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582. FORAMINIFERA FROM THE HAYAMA GROUP, MIURA PENINSULA*

KENJI KURIHARA

Institute of Geology and Mineralogy, Tokyo University of Education

三浦半島,葉山層群の有孔虫化石: 神奈川県,三浦半島の中央部に発達する葉山層群の 15 地点から,約 90 種の有孔虫化石を採集した。葉山層群の有孔虫フォーナは、おもに,砂質 種が卓越する底棲種からなり,日本の中・下部中新統に特徴的な種を含む,bathyal water の環境を示す,3 つの底棲有孔虫群集が認められる。浮遊性有孔虫は、産出が限られるが、下 部中新統の特徴種である Catapsydrax dissimilis や Globigerinatella insueta を含む群集 が認められる。底棲および浮遊性有孔虫から、葉山層群の対比を検討し、少くとも同層群最 下部の森戸層が下部中新統であることを示した。また、房総半島に分布する保田層群中に、 葉山層群の底棲有孔虫群集に類似する群集が存在することにふれるとともに、1 新種を記載し た。 栗 原 謙 二

Introduction

The Hayama group is distributed in the central part of the Miura Peninsula, Kanagawa Prefecture, within the zonal area extending from Yokosuka on the Tokyo Bay side to Hayama on the Sagami Bay side of the peninsula (Text-fig. 1). The stratigraphic studies of the group have been reported by many authors, and the detailed geological maps were published recently by MITSUNASHI and YAZAKI (1968) and WATANABE *et al.* (1968).

It is well known that the Hayama group is hardly yielding any fossil except for echinoid spines and *Makiyama* sp. (WATANABE, 1954). Subsequently, Boso and Miura Research Group (1958) reported the occurrence of some planktonic foraminifers from the Hayama group. As these are too inadequate to

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discuss their geologic age and there is no other paleontological report up to now, nobody has referred the geologic age of the group based on adequate paleontological evidences.

The present author found foraminiferal fossils at a few exposures during the course of the stratigraphical survey of the Hayama area in 1968. Although the foraminifers are very limited in occurrence and poorly preserved in general, he was just able to obtain fifteen samples from the Hayama group containing a fairly large number of the benthonic foraminifers. Among them, arenaceous ones are rather dominant and are sometimes associated with planktonic species. This foraminiferal fauna is believed to be very valuable for the consideration of the geologic age, correlation and paleoenvironment of the group. Therefore, the present paper treats of the fauna from the standpoint of above mentioned respects.



Text-fig. 1. Sample locality and geological map of the central part of the Miura Peninsula, mostly after WATANABE et al. (1968).

Stratigraphy and sample locality

The Hayama group is the oldest series in the Miura Peninsula. It is measured more than 3,000 m in thickness and consists mainly of tuffaceous sediments, such as tuff, tuffaceous mudstone, tuffaceous sandstone and tuffaceous conglomerate. It shows a general strike of NW-SE, dipping to northeast at angles from 50° to vertical. The Hayama group has rather complicated structure with a considerable number of faults running on the directions of E-W and NE-SW. The present group is divided into six formations as shown below in descending order. These formations are conformable with each other.

- Yabe Alternation: 600 m+. Alternation of tuffaceous sandstone and tuffaceous siltstone.
- Kinugasa Mudstone: 800 m+. Massive tuffaceous mudstone, sometimes intercalating thin tuffaceous sandstone beds.
- Oyama Sandstone: 700 m+. Cross-laminated tuffaceous fine- to medium-grained sandstone.
- Osawa Conglomerate: 300-400 m. Massive granule or pebble conglomerate; composed chiefly of well-rounded granules of chert and pyroclastics.
- Toneyama Alternation: 400-500 m. Alternation of tuffaceous fine- to coarse-grained sandstone and tuffaceous siltstone.
- Morito Mudstone: 700 m+. White finegrained tuff, sometimes intercalating tuffaceous coarse-grained sandstone and siltstone, with massive siltstone at the upper.

The radiolarians occur fairly common from the tuff and mudstone of the Hayama group associated with diatoms, foraminifers, *Makiyama* and fragments of molluscs, though the last ones are very few. The foraminifers are found from dark-grey or black colored siltstone which is less tuffaceous than other rocks. Among fifteen fossiliferous samples thirteen are collected from the Morito formation of the lowest part of the Hayama group and the rest from the Toneyama and Kinugasa formations respectively.

The locality, lithology and stratigraphic position of these samples are given in the following lines.

- Morito formation (Samples are arranged approximately from south to north. Asterisk indicates the upper part of the Morito formation.)
 - #7296: Roadside exposure at Koyasu, north of Hikageyama, Yokosuka City; black siltstone.
 - #7299: Small seaside exposure near the mouth of a stream, Akiya, Yokosuka City; dark-grey siltstone intercalated with fine- to mediumgrained sandstone.
 - #7435: Small western cliff in the upper course of the same stream; darkgrey siltstone intercalating thin fine- to medium-grained sandstone.
 - #7439: Western cliff in the upper course of the same stream; massive darkgrey siltstone.
 - #7287: Stream floor south of Okuzure, Yokosuka City; greenish-grey siltstone intercalated with medium-grained sandstone.
 - #7454: Exposure at the beach of Manase, Hayama Town; dark-grey sandy siltstone intercalated with conglomerate.
 - #7092 and 7091: Exposures at the beach of Morito, north of Morito Shrine, Hayama Town; dark-grey siltstone intercalated with medium-grained sandstone.
 - #7463: Exposure at the beach of Morito, north of Morito Shrine, Hayama Town; massive dark-grey siltstone.
 - #7086* and 7088*: Exposure along the path from Hiramatsu to Sengenyama, Hayama Town; massive dark-grey siltstone.
 - #7096*: Roadside cliff at a small valley

northwest of Takinosaka, Hayama Town; massive dark-grey siltstone.

#7116: Exposure along a stream at Teramae, Hayama Town; dark-grey siltstone intercalated with mediumgrained tuffaceous sandstone.

Toneyama formation

#7117: Roadside cliff at Kamiyamaguchi, Hayama Town; massive dark-grey siltstone, in the lower part of the Toneyama formation.

Kinugasa formation

#7452: Cliff about 400 m south of Kinugasa railway station, Yokosuka City; dark-grey tuffaceous mudstone intercalating thin medium-grained sandstone, in the upper part of the Kinugasa formation.

Fauna

About 90 species of benthonic and planktonic foraminifers are found in the 15 samples from the lower and upper parts of the Hayama group. The fauna is composed mainly of benthonic species, but planktonic forms are very few.

BENTHONIC FORAMINIFERA

From the association of the dominant and characteristic species three benthonic foraminiferal assemblages are distinguishable, that is, (1) Assemblage A consisting of rich arenaceous foraminifer, (2) Assemblage B consisting chiefly of calcareous benthonic species, and (3) Assemblage C comprising meagre arenaceous foraminifer.

Assemblage A is represented by five samples which are restricted to the lower or middle part of the Morito formation. Assemblage B is represented by a single sample (#7454) collected at the beach of Manase, Hayama Town, probably from the middle part of the Morito formation. Assemblage C may be more prevailed in the Hayama group. It occurs from the middle and upper parts of the Morito, the lower part of the Toneyama, and the upper part of the Kinugasa formations. In other words, three types of the assemblages are found within the Morito, and the arenaceous foraminiferal one (Assemblage C) extends in occurrence up to the Kinugasa of the upper part of the group.

The faunal characteristics of these three assemblages are briefly remarked as below.

Assemblage A: This assemblage consists of rather large number of species and individuals, and is characterized by the abundance of the arenaceous benthonic foraminifers including calcareous benthonic as well as planktonic species in low frequencies. This assemblage is predominated by Martinottiella communis (D'ORBIGNY) and Cribrostomoides kyushuense ASANO. The two species constitute usually more than 15 per cent of the total benthonic faunas respectively. The associated species are: Ammodiscus cf. intermedius HOEGLUND, Cyclammina orbicularis BRADY, C. pusilla BRADY, Dorothia sp. A, Reophax sp., Nodosaria longiscata D'ORBIGNY and "Globobulimina" sp. Nodosaria sp., Astrononion sp. and Melonis pompilioides (FICHTEL and MOLL) are found very rare in one sample (#7299).

Assemblage B: The assemblage is quite different from others in having a rich fauna consisting mostly of the calcareous foraminifers. Although it is represented by only one sample (\$\$7454\$), it contains about sixty species of the calcareous benthonic and ten species of arenaceous foraminifers. As most of these species are absent in the other two assemblages of the Hayama group, they are listed below. The predominant species in this assemblage are Martinottiella communis and Nodosaria longiscata, and both species constitute about 20 per cent of the total benthonic fauna respectively. The other common species are: "Globobulimina" sp., Hoeglundina elegans D'ORBIGNY, Bulimina striata D'ORBIGNY, Spirosigmoilinella compressa MATSUNAGA, Melonis pacificus (CUSHMAN) and Pullenia bulloides (D'ORBIGNY). The arenaceous species of Cyclammina and Cribrostomoides which are characteristic to the other assemblages are rare in this assemblage.

Proteonina sp.	+
Psammosphaera sp.	1
Ammodiscus cf. intermedius HOEGLUND	+
Reophax sp.	1
Spirosigmoilinella compressa MATSUNAGA	5
Haplophragmoides cf. scitulum (BRADY)	1
Cyclammina japonica Asano	+
C. pusilla BRADY	1
Trochammina nobensis Asano	+
Martinottiella communis (D'ORBIGNY)	20
Quinqueloculina seminula (LINNAEUS)	+
Q. vulgaris D'ORBIGNY	1
Pyrgo murrhina (SCHWAGER)	1
P. cf. fornasinii CUSHMAN and PARR	+
Sigmoilopsis schlumbergeri (SILVESTRI)	1
Nodosaria longiscata D'ORBIGNY	19
N. acuminata uniforminata LEROY	+
N. tosta SCHWAGER	+
N. sp.	1
Dentalina spinosa D'ORBIGNY	+
Lagena abiopleura LOEBLICH and TAPPAN	+
Lenticulina sp.	+
Plectofrondicularia cf. niinoi UCHIO	+
Fissurina sp.	+
Parafissurina ovalis TODD	+
Tosaia hanzawai TAKAYANAGI	1
Sphaeroidina bulloides D'ORBIGNY	+
Brizalina cf. albatrossi (CUSHMAN)	+
Stilostomella consoblina (D'ORBIGNY)	3
S. ketienziensis (ISHIZAKI)	+
S. lepidula (SCHWAGER)	+
S. SDD.	+
Bulimina rostrata BRADY	1
B. striata D'ORBIGNY	5
" Globobulimina " sp.	7
Uvigerina bosoensis AOKI	3
U. crassicostata SCHWAGER	+
Trifarina cf. kokozuraensis (ASANO)	1

Discorbis sp.	+
Eilohedra rotunda	
(HUSEZIMA and MARUHASI)	+
Laticarinina pauperata	
(PARKER and JONES)	+
Cibicides cf. aknerianus (D'ORBIGNY)	1
C. pseudoungerianus (CUSHMAN)	2
Pleurostomella alternans SCHWAGER	+
P. brevis Schwager	+
Cassidulina depressa	
Asano and Nakamura	+
C. kattoi Takayanagi	+
C. subglobosa BRADY	+
Astrononion cf. hanyudaense MATSUNA	.GA +
A. hayamaense n. sp.	+
Pullenia apertula Cushman	+
P. bulloides (D'ORBIGNY)	4
Gyroidina cf. orbicularis D'ORBIGNY	+
G. profunda Aoki	+
G. altiformis R.E. and K.C. STEWART	+
Oridorsalis umbonatus (Reuss)	2
Osangularia bengalensis (SCHWAGER)	+
Cibicidoides bradyi (TRAUTH)	2
Hanzawaia nipponica Asano	+
Melonis pacificus (Cushman)	4
M. pompilioides (FICHTEL and MOLL)	+
Hoeglundina elegans (D'ORBIGNY)	6
(Species abundance is given in per	cent.
Cross shows less than 1 per cent.)	

Assemblage C: The numbers of benthonic species and individuals are limited and usually ten or less numbers of specimens are obtained from each sample belonging to this assemblage. In total, it is composed of nine species of the arenaceous and two species of calcareous benthonic foraminifers. The latter forms are found in two samples, associated with the former ones. The most common species is Martinottiella communis. The three species of Cyclammina, that is, Cyclammina japonica ASANO, C. orbicularis and C. pusilla, occur in this assemblage. The following species are rarely found: Haplophragmoides cf. scitulum (BRADY), Ammodiscus cf. intermedius, Dorothia sp. A, Rhabdammina sp., Nodosaria longiscata and "Globobulimina" sp.

PLANKTONIC FORAMINIFERA

Among the fifteen samples the planktonic foraminifers are restricted within four samples from the Morito and Toneyama formations. Moreover, two of these planktonic foraminiferous samples yield only a small number of specimens which are so poorly preserved that they cannot be determined specifically.

Catapsydrax dissimilis (CUSHMAN and

BERMUDEZ) is rather frequent and about twenty specimens of this species are obtained from one planktonic foraminiferous sample of the lower or middle part of the Morito formation collected at Akiya, Yokosuka City (#7299). In addition to this species the following two species are recognized from the same locality, but about a half of planktonic specimens cannot be identified specifically, because of their poor preservation and deformation.

Table 1.	Distribution of benthonic Foraminifera in the	
	Hayama group (in per cent).	

Assemblage			A			В					С				
Sample Number	7296	7299	7435	7439	7287	7454	7092	7091	7463	7086	7088	7096	7117	7116	7452
Rhabdammina sp.			5									+		2	
Ammodiscus cf. intermedius HOEGLUND	6		1	2		+		+	+			+			
Reophax sp.	5		1	8		3						+		2	
Spirosigmoilinella compressa MATSUNAGA	;		3			5									
Cribrostomoides kyushuense Asano	20	18	9	24	15										+
Haplophragmoides cf. scitulum (BRADY)		-	2			1	+						+		
Cyclammina japonica Asano		+	+			+				+	+	+	+		
C. orbicularis BRADY	1	+	1	2			+				+				+
C. pusilla BRADY	9	3	11	15		+									
C. spp.	5						+								
Dorothia sp. A		2	3	3		1								2	-
D. sp. B			5	2											
Martinottiella communis (D'ORBIGNY)	30	40	36	17	73	20	+	+	+	+	+	+		81	
Nodosaria longiscata D'ORBIGNY		10		1	1	19								4	
Bulimina striata d'Orbigny						5									
"Globobulimina" sp.		20			7	7				-				4	+
Pullenia bulloides (D'ORBIGNY)						4									
Melonis pacificus (CUSHMAN)						4									
M. pompilioides (FICHTEL and MOLL)		3				+									
Hoeglundina elegans (D'ORBIGNY)						6									
spp. (Arenaceous)	24	3	23	26	2	2	+	+			+	+	+	5	+
spp. (Calcareous)		1			2	24			+						•
Plank./Bentho.+Plank.	0	7	0	0	2	40	0	0	0	0	0	. 0	0	6	0

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Catapsydrax dissimilis

(CUSHMAN and BERMUDEZ)	frequent
Globigerina glutinata Egger	rare
G. cf. praebulloides BLOW	rare

A rich planktonic fauna is found at the seaside exposure of Manase, Hayama Town, from the middle part of the Morito formation (#7454). In this sample the number of the planktonic specimens is fairly large and amounts up to 40 per cent of the total fauna. Fifteen species are identified as:

Globorotalia birnagea Blow	common
G. fohsi peripheroronda	
BANNER and BLOW	common
G. cf. scitula praescitula BLOW	rare
G. zealandica Hornibrook	rare
Globigerina glutinata Egger	common
G. angustiumbilicata BOLLI	rare
G. falconensis BLOW	rare
G. praebulloides BLOW	rare
Globoquadrina altispira	
(CUSHMAN and JARVIS)	rare
G. dehiscens (CUSHMAN,	
PARR and COLLINS)	common
Globigerinoides transitorius BLOW	rare
G. ruber subquadratus BRONNIMANN	rare
G. sacculifer (BRADY)	rare
Globigerinatella insueta	
CUSHMAN and STAINFORTH	rare
Sphaeroidinella seminulina	
(Schwager)	common
(rare <20 specimens, common >20 sp	ecimens)

Among them Sphaeroidinella seminulina and Globoquadrina dehiscens are most common and Globorotalia birnagea and Globigerina glutinata are also characteristic in this sample. Other species occur in lower frequencies than the former. Globigerinatella insueta is determined based on only two specimens.

Ecologic notes

The benthonic foraminiferal fauna of the Hayama group is dominated by the

species belonging to the genera Martinottiella, Cribrostomoides, Cyclammina and Nodosaria. Among these genera Cyclammina is most characteristic in deep water environment. It is also noteworthy that the genera Ammonia, Elphidium, Florilus and Hanzawaia which generally indicate shallow water environment are very rare in the group.

Some species of the benthonic foraminifers of the Hayama group are reported from the Recent sediments. Martinottiella communis predominates through the three assemblages of the group, and commonly occurs in the bathyal zone off the Pacific coast of Japan (ISHIWADA, 1964). Cyclammina orbicularis is consistently found in Assemblages A and C, and was reported from the bathyal and abyssal water of modern seas (BRADY, 1884; and other). Many calcareous benthonic species occur in Assemblage B. Most of these species show wide depth ranging from outer neritic to bathyal zones. Moreover, this assemblage contains some bathyal water species, such as Pyrgo murrhina, Bulimina striata and Laticalinina pauperata. The presence of shallow water species associated with these deeper water assemblages may be interpreted by the transport from the neritic zone.

Consequently, it can be said that the benthonic foraminiferal assemblages of the Hayama group consist of bathyal water species and indicate such water depth.

In addition the bathyal water environment seems to be also suggested by the planktonic foraminifers of the Hayama group. The planktonic foraminiferal assemblage found in the Morito formation is dominated by *Sphaeroidinella seminulina* which is having a thick wall with an outer cortex. BÉ (1965) stated that a Recent planktonic foraminifer, Sphaeroidinella dehiscens, secretes the outer cortex in order to adapt the high pressure of its deep water habitat usually in water depth from 300 to 2000 m in modern waters. Therefore, BANDY, INGLE and FRERICHS (1967) said that the occurrence of Sphaeroidinella seminulina is useful as one criterion interpreting as bathyal water depth.

Among the three benthonic foraminiferal assemblages of the Hayama group, arenaceous benthonic foraminifers extremely predominate in Assemblages A and C in which calcareous benthonic and planktonic forms are absent or rare. These arenaceous assemblages may be suggesting the presence of stagnant condition, which seems to be rather prevailing in time of the Hayama group, because of their common occurrence in this group. Similar arenaceous assemblages have been also reported from the Miocene deposits of Japan, and especially from those of the oilfields of Japan Sea coast region where the sedimentary basins are considered to be largely in stagnant condition judging from the and paleontological sedimentological studies (IWAMOTO and SHINBO, 1964; and others).

Correlation of the Hayama group

The Hayama group is overlain with distinct clino-unconformity by the Zushi formation which is generally regarded as Upper Miocene in age. Based on the stratigraphic sequence, lithological and structural characters, the Hayama group has been correlated with the Lower Miocene deposits of the Tanzawa group in Kanagawa Prefecture and the Yugashima group in the Izu Peninsula which yield larger foraminiferal assemblage consisting of *Lepidocyclina* and *Miogypsina* by KOJIMA (1954), WATANABE (1954) and others.

In the preliminary study of the planktonic foraminifers of the Miura and Boso Peninsulas the occurrence of *Globi*gerina cf. bulloides and *Globorotalia ha*yamaense (MS) which is regarded as the primitive form of *Globorotalia fohsi* (s.l.) group was reported from the Hayama group, and it was noted that at least a part of the Hayama group is considered to be Lower Miocene in age from the planktonic foraminiferal assemblages (Boso and Miura Research Group, 1958).

In the correlation and age-determination of the Hayama group, the planktonic foraminifers are very useful in spite of their restricted occurrence in the group. About sixteen species are found in the samples of the Morito formation as mentioned above. Among them, eight species appear first in the Miocene according to BOLLI (1957), BLOW (1959) and others. They are, Globorotalia birnagea, G. fohsi peripheroronda, Globigerina falconensis, G. glutinata, Globoquadrina altispira, Globigerinoides ruber subquadratus, Sphaeroidinella seminulina and Globigerinatella insueta. Although the ranges of some species are extended upwards to the Pliocene and even to the Recent, Globigerinatella insueta, Catapsydrax dissimilis, Globorotalia birnagea and G. fohsi peripheroronda have shortly restricted ranges within the Miocene.

Globigerinatella insueta occurs rarely in the middle part of the Morito formation (#7454) and it was reported to range from the base of the Catapsydrax stainforthi to the top of the next younger Globigerinatella insueta zones in Trinidad and Venezuela (BOLLI, 1957; BLOW, 1959). Catapsydrax dissimilis which is found in the lower or middle part of the Morito formation (#7299) was reported as ranging from the Truncorotaloides rohri (Eocene) to the top of the Catapsydrax stainforthi zones (BOLLI, 1957; BANNER and BLOW, 1962). Therefore, it may be reasonable that the horizon of the Morito formation is included within the interval from the *Catapsydrax stainforthi* zone to the *Globigerinatella insueta* zone in Trinidad and Venezuela. The ranges of the other associated species do not contradict this age-determination.

The Miocene planktonic foraminifers of various areas of Japan were studied in detail by SAITO (1963). He recognized the occurrence of Catapsydrax dissimilis in the Towata and Matsuba formations and Globigerinatella insueta in the Matsuba and Saigo formations all of the Mikasa group in the Kakegawa district. The latter species was also reported from the Chichibumachi group in Saitama Prefecture and the Fukushima formation in Gunma Prefecture both in the Kanto region. It is noteworthy that both species are found together in the Matsuba formation of the middle part of the Mikasa group. Their stratigraphic ranges are not determined in the Miura region, however, the common occurrence of these two species indicates that a part of the Morito formation is correlated with a part of the Mikasa group, probably with the Matsuba formation of the middle part of the group. The planktonic foraminiferal assemblages of the Matsuba formation as well as the Mikasa group are assigned to the Aquitanian of the Lower Miocene, that is, to the Globigerinita unicava zone, Globigerinatella insueta/Globigerinoides trilobus subzone and Globigerinatella insueta/Globigerinoides bisphericus subzone by SAITO (1963). It may be added that the benthonic foraminiferal assemblages of the Hayama group are very similar to those of the Mikasa group reported by SAWAI (1962).

The Hayama group comprises some

benthonic species characteristic to the Miocene deposits of Japan. The species of Cyclammina are common in the lower and middle of the Miocene deposits of Japan. For instance, Cyclammina orbicularis was reported from the Masuporo formation in Hokkaido and the Mikasa group in Kakegawa. Cyclammina japonica frequently occurs in the Miocene deposits of the oilfield of Japan Sea coast region, and Cyclammina pusilla is also found in the Miocene deposits of Japan (ASANO, 1951; SAWAI, 1962; and others). Spirosigmoilinella compressa was reported to range from the Nanatani to Teradomari formations which are regarded as Middle or Upper Miocene in age in the oilfield of Japan Sea coast region (MATSUNAGA, 1963). Cribrostomoides kyushuense is originally described from the Tsuma formation of the Miyazaki group in Kyushu and occurs in the Operculina and Miogypsina-bearing formations of western Japan (TAI, 1959). It is also pointed out that the benthonic fauna of the Hayama group contains numerous species which are found in the Miocene and Pliocene deposits of the Miura and Boso Peninsulas. The benthonic foraminifers of the Hayama group are, therefore, characterized by the socalled Miocene species which are frequent especially in the Lower and Middle Miocene deposits of Japan.

In the correlation of the Hayama group, it is generally accepted that the group is the correlative of the Hota group in the Boso Peninsula, on the opposite side of Tokyo Bay, because of close similarities of the lithological and structural characters. Though the foraminifers have not been reported previously from the Hota group, the present author could collect the foraminiferous samples at Godo and Heguri, east of Iwai in the western part of the Boso Peninsula. The following seven arenaceous species are found.

Ammodiscus cf. intermedius Reophax sp. Cribrostomoides kyushuense Cyclammina japonica C. orbicularis Martinottiella communis Rhabdammina sp.

It is interesting to note that all these species are commonly found also in the Hayama group. Furthermore, it can be said that the faunal characteristic is similar to Assemblage C of the group described above.

Description of new species

Astrononion hayamaense Kurihara, n. sp.

Pl. 15, Figs. 8a, b

Test small, inflated, equatorial periphery rounded, not lobulated, axial periphery broadly rounded, umbilical region slightly depressed, umbilicus insignificant, chambers 7, rarely 6, in the last whorl, supplementary chambers not distinct, elongate tube with terminal rounded pore, sutures slightly curved backwards, wall smooth, finely perforate, aperture arched narrow slit at the base of apertural face. Length of holotype, 0.29 mm, width, 0.24 mm, thickness 0.20 mm.

Holotype, Tokyo University of Education Paleontological Collection Reg. no. 68051, from sample #7454, seaside exposure at Manase, Hayama Town, Morito formation of the Hayama group, Lower Miocene, rare.

This form is characterized by small and inflated test. The species is similar to Astrononion pusillum HORNIBROOK described from the Upper Oligocene of New Zealand, but differs from it by having more inflated test and rounded equatorial periphery.

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Akiya	秋 谷	Kinugasa	衣 笠	Saigo	西 郷
Boso	房 総	Koyasu	子 安	Sengenyama	仙元山
Chichibumachi	秩父町	Manase	真名瀬	Takinosaka	滝ノ坂
Fukushima	福島	Masuporo	埴 幌	Tanzawa	丹 沢
Godo	合 戸	Matsuba	松 葉	Teradomari	寺 泊
Hayama	葉山	Mikasa	三笠	Teramae	寺 前
Heguri	平 群	Miura	三 浦	Toneyama	戸根山
Hikageyama	日影山	Miyazaki	宮 崎	Towata	戸 綿
Hiramatsu	平 松	Morito	森 戸	Tsuma	妻
Hota	保田	Nanatani	七 谷	Yabe	矢 部
Iwai	岩 井	Okuzure	大 崩	Yokosuka	橫須賀
Izu	伊豆	Osawa	大 沢	Yugashima	湯ケ島
Kakegawa	掛 川	Oyama	大 山	Zushi	逗 子
Kamiyamaguchi	上山口	Sagami	相模		

Explanation of Plate 15

Fig. 1. Cyclammina orbicularis BRADY, ×24, from sample #7439.

Fig. 2. Spirosigmoilinella compressa MATSUNAGA, ×60, from sample #7454.

Fig. 3. Martinottie!la communis (D'ORBIGNY), ×35, from sample #7439.

Fig. 4. Nodosaria longiscata D'ORBIGNY, ×35, from sample #7454.

Fig. 5. Bulimina striata D'ORBIGNY, ×60, from sample #7454.

Fig. 6. Pullenia bulloides (D'ORBIGNY), ×70, from sample #7454.

Fig. 7. Melonis pacificus (CUSHMAN), ×60, from sample #7454.

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Fig. 8. Astrononion hayamaense KURIHARA, n. sp., ×80, from sample #7454.

Fig. 9. Hoeglundina elegans (D'ORBIGNY), ×25, from sample #7454.

Fig. 10. Sphaeroidinella seminulina (SCHWAGER), ×50, from sample #7454.

Fig. 11. Globoquadrina dehiscens (CUSHMAN, PARR and COLLINS), ×90, from sample #7454.

Fig. 12. Catapsydrax dissimilis (CUSHMAN and BERMUDEZ), ×67, from sample #7299.

Fig. 13. Globigerinatella insueta CUSHMAN and STAINFORTH, ×110, from somple #7454.

la



















7a



8a



9b





9a



10a



10b



11c



11a



12b





13a



13b

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 83, pp. 143-161, pls. 16-18, September 20, 1971

583. NANNOFOSSILS FROM JAPAN IV. CALCAREOUS NANNOPLANKTON FOSSILS FROM THE TÔNOHAMA GROUP, SHIKOKU, SOUTHWEST JAPAN

SHIRO NISHIDA

Department of Earth Science, Nara University of Education, Nara, Japan

日本産超微化石 Ⅳ. 四国・唐ノ浜層群の石灰質ナノプランクトン化石: 今まで時代論か ら, また層序の上から問題とされてきた 唐ノ浜層群の登層と穴内層について石灰質 ナノプラ ンクトン化石からみた見解を述べた。 また両層から産出した1新種を含む 31種の石灰質ナノ プランクトンを記載した。 ナノプランクトン群集からみて 登層は HAY & SCHMIDT (1967) の Discoaster surculus 帯, MARTINI & WORSLEY (1970)の NN16 帯っまり Discoaster surculus 帯に対比され, 穴内層は前者の Discoaster extensus 帯または Discoaster brouweri 蒂, 後者の NN18 帯ないし NN17 帯つまり Discoaster brouweri 帯ないし Discoaster pentaradiatus 帯に対比される。しかし登層からは Discoaster dilatus, Discoaster kugleri, Discoaster stellulus, Discoaster tani や Ceratolithus aff. C. tricorniculatus のような中 新世を特徴づける種もかなりみられ、 その保存状態などから 二次化石であるとも 考えられな いことから, その時代はひとまず 最下部ないし下部鮮新世とし, 穴内層については下部ない し中部鮮新世としておく。 このことは有孔虫や貝化石からみた 結果ともよく調和する。 ナノ プランクトン群集は登層, 穴内層とも ディスコースターを除いては大きな差異はなく, 両層 の間に大きな時間的間隙は感じられないが 堆積環境のちがいは 明らかである。 同様のことが 松岡 (未発表) による両層からの Dinophyceae, Acritarcha や Pediastrum の産出状況か らも支持されている。 西田史朗

Introduction

Along the east coast of the Tosa Bay, Shikoku, Japan, the Pliocene called the Tōnohama group is scattered in a very limited geographical extent.

In the history of research on the group, OTSUKI (1904) presented a 1/200,000 geological map "Muroto Misaki" and SUZUKI (1929) published a 1/75,000 geological map "Muroto" both with explanations. Yo-KOYAMA (1926 & 1929) described the molluscan fossils from this group and considered its geological age to be Pliocene.

* Received Sept. 1, 1970; read Jan. 19, 1970 at Sendai. MAKIYAMA (1927 & 1931) correlated the Tonohama to the Kakegawa group and considered them to be lower Pliocene in age. OTUKA (1932) correlated the Takanabe, Tonohama and lower Kakegawa groups with each other, and concluded the age as early Pliocene. ASANO (1936 & 1937) studied the foraminifera of the Tonohama group and considered it to be the Pliocene. From the molluscan fossils of the group, NOMURA (1937) concluded it to be the lower part of the Pliocene. Those investigators supposedly dealt with the present-day Ananai formation of the Tonohama group.

KATTO, NAKAMURA and TAKAYANAGI (1953) published a paper on the strati-

graphy and paleontology of the Tonohama group. They divided it into three formations, which were the Ananai, Nahari and Nobori formations, descendingly. According to KATTO et al. (1953), these formations are conformable with one another, and the Ananai is a marine formation, the Nahari is non-marine and the Nobori is a marine formation. On the geologic ages they concluded from the foraminiferal evidence that the Ananai and the Nobori formations are early Pliocene and earliest Pliocene in age, respectively. But they pointed out that the foraminiferal assemblage of the Nobori formation resembles those of the Miocene deposits of the Kar Nicobar Islands in the Indian Ocean. KATTO and OZAKI (1955) concluded from the view point of the molluscan and pollen fossils that the Nobori is Miocene and the Ananai is lower Pliocene in age. They also concluded that the Nobori formation is covered by the Nahari and Ananai formations unconformably and should be separable from the Tonohama group. After that, KATTO (1960) renamed the Nahari as the Ropponmatsu formation and he considered that the Nobori is Miocene and the Ropponmatsu and Ananai are Pliocene in age. From the molluscan species TSUCHI (1961) concluded that the Nobori and Ananai formations should be included in a single sedimentary group of which geologic age is middle Pliocene. From the planktonic foraminiferal evidence TAKAYANAGI and SAITO (1962) correlated the Nobori formation with the Globorotalia cultrata cultrata/Globigerina nepenthes Zone of Venezuela and also correlated with the type Tortonian of Italy. SAITO (1963) correlated the Nobori formation with Globigerina nepenthes Zone. AOKI (1966) pointed out a possibility of being early Pliocene age for the Nobori formation from detailed molluscan fossil studies. From the benthonic and planktonic foraminiferal evidence. UCHIO (1967) considered that the Nobori formation is probably earliest or early Pliocene in age and the Ananai formation is early or middle Pliocene in age. KURIHARA (1968) revised the stratigraphic relationship of the Tonohama group, namely, the Nobori and Ropponmatsu formations are disconformable, and the Ropponmatsu and Ananai formations are conformable. He concluded that the Nobori and Ananai benthonic foraminifera belong to the same faunal group and there is no significant unconformities in the Tonohama group. He also stated that the Nobori formation is regarded to be lower Pliocene in age. TAKAYAMA (1969) compared the discoaster evidence with the type of Italy and suggested that the Nobori formation can be correlative to medial or upper Pliocene in age.

The present author investigated the calcareous nannoplankton fossils from the Tōnohama group and found thirtyone species of calcareous nannoplankton fossils including a new species by optical and electron microscopes. The geologic age was considered from the point of view of calcareous nannoplankton fossils.

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The present author wishes to express his sincere thanks to Professor Misaburo SHIMAKURA of Nara University of Education for his constant encouragement and valuable suggestions. Thanks are also due to Mr. Kazumi MATSUOKA for the field work with him. He received valuable suggestions from Dr. Toshiaki TAKAYAMA of Tohoku University. This research was supported by a grant from the Ministry of Education, Japan.

Samples studied

According to KURIHARA (1968) the stratigraphic succession of the Tonohama group is concluded as follows in descending order;

Ananai formation: 25-65 m. Fine grained sandstone with abundant molluscs and foraminifers. The lower part consists of coarse- to medium-grained sandstone with basal conglomerates.

····· conformity ·····

Ropponmatsu formation: 15-70 m. Non-marine conglomerate consisting of poorly sorted, subangular cobbles, often boulders at the base. Intercalated with thin lignite and lignitic siltstone beds.

····· disconformity ·····

Nobori formation: About 140 m. Massive siltstone. In the basal part coarse- to fine-grained sandstone, alternating with siltstone at some places. Abundant foraminifers and molluscs. Rarely found shark's teeth, otoliths and vertebrate bones.

Locality map of samples is shown in Text-fig. 1.



Text-fig. 1. Sample locality map.

The stratigraphic unit, location and the lithology for each sample are given below;

- KC-2, 5, 8, 10: Nobori formation. Osō, Hane, Muroto City. Gray siltstone.
- KC-12, 15, 16, 18, 20, 22, 23, 25, 28, 30, 32: Nobori formation. A quarry of Hane Industry Co., Nobori, Hane, Muroto City. Gray mudstone, siltstone and very finegrained sandstone.
- KC-33, 34, 35: Nobori formation. Nishihama, Hane, Muroto City. Gray siltstone.
- KC-37, 40, 41, 43: Nobori formation. A ruin of quarry, Nishitani, Hane, Muroto City. Gray siltstone.
- KC-45: Nobori formation. Nishitani, Hane, Muroto City. Gray siltstone.
- KC-49, 50, 51, 53, 54, 55: Ananai formation. Higashitani, Tonohama, Yasuda-cho, Akigun, Kochi Pref. Medium-grained sandstone.
- KC-57, 58, 59: Ananai formation. Ioki, Aki City. Medium-grained sandstone.
- KC-60: Ananai formation. Ioki cave, Ioki, Aki City. Medium-grained sandstone.
- KC-64, 66, 72, 73: Ananai formation. Shioya, Aki City. Medium-grained sandstone.

Method of the preparation was the same as in the previous paper (NISHIDA, 1969).

Electronmicrographs were taken using the Japan Electron Optics JEM-SS electron-microscope at an accelerating voltage of 30 kV and a filament current of 60 mA. Because the specimen itself was destroyed in the course of preparation, the type specimens described in this article are substituted by electronmicrographed negatives. Serial numbers were given to them. The negative films were deposited in Department of Earth Science, Nara University of Education, Nara, Japan.

Nannofossil assemblage and discussion

Occurrence of nannofossils in each sample is shown in Table 1. This table roughly shows the relative presentation in quantity. Each letter in the

	Rock Unit							N	0	30	RI	F	0	RN	AA	TI	ON							ANANAI FOR							RMATION					
	Location								N	۸U	RO	TC)	Н	A	١E								T	ON	101	ΗA	MA			٥ŀ	(AN	IAN	AI
Species	Sample No.	2	5	8	10	12	15	16	18	20	22	23 2	25 2	283	30	32	333	34 3	53	74	041	43	45	49	50	51	53	54 !	55	57 :	58 :	596	50	64 6	6 72	273
Braarudospi	haera bigelowi (Gran & Braarud)							1											Т					ε	r	s	f	r	s	s	r	f	s	r	r	
Ceratolithu	<i>s cristus</i> Kamptner				f			f			f		f				f	f																		
C. aff. C. 1	ricorniculatus Gartner				f				f			f			r		f																			
Coccolithus	pelagicus (Wallich)	a	с	с	α	с	a	с	с	с	с	с	с	с	с	c	с	c d	:	c c	с	с	с	с	с	с	с	с	с	с	с	с	c	с	c c	f
Cricolithus	sp.	f		f	f	s	s	f	s	f	f	s	f		f	s	f			f f	f	s	f				r		f							
Cyclococcol	i <i>thus leptoporus</i> (Murray & Blackman)	a	с	с	α	с	с	a	с	с	с	с	с	с	с	c	с	c (2 I	c c	с	с	c	с	с	s	s	s	с	с	с	с	с	с	c c	c
DiscolithInd	sp. B						s						s											s												
D.	sp.C	f	s	s	f	f	s	f	s	s	S .	f	f	f	f	s	s	s t	; ·	f s	s	f	f	s		s			f	s	s		s	s	5	f
Discoaster	<i>brouwerl</i> Tan Sin Hok (3rays)				r			r			r						f																			
D.	<i>brouweri</i> Tan Sin Hok (4rays)		f		f	f		f	f		f					f	f	f					f													
D .	<i>brouweri</i> Tan Sin Hok (5rays)	f	с	с	a	с	f	a	a	с	a	с	с	с	с	c	с	c c	: (c c	с	с	c	r		r		r		r	r					
D.	<i>brouweri</i> Tan Sin Hok (6rays)	с	α	с	с	с	с	с	с	f	a	с	с	с	с	c	a	c c	: (c c	f	с	с			r					r		r	r		
D.	<i>challengeri</i> Bramlette & Riedel	с	с	f	с	с	с	с	с	с	с	с	f	с	f	c	с	c (: -	c c	f	с	c													
D.	<i>dilatus</i> Hay				s	s				s	s		s					s																		
D.	<i>kugleri</i> Martini & Bramlette			r							r																									
D.	<i>pentaradiatus</i> Tan Sin Hok	с	с	f	с	с	с	с	с	с	f	с	f	с	с	c	f	C	: (c c	a	с	f							r	r		r	r		
D.	stellulus Gartner				f		f		f	f	f						f	f		f			f									r				
D.	<i>surculus</i> Martini & Bramlette	f	s	f	f	s	f	f	s	s	s	s	f	f	f	s	f	fs	; ·	f f	f	f	f											r		
D.	<i>tani</i> Bramlette & Riedel		s		s	s	f				s	s			f			s					s											r		
Ellipsoplace	olithus productuc Kamptner			s		s	s	f						-						s s		s	s			f			f			f				
Emiliania h	uxleyi (Lohmann)								r																											
Gephyrocap	<i>sa reticulata</i> Nishida n. sp.	a	с	с	a	с	с	a	с	a	с	a	с	с	с	c	с	сс	: 1	c c	с	a	c	с	С	с	с	с	c	с	с	с	с	с	c c	
Helicopontos	phaera kamptneri Hay & Mohler	с	с	с	a	a	с	с	с	с	с	с	с	с	с	c	a	сс	: ,	c c	с	с	с	с	с	с	с	с	c	с	с	с	c	с	c c	f
Pontosphaer	a discopora Schiller	s																		s																
P.	<i>japonica</i> (Takayama)	с	с	f	f	f	с	с	с	a	f	с	с	s	s	c	с	f	3	c c	с	f	f	a	a	a	f	f	٥	с	с	с	c	f	s s	
P.	<i>vadosa</i> Hay, Mohler & Wade	s			f	s	s		s	s	f	s	s	f			f			r f	f			f	r	r			r	f				f	r	
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Scyphospha	era apsteini Lohmann															f																				
Syracsphae	ra pulchra Lohmann						f									ʻ																				
Umbilicosph	aera cricota (Gartner)	s		f		r		r				s	f	r			s	r		s	f	s	$ \cdot $		f		r		f		r					
				r:	rar	e		f:f	ew			S:	seve	eral			C : (comr	non			a : c	bur	ndar	nt											

Table 1. Distribution of calcareous nannoplankton fossils from the Tonohama group.

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Shiro NISHIDA

table denotes as follows; r: represents rare, f: a few, s: several, c: common and a: abundant. Bold letters of the sample number, such as KC-5, 8, 12, 15, 18, 20, 23, 25, 28, 30, 32, 34, 37, 40, 43, 45, 50, 51, 54, 55, 59, 60 and 66, represent results by the electronmicroscopical observation. Results by the optical microscope are shown in thin letters, such as KC-2, 10, 16, 22, 33, 35, 41, 49, 53, 57, 58, 64, 72 and 73.

Throughout all samples, predominant species are Coccolithus pelagicus (WAL-LICH), Gephyrocapsa reticulata n. sp., Cyclococcolithus leptoporus (MURRAY & BLACKMAN), Helicopontosphaera kamptneri and Pontosphaera japonica (TAKA-YAMA). In the Nobori formation, besides the above mentioned species, Discoaster brouweri, D. challengeri, D. pentaradiatus and D. surculus are common. Especially 5-rayed Discoaster brouweri is representative. On the contrary, in the Ananai formation discoasters are meager and occur sporadically. Discoasters in the Ananai formation are not considered to be derived fossils judged from its state of preservation.

In the Nobori formation, Discoaster pentaradiatus, D. brouweri, D. surculus, Cyclococcolithus leptoporus (MURRAY & BLACKMAN), Helicopontosphaera kamptneri, Coccolithus pelagicus (WALLICH), Gephyrocapsa reticulata n. sp. and Pontosphaera japonica (TAKAYAMA) occur generally, and Scyphosphaera apsteini and Ceratolithus cristus occur sporadically. It may not be ignored that Discoaster dilatus, D. kugleri, D. stellulus, D. tani and Ceratolithus aff. C. tricorniculatus occur in considerable amount from this formation. They are common in the Miocene strata. Also Pleistocene species such as Ceratolithus cristus, Ellipsoplacolithus productus, Emiliania huxleyi (LOHMANN) and Syracosphaera pulchra occur sporadically in this formation. Supposedly the stratigraphic ranges of these species will date back to Pliocene in age.

In the Ananai formation Discoaster pentaradiatus, D. brouweri, Cyclococcolithus leptoporus (MURRAY & BLACKMAN), Helicopontosphaera kamptneri, Coccolithus pelagicus (WALLICH), Pontosphaera japonica (TAKAYAMA) and Gephyrocapsa reticulata n. sp. occur abundantly, and also they are all representative species in the Nobori formation. The occurrence of Braarudosphaera bigelowi (GRAN & BRA-ARUD) is restricted in the Ananai formation. The occurrence of discoasters is less common in the Ananai formation than in the Nobori formation.

Some biostratigraphers who deal with calcareous nannoplankton fossils emphasize the morphological change observed in number of rays of Discoaster brouweri. Recently, TAKAYAMA (1969) reported discoaster evidences from the Lamont Core V21-98 and from the Nobori formation. He examined the morphological variation of D. brouweri and presented relative frequencies of the discoasters. But he found no conspicuous morphological changes of D. brouweri in the Nobori formation. In the Lamont Core V21-98, he recognized gradual changes in the morphology of D. brouweri except 6-rayed form. From the Nobori formation the present author found 3, 4, 5 and 6-rayed forms of D. brouweri. Among them, representative forms are 5 and 6-rayed. In the Ananai formation 5 and 6-rayed forms of D. brouweri occur sporadically. In both formations no conspicuous morphological changes of D. brouweri are recognized stratigraphically.

From the Nobori and Ananai formations, molluscs, benthonic and planktonic foraminifera, shark teeth and pollen fossils are found by many investigators. MATSUOKA (personal communication) recently recognized many interesting plant microfossils, such as Dinophyceae and Acritarcha, from both formations. He found Hystricosphaera sp., Leptodinium sp. and Nematosphaeropsis sp. as Dinophyceae, Baltispheridium sp. and Cymatiosphaera sp. as Acritarcha and some other indeterminable species, and could not recognize any evident floral changes in both formations. Quantitatively, they occur abundantly in the Ananai but less in the Nobori formations. He found also some specimens of Pediastrum spp. (delicate fresh-water green algae) from the Nobori formation.

The calcareous nannoplankton fossil evidence suggests that there is no significant difference between the geologic ages of the Ananai and Nobori formations, and that there is a considerable difference in the environmental condition between the two formations. The evident occurrence of discoasters in the Nobori formation and the restricted occurrence of Braarudosphaera bigelowi (GRAN & BRAARUD) in the Ananai formation suggest the difference in the sedimentary environment between the two formations. The occurrence of plant microfossils such as Dinophyceae and Acritarcha gives positive support to this conclusion. The occurrence of Pediastrum spp. from the Nobori formation indicates that the formation is not necessarily pelagic or offshore sediment.

On the geologic age of the Nobori formation the present author correlates it to the *Discoaster surculus* Zone in Italy which is proposed by HAY & SCHMIDT (1967), because of a few or several occurrences of *Discoaster surculus* from the all samples treated. And he correlates the Ananai formation to the *Discoaster extensus* Zone or *Discoaster brouweri* Zone, both of the Submarex Hole on the Nicaragua Rise, because of the sporadical occurrences of Discoaster pentaradiatus and D. brouweri. BRAM-LETTE and WILCOXON (1967) correlated the middle. Tertiary calcareous nannoplankton of the Cipero section, Trinidad with the foraminiferal zones of BOLLI. They dealt the Eocene, Oligocene and Miocene sections. A comparison with their calcareous nannoplankton range chart does not result in any useful time markers in the present assemblages. This fact may indicate the possibility that the Nobori formation is the Plio-Recently, MARTINI and cene in age. WORSLEY (1970) proposed a standard Neogene calcareous nannoplankton zona-According to them, the Nobori tion. formation is correlated with their NN16, that is, Discoaster surculus Zone or at least lower than it, by the reason of common occurrence of Discoaster pentaradiatus and the several or a few occurrences of Discoaster surculus. The Ananai formation is correlated with their NN18 or NN17 Zone, that is, Discoaster brouweri Zone or Discoaster pentaradiatus Zone, by the reason of the rare occurrences of Discoaster brouweri and Discoaster pentaradiatus. The present author, considering the Neogene calcareous nannoplankton flora in Japan, proposes earliest or early Pliocene for the age of Nobori formation and early or middle Pliocene for the age of Ananai formation. The reason is that the present author does not ignore occurrences of some Miocene species in considerable amount, such as Discoaster dilatus, D. kugleri, D. stellulus, D. tani and Ceratolithus aff. C. tricorniculatus from the Nobori formation.

Systematic description

Genus Coccolithus SCHWARTZ, 1894

Coccolithus pelagicus (WALLICH) SCHILLER, 1930

Pl. 17, Figs. 12-15

- Coccosphaera pelagica WALLICH, 1877, p. 348, pl. 17, fig. 5.
- Coccolithus pelagicus (WALLICH) SCHILLER; MCINTYRE & BE, 1967, pp. 569-570, pl. 8, figs. A-C.

Description: Placolith, oval in plane view with wide shields convex distally, concave proximally and a narrow elliptical central pore. In the distal view the outer elements have radial suture with dextral imbrication. In the center a number of rhomboidal elements arranged helically. The proximal shield is smaller and the fine sutures incline dextrally. Normally there is a bar made of rhombic elements that crosses the pore at its center making a right angle with the long axis of the pore.

The length of the distal shield of the hypotypes ranges from $9\,\mu$ to $11\,\mu$. The width ranges from $7\,\mu$ to $8\,\mu$.

Hypotype: Pl. 17, Figs. 12–15. (12; KC 18R–3, 13; KC54R–13, 14; KC60R–29, 15; KC54R–9).

Genus Cricolithus KAMPTNER, 1958

Cricolithus sp.

Pl. 16, Fig. 15

Description: Placolith, circular in plane view with wide ring-like shields and a wide central pore. Rhombic calcite segments radiate and imbricate dextrally.

Diameter of the shield is 6μ and diameter of the central pore is 3μ . Width of the shield is 1.5μ .

Hypotype: Pl. 16, Fig. 15. (KC18R-49).

Genus Cyclococcolithus KAMPTNER, 1954

Cyclococcolithus leptoporus (MURRAY & BLACKMAN) KAMPTNER, 1954

Pl. 16, Figs. 1-4

- Coccosphaera leptopora MURRAY & BLACK-MAN, 1898, pp. 430-437 & 439, pl. 15, figs. 1-7.
- Coccolithophora leptopora (MURRAY & BLACK-MAN) LOHMANN, 1902, pp. 137–138, pl. 5, fig. 52.
- Coccolithus leptoporus (MURRAY & BLACK-MAN) SCHILLER; BLACK & BARNES, 1961, p. 143, pl. 24, figs. 3-4.
- Umbilicosphaera leptopora (MURRAY & BLACK-MAN) COHEN & REINHARDT, 1968, p. 296, pl. 20, fig. 11.
- Coccolithus leptoporus (MURRAY & BLACK-MAN) KAMPTNER var., A, MCINTYRE et al., 1967, pp. 9-10, pl. 4, figs. C-D.
- Cyclococcolithus leptoporus (MURRAY & BLACK-MAN) KAMPTNER, 1954, p. 23, fig. 20; Cohen, 1964, p. 237, pl. 2, fig. 4.

Description: Placolith, circular in plane view with symmetrical shields convex distally and concave proximally. Segments petaloid with dextral imbrication in the distal shield and sinistral in the proximal shield. A central pore open. Segments are counted about forty in number.

The diameter of the distal shield of the hypotype ranges from 10μ to 14μ . The proximal shield is about 10μ . The diameter of the central pore is approximately 2μ .

Hypotype: Pl. 16, Figs. 1-4. (1; KC18 R-40, 2; KC25R-24, 3; KC12R-6, 4; KC 18R-4).

Genus Discolithina LOEBLICH & TAPPAN, 1963

Discolithina sp. A

Pl. 16, Fig. 7

Description: Discolith, elliptical in

plane view with a narrow rim and a wide central area. The rim is composed of fine rhomboidal elements arranged radially. The central area is completely infilled with fine calcite crystals arranged in a slightly rotated pattern.

Length of this specimen is supposed to be more than $20 \ \mu$.

Hypotype: Pl. 16, Fig. 7. (KC18R-28).

Discolithina sp. B

Pl. 17, Fig. 16

Description: Discolith, elliptical in plane view with a thick and wide rim, and perforated central area. In the central area perforation is arranged in 4 to 7 rows on a side of the longitudinal central fissure.

Length of this specimen is approximately 6μ .

Hypotype: Pl. 17, Fig. 16. (KC20R-44).

Discolithina sp. C

Pl. 16, Fig. 9

Description: Elliptical disc, with distinct flat rim and uneven central area.

Length of this specimen is approximately 8μ .

Present specimen differs from *Ponto-sphaera japonica* (TAKAYAMA) in numerous perforated pores, longitudinal central fissure and dimension.

Hypotype: Pl. 16, Fig. 9. (KC15R-47).

Genus Ellipsoplacolithus KAMPTNER, 1963

Ellipsoplacolithus productus KAMPTNER, 1963

Pİ. 17, Figs. 9-11

Ellipsoplacolithus productus KAMPTNER, 1963, pp. 172-173, pl. 8, figs. 42 & 44.

Description: Placolith, elliptical im plane view with shields convex distally, concave proximally. Segment petaloid with slightly sinistral imbrication in the proximal shield at the view from the proximal side. Central longitudinal slit is conspicuous.

The longitudinal diameter of the distal shield ranges from 3μ to 5μ .

Hypotype: Pl. 17, Figs. 9-11. (9; KC^{*} 12R-19, 10; KC43R-5; 11; KC12R-52).

Genus Emiliania HAY & MOHLER, 1967

Emiliania huxleyi (LOHMANN) HAY & MOHLER, 1967

Pl. 17, Fig. 6

- Pontosphaera huxleyi LOHMANN, 1902, pp. 129-130, pl. 4, figs. 1-9 & pl. 6, fig. 69.
- Coccolithus huxleyi (LOHMANN) KAMPTNER; KAMPTNER, 1952, p. 234, fig. 10; BRAARUDet al., 1952, pp. 129–131, text-fig. 3, pl. 1, figs. a-f.

Emiliania huxleyi (LOHMANN) HAY & MOH-LER, 1967, p. 447, pls. 10-11, figs. 1-2.

Description: Placolith, oval in plane view with shields equal in size, convex, distally and concave proximally. Largeelliptical pore. The T-shaped segments from both shields in present specimen. The end of each element slightly interlocked. From the morphology of elements in the proximal shield, the present specimen seems to be warm water species.

The length of the hypotype is 3.5μ . Hypotype: Pl. 17, Fig. 6. (KC18R-2).

Genus Gephyrocapsa KAMPTNER, 1943

Gephyrocapsa reticulata NISHIDA, n. sp.

Pl. 17, Figs. 1-3

Remarks: Elliptical placolith with a.



Text-fig. 2. Gephyrocapsa reticulata NISHIDA n. sp. Left: Distal view. Right: Proximal view. Scale bar 1 micron.

chest-bone-shaped structure in the central opening.

Description : Placolith, elliptical in plane view with closely appressed shields convex distally, concave proximally and a conspicuous chest-boneshaped structure in the central opening. The distal shield larger than the proximal one, composed of about fifty-five segments which imbricate slightly dextrally. Outer margin indentate. Smaller proximal shield is composed of the same number of segments which imbricate sinistrally. The chest-bone-shaped structure in the central pore is composed of a central longitudinal bar and ten to fifteen limbs in a side which branch out from the central bar, and some limbs branch out again at outer ends.

The length of the distal shield ranges from 5μ to 6μ . The length of the proximal shield is approximately 4μ . The length of the central opening ranges from 1.5μ to 2μ .

The present new species has been elected on the basis of its dimensional

and constructional differences from described species which belong to the same genus. The present species differs distinctly from Gephyrocapsa aperta, G. caribbeanica, G. ericsoni and G. oceanica in having a bridge structure on the central pore. This species differs also from G. kamptneri in its dimension of the shield and in the number of segments. The figure presented as Cyclococcolithus sp. aff. C. dictyodus (DEFLAN-DRE and FERT) by BARTOLINI (1970) resembles this species but differs on the chest-bone structure in the central pore, especially in having the central longitudinal bar.

Holotype: Pl. 17, Fig. 2. (KC18R-1).

Paratype: Pl. 17, Figs. 1 & 3. (1; KC 18R-51, 3; KC18R-22).

Gephyrocapsa sp.

Pl. 16, Fig. 13

Description: Placolith, elliptical in plane view with closely appressed

shields convex distally and concave proximally. Indentated outer margin in both shields. The central area is covered. The number of segments is about forty in each shield.

The length of the specimen is 5μ . Hypotype: Pl. 16, Fig. 13. (KC15R-48).

Genus Helicopontosphaera HAY & MOHLER, 1967

Helicopontosphaera kamptneri HAY & MOHLER, 1967

Pl. 17, Figs. 17-18

Coccolithus carteri (WALLICH) KAMPTNER, 1941, p. 93, pl. 8, figs. 134-136.

Helicosphaera carteri (WALLICH) KAMPTNER, 1954, p. 22, figs. 17–19; BLACK & BARNES, 1961, p. 139, pl. 22, fig. 1 & pl. 23, figs. 1–2.

Helicopontosphaera kamptneri HAY & MOHLER, 1967, p. 448, pls. 10-11, fig. 5.

Description: This species is described thoroughly by BLACK & BARNES (1961) with excellent figures. Both perforate and imperforate specimens occur in the same sample.

Length of the hypotype ranges approximately from 7μ to 10μ .

Hypotype: Pl. 17, Figs. 17–18. (17; KC 15R–62, 18; KC37R–12).

Genus Pontosphaera LOHMANN, 1902

Pontosphaera alboranensis BARTOLINI, 1970

Pl. 17, Figs. 7-8

Pontosphaera sp., HAY et al., 1967, pls. 10-11, fig. 6.

Pontosphaera alboranensis BARTOLINI, 1970, pp. 148-150, pl. 6, figs. 6-7, text-fig. 9.

Description: Lopadolith, elliptical with wide, flat and perforated central area

and lamellar rim which gently twists dextrally throughout.

Length of the hypotype is approximately 9.0 μ . Length of the central area is 6.5 μ and width of the rim is about 2.0 μ . Diameter of the perforation is approximately 0.5 μ .

Hypotype: Pl. 17, Figs. 7-8. (7; KC5R-71, 8; KC40R-12).

Pontosphaera japonica (TAKAYAMA)

Pl. 16, Figs. 10-11

Discolithina millepuncta GARTNER, 1967, p. 5, pl. 8, figs. 1-2.

Discolithina japonica TAKAYAMA, 1967, pp. 189–190, pl. 9 & pl. 10, fig. 1.

Description: Lopadolith, elliptical with flat rim and longitudinal central fissure. Numerous perforations in the central disc.

Length of the hypotype ranges approximately from 12μ to 15μ . Width of the rims ranges from 2.5μ to 4.0μ . Diameter of the pore in the central area is 0.1μ .

Electronmicrographs of the present species are presented as *Pontosphaera japonica* (TAKAYAMA) in figures 9 and 10 of "Atlas of Japanese Fossils" No. 6-31 (HONJO & OKADA, 1969) with a brief description and in a plate in "Koseibutsugaku-Nyûmon" (meaning Introduction to Paleontology in Japanese, ASANO, 1969) without description.

Hypotype: Pl. 16, Figs. 10–11. (10; KC 60R–17, 11; KC50R–13).

Pontosphaera cf. P. vadosa HAY, MOHLER & WADE, 1966

Pl. 16, Figs. 8 & 12

Pontosphaera vadosa HAY, MOHLER & WADE, 1966, p. 391, pl. 8, fig. 4.

Discolithina sp., TAKAYAMA, 1967, p. 191, pl. 1, fig. 7 & pl. 3, figs. 1-19.

Description: Lopadolith, elliptical with slightly concave central area in proximal view. Longitudinal central fissure in the central area.

Length of the hypotype is approximately 11μ .

Present specimen differs from *Ponto-sphaera vadosa* in the number of perforations.

Hypotype: Pl. 16, Figs. 8 & 12. (8; KC25R-6, 12; KC15R-81).

Pontosphaera sp.

Pl. 16, Figs. 5-6

Description: Lopadolith, elliptical with a distinct wide rim and perforated flat central area. On the rim fine striae wind sinistrally or dextrally in a specimen. Perforated holes in the central area arrange regularly.

Length of the hypotype is approximately 13μ . Length of the central area is 10.5μ and width of the rim is 2μ . Diameter of the perforation is approximately 0.5μ .

Present specimen somewhat resembles Discolithina distincta but differs in the number of holes, and resembles the figure shown as Discolithus sp. 1 by SALES (1967). Both figures of Discolithina distincta and Discolithus sp. 1, to which the present author referred, are optical micrographs. Electronmicrographs of the species are wanted.

Hypotype: Pl. 16, Figs. 5-6. (5; KC15R-80, 6; KC18R-18).

Genus Syracosphaera LOHMANN, 1902

Syracosphaera pulchra LOHMANN, 1902

Syracosphaera pulchra LOHMANN, 1902, pp.

133-134, pl. 4, figs. 33 & 36-37; Deflandre & Fert, 1954, pl. 5, figs. 1 & 4-5.

Syracosphaera sp., Сонем, 1965, р. 20, pl. 25, fig. f.

Description: Discolith, nearly elliptical with narrow, thick double marginal rings. Large central area with radial ribs. The radial ribs are seen to be arranged in bundles or sieves, overlapping to some extent at the center.

Length of the hypotype is approximately 3μ .

Hypotype: (KC15R-51).

Genus Umbilicosphaera LOHMANN, 1902

Umbilicosphaera cricota (GARTNER) COHEN & REINHARDT, 1968

Pl. 17, Figs. 4-5

Ellipsoplacolithus lacunosus KAMPTNER, 1963, p. 172, pl. 9, fig. 50.

Ellipsoplacolithus exsectus KAMPTNER, 1963, p. 171, pl. 9, figs. 51-52.

- Coccolithus doronicoides BLACK & BARNES, MCINTYRE et al., 1967, pl. 3, fig. A.
- Cyclococcolithus cricotus GARTNER, 1967, p. 5, pl. 7, figs. 5-6.

Umbilicosphaera cricota (GARTNER) COHEN & REINHARDT, 1968, p. 296, pl. 21, fig. 3.

Description: Placolith, circular in plane view with large shields convex distally, concave proximally and a wide central pore. In the larger distal shield, T-shaped segments radiate from the inner ring and make the pencil-shaped opening between them. Proximal shield is narrow in width, and composed of narrow and short segments arranged without space.

Diameter of the hypotype is approximately 4.5μ . Diameter of the central opening is 2μ . Width of the distal shield is 1.2μ .

Hypotype: Pl. 17, Figs. 4-5. (4; KC55R-

9, 5; KC43R-14).

Genus Discoaster TAN SIN HOK, 1927

Discoaster brouweri TAN SIN HOK, 1927

Pl. 18, Figs. 7 & 9

Discoaster brouweri TAN SIN HOK; sens emend., BRAMLETTE & RIEDEL, 1954, p. 402, pl. 39, fig. 12.

Description: Asterolith with 3, 4, 5 or 6 long slender and gently curved rays. 5 and 6 rayed forms are common in both the Nobori and Ananai formations.

Length of the hypotype ranges from 7 μ to 11 $\mu.$

Hypotype: Pl. 18, Figs. 7 & 9. (7; KC 25R-48, 9; KC18R-52).

Discoaster brouweri Tan Sin Hok rutellus Gartner, 1967

Pl. 18, Figs. 5 & 8

Discoaster brouweri TAN SIN HOK rutellus GARTNER, 1967, p. 2, pl. 1, figs. 1-2.

Description: Asterolith, with 6 slender and gently curved rays. Rays sharply bent near the end and extend like broad blade.

Dimension of the hypotype ranges approximately from 11μ to 15μ .

Hypotype: Pl. 18, Figs. 5 & 8. (5; KC 20R-39, 8; KC45R-36).

Discoaster challengeri BRAMLETTE & RIEDEL, 1954

Discoaster challengeri BRAMLETTE & RIEDEL, 1954, p. 401, pl. 39, fig. 10.

Description: Asterolith, with 5 or 6 long rays which are subcylindrical and

distally bifurcated into short, round terminations. Widening of the rays in the central area is not pronounced. In the central area there is a small, circular knob.

Dimension of the hypotype is approximately 12μ .

Hypotype: (KC15R-66).

Discoaster dilatus HAY, 1967

Pl. 18, Fig. 2

Discoaster dilatus HAY, 1967, pp. 450-451, pl. 4, figs. 3-4.

Description: Asterolith with 6 broad flaring, flatly terminated rays.

Length of the hypotype is approximately 14μ .

Hypotype: Pl. 18, Fig. 2. (KC20R-34).

Discoaster kugleri MARTINI & BRAMLETTE, 1963

Pl. 18, Fig. 1

Discoaster kugleri MARTINI & BRAMLETTE, 1963, p. 853, pl. 102, figs. 11-13.

Description: Asterolith, with 6 short bluntly terminated rays, and a large and flat central area. In the central area a small knob and a ridge are observable.

Dimension of the hypotype is approximately 14μ .

Hypotype: Pl. 18, Fig. 1. (KC8R-15).

Discoaster pentaradiatus TAN SIN HOK, 1927

Pl. 18, Figs. 3, 6 & 13-14

Discoaster pentaradiatus TAN SIN HOK; sens emend., BRAMLETTE & RIEDEL, 1954, pp. 401-402, pl. 39, fig. 11, text-fig. 2.

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Description: Asterolith, with 5, rarely 6, thin bifurcated rays. Bifurcated ends are sharp and delicate. Interray margin curves round and smoothly.

Dimension of the hypotype ranges from $12 \ \mu$ to $17 \ \mu$.

Hypotype: Pl. 18, Figs. 3, 6 & 13-14. (3; KC43R-35, 6; KC23R-11, 13; KC25R-36, 14; KC12R-5).

Discoaster stellulus GARTNER, 1967

Pl. 18, Figs. 10-11

Discoaster stellulus GARTNER, 1967, p. 3, pl. 4, figs. 1-2.

Description: Asterolith, with 6 short, round-end rays. A prominent parallel ridge on the surface of each ray.

Dimension of the hypotype is approximately 5μ .

Hypotype: Pl. 18, Figs. 10-11. (10; KC 20R-43, 11; KC15R-63).

Discoaster surculus Martini & Bramlette, 1963

Pl. 18, Fig. 4

Discoaster brouweri TAN SIN HOK; STRADNER & PAPP, 1961, pl. 20, figs. 2 & 3.

Discoaster surculus MARTINI & BRAMLETTE, 1963, p. 854, pl. 104, figs. 10-12.

Description: Asterolith, with 6 rays. Two short and small bifurcations on both sides of each ray. A stellate knob is observed in the middle of the central area. From the knob thin ridges extend along the rays. The end of the ray makes a slight flare and a blunt termination.

Dimension of the hypotype is approximately 12μ .

Hypotype: Pl. 18, Fig. 4. (KC32R-37).

Discoaster tani BRAMLETTE & RIEDEL, 1954

Pl. 18, Fig. 12

Discoaster tani BRAMLETTE & RIEDEL, 1954, p. 397, pl. 39, fig. 1.

Description: Asterolith, with 6 rays. Rays rather heavy and of almost uniform width, abruptly truncated.

Dimension of the hypotype is approximately 12μ .

Hypotype: Pl. 18, Fig. 12. (KC15R-18).

Genus Braarudosphaera DEFLANDRE, 1947

Braarudosphaera bigelowi (GRAN & BRAARUD) DEFLANDRE, 1947

Pl. 16, Fig. 17

Pontosphaera Bigelowi GRAN & BRAARUD, 1935, pp. 388-389, text-fig. 67.

Braarudosphaera bigelowi (GRAN & BRAARUD) DEFLANDRE, 1947, pp. 439-441, figs. 1-5.

Description: Pentalith formed by characteristic five segments.

Dimension of the hypotype is approximately 22μ .

Hypotype: Pl. 16, Fig. 17. (Optical micrograph KC49).

Genus Ceratolithus KAMPTNER, 1950

Ceratolithus cristus KAMPTNER, 1950

Ceratolithus cristus KAMPTNER; DEFLANDRE, 1952, p. 468, figs. 44-45.

Description: Horseshoe-shaped small calcareous body with pointed ends.

Dimension of the specimen ranges from 4μ to 8μ .

Hypotype: Undesignated.

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Ceratolithus aff. C. tricorniculatus GARTNER, 1967

Pl. 16, Fig. 16

Ceratolithus tricorniculatus GARTNER, 1967, p. 5, pl. 10, figs. 4-6.

Description: Ceratolith, with two symmetrically curved horns of the same thickness. A short horn projects on the convex side of the specimen.

Length of the hypotype is approximately 17 $\mu.$

Explanation of Plate 16

Electronmicrographs of carbon replica except figure 17. Scale bar represents 5 microns. The bar under figure 17 represents 10 microns.

Fig.	1.	Cyclococcolithus leptoporus (MURRAY & BLACKMAN) KAMPTNER Distal view. KC18R-40. Nobori formation. Nobori, Hane, Muroto City.
Fig.	2.	Cyclococcolithus leptoporus (Murray & BLACKMAN) KAMPTNER Proximal view, KC25R-24, Nobori formation, Nobori, Hane, Muroto City,
Fig.	3.	Cyclococcolithus leptoporus (MURRAY & BLACKMAN) KAMPTNER Proximal view of the distal shield. KC12R-6. Nobori formation. Nobori, Hane, Muroto City.
Fig.	4.	Cyclococcolithus leptoporus (MURRAY & BLACKMAN) KAMPTNER Distal view. KC18R-4. Nobori formation. Nobori, Hane, Muroto City.
Fig.	5.	Pontosphaera sp. KC15R-80. Nobori formation. Nobori, Hane, Muroto City.
Fig.	6.	Pontosphaera sp. KC18R-18, Nobori formation, Nobori, Hane, Muroto City,
Fig.	7.	Discolithina sp. A KC18R-28. Nobori formation. Nobori Hane, Muroto City.
Fig.	8.	Pontosphaera cf. P. vadosa HAY, MOHLER & WADE KC25R-6 Nobori formation Nobori Hane Murato City
Fig.	9.	Discolithina sp. C KC15R-47 Nobori formation Nobori Hane Muroto City
Fig.	10.	Pontosphaera japonica (TAKAYAMA)
Fig.	11.	Pontosphaera jabonica (Takayama)
- 0		KC50R-13. Ananai formation. Higashitani, Tōnohama, Yasuda-chō, Aki-gun, Kōchi Pref.
Fig.	12.	Pontosphaera cf. P. vadosa HAY, MOHLER & WADE
		KC15R-81. Nobori formation. Nobori, Hane, Muroto City.
Fig.	13.	Gephyrocapsa sp. KC15R-48. Nobori formation. Nobori, Hane, Muroto City.
Fig.	14.	? Thoracosphaera sp. KC51-25. Ananai formation. Higashitani, Tōnohama, Yasuda-chō, Aki-gun, Kōchi Pref.
Fig.	15.	Cricolithus sp. KC18R-49. Nobori formation. Nobori, Hane, Muroto City.
Fig.	16.	Ceratolithus aff. C. tricorniculatus GARTNER KC18R-41, Nobori formation, Nobori, Hane, Muroto City,
Fig.	17.	Braarudosphaera bigelowi (GRAN & BRAARUD) DEFLANDRE Optical micrograph. KC4?. Ananai formation. Higashitani, Tōnohama, Yasuda-chô,, Aki-gun, Kōchi Pref.

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Present specimen somewhat resembles Ceratolithus tricorniculatus in the outer shape but differs in length of the horn. Hypotype: Pl. 16, Fig. 16. (KC18R-41).

Genus Rhabdosphaera HAECKEL, 1894

Rhabdosphaera claviger MURRAY & BLACKMAN, 1898

Rhabdosphaera claviger MURRAY & BLACK-MAN, 1898, pl. 15, fig. 1.

Description: Specimen composed of a club-shaped stem and a trumpet-like basal part.

Dimension of the specimen is commonly 7 μ .

Hypotype: Undesignated.

Genus Scyphosphaera LOHMANN, 1902

Scyphosphaera apsteini LOHMANN, 1902

Scyphosphaera apsteini LOHMANN, 1902, p. 132, pl. 4, figs. 26-30.

Description: Comparatively large beerbarrel-shaped lopadolith.

Height approximately 15μ and width 12μ .

• Hypotype: Undesignated.

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Shiro NISHIDA

Explanation of Plate 17

Electronmicrographs of carbon replica. Scale bar represents 5 microns.

- Fig. 1. Gephyrocapsa reticulata NISHIDA n. sp. Distal view. Paratype. KC18R-51. Nobori formation. Nobori, Hane, Muroto City.
- Gephyrocapsa reticulata NISHIDA n. sp. Distal view. Holotype. KC18R-1. Nobori formation. Nobori, Hane, Muroto City. Fig. 2. Gephyrocapsa reticulata NISHIDA n. sp. Fig. 3.
- Proximal view. Paratype. KC18R-22. Nobori formation. Nobori, Hane, Muroto City. Fig. 4.
- Umbilicosphaera cricota (GARTNER) COHEN & REINHARDT Distal view. KC55R-9. Ananai formation. Higashitani, Tōnohama, Yasuda-chō, Aki-gun, Kōchi Pref.
- Umbilicosphaera cricota (GARTNER) COHEN & REINHARDT Distal view. KC43R-14. Nobori formation. Nishitani, Hane, Muroto City. Fig. 5.
- Fig. 6. Emiliania huxleyi (LOHMANN) HAY & MOHLER Distal view. KC18R-2. Nobori formation. Nobori, Hane, Muroto City.
- Fig. 7. Pontosphaera alboranensis BARTOLINI KC5R-71. Nobori formation. Osō, Hane, Muroto City. Pontosphaera alboranensis BARTOLINI Fig. 8.
- KC40R-12. Nobori formation. Nishitani, Hane, Muroto City. Fig. 9.
- Ellipsoplacolithus productus KAMPTNER Distal view. KC12R-19. Nobori formation. Nobori, Hane, Muroto City.
- Fig. 10. Ellipsoplacolithus productus KAMPTNER
- Proximal view. KC43R-5. Nobori formation. Nishitani, Hane, Muroto City. Ellipsoplacolithus productus KAMPTNER Fig. 11.
- Proximal view. KC12R-52. Nobori formation. Nobori, Hane, Muroto City. Coccolithus pelagicus (WALLICH) SCHILLER Distal view. KC18R-3. Nobori formation. Nobori, Hane, Muroto City. Fig. 12.
- Coccolithus pelagicus (WALLICH) SCHILLER Fig. 13.
- Proximal view of the distal shield. KC54R-13. Ananai formation. Higashitani, Tōnohama, Yasuda-chō, Aki-gun, Kōchi Pref.
- Coccolithus pelagicus (WALLICH) SCHILLER Proximal view. KC60R-29, Ananai formation. Ioki, Aki City. Fig. 14.
- Fig. 15.
- Coccolithus pelagicus (WALLICH) SCHILLER Distal view. KC54R-9. Ananai formation. Higashitani, Tōnohama, Yasuda-chō, Aki-gun, Köchi Pref.
- Fig. 16. Discolithina sp. B
- KC20R-44. Nobori formation. Nobori, Hane, Muroto City.
- Fig. 17. Helicopontosphaera kamptneri HAY & MOHLER
- Proximal view. KC15R-62. Nobori formation. Nobori, Hane, Muroto City.
- Helicopontosphaera kamptneri HAY & MOHLER Fig. 18. Distal view. KC37R-12. Nobori formation. Nishitani, Hane, Muroto City. Fig. 19. Coccosphere
- Coccosphere of Gephyrocapsa reticulata NISHIDA. KC55R-11. Ananai formation. Higashitani, Tōnohama, Yasuda-chō, Aki-gun, Kōchi Pref.
- Coccosphere Fig. 20. Coccosphere of Gephyrocapsa reticulata NISHIDA. KC25R-63. Nobori formation. Nobori, Hane, Muroto City.
- Coccosphere Fig. 21.
- KC32R-27. Nobori formation. Nobori, Hane, Muroto City. Fig. 22. Coccosphere
- Coccosphere of Gephyrocapsa reticulata NISHIDA. KC59-29. Ananai formation. Ioki, Aki City.
- Fig. 23. Coccosphere Coccosphere of Gephyrocapsa reticulata NISHIDA. KC55R-1. Ananai formation. Higashitani, Tōnohama, Yasuda-chō, Aki-gun, Kōchi Pref. Fig. 24. Coccosphere
- Coccosphere of Gephyrocapsa reticulata NISHIDA. KC30R-28. Nobori formation. Nobori, Hane, Muroto City.



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Explanation of Plate 18

Electronmicrographs of carbon replica. Scale bar represents 5 microns.

Fig.	1.	Discoaster kugleri Martini & Bramlette
		KC8R-15. Nobori formation. Osō, Hane, Muroto City.
Fig.	2.	Discoaster dilatus Hay
		KC20R-34. Nobori formation. Nobori, Hane, Muroto City.
Fig.	3.	Discoaster pentaradiatus TAN SIN HOK
		KC43R-35. Nobori formation. Nishitani, Hane, Muroto City.
Fig.	4.	Discoaster surculus Martini & Bramlette
		KC32R-37. Nobori formation. Nobori, Hane, Muroto City.
Fig.	5.	Discoaster brouweri Tan Sin Hok rutellus Gartner
		KC20R-39. Nobori formation. Nobori, Hane, Muroto City.
Fig.	6.	Discoaster pentaradiatus TAN SIN HOK
		KC23R-11. Nobori formation. Nobori, Hane, Muroto City.
Fig.	7.	Discoaster brouweri Tan Sin Hok
		KC25R-48. Nobori formation. Nobori, Hane, Muroto City.
Fig.	8.	Discoaster brouweri TAN SIN HOK rutellus GARTNER
		KC45R-36. Nobori formation. Nishitani, Hane, Muroto City.
Fig.	9.	Discoaster brouweri Tan Sin Hok
		KC18R-52. Nobori formation. Nobori, Hane, Muroto City.
Fig.	10.	Discoaster stellulus GARTNER
		KC20R-43. Nobori formation. Nobori, Hane, Muroto City.
Fig.	11.	Discoaster stellulus GARTNER
		KC15R-63. Nobori formation. Nobori, Hane, Muroto City.
Fig.	12.	Discoaster tani Bramlette & Riedel
		KC15R-18. Nobori formation. Nobori, Hane, Muroto City.
Fig.	13.	Discoaster pentaradiatus TAN SIN HOK
		KC25R-36. Nobori formation. Nobori, Hane, Muroto City.
Fig.	14.	Discoaster pentaradiatus TAN SIN HOK
	-	KC12R-5. Nobori formation. Nobori, Hane, Muroto City.

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Aki	安		芸	Nishitani	西		谷
Ananai	穴		内	Nobori		登	
Hane	33		根	Osō	尾		僧
Higashitani	東		谷	Ropponmatsu	六	本	松
Ioki	伊」	尾	木	Shioya	塩		屋
Kakegawa	掛		וון	Takanabe	商		鍋
Kōchi	高		知	Tōnohama	唐	1	浜
Muroto	室		戸	Tosa	土		佐
Nahari	那	半	利	Yasuda	安		囲

Erratum

The following correction should be made on page 145, right side of Text-fig. 1: for, 33°90′ read, 33°28′ Trans. Proc. Palaeont. Soc. Japan, N.S., No. 83, pp. 162-165, September 20, 1971

584. PECULIAR MARKINGS ON A SANDSTONE LAYER OF THE HAGINO FORMATION, NAGANO PREFECTURE*

KOTORA HATAI and HIROSHI NODA

Institute of Geology and Paleontology, Faculty of Science, Tohoku University, Sendai, Japan

長野県萩野層砂岩層理面上の特異な痕跡について: 長野県上水内郡初引の土尻川沿いに 発達する萩野層の砂岩・シルト岩互層の砂岩層理面上に ripple-like current structure が 発達し,その面上に Arenicola, Balanoglossus, Cosmorhaphe 等の匍跡に似た痕跡が発見さ れた。これを検討した結果,生物に起因するものでなく,濁色砂岩堆積後 lutite の葉(理)層 が発達し,海水による過飽和状態の下位の砂岩が Quick sand として流動した際に,ripplelike current structure を形成し, lutite 葉層の破壊がそれらの表面上で生物の匍跡状 (Trail-like) のものとなったことを結論し,それらの産状,形態及びその生成過程について 論じた。 如井小虎・野田浩司

Abundant trail-like peculiar markings of small size were found on the surface of a rippled sandstone layer exposed along the Dojiri stream below the bridge at Hatsuhiki, Ogawa-mura, Kami-Minochi-gun, Nagano Prefecture. These peculiar markings show considerable resemblance with detached or broken parts of the castings of such marine annelids as the living Arenicola and Balanoglossus (HATAI and MII, 1955), the detached or small broken piece of Cosmorhaphe (HÄNTZSCHEL, 1962, p. W189, fig. 118-3), which is a trace fossil found in flysch deposits, and also probably with trails of other kinds of marine animals (HÄNTZ-SCHEL, 1962). The trail-like markings or ones of similar morphology were not recognized in stratigraphically lower or higher horizons of the sandstone layers of the rather thick alternation of sandstone and siltstone beds. Thus it can

be said that the peculiar trail-like markings occupy only a particular horizon of the Hagino Formation, are restricted to only a small area of the sandstone layer, show variation in their shapes and small size, and resemble in their morphology two different things, e.g., casting and trail of marine animals. Having such peculiar characteristics they seem worthy of description and interpretation, and this is the purpose of the present article.

The sandstone layer preserving the trail-like markings as shown in the textfigure occupies the middle part of the Hagino Formation and is situated in a sandstone rich alternation of sandstone and siltstone superposed upon a granulepebble conglomerate with marine molluscan remains. The latter facies lie upon a mudstone rich alternation of mudstone and sandstone of the Senmi Formation. The sandstone layer in question exhibits current ripple-like structures with the trail-markings mostly

^{*} Received Sept. 13, 1970; read Sept. 13, 1970 at Tokyo.



Text-fig. 1. Columnar section of the Hagino Formation showing the stratigraphic horizon of the trail-like markings, and, position of the Hagino Formation in the sequence of formations distributed in the area.

occupying the troughs. The sandstone with the markings was collected by Mr. Michio KATO of our Institute during his field work in the summer of 1969, and to him we express our thanks.

Examination of the abundant trail-like markings gave the impression that all were originally filled and covered with mudstone or lutite, but later removed by either weathering or erosion or both agencies so that at present only variously curved shallow to rather deep grooves remain on the surface of the sandstone laver. The sandstone is medium grained, of muddy aspect, with current-like ripple structure on the surface, apparently non-fossiliferous, and only 15-25 mm thick, the former being measured at the troughs and the latter at the crests of the ripple-structures. Near the top of this rather thin sandstone layer is a discontinuous streak of lutite material megascopically the same as the underlying muddy layer forming a part of the beds of alternating sandstone (mudstone).

The trail-like markings are slightly to

rather strongly sigmoidal, some extending for a distance of about 30 mm in maximum, some for only about 10 mm, and others only a few millimeters in length, and range up to or a little more than 5 mm in maximum width. The majority of the trail-like markings are represented as grooves about several millimeters in depth. Some of the markings are continuous, others discontinuous, some ending in pitlike depressions, others merely horse-shoe shaped, bow shaped, pinched at extremities, and stretched and streaked-out, but in general all show some kind of curvature.

The markings are situated variously. The majority are found to occupy the troughs of the ripple-structures, some occur on the backs, all of the just mentioned are typically trail-like in plain-view as shown in the text-figure. On the other hand, the pit-like depressions occur where there is a break in the slope of the ripples, whether on back, in trough or on the front slope, and the size and depth of the grooves as well as shapes are various.



Text-fig. 2. Photograph of the trail-like markings on the rippled sandstone layer of the Hagino Formation. (Natural size)

The ripples appear as current ripples, having their backs dipping at about 16-18 degrees and their front side (foreslope) with angles of from 30 to 40 degrees, the crest-to-crest length is about 70-80 mm. Although the general measurements can be made there is considerable variation in the angles of both back and front slopes as well as in their wave-lengths. In lateral view, the sandstone layer exhibits the development of dark streaks, generally discontinuous, usually horizontal or parallel with the bedding of the underlying alternating layers of sandstone and siltstone (mudstone), sometimes broadly concave, at times lumpy, frequently flaring upwards as if making a multi-thrust structure, and some broad to narrowly convex.

When the dark streaks are broadly

concave their terminal parts may appear at the surface, one at the foot of the steep side of the ripple structure and the other at the foot of the low-angled backs in broad shallow synclinal form. The foot of the steep side of the ripples is generally marked by a streak(s) of the same kind of dark colored muddy material as mentioned already. The trail-like markings are found mostly in the troughs between the crests, on the low-angled back-slope and the pit-like depressions where there is a break in the slope of the ripples.

In some cases at the lower part of the gentle slopes bordering the troughs and steep slope of the preceding ripple there is developed a close assemblage of fine more or less continuous wrinkles arranged parallel to the troughs in general, and sometime at an angle. Although less distinct such wrinkles are also found in some cases at the foot of the steep slope and adjacent to the troughs, and in such case trail-like markings show close assemblage. Wrinkling though obscure can also be recognized on the backs of the ripples near to the crests.

The ripples are characteristic in resembling current-ripples, yet differing therefrom in that the general trend of the front or foreslope (steep sides slope) is varied, not parallel with one another, appearing as if linguloid in part, and some are developed at right angles to the adjacent one. some have a small crest in a shallow but broad trough, others a high crest as a normal currentripple, and in some cases it appears as if the crest were nothing but that of a small anticlinal structure because both sides have nearly the same slope angle.

From the features described above, the undermentioned interpretation may be given. After deposition of dirty sands there was deposited a laminae of lutitic material over which dirty sands were deposited rapidly. As the dirty sands were over-saturated or saturated with sea water they formed quick sand, and this was subject to gravitational movement resulting in flowage sand. By this flowage which had strong traction activity, the underlying laminae was, in part, pushed forwards, churned, incorporated into the moving quick sand as minute mud balls or particles, and folded-in the sand as detached laminae taking the form reflected by the gliding surface and non-uniform velocity of the moving sand, and various other kinds of forms. By being pushed forwards some of the laminae were forced to crumple, or wrinkle, overlap the preceding one and to take shapes according to the shape and velocity of the moving front and were forced up on the backs of the ripple structure in front. When the moving sand was slow wrinkles were developed at the foot of the ripple-slope in front. Since the flowage of the sand was not of the same velocity due to the friction of the underlying sediments and other reasons, the angle of the slope, and to the different load, the resulting ripple-like structure differed from that produced by water current, and was characterized by its irregular discon-After the variously tinuous shapes. shaped discontinuous wrinkles of muddy sediment consolidated the muddy parts were removed by weathering and erosion, resulting in the preservation of the trail-like structures sporadically distributed at random on the surface of the ripple-structure of flowage sand.

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Hagino 萩 野

Hatsuhiki 初 引

Senmi 千 見

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 83, pp. 166-178, pls. 19-21, September 20, 1971

585. ON SOME PATINOPECTEN FROM NORTH AMERICA*

KÔICHIRÔ MASUDA

Department of Geology, Miyagi University of Education, Sendai, Japan

北米産数種の Patinopecten について: 筆者は以前, 日本産のいわゆる Patinopecten について研究し, Patinopecten に属するものは現生・化石共に日本には存在しないことを明 らかにした (MASUDA, 1963)。その際、北米西海岸各地の新生界から報告された Patinopecten のすべての種が, 果して真の Patinopecten に属するものか否か疑問であると報告し た。

今回, 北米西海岸から報告された Patinopecten について検討した結果, メキシコ西海岸 の鮮新統から HANNA and HERTLEIN (1927) および DURHAM (1950) が記載した Patinopecten の三種, すなわち, P. bakeri, P. bakeri diazi および P. marguerensis は, Patinopecten とは全く別系統の Amussiopecten に近縁のものであることが明らかになった。

また、ワシントン州の Montesano Formation から ADDICOTT (1966) が報告した Patinopecten, n. sp. は、日本産のいわゆる Patinopecten に対して筆者が提唱した Mizuhopecten の新種であり、さらに MACNEIL (1967) が、カナダ西海岸の鮮新世と思われる地層 から記載した Patinopecten (Mizuhopecten) skonunensis は、Mizuhopecten ではなく Patinopecten そのものであることが明らかになった。

今回の研究によって、Patinopecten の地理的分布が、従来考えられていたよりもずっ と北にかたよっていたことが明らかになったので、暖流系の貝類その他の化石が、寒流系の Patinopecten と共存していることの解釈についての従来の議論に終止符が打たれた。さらに、 鮮新世初期には、東アジアから移動した Mizuhopecten, Swiftopecten その他が、北米西海 岸北部に分布していたことが確認された。従って、本研究の結果は、北太平洋地域における 新第三系の対比、古動物地理区の変遷、古地理の解釈などの上に重要な意義を持っている。 増田孝一郎

Introduction

The genus *Patinopecten* is one of the most interesting among the Cenozoic Pectinidae of North America, because it is abundant in species and individuals, is restricted in its distribution to the eastern North Pacific Ocean, and shows a wide range of morphological characters. Also, it has a rather restricted geologic range.

Patinopecten was established by DALL in 1898 as a section of the genus Pecten

based upon Pecten caurinus GOULD, a: common Recent scallop of the eastern North Pacific. Thenceforth, Patinopecten has frequently been described from the Recent seas of North Pacific, Tertiary and Quaternary formations in the West Coast of North America, Japan, Sakhalin and Kamchatka. In 1961 MACNEIL proposed the new subgenus Lituyapecten based upon Patinopecten (Lituyapecten) lituyaensis MACNEIL from the Late Miocene (?) or Early Pliocene of Alaska. On the other hand, from a study of the so-called Patinopecten of Japan the writer (MASUDA, 1963) pointed out that every species of the so-called Patinopecten.

^{*} Received Sept. 22, 1970; read Sept. 13, 1970 at Tokyo.

ranging from the Late Oligocene to Recent in Japan differs from the true Patinopecten of North America, and he proposed a new genus Mizuhopecten for most of the species of the so-called Patinopecten of Japan, based upon Pecten yessoensis JAY, a common Recent scallop in Northern Japan. Moreover, the writer pointed out that it is open to question whether all species described under the genus or subgenus Patinopecten or referred to Patinopecten on the West Coast of North America can be referred to the true Patinopecten or Lituyapecten.

The writer studied numerous specimens of Recent and fossil species of *Patinopecten* from the West Coast of North America in connection with the above mentioned problems. The specimens studied are preserved in the Department of Geology, Stanford University, Department of Paleontology, University of California in Berkeley, California Academy of Sciences in San Francisco, Division of Mollusks, Smithsonian Institution in Washington, D. C., U. S. Geological Survey in Menlo Park and American Museum of Natural History in New York.

The results of examination of those specimens lead the writer to consider that among the species of Patinopecten in North America, Pecten (Patinopecten) bakeri HANNA and HERTLEIN (1927), Patinopecten bakeri diazi DURHAM (1950), and Patinopecten marquerensis DURHAM (1950) can not be referred to the genus Patinopecten. Therefore, these species described from the Pliocene formations in Baja California, Mexico are in need of a new classification. Moreover, it became evident that Patinopecten (Mizuhopecten) skonunensis MACNEIL (1967) can not be referred to Mizuhopecten; but Patinopecten n. sp., illustrated by ADDICOTT (1966), from the Montesano

Formation in Washington represents a new species of *Mizuhopecten*.

In the present article the discussions on classification, descriptions and remarks on the above mentioned species are given and also general considerations concerning the systematics and occurrences of the genus *Patinopecten*.

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Notes on Patinopecten

DALL (1898, p. 695) gave the following diagnosis of the section Patinopecten of the genus Pecten: "Valves with small ribs, flat on the right valve and sometimes dichotomous; smaller and more rounded on the left valve; concentric sculpture inconspicuous; radial striae absent or obsolete; ears subequal; valves nearly equilateral". Subsequently, many species were described from the Tertiary and Quaternary formations in the North America, Japan, Sakhalin and Kamchatka. ARNOLD (1906) and GRANT and GALE (1931) used Patinopecten as a subgenus of genus Pecten. GRANT and GALE (1931, p. 192) gave the following diagnosis for Patinopecten: "Shell large, thin, sometimes of a somewhat pearly texture, having a circular outline and very low convexity, valves usually equal, although at times one or the other may become nearly flat; radial sculpture consisting of distinct ribs without minor striation. sometimes with microscopic cross-hatching, ribs of the right valve comparatively broad and squarish, sometimes with a medial sulcus, those of the left valve narrow, often sharp, with intercalaries if the ribs of the right valve are sulcated; hinge line usually short, ears of almost equal length, byssal notch deep in the older species, more shallow in Recent species". However, they did not state any morphological characteristics of the interior surface.

In 1950 DURHAM raised *Patinopecten* to the generic ranking, as do most recent authors, and described two species and one subspecies of *Patinopecten* from the

Pliocene formations in Baja California, Mexico. Subsequently, MACNEIL (1961) described several Tertiary pectinids from Alaska and other northern regions of the West Coast of North America and he raised *Patinopecten* to generic rank as DURHAM had done, and established *Lituyapecten* as a subgenus of *Patinopecten*.

Later, the writer (MASUDA, 1963) discussed the so-called Patinopecten of Japan and pointed out that all species of Patinopecten in Japan ranging from Oligocene to Recent can not be referred to the true Patinopecten on the West Coast of North America but should be referred to the other genera including some new genera. And he proposed a new classification for the so-called Patinopecten in Japan. A single Pliocene species, Pecten tokunagai YOKOYAMA, was made the type species of a new genus Yabepecten and was grouped with the true Patinopecten and Lituyapecten on the West Coast of North America. At that time, based upon the true Patinopecten in North America, he added the following morphological features to the descriptions by DALL (1898) and GRANT and GALE (1931): "Rather thick, conspicuous auricular crura along inner margin of auricles with a conspicuous, rounded, oblong distal denticle at extremity of posterior part, that at anterior part extends ventrally and terminates distally in an oblong, rather obscure denticle in right valve; left. valve with distal denticle at each extremity of hinge more conspicuous than that of right valve". Lately MACNEIL (1967) used Mizuhopecten which was established by the writer (MASUDA, 1963, p. 151) based upon Pecten yessoensis JAY, a common Recent scallop in Northern Japan, for many Japanese species formerly treated as Patinopecten, as a subgenus of Patinopecten.

Systematic Descriptions and Discussions

Family Pectinidae

Subfamily Pectininae

Genus Patinopecten DALL, 1898

Patinopecten DALL, 1898, p. 695.

Type-species (Original designation):-Pecten caurinus GOULD, 1850. Recent, Puget Sound, Washington, U. S. A.

Geological and geographical distribution:-Late Middle Miocene to Recent. Alaska to California.

Remarks:—Patinopecten can be distinguished from Mizuhopecten (so-called Patinopecten in Japan) by its smaller auricles of which the anterior auricle of the right valve has a deep byssal notch, by the much smaller posterior auricle in comparison to the anterior one on the left valve; depressed right valve; rather squarish radial ribs which are narrower or nearly equal to their interspaces on the right valve and distinct, oblong auricular crura which are quite distinct in the younger stage but tend to become obscure with growth (Text-figs. 1-2).

Patinopecten (Patinopecten) skonunensis MACNEIL, 1967

 1967. Patinopecten (Mizuhopecten) skonunensis MACNEIL, U.S. Geol. Surv., Prof. Paper 553, p. 42, pl. 4, fig. 2, pl. 6, fig. 7.

Holotype:--Univ. Calif. Los Angeles, No. 39474.

Remarks:—This species was described by MACNEIL based upon an incomplete right valve. However, it has auricular crura which are considered to be a very important shell character of *Patinopecten* (MASUDA, 1963). This species can not be referred to *Mizuhopecten*.

Type locality:—Skonun Point, about 5 miles east of Masset on the north coast



Text-fig. 1. Graph showing the relationship between the height and hinge length of shell.



Text-fig. 2. Graph showing the relationship between the height and depth of right valve.

of Graham Island, Queen Charlotte Is; lands, British Columbia, Canada. Skonun Formation. Late Miocene (?) or Early Pliocene.

Subfamily Fortipectininae

Genus Mizuhopecten MASUDA, 1963

Mizuhopecten MASUDA, 1963, p. 151. Type-species (Original designation):— Pecten yessoensis JAY, 1857. Recent, Northern Japan.

Geological and geographical distribution:-Late Oligocene to Recent. Japan to West Coast of North America.

Mizuhopecten warreni MASUDA, n. sp.

Pl. 19, figs. 1-3, Pl. 21, fig. 3

1966. Patinopecten n. sp., ADDICOTT, Jour. Paleont., Vol. 40, no. 3, p. 644, pl, 76, fig. 8.

Holotype:—U.S. Natl. Mus., no. 646491.

Description:—Shell medium in size and thickness, smooth, compressed, orbicular in outline, equilateral except for auricles, subequivalve; valves radiately ribbed and forming an angle of about 110° at apex.

Right valve with about 20 flattish, round-topped radial ribs and fine concentric incremental lines; radial ribs rather low, rounded, broader than their interspaces, rarely bifurcate towards ventral margin; auricles medium in size, subequal, anterior one with wide and shallow byssal notch, a few faint, fine radial threads and fine concentric lines; posterior one truncated behind forming an obtuse angle and with concentric lines; interior surface rather smooth but slightly folded corresponding to external sculpture. Left valve with low, rounded, fine radial ribs, fine intercalary threads, fine concentric lines and rather obscure fine network; intercalary threads usually appear at middle of shell length and tend to become somewhat distinct towards ventral margin; radial ribs much narrower than their interspaces. Hinge with simple, fine cardinal crura but without auricular crura.

Dimensions (in mm):-

Valve	R*	R	R	R	R-L	L	L
Height	1.00	90	65		74	85	65
Length	100		65	110		85	65
Depth	10	10	5	12	14**	7	5

*-holotype, **-thickness

Remarks:—This species is named in honor of Dr. Warren O. ADDICOTT of the U. S. Geological Survey.

From the above mentioned morphological characteristics it is evident that this species should be assigned to the genus *Mizuhopecten*. It can be distinguished from *Mizuhopecten yessoensis* (JAY) by its small size, lack of radial threads on the auricles and the presence of intercalary threads in the interspaces between the radial ribs.

Type locality:—U. S. Geol. Surv., Loc. No. M2978. West Fork of Wishkah River, Grays Harbor County, Washington. Montesano Formation. Early Pliocene.

Associated fauna:—Yabepecten condoni (HERTLEIN).

Subfamily Amusiinae

Genus Leopecten MASUDA, n. gen.

Type-species:—Pecten (Patinopecten) bakeri HANNA and HERTLEIN, 1927. Pliocene. Baja California, Mexico.

Geological and geographical distribution:—Early Pliocene to Late Pliocene. Baja California, Mexico.

Diagnosis :-- Shell large, gently inflat-

ed, of medium thickness, longer than high, equilateral, subequivalve, right valve a little more inflated than left valve which is nearly flat in younger stage but tends to become inflated with growth; right valve with distinct, perpendicular sided, flatly round-topped radial ribs which are sculptured with sometimes faint, fine radial threads, fine intercalary threads and fine, rugose incremental lines; left valve with distinct but low, narrow radial ribs usually sculptured with a few faint, fine radial threads, a few fine intercalary threads, and raised, regularly spaced, rugose, fine incremental lines; auricles large; right anterior auricle angulated at end, with very wide and shallow byssal notch; hinge with very simple, low, fine cardinal crura with fine provinculum and wide and shallow resilial pit; auricular crura well developed, terminating distally in a distinct oblong denticle at each extremity; interior surface with distinct paired internal ribs at lower part.

Remarks:—The present new genus is named in honor of Dr. Leo G. HERTLEIN of the California Academy of Sciences.

The present genus resembles Patinopecten externally but Patinopecten lacks paired internal ribs and has a well developed byssal notch below the right anterior auricle. Amussiopecten (SACCO, 1897, p. 55) is closely related to the present genus but it is distinguishable from *Leopecten* by its radial ribs which tend to become obsolete towards the ventral and lateral margins, lack of radial threads on the surface of the radial ribs and no intercalary threads in the interspaces between the radial ribs. The morphological characteristics of these two genera are somewhat similar to each other in their younger stages but the surface sculpture in the adult stage is quite different. That is to say,

it seems that the general morphologic characters in the younger stage of *Amussiopecten* are retained in the adult stage in *Leopecten*. Therefore, it is inferred that *Leopecten* may have descended from *Amussiopecten* before the Early Pliocene, but no intermediate form is known between the two.

Flabellipecten (SACCO, 1897, p. 55) is distinguishable from the present one by its rather more inflated right valve, plano-convex left valve, rather small auricles and more distinct and complicated cardinal crura.

Considered from the standpoint of the associated fauna, it appears that *Leopecten* might have been a tropical or subtropical inhabitant as was *Amussiopecten*.

This new genus includes the following species: Pecten (Patinopecten) bakeri HANNA and HERTLEIN, 1927, Patinopecten bakeri diazi DURHAM, 1950 and Patinopecten marquerensis DURHAM, 1950.

Leopecten bakeri (HANNA and HERTLEIN, 1927)

Pl. 20, figs. 1, 2

- 1927. Pecten (Patinopecten) bakeri HANNA and HERTLEIN, Proc. Calif. Acad. Sci., Ser. 4, Vol. 16, p. 153, pl. 5, fig. 1.
- 1931. Pecten (Janira) stearnsii var. bakeri HANNA and HERTLEIN, GRANT and GALE (in part), Mem. San Diego Mus. Nat. Hist., Vol. 1, p. 224 (not pl. 4, figs. 1a, 1b).
- 1950. Patinopecten bakeri (HANNA and HERT-LEIN), DURHAM, Mem. Geol. Soc. Amer., 43, p. 66, pl. 12, fig. 1, pl. 13, fig. 7.

Holotype:—Calif. Acad. Sci., No. 1865. Remarks:—As this species was first described by HANNA and HERTLEIN (1927) based upon two left valves, the characteristics of its right valve were unknown. In 1931 GRANT and GALE included this species as a variety of *Pecten* (*Janira*) stearnsii DALL. They believed that *Pecten* (*Pecten*) bösei HANNA and HERTLEIN, described at the same time with bakeri, should be considered to be a young form of *P. bakeri*.

According to the writer's examination of type specimens the following features must be added; Shell large, longer than high, equilateral, nearly equivalve but right valve a little more convex than left; surface with distinct radial ribs and raised, regularly spaced, distinct incremental lines; right valve with about 23 rather low, flat-topped, square sided radial ribs which are broader than their interspaces and with a few faint, fine radial threads on their surface near ventral margin; radial threads on surface of radial ribs appear at about middle part of shell and tend to become somewhat distinct towards ventral margin ; interspaces between radial ribs with an intercalary thread, appearing at about middle part of disc and tending to become distinct towards ventral margin, also with secondary intercalary threads near ventral margin; auricles rather large, with a very shallow byssal notch below anterior one, provided with rather distinct concentric lines and rarely with a few faint, fine radial threads; interior surface provided with paired internal ribs that are distinct near ventral margin; hinge with very low, simple, fine cardinal crura, wide and shallow resilial pit with very fine, flat, internal ridges which diverge downward, and auricular crura which terminate distally in a distinct, oblong denticle at each extremity.

This species was first described in the subgenus *Patinopecten* and later raised by DURHAM (1950) to generic rank. Externally the present species somewhat resembles *Patinopecten*, but that genus lacks the paired internal ribs and has rather small auricles with a deep byssal notch below the right anterior auricle and rather weak auricular crura: actually it is quite distinct.

GRANT and GALE (1931) considered Pecten (Janira) bösei HANNA and HERT-LEIN (1927) to be a young form of P. bakeri as mentioned earlier, but P. bösei differs from P. bakeri in the smaller inequivalved shell, more inflated right valve, plano-convex left valve which is a little inflated at a very young stage but tends to become flat or concave with growth and then a little inflated downward, and sculptured with low radial ribs.

Dimensions (in mm):—

Valve	L*	R-L	R-L	R	L
Height	135	1.40	131	94	133
Length	1.50	1.68	155	99	147
Depth	ca. 12	ca. 27**	23**		

*-holotype, **-thickness

Type locality:—"Cuesta Blanca" in Arroyo de Arce, 15 miles north of Loreto, Baja California, Mexico. San Marcos Formation. Early Pliocene.

Distribution :- Baja California, Mexico.

Leopecten bakeri diazi (DURHAM, 1950)

Pl. 20, figs. 3, 4

- 1931. Pecten (Janira) stearnsii DALL, var. bakeri HANNA and HERTLEIN, GRANT and GALE (in part), Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 224, pl. 4, figs. 1a, 1b.
- 1950. Patinopecten bakeri diazi DURHAM, Mem. Geol. Soc. Amer., 43, p. 66, pl. 12, figs. 2, pl. 13, fig. 4.

Holotype:--Mus. Paleont. Univ. Calif. Berkeley, No. 15968.

Remarks:—This subspecies is characterized by its large, compressed, subequivalved shell which is longer than high, right valve with squarish, distinct radial ribs with very faint, fine threads on surface of radial ribs near ventral and lateral margins, an intercalary thread between radial ribs in adult specimens, and raised, rugose, regularly spaced incremental lines; somewhat angulated auricles with a wide, shallow byssal notch below anterior auricle. It is sculptured with fine concentric lines and several faint, fine radial threads; the left valve having somewhat square sided radial ribs in younger stage, with three fine radial threads, and an intercalary thread in interspaces between radial ribs, crossed by raised, rugose, regularly spaced, fine incremental lines; simple cardinal crura; shallow resilial pit; and paired internal ribs and distinct auricular crura which terminate distally in an oblong denticle at each extremity.

Leopecten bakeri (HANNA and HERT-LEIN) differs from the present subspecies in having the right valve with many fine radial threads at lateral margins and the left valve with perpendicular sided major radial ribs, distinct radial threads on surface of radial ribs and tertiary intercalary threads in interspaces between radial ribs.

Dimensions (in mm):-

Valve	R-L*	R-L	R-L	R-L	R	L
Height	137	132	125	54	96	1.06
Length	154	1.60	145	63	105	120
Thickne	ss 19	23	18	12	14**	13**

*-holotype, **-depth

Type locality:--Mus. Paleont. Univ. Calif. Berkeley, Loc. No. A3566. East side of Monserrate Island, Baja California, Mexico. Carmen Formation. Middle Pliocene.

Distribution:--Monserrate Island; Salinas Bay, Carmen Island; Oto Bay, Carmen Island; Baja California, Mexico. Leopecten marquerensis (DURHAM, 1950)

Pl. 21, figs. 1, 2

1950. Patinopecten marquerensis DURHAM, Mem. Geol. Soc. Amer., 43, p. 67, pl. 14, figs. 1, 2.

Holotpye:--Mus. Paleont. Univ. Calif. Berkeley, No. 15475.

Remarks:—This species is characterized by its subequivalved shell. in which the right valve is a little more inflated than the left valve; with a very wide and shallow byssal notch below the right anterior auricle; several fine radial threads on the auricles of the left valve but those of the right valve with only concentric lines; radial ribs on right valve without radial threads on their surface.

This species differs from the other species of *Leopecten* in having no radial threads on the surface of the radial ribs and in the interspaces between the radial ribs of the right valve.

The external features of this species somewhat resemble those of *Pecten solarioides* HEILPRIN (1887) from the Pliocene Caloosahatchie Formation of Florida and also those of *Chlamys planicosta* GARD-NER (1943) from the Miocene Yorktown Formation of North Carolina, but those species from the Atlantic Coast differ from the present one in having both valves greatly inflated, more distinct radial ribs, characteristic rugose incremental lines, larger auricles, very complicated cardinal crura, greatly projected resilial pit, and deep notch under the resilial pit.

Dimensions (in mm) :---

Valve	R-L*	R	R	R	L	L
Height	158	160	150	136	152	126
Length	176	177	175	140	174	140
Depth	28**	15	17	11		10

*--holotype, **--thickness

Type locality:--Mus. Paleont. Univ. Calif. Berkeley, Loc. No. A3518. Marquer Bay, Carmen Island, Baja California, Mexico. Marquer Formation. Late Pliocene.

Distribution :- Baja California, Mexico.

Remarks on *Patinopecten* from North America

In North America the following species or subspecies have hitherto been described in the genus or subgenus *Patinopecten* or referred to *Patinopecten* by subsequent authors as indicated by a parenthesis.

- 1. Pecten (Patinopecten) propatulus CONRAD, 1849 (DALL, 1898)
- 2. Pecten (Patinopecten) caurinus GOULD, 1850 (DALL, 1898)
- 3. Pecten (Patinopecten) meekii CONRAD, 1857 (DALL, 1898)
- 4. Pecten (Patinopecten) coosensis SHUMARD, 1858 (DALL, 1898)
- 5. Pecten (Patinopecten) expansus DALL, 1898
- 6. Pecten (Patinopecten) dilleri DALL, 1901 (ARNOLD, 1906)
- 7. Pecten (Patinopecten) oweni ARNOLD, 1906
- 8. Pecten (Patinopecten) healeyi ARNOLD, 1906

- 9. Pecten (Patinopecten) purisimaensis ARNOLD, 1906
- 10. Pecten (Patinopecten) turneri ARNOLD, 1906
- 11. Pecten (Patinopecten) weaveri CLARK, 1915
- 12. Pecten (Patinopecten) rhytidus DALL, 1921
- 13. Pecten (Patinopecten) oregonensis HOWE, 1922 (SLODKEWITSCH, 1934)
- 14. Pecten (Patinopecten) kernensis HERTLEIN, 1925
- 15. Pecten (Patinopecten) bakeri HANNA and HERTLEIN, 1927
- 16. Pecten (Patinopecten) lohri HERTLEIN, 1928
- 17. Pecten (Patinopecten) yakatagensis CLARK, 1932
- Patinopecten bakeri diazi DURHAM, 1950
- 19. Patinopecten marquerensis DURHAM, 1950
- 20. Pecten (Patinopecten) haywardensis LUTZ, 1951
- 21. Pecten (Patinopecten) haywardensis calaverasensis HALL, 1958
- 22. Patinopecten (Lituyapecten) poulcreekensis MACNEIL, 1961
- 23. Patinopecten (Lituyapecten) lituyaensis MACNEIL, 1961
- 24. Patinopecten (Lituyapecten) falorensis MACNEIL, 1961

Explanation of Plate 19

(Natural size)

Mizuhopecten warreni MASUDA, n. sp.

- Fig. 1. Right valve. Holotype, U.S. Natl. Mus., No. 646491. Loc.: U.S. Geol. Surv., M2978. West Fork of the Wishkah River, Grays Harbor County, Washington. Montesano Formation. Early Pliocene.
- Figs. 2a-b. a, Right valve. b, Left valve. Paratype, U.S. Natl. Mus., No. 646492. Loc.: U.S. Geol. Surv., Loc. No. M2987. Same as above.
- Fig. 3. Right valve. Paratype, U.S. Natl. Mus., No. 646493. Loc.: U.S. Geol. Surv., Loc. No. M3038. Same as above.

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Patinopecten, n. sp. ADDICOTT, 1966 Patinopecten (Mizuhopecten) skonunensis MACNEIL, 1967

Among the species or subspecies listed above, the names Pecten expansus DALL and Pecten oweni ARNOLD are invalid because these specific names were preoccupied. Therefore, Pecten expansus DALL was renamed by ARNOLD as Pecten (Patinopecten) healeyi in 1906 and Pecten oweni ARNOLD as Pecten (Patinopecten) lohri by HERTLEIN (1928). Pecten rhytidus DALL described from Alaska represents a left valve of Fortipecten hallae (DALL) as already pointed by MACNEIL (1943). Moreover, as stated above, it is evident that Patinopecten bakeri, Patinopecten bakeri diazi and Patinopecten marquerensis can not be referred to the genus Patinopecten. Patinopecten n. sp. (ADDI-COTT, 1966) should be referred to the genus Mizuhopecten, and Patinopecten skonunensis can not be.

From the above mentioned it is to be noted that the occurrence of the genus Mizuhopecten from the Montesano Formation on the West Coast of North America in association with Yabepecten condoni (HERTLEIN) (MASUDA and ADDI-COTT, 1970) is very significant for the interpretation of paleozoogeography of the Northern Pacific during the Late Tertiary. The genus Yabepecten is known from the Early Pliocene formations distributed in the Japan Sea Borderland (MASUDA, 1962b) and considered to be a cool to cold water inhabitant. On the other hand, Mizuhopecten is known from Late Oligocene to Recent in Japan (MASUDA, 1963) and from paleontological data it is believed that Mizuhopecten might have been originally a warm water inhibitant in Late Oligocene to Early Miocene time. The changes in the marine environmental conditions from the Late Oligocene to Recent probably have greatly influenced the biological conditions of the marine fauna, but *Mizuhopecten* has become adapted to different environmental conditions. Therefore, it is inferred that *Mizuhopecten warreni* branched off from the *Mizuhopecten stock* as a result of its eastward migration from the East Asia to the West Coast of North America followed by localization and adaptation in the Early Pliocene.

As a result of gradual changing of environmental conditions from Tertiary to Recent it is considered that only Mizuhopecten yessoensis (JAY), which may have acquired its stasigenesis (stability as a species) in the Early Pliocene, could servive to the Recent but the other species became extinct. Similarly, the genus Patinopecten on the West Coast of North America should have been influenced by the changes of the marine environmental conditions from the Late Miocene to Recent and only Patinopecten caurinus (GOULD) which first appeared in the Early Pliocene formations in the northern part of the West Coast of North America survived to the Recent but the other species became extinct at the end of Tertiary. These changes in the environmental conditions from the Tertiary to Recent in the West Coast of North America (DURHAM, 1950b) coincide well with those in the Japanese Islands (MASUDA, 1962b).

Therefore, the occurrences of the Japanese pectinid genera such as Yabepecten (MASUDA and ADDICOTT, 1970), Fortipecten (MACNEIL, 1943), Swiftopecten (MASUDA, 1959) or Mizuhopecten in the Pliocene formations of the northern part of the West Coast of North America are very significant for circum-Pacific correlation of the Neogene formations and for the interpretation of paleozoogeography in the North Pacific.

From the Pliocene formations developed on the North Sakhalin and Kamchatka Peninsula, SLODKEWITSCH (1934, 1938), ILYINA (1963) and KRISHTOFOVICH (1964) described some species of Patinopecten, but judging from the descriptions and the figures their species of Patinopecten almost all should be allocated to the genus Mizuhopecten but some of them should be referred to the genus Fortipecten. Therefore, it is evident that the true Patinopecten does not occur in Sakhalin or in Kamchatka or in the Japanese Islands.

The appearance of *Leopecten* in Early Pliocene formations in Baja California is very interesting and may be of considerable significance for the interpretation of the paleogeography of Central America and North America. Because Leopecten is known only from the Pliocene formations in the southern part of the West Coast of North America and not known from the Pliocene formations in the East Coast of North America, it can be inferred that the phylogenetic changes from Amussiopecten to Leopecten were related to the changes of oceanographic conditions. That is to say, it is thought that the Pacific and Atlantic Oceans must have been separated by the land bridge connecting North America and South America at least in the very Late Miocene to Early Pliocene (WOOD-RING, 1966). This is also supported by the study of DURHAM (1961).

In 1942 HAAS reported the occurrence of *Patinopecten propatulus* (CONRAD) (?) from the Middle Miocene formation in Costa Rica, but such assignment is very questionable, because *Patinopecten* is restricted in its distribution to the central and northern part of the West Coast and its geological range is restricted to the Late Miocene to Recent.

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Explanation of Plate 20

(All figures $\times 1/2$)

- Figs. 1, 2. Leopecten bakeri (HANNA and HERTLEIN). 1, Right valve. Topotype, Mus. Paleont. Univ. Calif. Berkeley, No. 30053. 2, Left valve. Holotype, Calif. Acad. Sci., No. 1865. Loc.: Calif. Acad. Sci., Loc. No. 794. "Cuesta Blanca" in Arroyo de Arce, 15 miles north of Loreto, Baja California, Mexico. San Marcos Formation. Early Pliocene.
- Figs. 3, 4. Leopecten bakeri diazi (DURHAM). 3, Right valve. Paratype, Mus. Paleont. Univ. Calif. Berkeley, No. 15969. 4, Left valve. Holotype, Mus. Paleont. Univ. Calif. Berkeley, No. 15968. Loc.: Mus. Paleont. Univ. Calif. Berkeley, Loc. No. A3566. East side of Monserrate Island, Baja California, Mexico. Carmen Formation. Middle Pliocene.



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Explanation of Plate 21

- Figs. 1, 2. Leopecten marquerensis (DURHAM). ×1/2. 1, Right valve. Holotype, Mus. Paleont. Univ. Calif. Berkeley, No. 15475. 2, Left valve. Paratype, Mus. Paleont. Univ. Calif. Berkeley, No. 15462. Loc.: Mus. Paleont. Univ. Calif. Berkeley, Loc. No. A3518. Marquer Bay, Carmen Island, Baja California, Mexico. Marquer Formation. Late Pliocene.
- Fig. 3. Mizuhopecten warreni MASUDA, n. sp. ×1. Right valve. Paratype, U.S. Natl. Mus., No. 646494. Loc.: U.S. Geol. Surv., Loc. No. M2978. West Fork of the Wishkah River, Grays Harbor County, Washington. Montesano Formation. Early Pliocene.

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例会通知

	開	化	崔	地	開	催	日	言共	演	申	込	締	切	日
108回例 会	九	州	大	学	1971	年10月22	-24日	19	71	年	6	月	10	日
1972年 総会·年会	千	葉	大	学	1972	年1月一	下旬	19	71	年	12	月	10	日
109回例会	宇都	。宮大	学(子	·定)	1972	年6月一	下旬	19	72	年	5	月	20	月

○ 108回例会(九州大学)は日本地質学会ほか3学会と共催。本会に関連あるシンポジウムとしては、「九 州周辺海域の地質学的諸問題」(世話人・奈須紀幸,鹿間時夫,星野通平,水野篤行,鎌田泰彦,加賀 美英雄,小西健二,高橋良平,首藤次男)が予定されている。

お知らせ

本学会内の「化石硬組織同位体」研究グループの第3回研究発表会が11月5日(金)と6日(土)の両日, 東京都中野区南台1-15-1・東大・海洋研究所で開催されます。

学会記事

◎ 1971年6月28日の評議員会で、次の4名の諸君の入会が認められた。(順不同・敬称略) 西宮克彦,字野博子,横川 巌,斉藤 豊。

◎ 同上評議員会において,次の諸君の退会が認められた。 青木 滋,原田幹彦,市川健雄,井上英二,井上寛生,牧野 融,榊原信夫,佐々保雄,清水 勇,田 中 収,山崎 裕, C.R. Jones。

News

- ◎ 本会在外会員 R.W. CHANEY 君は 1971年3月3日に逝去された。
- ◎ 本会名誉会員 遠藤誠道君は, 1971年9月6日に逝去された。
- ◎ 西独の名高い古生物学者 O.H. SCHINDEWOLF 教授が1971年6月10日に逝去された旨,本会宛通知があった。

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