sigmoidal series, later chambers removed from aboral end; sutures distinct, flush with surface; wall calcareous, finely perforate, surface smooth; aperture terminal, radiate.

Types and dimensions: Holotype and paratypes at the top of this page.

Remarks: This species somewhat resembles *S. crassa* (Roemer) figured by Cushman and Ozawa (1930), but differs in the chamber arrangement in an aboral end view. It has a much smaller proloculus and less rounded periphery than those of *S. obesa* Hornibrook from the Lower Oligocene of New Zealand.

Occurrence in study area: Rare in the middle and upper part of the Poronai Formation and very rare in the basal part.

Suborder Rotaliina Delage and Hérouard, 1896, s. str. by Leoblich and Tappan, 1981
Superfamily Buliminacea Jones, 1875
Family Bolivinitidae Cushman, 1927
Genus *Brizalina* Costa, 1856
Brizalina saitoi Kaiho, n. sp.

Pl. 8, figs. 10a, b

Description: Test elongate, compressed, tapering to subrounded aboral end, elongate-ovate in transverse section, peripheral margin subrounded, peripheral outline not lobulate except for later portion; chambers biserially arranged throughout, up to nine pairs, increasing gradually in height, breadth and thickness, each inner end of later chambers developing a slight lobe; sutures distinct, limbate, flush with surface, earlier ones gently curved, later ones strongly oblique; wall calcareous, finely perforate, translucent, surface smooth; aperture loop-shaped, extending up from the base of final chamber.

Type and dimensions: Holotype, IGPS 98100, length 0.36 mm, breadth 0.17 mm, thickness 0.09 mm, sample PRN34, Poronai Formation.

Remarks: This species is close to *B. kleinpelli* Beck from the Eocene Cowlitz Formation in Washington, but differs in having a more stout smaller test and more rounded periphery. The tests of the present specimens are rarely twisted.

This species is named in hornor of Prof. Tsunemasa Saito of Yamagata University, Japan, in recognition of his work on Paleogene foraminifera.

Occurrence in study area: This species appears to become extinct at or near the last occurrence of *B. schwageri*. Ranges from the *B. schwageri-H. umbilicatus* Assemblage-zone to the *B. schwageri-G. yokoyamai* Assemblage-zone, but extends to the lower part of the *N. ezoensis-C. pacifica* Assemblage-zone in the Kushiro region and the *H. umbilicatus-H. subevolutus* Assemblage-zone in the Rumoi region.

Brizalina serrata Kaiho, n. sp.

Pl. 8, figs. 11a–12 b

Description: Test elongate, tapering to bluntly pointed aboral end, ovate in transverse section, peripheral margin rounded, peripheral outline of both sides distinctly serrated; chambers biserially arranged throughout, six to seven pairs, somewhat inflated, increasing rapidly in size as added, last two pairs occupying approximately two-thirds to half the length of test; sutures distinct, depressed, at angles of more than 45° with test axis; wall calcareous, finely perforate, surface smooth; aperture loop-shaped, extending up from the base of final chamber.

Types and dimensions: Holotype, figs. 11a, b, IGPS 98101, length 0.34 mm, breadth 0.20 mm, thickness 0.14 mm, sample PRN34; paratype, figs. 12a, b, IGPS 98102, length 0.37 mm, breadth 0.19 mm, thickness 0.13 mm, sample KUM47. Both from the Poronai Formation.

Remarks: This new species differs from *Bolivina euplectella* Yokoyama from the Poronai Formation in having sutures at higher angles to the test axis, serrated periphery, and more rapidly increasing chambers.

Occurrence in study area: Ranges from the *B. schwageri–H. umbilicatus* Assemblage-zone to the *N. ezoensis–C. pacifica* Assemblage-zone.

Family Uvigerinidae Haeckel, 1894

Genus *Uvigerina* d'Orbigny, 1826

Uvigerina ombetsuensis Kaiho, n. sp.

Pl. 9, figs. 1a–c

Description: Test free, large, elongate, somewhat flaring from bluntly rounded aboral end; chambers triserially arranged, somewhat inflated, increasing rather rapidly in size as added; sutures distinct, depressed, but indistinct in earliest portion; wall calcareous, finely perforate, surface ornamented with longitudinal, partially continuous costae which are highly prominent, platelike in early portion, but gradually become lower and thinner in later portion; last chamber lacks costae or has very weekly developed ones; aperture terminal, rounded to ovate, with a very short cylindrical neck within a slight depression in chamber wall.

Type and dimensions: Holotype, IGPS 98119, length 0.82 mm (ranges 0.73–1.02 mm), maximum breadth 0.44 mm (ranges 0.42–0.58 mm), maximum breadth/length ratio 0.54 (ranges 0.50–0.61 mm), sample STNa03, Charo Formation.

Remarks: This new species shows some affinities with *Uvigerina nuttalli* Cushman and Edwards, but has a shorter neck and less depressed outer wall at the base of the neck.

Occurrence in study area: Only found from the Charo Formation.

Genus *Trifarina* Cushman, 1923

Trifarina maiyai Kaiho, n. sp.

Pl. 9, figs. 2a–4b

Description: Test free, elongate, twice to three times as long as broad, triangular in transverse section, angles fairly rounded in early portion, more or less rounded in later one, sides slightly inflated in early portion, somewhat concave in later one; chambers triserially arranged, inflated, gradually increasing in size as added, later ones tending to become uniserial, crescent-shaped in side view; sutures depressed, strongly wavely curved in later portion; wall calcareous, medium perforate, surface smooth, or possessing fine costae which show double keeled edges on each angle. Aperture terminal, roughly ovate on very short neck with thin rim.

Types and dimensions: Holotype, figs. 2a, b, IGPS 98120, length 0.33 mm, maximum breadth 0.16 mm, sample PRN51, Poronai Formation. Paratype,

figs. 4a, b, IGPS 98121, length 0.50 mm, maximum breadth 0.20 mm, sample UTN04, Utsunai Formation. Paratype, figs. 3a, b, IGPS 98122, length 0.31 mm, maximum breadth 0.17 mm, sample KUM45, Poronai Formation.

Remarks: This new species differs from *T. advena* Cushman var. *californica* Mallory in having more rounded peripheral angles, especially in early portion. It is named after Dr. Seijuro Maiya of Technical Laboratory, Japan Petroleum Exploration Company, in recognition of his work on the Paleogene foraminifera in Hokkaido, Japan.

Occcurrence in study area: Ranges from the *H. umbilicatus-H. subevolutus* Assemblage-zone to the *B. schwageri-G. yokoyamai* Assemblage-zone.

Superfamily Discorbacea Ehrenberg, 1838

Family Discorbidae Ehrenberg, 1838

Subfamily Discorbinae Ehrenberg, 1838

Genus *Epistominella* Husezima and Maruhasi, 1944

Epistominella exigua multiloculata Kaiho, n. subsp.

Pl. 9, figs. 5a-c

Description: Test free, low trochospiral, biconvex, peripheral margin acute, peripheral outline very slightly lobulate, composed of three whorls; chambers five to seven, usually seven in each whorl, increasing gradually in size as added; sutures oblique, straight on spiral side, nearly radial, straight or slightly curved on umbilical side; wall calcareous, rather coarsely perforate, surface smooth; aperture an elongate vertical slit in face, near and parallel to peripheral keel.

Type and dimensions: Holotype, IGPS 98124, maximum diameter 0.16 mm, thickness 0.08 mm, sample UTN04, Utsunai Formation.

Remarks: This new subspecies differs from typical *E. exigua* (Brady) in having a tendency to have more chambers and in being much smaller (maximum diameter of the holotype of *E. exigua* 0.4 mm). This subspecies exhibits a great deal of variability in its convexity: Some are more convex on umbilical side, others are more covex on spiral side and some others have almost the same convexity on both sides.

Occurrence in study area: Ranges from the *B. schwageri-H. umbilicatus* Assemblage-zone to the *N. ezoensis-C. pacifica* Assemblage-zone.

Family Eponididae Hofker, 1951

Genus *Eponides* de Montfort, 1808

Eponides lobatus Kaiho, n. sp.

Pl. 9, figs. 6a-c

Description: Test free, small, trochospiral, biconvex, spiral side more convex than umbilical side, thickness approximately half the length of maximum diameter, peripheral margin acute, peripheral outline somewhat lobulate in later portion, composed of two and half to three whorls; chambers six to seven in a whorl, increasing slowly in size as added; sutures straight to somewhat curved on spiral side, radial, straight, slightly depressed, radiating out of flat small umbilical region on umbilical side; wall calcareous, finely perforate, surface smooth; aperture an interiomarginal, low opening on umbilical side.

Type and dimensions: Holotype, IGPS 98128, maximum diameter 0.34 mm, minimum diameter 0.32 mm, maximum thickness 0.18 mm, sample KUM35, Poronai Formation.

Remarks: This species differs from *E. nagasakiensis* Asano and Murata from the Upper Eocene Okinoshima Formation in northern Kyushu, in having smaller numbers of both whorls and chambers per whorl and smaller test.

Occurrence in study area: Ranges from the *H. subevolutus-C. pacifica* Assemblage-zone to the *B. schwageri-G. yoko-*

yokoyamai Assemblage-zone.

Family Cibicididae Cushman, 1927
Subfamily Cibicidinae Cushman, 1927
Genus *Cibicides* de Montfort, 1808
Cibicides biconvexus Kaiho, n. sp.

Pl. 9, figs. 7a–c

Description: Test trochospiral, biconvex, spiral side slightly convex, umbilical side fairly convex with central umbo composed of clear shell material, not raised, peripheral margin subacute, with keel; chambers usually eight to nine, rarely ten in final whorl, increasing gradually in size as added; sutures very distinct, limbate, curved, flush with surface on both sides; wall calcareous, coarsely perforate, surface smooth; aperture an interiomarginal arch extending from periphery to both sides.
Type and dimensions: Holotype, IGPS 98130, maximum diameter 0.37 mm, minimum diameter 0.31 mm, maximum thickness 0.16 mm, sample KUM44, Poronai Formation.
Remarks: This species is distinguished from *Cibicides pippeni* Cushman and Garrett var. *stavensis* Bandy from the Middle Eocene Tallahatta Formation of Alabama in having a less convex spiral side, larger numbers of chambers, more oblique sutures on the spiral side, and lacking a large coalescing thickened area on the spiral side.
Occurrence in study area: Only known from the Poronai (upper part) and Momijiyama (lower part) Formations.

Cibicides complanatus Kaiho, n. sp.

Pl. 9, figs. 8a–c

Description: Test small, plano-convex, spiral side flattened, partially evolute, composed of about two whorls, umbilical side convex and nearly flattened over umbilical region, peripheral margin bluntly angled, somewhat keeled; chambers eight or nine in final whorl, increasing gradually in size as added, slightly inflated in later portion of spiral side; sutures gently curved, flush with surface in early portion, somewhat depressed in later one on both sides; wall calcareous, comparatively finely perforate, surface smooth; aperture an interiomarginal low arch with thin lip, extending nearly one half distance to umbilicus on umbilical side and extending across periphery along spiral suture of last chamber on spiral side.
Type and dimensions: Holotype, IGPS 98131, maximum diameter 0.29 mm, minimum diameter 0.24 mm, maximum thickness 0.12 mm, sample UTN02, Utsunai Formation.
Remarks: This species somewhat resembles *C. glabratus* Hussey from the Eocene Cane River Formation in Louisiana, but is distinguished by the absence of knobs in the umbilical portion and less oblique sutures. It has more gradually increasing chambers in size as added than *C. dutemplei* (d'Orbigny) var. *oligocenicus* Samoilova from the lower Oligocene of Crimea, U.S.S.R. The perforation is not visible for most of the specimens owing to a poor state of preservation.
Occurrence in study area: Basal part of the Utsunai Formation.

Superfamily Rotaliacea Ehrenberg, 1839
Family Elphidiidae Galloway, 1933
Subfamily Elphidiinae Galloway, 1933
Genus *Elphidium* de Montfort, 1808
Elphidium asanoi Kaiho, n. sp.

Pl. 10, figs. 1a, b

Description: Test free, of medium size, robust, planispirally coiled and involute, slightly asymmetrical in lateral view, sides almost flat, with slightly depressed umbilical regions, peripheral margin broadly rounded, peripheral outline very slightly lobulate; chambers 11 to 13 in final whorl, slightly inflated, increasing very gradually in size as added; sutures

gently curved, distinct, depressed, especially near umbilicus; retral processes very short, usually indistinct; wall calcareous, finely perforate, surface smooth, umbilical area filled with secondary shell material; aperture interiomarginal, equatorial openings.

Type and dimensions: Holotype, IGPS 98157, maximum diameter 0.60 mm, minimum diameter 0.55 mm, thickness 0.30 mm, sample PNK-7-852, Wakkanabe Formation.

Remarks: This species resembles *Polystomella texana* Cushman and Applin from the Upper Eocene Jackson Formation of Texas, but differs in having less curved sutures and nearly parallel lateral sides. The species possesses larger numbers of chambers and a more compressed test than *E. sorachiense* Asano.

This species is named in honor of Dr. Kiyoshi Asano, Professor Emeritus of Tohoku University, in recognition of his work on Paleogene foraminifera in Japan.

Occurrence in study area: Only from the Wakkanabe Formation.

Elphidium ishikariense Kaiho, n. sp.

Pl. 10, figs. 2a, b

Description: Test, free, of medium size, planispiral and involute, compressed, sides almost flat, with slightly depressed umbilical region, peripheral margin subrounded, peripheral outline slightly lobulate; chambers 12 to 14, rarely 17 in final whorl, slightly inflated, apertural face higher than breadth; sutures distinct, depressed, curved; retral processes only slightly developed; wall calcareous, finely perforate, surface smooth, umbilical area occupied by a large flat boss which often bears a granular ornamentation; aperture interiomarginal, equatorial openings.

Type and dimensions: Holotype, IGPS 98158, maximum diameter 0.62 mm, minimum diameter 0.50 mm, thickness 0.23 mm, sample TNZ08, Akabira Formation.

Remarks: This species resembles *E. simplex* Cushman from off Nairai, Fiji Islands, South Pacific Ocean, but differs in having greater numbers of chambers and less curved sutures. *E. ishikariense* has a more compressed test with more angular periphery than *E. asanoi*.

Occurrence in study area: The most dominant species in the Akabira and Hiragishi Formations.

Superfamily Cassidulinacea d'Orbigny, 1839

Family Caucasinidae N.K. Bykova, 1959

Subfamily Fursenkoininae Loeblich and Tappan, 1961

Genus *Fursenkoina* Loeblich and Tappan, 1961

Fursenkoina uchioi Kaiho, n. sp.

Pl. 10, figs. 3a, b

Description: Test free, elongate, slender, tapering gradually toward subrounded aboral end, twisted-biserial in early portion, later typically biserial, ovate in transverse section; chambers elongate, about four pairs, increasing rapidly in size as added, the base of final chamber attains approximately half the length of test; sutures depressed, oblique to test axis; wall calcareous, finely perforate, surface smooth; aperture an elongate loop-shaped opening extending up to the face of final chamber.

Type and dimensions: Holotype; IGPS 98162, length 0.66 mm, maximum breadth 0.21 mm, sample KUM12, Poronai Formation.

Remarks: This species is close to *Virgulina schreibersiana* Czjžek from Austrian Tertiary, but differs in having a larger last chamber.

The specific name is given in honor of Professor Takayasu Uchio of the University of Tokyo in recognition of his work on Paleogene foraminifera of Hokkaido.

Occurrence in study area: Ranges from the *E. ishikariense-B. yabei* Assemblage-zone to the *N. ezoensis-C. pacifica* Assemblage-zone.

Family Cassidulinidae d'Orbigny, 1839
Genus *Cassidulina* d'Orbigny, 1826
Cassidulina lobatula Kaiho, n. sp.

Pl. 10, figs. 4a–5c

Description: Test free, compressed, biconvex, biumbonate, peripheral margin subrounded to subacute, peripheral outline slightly to fairly lobulate, periphery slightly sinuous in peripheral view; chambers enrolled-biserially arranged, elongate, five pairs in final whorl; last two pairs of chambers somewhat tapering toward periphery as seen in equatorial views; sutures curved, slightly depressed, limbate; wall calcareous, finely perforate, surface smooth; aperture, a narrow, elongate, straight slit, nearly parallel to the periphery.
Type and dimensions: Holotype, figs. 5a–c, IGPS 98163, maximum diameter 0.46 mm, minimum diameter 0.38 mm, thickness 0.20 mm; paratype, figs. 4a–c, IGPS 98164, maximum diameter 0.41 mm, minimum diameter 0.34 mm, thickness 0.20 mm. Both from sample KUM07, Poronai Formation.
Remarks: This species resembles *C. excavata* Voloshinova from the upper Miocene of Sakhalin Island, but differs in having the last two pairs of which height tapers toward the periphery as seen in equatorial view, less acute periphery and possessing no apertural tooth. The height of the last two pairs of chambers of *C. excavata* tapers toward the umbilical region. The holotype specimen has a more lobulate periphery than most of the specimens.
Occurrence in study area: Only found from the middle and upper part of the Poronai Formation.

Cassidulina yubariensis Kaiho, n. sp.

Pl. 10, figs. 6a–7c

Description: Test free, subcircular in outline, biconvex, peripheral margin subrounded; chambers enrolled-biserially arranged, portion of chambers of earlier whorls visible through very small, semi-transparent umbilical region, four to five pairs, usually five, in final whole; sutures flush with surface in early portion, slightly depressed in later portion; wall calcareous, finely perforate, surface smooth; aperture, an elongate, narrow slit, nearly parallel to peripheral margin.
Type and dimensions: Holotype, figs. 6a–c, IGPS 98165, maximum diameter 0.30 mm, minimum diameter 0.26 mm, thickness 0.18 mm; paratype, figs. 7a–c, IGPS 98166, maximum diameter 0.27 mm, minimum diameter 0.22 mm, thickness 0.16 mm. Both from sample SRR12, Poronai Formation.
Remarks: This species resembles *Cassidulina usitata* Ivanova from the Oligocene Nizhnevorotyshche Formation of Ukrainian S.S.R., but differs in having a more ovate test with subangular periphery throughout instead of the latter species which develops rounded periphery with growth.
Occurrence in study area: It occurs mainly in the middle and upper parts, rarely in the lower part, of the Poronai, Shimokine and Omagari Formations.

Superfamily Nonionacea Schultze, 1854
(nom. transl. Subbotina, 1959, ex subfamily)
Family Nonionidae Schultze, 1854
Subfamily Nonioninae Schultze, 1854
Genus *Nonion* de Montfort, 1808
Nonion angulatus Kaiho, n. sp.

Pl. 11, figs. 1a, b

Description: Test free, small, planispiral, involute, compressed, peripheral margin acute, peripheral outline not lobulate or slightly lobulate in earlier

portion, lobulate in later one, with large umbilicus which is slightly depressed but filled with granular shell material; chambers nine to ten in final whorl, increasing rather rapidly in size as added, slightly inflated; sutures curved, flush with surface in earlier portion, slightly depressed in later one; wall calcareous, finely perforate, surface smooth except umbilical region; aperture, an interiomarginal equatorial arch.
Type and dimensions: Holotype, IGPS 98170, maximum diameter 0.28 mm, minimum diameter 0.22 mm, thickness 0.11 mm, sample STNa15, Nuibetsu Formation.
Remarks: This species differs from *Nonion ibericum* Cushman from Pleistocene of Malaga, Spain in having more angular periphery and non-limbate sutures.
Occurrence in study area: Common in the upper part of the Nuibetsu Formation.

Nonion ezoensis Kaiho, n. sp.

Pl. 11, figs. 2a, b

Description: Test free, medium in size, ovate to auriculate in outline, planispiral, involute and almost bilaterally symmetrical, biumbilicate, flaring, peripheral margin rounded; chambers eight to nine in final whorl, inflated, low, increasing rapidly in breadth and thickness, apertural face large, inflated, higher than breadth; sutures curved, narrow, depressed, deepened toward umbilicus; wall calcareous, finely perforate, surface smooth; aperture, an interiomarginal equatorial arch.
Type and dimensions: Holotype, IGPS 98171, length 0.48 mm, width 0.32 mm, thickness 0.26 mm, sample PKP03, Poronai Formation.
Remarks: This new species resembles *Nonion alabamensis* Cushman and Todd from the Oligocene Byram Marl of Hinds County, Mississippi, but is distinct in having a more rounded periphery, fewer chambers and the less protruding inner end of the final chamber into the central depression. The present species also differs from *Nonion acutidorsatus* ten Dam from the Eocene of the Netherlands in having a larger test with more rounded periphery and the less protruding inner end of the final chamber into the central depression.
Occurrence in study area: Ranges from the *B. schwageri-H. umbilicatus* Assemblage-zone to the *N. ezoensis-C. pacifica* Assemblage-zone.

Nonion takayanagii Kaiho, n. sp.

Pl. 11, figs. 3a, b

Description: Test free, small, roughly ovate in outline, planispiral, involute and bilaterally symmetrical, slightly biumbonate, peripheral margin subacute; chambers low, 10 to 12 in final whorl, increasing rather rapidly in breadth, but gradually in thickness and height as added; sutures limbate, flush with surface, strongly curved; wall calcareous, finely perforate, surface smooth, except in umbilical regions covered with finely granular ornamentation; aperture interiomarginal, an arched equatorial, slit.
Type and dimensions: Holotype, IGPS 98172, maximum diameter 0.29 mm, minimum diameter 0.23 mm, thickness 0.14 mm, sample SSB03, Shimokine Formation.
Remarks: The present new species is characterized by its somewhat flaring test with a subacute periphery, strongly curved sutures and finely granular ornamentation in umbilical region. The present species can be distinguished from *Nonion belridgensis* Barbat and Johnson from the Upper Miocene of Kern County, California, in having a smaller test with more gradually increasing chambers in breadth.

The specific name is given in honor of

Prof. Yokichi Takayanagi of Tohoku University, Japan, in recognition of his work on foraminifera.
Occurrence in study area: Only from the Shimokine Formation.

Family Anomalinidae Cushman, 1927
Subfamily Anomalininae Cushman, 1927
Genus *Anomalinoides* Brotzen, 1942
Anomalinoides sasai Kaiho, n. sp.

Pl. 11, figs. 4a–c

Description: Test free, small, trochospiral, spiral side nearly flattened with two to two and half whorls visible, final whorl somewhat overlapping the inner whorl, umbilical side convex, periphery broadly rounded; chambers usually nine rarely 10 in final whorl, increasing gradually in size as added; sutures distinct, limbate, gently curved, flush with surface in earlier portion, slightly depressed in later portion on both sides; wall calcareous, coarsely perforate, surface smooth; aperture interiomarignal, a low slit, margined by a prominent lip extending from umbilicus onto spiral side.
Type: Hypotype, IGPS 98179, sample KUM32, Poronai Formation.
Remarks: This species resembles *Anomalina alazanensis* Nuttall from the lower Oligocene Alazan Shale of Mexico, but differs in having a comparatively thicker test with more chambers, closed umbilicus and not raised sutures. The present species has a more evolute test with more rounded periphery and less curved sutures than *Anomalinoides* sp. A from the Utsunai Formation of the Nakatombetsu area.

This species is named in honor of Dr. Yasuo Sasa, Professor Emeritus of Hokkaido University, in recognition of his work on the Paleogene stratigraphy of Hokkaido, Japan.
Occurrence in study area: Ranges from the *H. umbilicatus–H. subevolutus* Assemblage-zone to the *B. schwageri–G. yokoyamai* Assemblage-zone.

Genus *Heterolepa* Franzenau, 1884
Heterolepa poronaiensis Kaiho, n. sp.

Pl. 11, figs. 5a–c, 7a–c

Description: Test free, large, trochospiral, unequally biconvex, spiral side somewhat convex with three whorls visible, umbilical side strongly convex with small umbo flushed with surface, periphery subacute, keeled; chambers seven in penultimate whorl and nine in final whorl, increasing slowly in size as added; sutures distinct, limbate, flush with surface on both sides, oblique on spiral side, curved on umbilical side; wall calcareous, coarsely perforate, on both sides between sutures, surface smooth; aperture slit-like, interiomarginal, extending approximately half the distance to umbilicus on umbilical side, and extending for a little distance across periphery along spiral suture.
Type and dimensions: Holotype, figs. 5a–c, IGPS 98181, maximum diameter 1.08 mm, minimum diameter 0.92 mm, thickness 0.54 mm; paratype, figs. 7a–c, IGPS 98182, maximum diameter 0.76 mm, minimum diameter 0.62 mm, thickness 0.38 mm. Both from sample PRN01, Poronai Formation (basal part).
Remarks: This new species can be distinguished from *Cibicides perlucida* Nuttall from the Oligocene Alazan Shale of Vera Cruz, Mexico, in having non-lobulate peripheral margin, nearly straight sutures on the spiral side and thinner keel. It differs from *Cibicides floridanus* (Cushman) var. *suturatus* Ascoli from the Tortonian of Italy in having a smaller test and not depressed sutures.
Occurrence in study area: Only from the *H. tanaii–H. subevolutus* Assemblage-zone.

Genus *Melonis* de Montfort, 1808

Melonis crassus Kaiho, n. sp.

Pl. 11, figs. 6a, b

Description: Test free, of medium size, planispiral, involute, biumbilicate, with large, excavated umbilicus surrounded by non-perforate thickened rim, peripheral outline roughly elliptical, generally not lobulate, but becoming lobulate in later portion in exceptionally large specimen, peripheral margin rounded; final whorl, rather rapidly increasing in breadth, but slowly increasing in thickness and height as added; sutures distinct, limbate, flush with surface, radial, somewhat curved; wall calcareous, coarsely perforate, surface smooth; aperture interiomarginal, an elongate equatorial low arch bordered by thin lip, which extends laterally to umbilicus on both sides of test.

Type and dimensions: Holotype, IGPS 98183, maximum diameter 0.57 mm (range 0.52–0.69 mm), minimum diameter 0.48 mm, thickness 0.28 mm, sample SSB02, Shimokine Formation. Ratio of minimum diameter to maximum diameter 0.77–0.84.

Remarks: This new species resembles *Nonion erucopsis* Todd from the upper Miocene or lower Pliocene of Alaska, which has an elliptical peripheral outline of the new species, but differs in having a thinner test with fewer chambers and broader umbilical rims. It is also distinct from *Nonion omagariense* Asano described from the Omagari Formation of east Hokkaido in having non-inflated chambers which increase more gradually in thickness as added.

Occurrence in study area: Ranges from the *E. ishikariense–B. yabei* Assemblage-zone to the *H. umbilicatus–H. subevolutus* Assemblage-zone.

Melonis elegans Kaiho, n. sp.

Pl. 11, figs. 9a, b

Description: Test free, small, planispiral, involute, biumbilicate, with nonperforate thickened rim surrounding small umbilicus, peripheral outline not lobulate in early portion, usually slightly lobulate in later portion, peripheral margin rounded; chambers eight to ten, usually nine in final whorl, increasing rather rapidly in breadth and height as added, but gradually in thickness; sutures distinct, limbate, curved flush with surface in earlier portion, slightly depressed in later one; wall calcareous, coarsely perforate, surface smooth; aperture interiomarginal, an elongate, equatorial, low slit, bordered by a very thin apertural lip extending laterally to umbilicus on both sides of test.

Type and dimensions: Holotype, IGPS 98184, maximum diameter 0.29 mm, minimum diameter 0.25 mm, thickness 0.15 mm, sample PKP03, Poronai Formation.

Remarks: This new species bears some affinity with *Nonion planatum* Cushman and Thomas from the Eocene of Texas, but has more elliptical peripheral outline and broader sutures. The present species also resembles *Nonion agdarensis* Chalilov and *Nonion insolitus* Chalilov described from the upper Eocene of Azerbaidzhan, but differs in having more elliptical peripheral outline. It is further distinguished from *N. agdarensis* by having fewer chambers and by the less depressed sutures of *N. insolitus*. It is distinguishable from *Melonis crassus* Kaiho, n. sp. in having a more delicate smaller test with more curved sutures, indistinct apertural flap and narrower umbilical rim. The present species exhibits variability in the size of umbilici.

Occurrence in study area: Ranges from the *H. subevolutus–C. pacifica* Assemblage-zone to the *B. schwageri–G. yokoyamai* Assemblage-zone.

Melonis lobatus Kaiho, n. sp.

Pl. 11, figs. 10a, b

Description: Test free, small, planispiral, involute, biumbilicate, about one half as thick as maximum diameter, sides nearly parallel, peripheral margin rounded, peripheral outline somewhat lobulate in later portion; chambers nine to ten in final whorl, increasing regularly in size as added; umbilicus large, excavated, surrounded by a non-perforate thickened rim; sutures distinct, limbate, curved flush with surface in earlier portion, slightly depressed in later portion; wall calcareous, somewhat coarsely perforate, surface smooth; aperture interiomarginal, an equatorial arch, bordered by fairly thick lip, extending laterally to umbilicus on both sides of test.

Type and dimensions: Holotype, IGPS 98185, maximum diameter 0.36 mm, minimum diameter 0.31 mm, thickness 0.16 mm, sample KUM23, Poronai Formation.

Remarks: This species is distinguishable from *Melonis crassus* Kaiho, n.sp., in having a smaller test with somewhat lobulate periphery, more curved sutures, more protruding apertural lip and narrower umbilical rim.

Occurrence in study area: Rare in the upper part of the Poronai Formation.

Melonis subevolutus Kaiho, n. sp.

Pl. 11, figs. 8a, b

Description: Test free, of medium size, ovate in outline, planispiral, nearly involute, inner whorl partially visible being strongly overlapped by final whorl, biumbilicate, with umbilicus surrounded by none-perforate thickened rim, approximately one half as thick as maximum diameter; chambers nine to ten final whorl, increasing gradually in size as added, periphery rounded; sutures distinct, broadly limbate, slightly depressed, curved; wall calcareous, coarsely perforate, surface smooth; aperture interiomarginal, an elongate equatorial slit bordered by a narrow lip extending laterally to umbilicus on both sides of test.

Type and dimensions: Holotype, IGPS 98188, maximum diameter 0.67 mm, minimum diameter 0.58 mm, thickness 0.32 mm, thickness of the earliest portion of the final whorl 0.17 mm, sample PRN01, Poronai Formation (basal part).

Remarks: This species differs from *Melonis crassus* Kaiho, n.sp., in having a slightly evolute test with chambers which increase more rapidly in thickness as added. The apertural face is comparatively small compared with the other species of *Melonis* from the studied areas.

Occurrence in study area: Several specimens from the Poronai (basal part), Shimokine and Charo Formations.

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Plate 7

Fig. 1. *Reophax minutirectus* Kaiho, n. sp.
IGPS 98010 (holotype), sample PRN24, Poronai Formation. ×93.

Figs. 2a, b. *Reophax multicameratus* Kaiho, n. sp.
IGPS 98011 (holotype), sample SRO09, Poronai Formation. ×16.

Figs. 3a, b. *Haplophragmoides crassiformis* Kaiho, n. sp.
IGPS 98015 (holotype), sample SRR11, Poronai Formation. ×31.

Figs. 4a, b. *Haplophragmoides yokoyamai* Kaiho, n. sp.
IGPS 98020 (holotype), sample KUM39, Poronai Formation. ×48.

Figs. 5a, b. *Haplophragmoides tanaii* Kaiho, n. sp.
IGPS 98018 (holotype), sample PRN02, Poronai Formation. ×34.

Figs. 6a, b. *Haplophragmoides umbilicatus* Kaiho, n. sp.
IGPS 98019 (holotype), sample PRN08, Poronai Formation. ×34.

Figs. 7a, b *Haplophragmoides subevolutus* Kaiho, n. sp.
IGPS 98017 (holotype), sample PRN02, Poronai Formation. ×29.

Figs. 8a–c. *Eggerella takayanagii* Kaiho, n. sp.
IGPS 98036 (holotype), sample UTN09, Utsunai Formation. ×63.

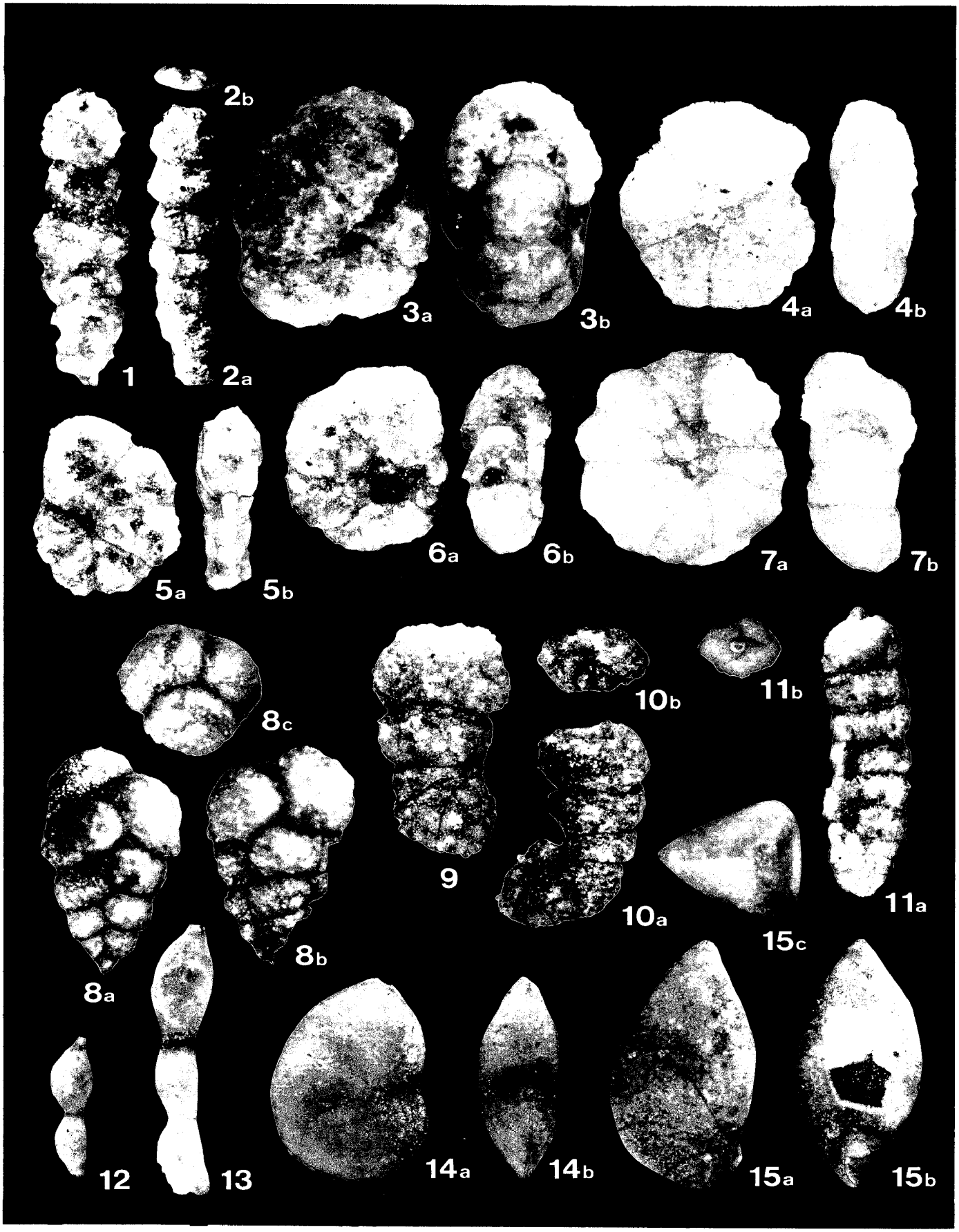
Figs. 9–10b. *Martinottiella crassa* Kaiho, n. sp.
9, IGPS 98041 (paratype), sample SNT01. 10a, b, IGPS 98040 (holotype), sample TUR04. Both from the Poronai Formation. ×29.

Figs. 11a, b. *Martinottiella rectidelicata* Kaiho, n. sp.
IGPS 98042 (holotype), sample PKP03, Poronai Formation. ×54.

Figs. 12, 13. *Dentalina minuta* Kaiho, n. sp.
12, IGPS 98053 (paratype). 13, IGPS 98052 (holotype). Both from sample KUM14, Poronai Formation. ×46.

Figs. 14a, b. *Lenticulina ishikariensis* Kaiho, n. sp.
IGPS 98064 (holotype), sample SKS07, Poronai Formation. ×62.

Figs. 15a–c. *Saracenaria ujiiei* Kaiho, n. sp.
IGPS 98070 (holotype), sample KUM13, Poronai Formation. ×46.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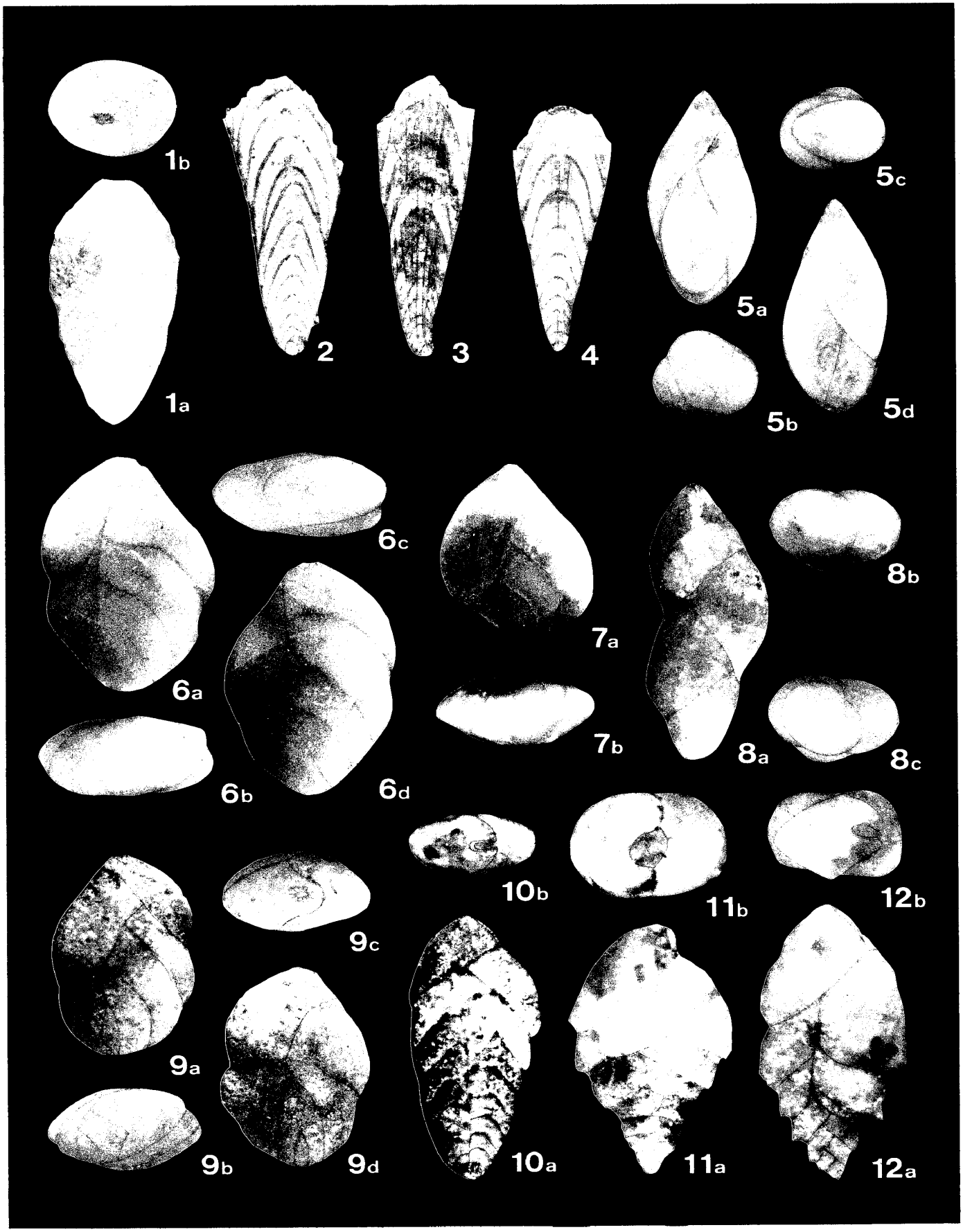
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Plate 8

Figs. 1a, b. *Pseudonodosaria shitakaraensis* Kaiho, n. sp.
IGPS 98069 (holotype), sample NIB14, Shitakara Formation. ×31.

Fig. 2. *Plectofrondicularia delicatula* Kaiho, n. sp.
IGPS 98072 (holotype), sample SKS06, Poronai Formation. ×70.

Figs. 3, 4. *Plectofrondicularia smithi* Kaiho, new name
3, IGPS 98076. 4, IGPS 98077. Both from sample SRO10, Poronai Formation. ×31.

Figs. 5a–d. *Guttulina takayanagii* Kaiho, n. sp.
IGPS 98083 (holotype), sample SNT08, Poronai Formation. ×64.

Figs. 6a–7b, 9a–d. *Sigmomorphina ezoensis* Kaiho, n. sp.
6a–d, IGPS 98090 (paratype). 7a, b, IGPS 98089 (paratype). Both from sample SNT12, Poronai Formation.
9a–d, IGPS 98088 (holotype), sample KUM47, Poronai Formation. All ×23.

Figs. 8a–c. *Pseudopolymorphina hokkaidoana* Kaiho, n. sp.
IGPS 98085 (holotype), sample KUM43, Poronai Formation. ×48.

Figs. 10a, b. *Brizalina saitoi* Kaiho, n. sp.
IGPS 98100 (holotype), sample PRN34, Poronai Formation. ×98.

Figs. 11a–12b. *Brizalina serrata* Kaiho, n. sp.
11a, b, IGPS 98101 (holotype), sample PRN34. 12a, b, IGPS 98102 (paratype), sample KUM47. Both from the Poronai Formation. ×100, 105.

Plate 9

Figs. 1a–c. *Uvigerina ombetsuensis* Kaiho, n. sp.
IGPS 98119 (holotype), sample STNa03, Charo Formation. ×42.

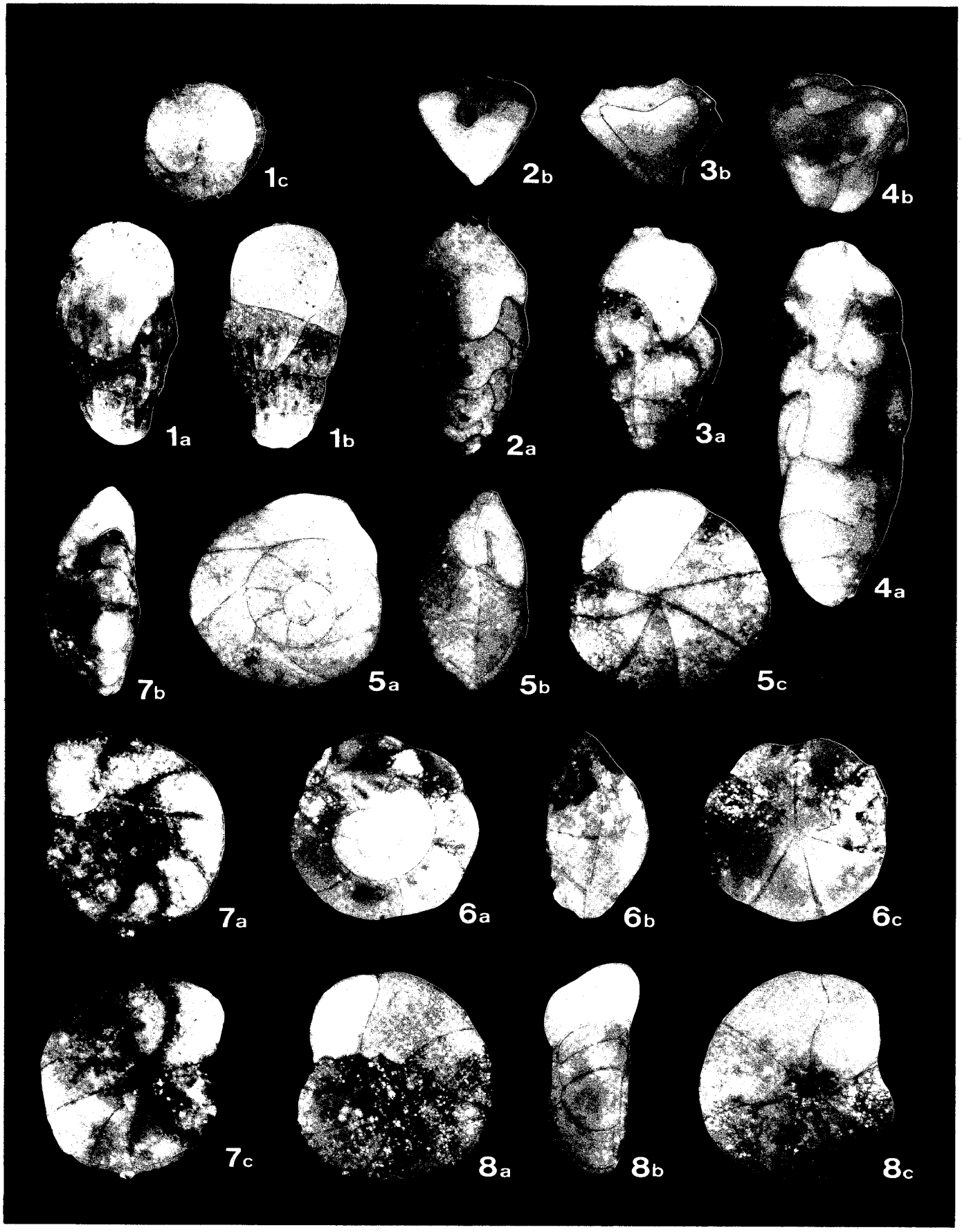
Figs. 2a–4b. *Trifarina maiyai* Kaiho, n. sp.
2a, b, IGPS 98120 (holotype), sample PRN51. 3a, b, IGPS 98112 (paratype), sample KUM45. Both from the Poronai Formation. 4a, b, IGPS 98121 (paratype), sample UTN04, Utsunai Formation. All ×111.

Figs. 5a–c. *Epistominella exigua multiloculata* Kaiho, n. subsp.
IGPS 98124 (holotype), sample UTN04, Utsunai Formation. ×214.

Figs. 6a–c. *Eponides lobatus* Kaiho, n. sp.
IGPS 98128 (holotype), sample KUM35, Poronai Formation. ×96.

Figs. 7a–c. *Cibicides biconvexus* Kaiho, n. sp.
IGPS 98130 (holotype), sample KUM44, Poronai Formation. ×96.

Figs. 8a–c. *Cibicides complanatus* Kaiho, n. sp.
IGPS 98131 (holotype), sample UTN02, Utsunai Formation. ×126.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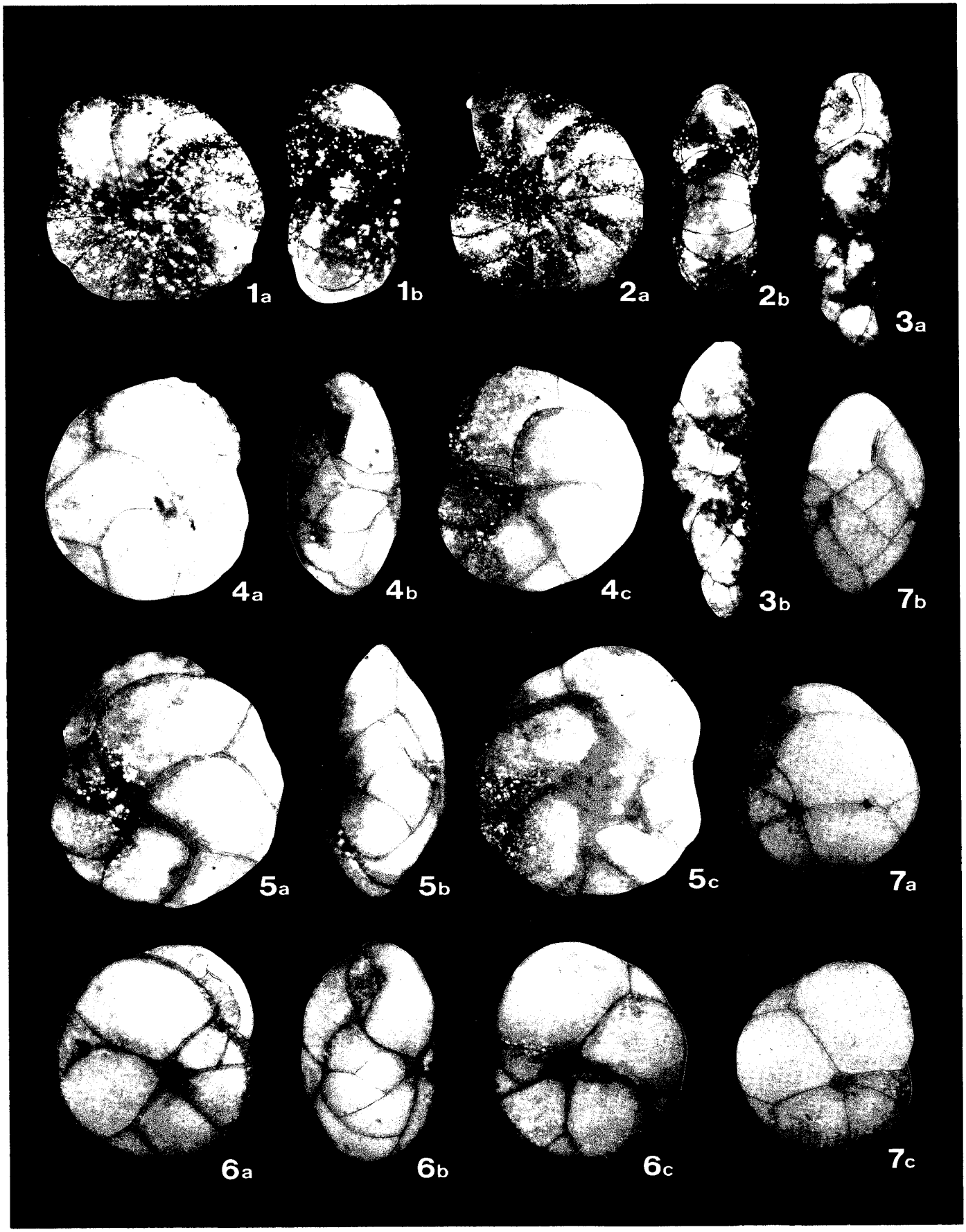
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Plate 10

Figs. 1a, b. *Elphidium asanoi* Kaiho, n. sp.
IGPS 98157 (holotype), sample PNK-7-852, Wakkanabe Formation. ×62.

Figs. 2a, b. *Elphidium ishikariense* Kaiho, n. sp.
IGPS 98158 (holotype), sample TNZ08, Akabira Formation. ×62.

Figs. 3a, b. *Fursenkoina uchioi* Kaiho, n. sp.
IGPS 98162 (holotype), sample KUM12, Poronai Formation. ×70.

Figs. 4a–5c. *Cassidulina lobatula* Kaiho, n. sp.
4a–c, IGPS 98164 (paratype). 5a–c, IGPS 98163 (holotype). Both from sample KUM07, Poronai Formation. ×93.

Figs. 6a–7c. *Cassidulina yubariensis* Kaiho, n. sp.
6, IGPS 98165 (holotype). 7, IGPS 98166 (paratype). Both from sample SRR12, Poronai Formation. ×126.

Plate 11

Figs. 1a, b. *Nonion angulatus* Kaiho, n. sp.
IGPS 98170 (holotype), sample STNa15, Nuibetsu Formation. ×126.

Figs. 2a, b. *Nonion ezoensis* Kaiho, n. sp.
IGPS 98171 (holotype), sample PKP03, Poronai Formation. ×70.

Figs. 3a, b. *Nonion takayanagii* Kaiho, n. sp.
IGPS 98172 (holotype), sample SSB03, Shimokine Formation. ×126.

Figs. 4a–c. *Anomalinoides sasai* Kaiho, n. sp.
IGPS 98179 (holotype), sample KUM32, Poronai Formation. ×125.

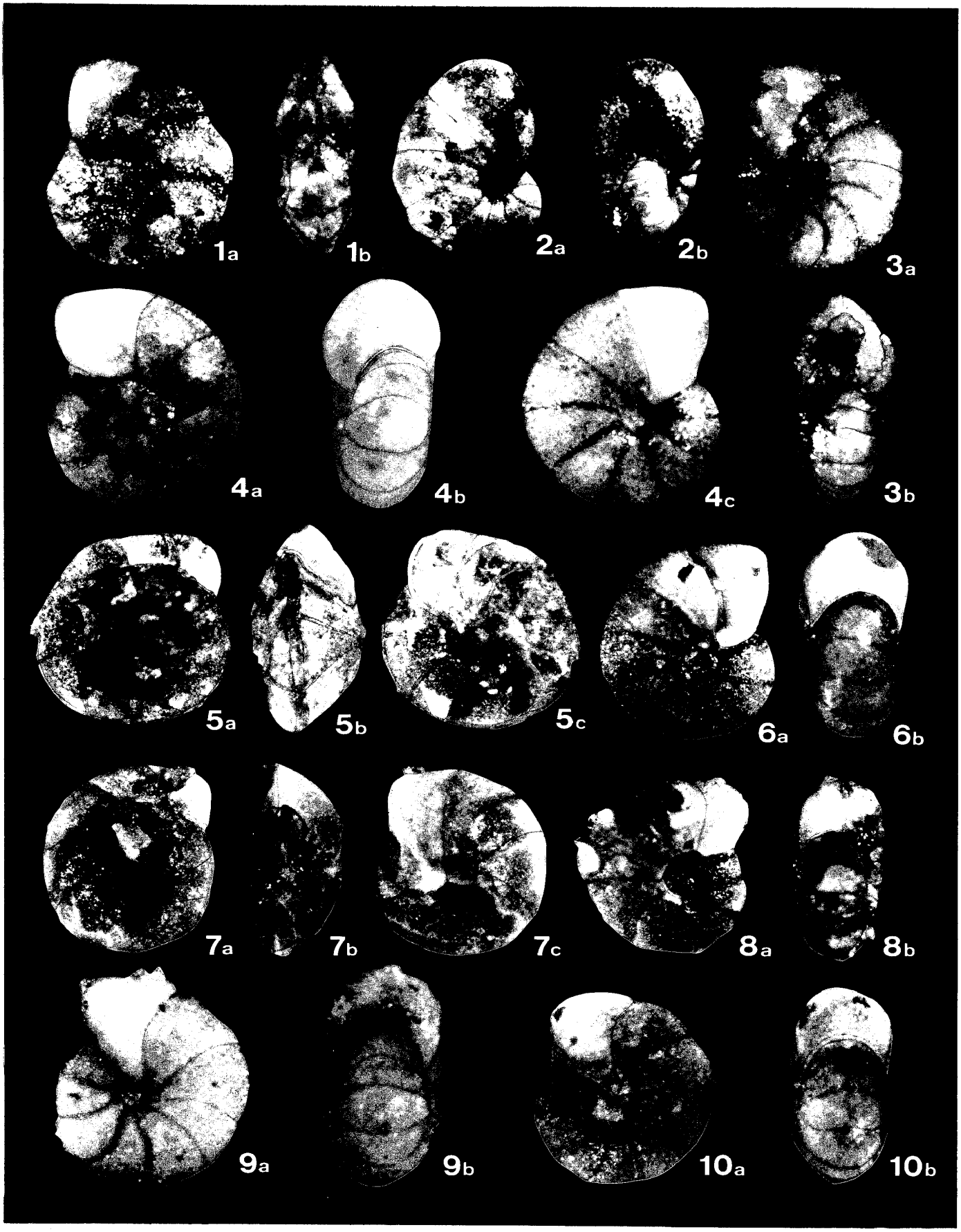
Figs. 5a–c, 7a–c. *Heterolepa poronaiensis* Kaiho, n. sp.
5a–c, IGPS 98181 (holotype). 7a–c, IGPS 98182 (paratype). Both from sample PRN01, Poronai Formation. Figs. 5a–c, ×34, Figs. 7a–c, ×48.

Figs. 6a, b. *Melonis crassus* Kaiho, n. sp.
IGPS 98183 (holotype), sample SSB02, Shimokine Formation. ×64.

Figs. 8a, b. *Melonis subevolutus* Kaiho, n. sp. IGPS 98188 (holotype), sample PRN01, Poronai Formation. ×48.

Figs. 9a, b. *Melonis elegans* Kaiho, n. sp.
IGPS 98184 (holotype), sample PKP03, Poronai Formation. ×133.

Figs. 10a, b. *Melonis lobatus* Kaiho, n. sp.
IGPS 98185 (holotype), sample KUM23, Poronai Formation. ×96.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