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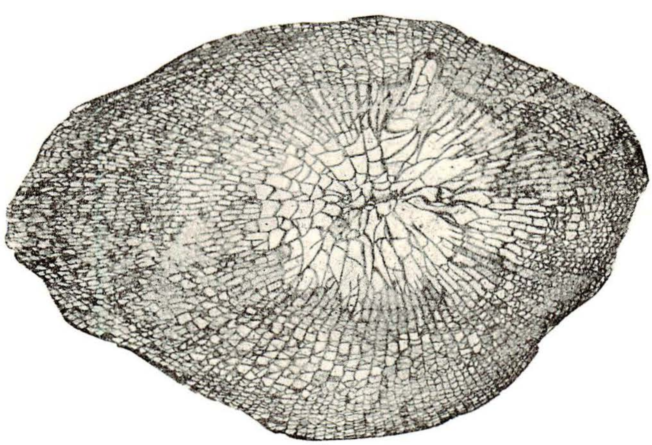

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540. ON THE *TAENIOPTERIS* FROM THE TOGADANI FLORA (TEDORIAN), AT TOGADANI, ISHIKAWA PREFECTURE CENTRAL JAPAN*

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鴇ヶ谷植物群（手取統（テドリアン））に産出した *Taeniopteris* について：石川県手取川（テドリガワ）流域の手取統岩層群を研究中の大村が1965年夏，石川県尾口村鴇ヶ谷地区で採集した *Taeniopteris* 2種を報告する。その中の *T. vittata* は本邦の Jurasso-Cretaceous 岩層には最初の産出である。この種に関連して，手取統の小史を述べてみたが，従来の手取統即上部ジュラ系の観念は陰をひそめなければならないと思う。

また，従来の手取植物群の産出岩層である手取川流域の桑島累層に，各々の構成種としては大差を認めることは出来ないが，下位より鴇ヶ谷，加賀，紅滝の三植物群を認める事が出来た。

松 尾 秀 邦・大 村 一 夫

Introduction

One of these writers, K. ÔMURA, has been engaged in the study of the Tedori** Series (Tedorian) of the upper reaches of the Tedori-gawa, Inner side of Central Japan. In the summer of 1965, he discovered two species of *Taeniopteris* at Togadani. One of them is *T. emarginata* ÔISHI which was described by S. ÔISHI in 1940 as a new species of the upper Jurassic at Kuwajima. The other is *T. vittata* BRONGNIART which has been abundantly found in the Jurassic beds of the Northern Hemisphere.

The former species very closely resemble *Nilssoniopteris ovalis* SAMYLINA which was established by V.A. SAMYLINA in the material from the lower Cretaceous deposits in Siberia (1963; 89-90, XIX, fig. 5). It is very closely similar to *T. rhitidorachis* KRYSHTOFOVICH from the lower Cretaceous bed at the Aldan River locality in 1963 (SAMYLINA: 93-94, XXII, figs. 3 and 4).

Thus, the Tedori Group (syn. Itoshiro Group), by including these species, has a reason to be believed that it occupies an age between Jurassic and Cretaceous although it has been regarded customarily to represent the upper Jurassic age.

The writers wish to express their sincere thanks to Dr. I. HAYASAKA for his kind criticism and reading the manuscripts.

* Received Sept. 2, 1967; read Jan. 25, 1966 at Sendai.

** The Tedori-gawa is the traditional local pronunciation, from which different geographical and geological names have been derived. But in early scientific writings the phonetically flat *d* seems to have been replaced by *t*, which measure has been in use ever since among the people who are not particularly concerned themselves about the traditions.

Geological Notes

These two *Taeniopteris* species were collected by K. ÔMURA from the lower part of the Kuwajima formation of the Tedori Group at Togadani locality; this Group has long been known as a member of the "Tetori Group" of the "Tetori Series" and considered to be the sedimentary facies of the upper Jurassic in the Inner side of Central Japan.

According to the present knowledge, the "Tetori Series" belongs to the Jurasso-Cretaceous age.

Before entering into the text of our study, the writers try a brief historical sketch on the "Tetori Series".

a) *A Short History of the Tedori Series*

H. Th. GEYLER (1877) described twelve species and four varieties from the Kuwajima locality, where J. J. REIN in 1875 discovered abundant fossils. Dr. GEYLER considered these plant fossils to be compared with the middle Jurassic in Siberia.

At the Kuwajima locality, B. KOTÔ (1880) collected some plant fossils, and these species were examined by Dr. D. BRAUNS, professor of the Tokyo Imperial University in 1879–1882; they were found to contain *Podojamites*, *Asplenium argutum* HEER, *Thyrsopteris elongata* GEYLER, *Adiantites*, *Taeniopteris solitaria* PHILLIPS (*Scolopendriites solitarius*) and *Ginkgo sibirica* HEER (after M. YOKOYAMA in 1889). Among those species,

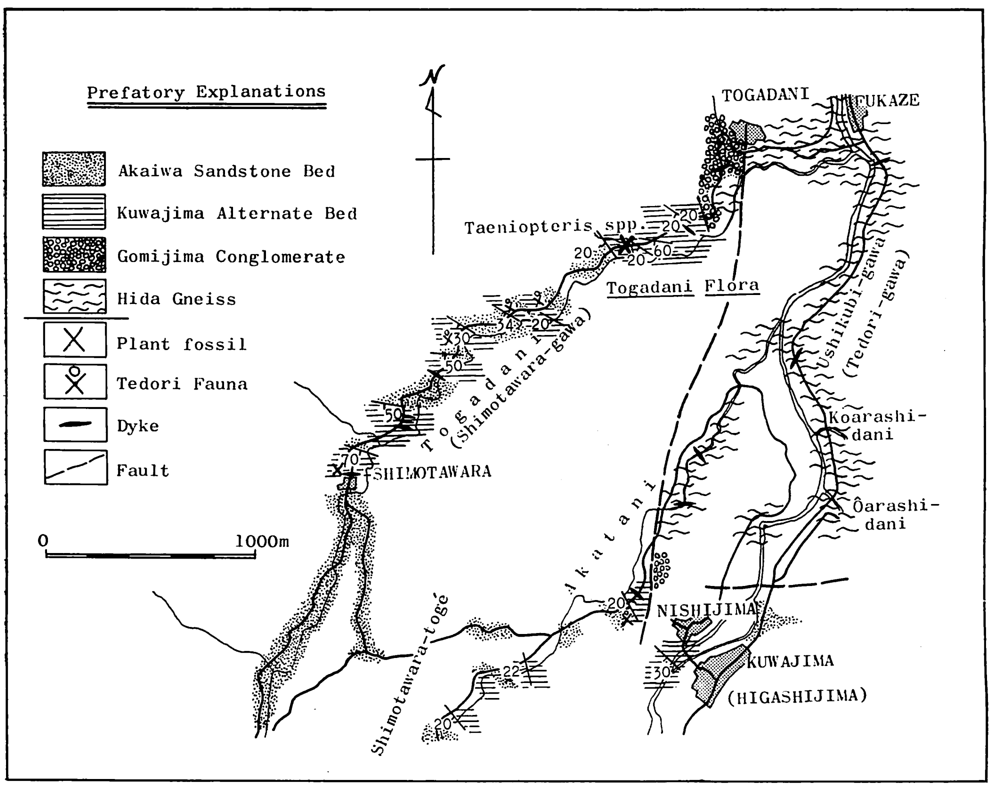

Fig. 1. Route-map of the Togadani, upper reaches of the Tedori-gawa, Central Japan. (Topographical map "1/50,000: Shiramine") (ÔMURA, K.: 1964)

Taeniopteris species was revised by M. YOKOYAMA (1889), and was proved to be a new species *Nilssonia ozoana*.

YOKOYAMA (1889) described 49 species from the following sorces; collections of B. KOTÔ (at Kuwajima, Yanagidani and Ozô, in the upper reacnes of the Tedori-gawa), and of T. KOCHIBE (at Hakogase in the upper reaches of Kuzuryû-gawa; at Tani, in the outskirts of Katsuyama City; at Okamigô and Ushimaru, in the upper reaches of Shô-gawa). Having studied on the collections of the Outer side of Southwest Japan, Dr. YOKOYAMA established the "Tetori Series" as follows (1894; 212):

"—For convenience sake I propose the name of Ryôseki Series for all those strata containing Younger Mesozoic plants in distinction to those containing Middle Jurassic ones. For the latter I also suggest the name Tetori Series, from the valley of the river Tetori in Kaga, where they were first discovered".

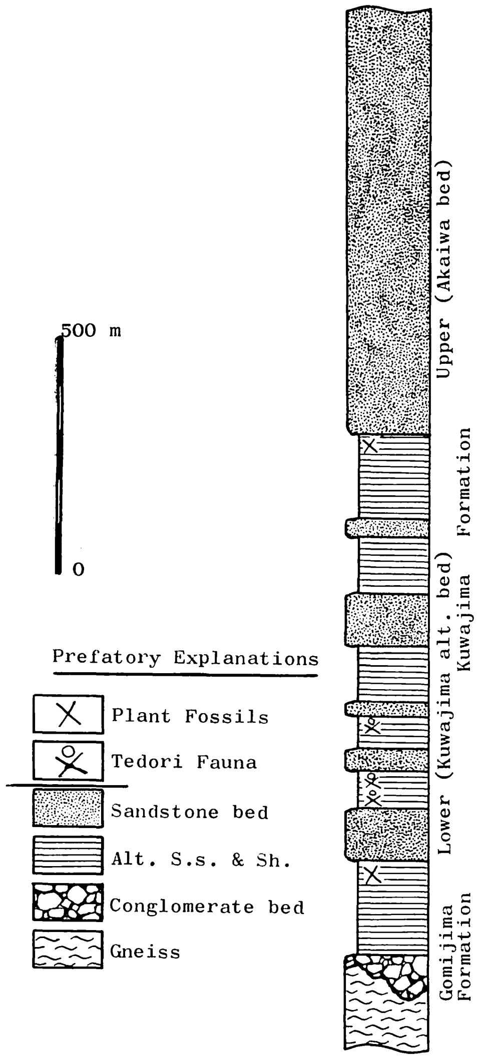

Fig. 2. Columnar Section of the Tedori Group, at Togadani. (ÔMURA, K.: 1964)

In 1940, S. ÔISHI who summarized the Mesozoic floras in Japan proposed three major floral divisions of our Mesozoic rocks, as follows (1940; 168):

I. *Dictyohpyllum* Series (Up. Triassic—Mid. Jurassic)
II. *Onychiopsis* Series (Up. Jurassic—Low. Cretaceous)
III. Angiosperm Series (Up. Cretaceous)

And, the *Onychiopsis* Series he separated into three sub-divisions, namely (1940; 157):

Upper ....(iii) Monobegawa Series
Middle....(ii) Ryôseki Series
Lower ....(i) Tetori Series

He considered that the "Tetori Series" in Central Honshû is the upper Jurassic terrestrial deposits. His observation is as follows (1940; 159):

"The Upper Jurassic terrestrial deposits (Tetori Series s. s.) in Central Honshu are extensively developed in Isikawa, Hukui, Gihu, and Toyama prefectures and rest on the eroded surface of the Gneiss System by means of blended unconformity. The Jurassic complex is divisible into three beds, viz., the lower or basal conglomerate, the middle or fossiliferous beds and the upper or non-fossiliferous sandstones".

About these three divisions of the

"Tetori Series", he commented as follows (1933; 619):

Upper ....Akaiwa sandstone Bed
Middle....Kuwasima (local name is Kuwajima*) Bed
Lower ....Gomisima (local name is Gomijima*) Conglomerate Bed (Basal Conglomerate Bed).

In 1949, R. UEDA, a student of the Tôhoku University discovered an unconformity relation between the Yanbara conglomerate bed and Asahi bed, in the "Tetori Group" at Yanbara locality (1949: MS. and R. UEDA & H. MATSUO: 1950, 286).

S. MAEDA divided the "Tetori Group" into two groups at Umagatani locality, a tributary valley of the Ishidoshiro-gawa, as follows (1950; 286).

Upper ....Itoshiro (local name is Ishidoshiro or Itoshiro) Group
Lower ....Kuzuryû Group

In 1951, S. MAEDA proposed to divide the "Tetori Group" into three groups, as follows (1951; 276):

Upper ....Betsuzandani Group (revised to the Akaiwa Group in 1952, by S. MAEDA)
Middle....Itoshiro Group
Lower ....Kuzuryû Group

In 1952, S. MAEDA discovered a red tuff layer and dicotyledonean leaves at Ômichidani, a branch stream of the Tedori-gawa, and these characters were shown in the uppermost layer of the Akaiwa Group. S. ENDÔ and M. AMANO examined these dicotyledonean leaves. Their opinions agreed that these fossils contain late Cretaceous elements, and that they geological horizon of those elements tend to suggest their geological age to correspond to that of the Hakobuchi flora of Hetonian (the upper most Cretaceous age) in Hokkaidô (1952; 173).

Concerning the Ômichidani bed, H. MATSUO is of opinion (1964) that it corresponds to the Sarao Bed of the Asuwa Group (the lower part of the upper Cretaceous).

In 1953, S. MAEDA discovered many early Cretaceous molluscan shells at Sugiyamadani, outskirts of Katsuyama City, and he holds the view that the Akaiwa bed is the lower Cretaceous in age.

Taking all these into account, the

* *Jima* and Sima phonetic inflections of the same word implying island.

	Kuzuryû Area	Tedori Area				
1894–1940	S. MAEDA (1952)	M. KAWAI (1961)	H. MATSUO & K. ÔMURA (1965)			
Tetori Group	Akaiwa Group	Myôdani Formation $M_1 \sim M_2$	Tedori Group	Myôdani Bed	Upper	Kuwajima Formation
		Akaiwa Formation $A_5 \sim A_1$		Akaiwa Bed		
	Itoshiro Group	Oguchi Formation: Kuwajima Alternate Bed, Gomijima Conglomerate Bed		Kuwajima Bed	Lower	
				Gomijima Formation		
	Kuzuryû Group					

writers have tried to summarize the stratigraphical succession of the Tedori Series (Tedorian), and arrived at the conclusion as Table on front page.

b) *Geological Notes of the Kuwajima Formation*

The Kuwajima formation conformably overlies the Gomijima formation, which shows the basal part of the Tedori Group in the Tedori-gawa area.

This formation is divisible into two horizons: the upper part contains two sub-divisions of the Myôdani bed (upper) and the Akaiwa bed (lower).

The lower part of the Kuwajima formation consists of the alternation of micaceous sandstone and muddy shale layers. The latter has the three floras (Togadani, Kaga* and Benitaki floras) and brackish or fresh water molluscan shells.

The Kaga flora contains many ferns including *Onychiopsis elongata*, *Cladophlebis exiliformis*, etc.; primitive forms of cycas *Nilssonia orientalis*, *N. nipponica* and *N. kotoi*; of Ginkgoales *Ginkgo sibirica* and *Ginkgoidium nathorsti*; and indeterminate conifers *Podozamites reinii*, *P. lanceolatus*, etc. These species have been usually considered to involve the plants of "*Onychiopsis* Series" by S. ÔISHI.

The layer with brackish molluscan shells was discovered at a lower horizon of the Kaga flora bed. This brackish fauna contains *Liostrea ryosekiensis* (KOBAYASHI and SUZUKI) HAYAMI, *Astarte*? sp., *Tetoria yokoyamai* KOBAYASHI & SUZUKI at Chugû locality; and in the Setono locality occurs some specimens of *Protocyprina naumanni* (NEUMAYER) HAYAMI, which is the characteristic of the lower Cretaceous in the Outer side of Japan.

Then, the Kuwajima formation does possibly belong to the lower Cretaceous, besides, its interfinger-relation with the Akaiwa bed is doubtful: the latter bed yielded many Lower Cretaceous fresh-water molluscan shells at Sugiyamadani locality as put on record by S. MAEDA in 1953, namely, of pelecypods *Unio* (*Nippononaia*) sp., *Plicatounio* sp. and *Nakamuranaia chingshaensis* (GRABAU); and a gastropod *Viviparus* (*Sinotaia* ?) *keishoensis* SUZUKI.

c) *Geological Notes on the Taeniopteris Species*

The genus *Taeniopteris* is an important element of the Mesophyta, according to A. C. SEWARD (1919, 485) namely,

> "The genus *Taeniopteris*, though most abundant in Rhaetic and Jurassic strata, occurs also in Upper Carboniferous and Lower Permian rocks."

The species *T. vittata* is a characteristic element of the Jurassic floras, however. SEWARD's note is as follows (1919; 492):

> "The simple leaves to which BRONGNIART applied this name are characteristic of the Inferior Oolite flora of England, and examples of the same type are recorded from Jurassic rocks of India, Poland, the Arctic regions, Japan, China, Australia and other countries.— It is exceedingly difficult to use *Taeniopteris* leaves of this form as evidence in regard to the Jurassic or Rhaetic age of plant-bearing strata.

Now, the specimen of the Togadani flora possibly belongs to the Jarassic by reason of the existence of *T. vittata*, and then the Kuwajima formation should be referred to the Jurassic. This result contradicts against the molluscan evidence referred to above mentioned molluscan evidences.

It is considered plausible from the fact

* M. YOKOYAMA (1894; 201) used this name Kaga flora, from the Kaga Province, where he had first reported the upper Jurassic plant fossils at Kuwajima locality.

Table 1. Three floras in the Kuwajima Formation, the Tedori-gawa Area.

Species \ Flora	Lower Togadani	Middle Kaga	Upper Benitaki
Marchantites yabei KRYSHTOFOVICH		*	*
Equisetites ushimarensis (YOKOYAMA) ÔISHI		*	*
Gleichenites nipponensis ÔISHI		*	*
Coniopteris burejensis (ZALESSKY) SEWARD		*	*
C. heeriana (YOKOYAMA) YABE		*	
C. hymenophylloides (BRONGNIART) SEWARD		*	*
C. sp.			*
Onychiopsis elongata (GEYLER) YOKOYAMA	*	*	*
Adiantites sewardi YABE		*	*
A. sp.	*		
Sphenopteris (Ruffordia) geopperti DUNKER		*	*
S. kochibeana (YOKOYAMA) ÔISHI		*	
S. nitidula (YOKOYAMA) ÔISHI		*	
Cladophlebis argutula (HEER)		*	
C. denticulata (BRONGNIART)		*	*
C. distans (HEER) YABE	*	*	*
C. exiliformis (GEYLER) ÔISHI	*	*	*
C. isikawaensis ÔISHI		*	
C. kuwasimaensis ÔISHI		*	
C. (Eboracia ?) lobifolia (PHILLIPS) BRONGNIART		*	
Cladophlebis triangularis ÔISHI		*	
Ctenis kaneharai YOKOYAMA		*	
Nilssonia kotoi (YOKOYAMA) ÔISHI	*	*	*
N. nipponensis YOKOYAMA	*	*	*
N. orientalis HEER	*	*	*
Dictyozamites falcatus (MORRIS) OLDHAM	*	*	*
D. reniformis ÔISHI		*	
D. imamurae ÔISHI	*	*	*

(Continued from Table 1)

Species \ Flora	Lower	Middle	Upper
	Togadani	Kaga	Benitaki
D. kawasakii TATEIWA			*
Otozamites klipsteinii (DUNKER) SEWARD		*	
O. endoi KIMURA			*
Pseudocycas ? acutifolia ÔISHI		*	*
Pseudocycas sp.	*		
Pterophyllum lyellianum DUNKER?		*	
Ginkgoites digitata (BRONGNIART) SEWARD		*	*
G. sibirica (HEE) SEWARD		*	*
Ginkgoidium nathorsti YOKOYAMA		*	*
Szekanowskia rigida HEER		*	
? *Elatocladus tennerima* (FEISTMANTEL) SHANT		*	
Podozamites lanceolatus (LINDLEY et HUTTON)	*	*	*
P. reinii GEYLER		*	*
Taeniopteris emarginata ÔISHI	*	*	*
T. vittata BRONGNIART	*		
T. richthofeni (SCHENK)		*	

Togadani flora : Collections of H. MATSUO and K. ÔMURA in 1963–1965.
Kaga flora : M. YOKOYAMA (1889 & 1894) ; S. ÔISHI (1933 & 1940) and H. MATSUO et K. ÔMARA in 1966.
Benitaki flora : S. ÔISHI (1933 & 1940) ; T. KIMURA (1958 & 1961) ; T. KIMURA et S. SEKIDO (1966) and H. MATSUO et K. ÔMURA in 1966.

just mentioned, to regard the Tedori Group to occupy a horizon between the Jurassic and the Cretaceous, namely Jurasso-Cretaceous horizon.

Furthermore, the species *T. vittata*-type are reported from the upper Jurassic coal mines of Southeast and North Manchuria by ÔISHI (1935) and S. TOYAMA & S. ÔISHI (1935).

Thus, the *Taeniopteris vittata*-bearing Tedorian is a land facies formation of a particular age in Far East.

Descriptions of two species of Togadani *Taeniopteris*

a) On the *Taeniopteris vittata* BRONGNIART (plate 29; figs. 1, 1a & 1b)

The genus *Taeniopteris* was established A. BRONGNIART in 1828 (263∼265, LXXXII, figs. 1∼4) and the species *T. vittata*, a characteristic simple leaf of the upper Jurassic of England, was compared by him with the pinnules of

Danaea and *Angiopteris*. Diagnosis of this species by A. C. SEWAD (1919; 492) is as follows:

"Leaf linear-lanceolate, reaching a length of more than 20 cm. and a breadth of 3 cm. The lamina increases gradually in breadth from the base and tapers towards the apex. Numerous secondary veins are given off at right angles from a broad midrib: the lateral veins may be simple or forked close to their origin, near the margin, or in the intermediate portion, of the lamina."

Togadani specimen consists of only a single specimen at hand, which lacks apical and basal parts; but it shows a broad characteristic midrib of the very species *vittata*. The specimen is 145 mm. long; the broadest part measures 22 mm. and the narrowest part 14 mm. In other features the leaf is similar to those mentioned in SEWARD'S note.

Discussion: Togadani specimen closely resembles in shape *T. vittata*? from the Chalari-nor colliery in North Manchuria mentioned by S. TOYAMA and S. ÔISHI (1935) and *T. uwatokoi* from the Tungning colliery in the western part of Manchuria by S. ÔISHI (1935). These Manchurian materials were reported to belong to the upper Jurassic strata by S. ÔISHI.

The Siberian species *T. rhitidorachis* KRYSHTOFOVICH was reported by SAMYLINA in 1963 from the Aldan River area. According to her note, *T. rhitidorachis* occurred from the lower Cretaceous strata and was considered to be comparable with *Nilssoniopteris ajarpokensis* HARRIS from the Cretaceous bed of Scoreby Sound in Greenland. This Siberian species very closely resembles the Togadani specimen; and the writers consider that the former should be grouped with *T. vittata*.

Thus, the vertical distribution of *T. vittata* is widened in range from the upper Jurassic to the lower Cretaceous.

b) On the *Taeniopteris emarginata* ÔISHI (plate 29; figs. 2 & 2a)

This species was established by S. ÔISHI in 1940 (XLVI, figs. 1~3) on the material from the Kuwajima locality. He remarked as follows (1940; 424):

"The present species also resembles *Nilssonia orientalis* HEER, but in this the lateral nerves are always simple. In all the specimens at hand the lamina shows the lateral attachment to the rachis in conformity with the diagnosis of the genus *Taeniopteris*."

This species shows a very close resemblance to *Nilssonia orientalis* HEER, namely, a characteristic shape of the leaves show elliptical and obovate outline with notched apex and cordate base.

Its shape closely resembles *Nilssoniopteris ovalis* SAMYLINA from the Siberian lower Cretaceous, but the slight depression on apex is shallower in the latter than in the former.

The Togadani specimen is an incomplete impression, namely, the apex is lost, but the cordate base shows a characteristic form of *T. emarginata* from the Kuwajima locality.

The three floras of the Kuwajima Formation

There are three floras in the Kuwajima Formation, namely, the Kaga, Benitaki and Togadani floras; these were found in the localities Kuwajima, Mekkodani and Togadani in the upper reaches of the Tedori-gawa.

The name of Kaga flora was used by M. YOKOYAMA (1894: 201) from the Kuwajima locality in Kaga Province (Ishikawa Prefecture), when he established the "Tetori Series".

The so-called "Tetori flora" was used by I. TATEIWA (1925; 504): his note (in

Japanese) is as follows: " —, these three species were found in the Tetori Series, and the so-called Tetori flora and the Naktong flora— ".

When, H. YABE studied on the flora of Naktong Series in S. Korea, he used the term " the Flora of Tetori Series " for the plant fossils of the Tedori Group, in 1906 and 1922.

The Benitaki flora was found in the close proximity of the fall of Benitaki (" beni " means rouge or red colour in Japanese) in the valley of Mekkodani: this locality has been long known for the excellently preserved specimens. In this locality, S. ÔISHI (1933) noted the representative Benitaki flora after the graduation thesis of S. NAGAO was published in 1931, by the Tôhoku Imperial University, Sendai.

Very recently, T. KIMURA and S. SEKIDO reported on several plant fossils which they have studied (1958; 1961 and 1966).

The Togadani flora represents the lowest horizon of these localities, the next older horizon being the Kaga, and the youngest the Benitaki; the latter two horizons overlie the fresh water molluscan bed, while the Togadani contains the lower part of the fresh water molluscan bed.

Now, the writers try a correlation of three floras in the Table 1.

Conclusion

1. *Taeniopteris vittata* of the Togadani locality is the new evidence of the Tedorian floras.
2. *T. vittata* was known to be a characteristic species of the upper Jurassic in the Northern Hemisphere, but its life range lasts to the lower Cretaceous.
3. Then, the Togadani flora, the lowest flora of the Tedorian, is an element of the Jurasso-Cretaceous floras in the Far East.
4. Kuwajima Formation contains three floras, namely, the Togadani flora (lower), Kaga flora (middle) and Benitaki flora (upper).

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Explanation of Plate 29

Locality: Togadani, Oguchi-mura, Ishikawa-gun, Ishikawa Prefecture.

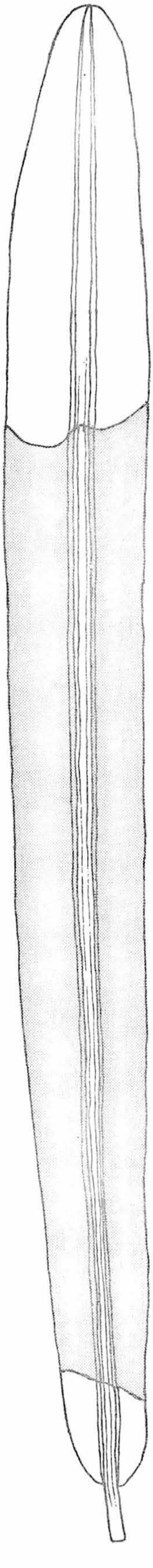
Figs. 1, 1a, 1b. *Taeniopteris vittata* BRONGNIART

Fig. 1a; Anticipative figure of the fig. 1: Fig. 1b; Lateral venation of the fig. 1. Reg. No.; DGLAKZ-15033.

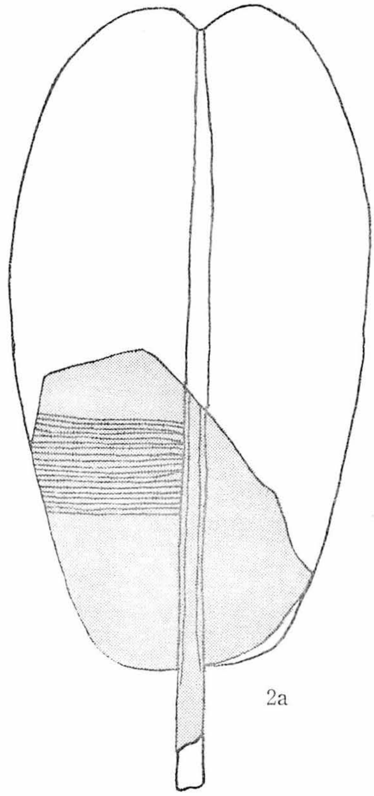
Figs. 2, 2a. *Taeniopteris emarginata* ÔISHI

Fig. 2a; Anticipative figure of the fig. 2. Reg. No.; DGLAKZ-15054a.

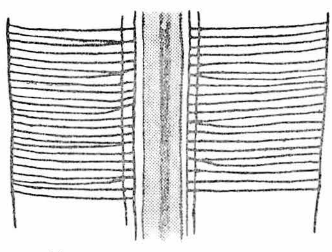
1



1a



2a



1b

2

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Asahi	朝日	Kuwajima	桑島	Setono	瀬戸野
Asuwa	足羽	Kuzuryû-gawa	九頭龍川	Shô-gawa	庄川
Benitaki	紅滝	Mekkodani	日附谷	Sugiyamadani	杉山谷
Betsuzandani	別山谷	Monobegawa	物部川	Tani	谷
Chugû	中宮	Myôdani	明谷	Tedori-gawa	手取川
Gomijima	五味島	Naktong	洛東	Togadani	鴇ケ谷
Hakobuchi	函渕	Oguchi	尾口	Tung-ning	東寧
Hakogase	箱ケ瀬	Okamigô	尾上郷	Umagatani	馬ケ谷
Itoshiro (Ishidoshiro)	石徹白	Ômichidani	大道谷	Ushimaru	牛丸
		Ozô	尾添	Yanagidani	柳谷
Kaga	加賀	Ryôseki	領石	Yanbara	山原

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 71, pp. 296-307, Sept. 30, 1968

541. SOME PLEISTOCENE FISH-OTOLITHS FROM THE BOSO AND MIURA PENINSULAS*

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房総・三浦半島からの更新世の魚耳石： 中部更新統の長沼，地蔵堂，藪，瀬又，大津，東京，成田の各層，および上部更新一完新統の沼層のあわせて23の化石産地から，約700個の魚の耳化石を採集した，おもに貝化石を含む浅海一内湾性の砂一泥質砂層から産する。とくに地蔵堂層の模式地には多産するが，保存不良でほとんどの標本が同定できないでいる。ほか，長沼層および成田層の桜井，不入斗などの産地には耳石が多い。採集標本のほゞ半数のものが現在未同定で，残りのなかに，ハゼ，アナゴ，イワシ，キス，アジ，タイおよびニベ類の14種（うち新種は9）を識別した。それぞれの種は図示して記載した。同定した標本の約2/3はハゼ類に属するものであり，ついでアナゴおよびイワシ類が多い。 青 木 直 昭

Introduction

Collection of fossil fish-otoliths in the Pleistocene of the Boso and Miura Peninsulas has been carried out at every opportunity during the course of molluscan and foraminiferal studies, because the knowledge of the fossil fish faunas is believed to enable us to infer the paleo-oceanographic conditions at the time of deposition. Apart from the taxonomic classifications, it is worthy to deal with this kind of fossil as an indicator of paleoecology and paleo-environments for the geologic and paleontologic reconstruction of the Quaternary marine basin. This paper is the first step of the project. The occurrences of the fourteen or more species of fish-otoliths are first reported, and these species are described and figured, proposing 9 new specific names.

Occurrences

Recently it has become obvious that the fish-otoliths occur everywhere in the fossiliferous sandy sediments of the two peninsulas, particularly deposited in shallow water of relatively calm and protected environments. More than 700 specimens were obtained from a total of widely scattered 23 fossil-localities of the middle Pleistocene molluscan shell beds as described below, except for one of the upper Pleistocene or Holocene Numa formation, largely through the kindness of Mr. Katsuyoshi BABA who is studying molluscan fossils of this area. The taxonomic affinities of these fossil otoliths were examined as many as possible through direct comparison with those of Recent fishes which are also being gathered. Fortunately the marine Pleistocene of this area is composed of shallow-water deposits, which are ready to yield the otoliths of shallow-water fishes and, therefore, are very useful to the present author.

* Received January 22, 1968; read September 23, 1967, at Tokyo.

Of the total number of specimens collected, about a half (330) were obtained at the type locality of the Jizodo formation. It is the most productive locality and exceptional. The next important fossil localities abounding in fossil otoliths are three, that is, Nagayato of the Naganuma formation, Sakurai and Iriyamazu of the Narita formation, in which molluscan shell fossils are also common and well-preserved. About 80-100 otolith specimens came from each locality.

On the other hand, the otoliths are scarce in the fossiliferous nearshore sandstones and brackish sandy mudstones of the following formations, from each locality of which less than 11 specimens were collected.

(1) Tokyo formation (2 localities)
(2) Owtsu formation (3 localities)
(3) Semata formation (1 locality)
(4) Yabu formation (1 locality)
(5) Narita formation (9 localities except the above-mentioned two)

Generally speaking, the specimens collected from loosely cemented, coarse-grained sandstones of neareshore environments are poorly preserved to a greater or lesser degree, and the Jizodo specimens had been so strongly abraded with currents and much corroded by seepage water that it is not easy to know their morphological details for taxonomic grouping. Moreover, any Recent specimens of otolith related to many of the Jizodo species have not been obtained for comparison at present. For these reasons, the systematic positions, even of higher ranks, cannot be determined for the majority (90%) of the Jizodo fauna. Including the indeterminable specimens from other localities, about 370 specimens that amount to more than a half of the sampled faunas had to be put aside and are left for future study.

As a result of the examination, it is found that the specimens of the genus *Gobius* are the most frequent element, particularly at the above-mentioned three localities, namely, Nagayato, Sakurai and Iriyamazu. The *Gobius* specimens are found also at 13 other localities among 20 and from some different horizons, although the frequency is relatively low. Totally they amount up to about 250 specimens or more than 70% of the determined species at hand. It can be said that the genus *Gobius* is one of the representatives of the fish-otolith faunas of the middle Pleistocene deposits in the two peninsulas.

Four or more forms of this genus could be discriminated. The most dominant otolith species having a broadly arched ventral margin is named *Gobius copiosus*, n. sp. The next dominant one with a comparatively more straight ventral margin of the otolith is named *Gobius urbanus*, n. sp., in this paper. These two species seem to be widely distributed in this area and occupy about 65% and 20% respectively of the total number of the *Gobius* specimens. The otolith assemblages from the three productive localities mentioned above are essentially similar to one another as these two species of *Gobius* are common.

Two other new species of *Gobius* are found in the samples of the Naganuma formation; one is extremely large in size, and the other is smaller with a circular outline. They are newly named *Gobius ingens* and *G. puellaris*, respectively. Specifically indiscriminated species of the genus *Gobius* and its allies are frequent in some samples of the Narita, Tokyo and Numa formations.

The solid or heavy, seed-like otoliths of the family Congridae appear to have a strong resistance against abrasion and weathering. They were found to be comparatively well-preserved in coarse-grained sediments of the Jizodo, Yabu, Semata and Narita formations. Two species are discriminated and described as new; they are, *Conger durus* frequently found in the Jizodo formation and *Otolithus* (*Congridarum*) *bellus* from the Narita formation.

The well-preserved and easily distinguishable otoliths of a *Sillago* species are found at Nagayato, Naganuma formation. The species is tentatively referred to *Sillago sihama* (FORSKAL), a living fish in Japan. Another indetermined species of *Sillago* occurs in the Narita formation.

Besides the above-mentioned species, the following 6 species are found in association with abundant *Gobius* specimens in many sandstone samples of the warm water horizons at Sakurai, Gion, Kamiizumi and Iriyamazu, all in the southern portion of the Narita formation. They are:

Sardinops cf. *melanosticta* (TEMMINCK & SCHLEGEL)
Engraulis cf. *japonica* (HOUTTUYN)
Otolithus (*Crangidarum*) *calidus* n. sp.
Nibea gemma n. sp.
Otolithus (*Sparidarum*) *babai* n. sp.
Platycephalus cf. *indicus* (LINNÉ)

Fossil locality

The localities of fossil otoliths in the Boso and Miura Peninsulas are listed below by horizon stratigraphically from lower to upper.

Naganuma formation
(1) Toyoda, near the Toyoda Primary School, Naganuma, S of Totsuka, Yokohama.
(2) Nagayato, S of Kaigara-saka, Naganuma.
(3) Naganuma, W of Uchikoshi, 0.4 km W of Kaigara-saka, Naganuma.

Jizodo formation
(4) Jizodo, 3.6 km E of Makuta Stn., Fukuta-machi, Kimitsu-gun, Boso. (type locality for this formation)

Yabu formation
(5) Yabu, 2.8 km E of Makuta Stn., Fukuta-machi. (type locality for this formation)

Semata formation
(6) Semata (=Semata-no-seki), 2.4 km SE of Honda Stn., Toke-machi, Sambu-gun, Boso. (type locality for this formation)

Owtsu formation
(7) Mabori, 0.9 km E of Mabori-Kaigan Stn., Yokosuka, Miura.
(8) Horinouchi, Miharu-machi 5-chome, 0.6 km SW of Horinouchi Stn., Yokosuka. (AOKI, 1967)
(9) Hebinuma, 0.3 km SE of Shin-Owtsu Stn., Yokosuka. (AOKI, 1967)

Tokyo formation
(10) Asaka, a road-side cutting at Negishi, 1.5 km NE of Asaka Stn., Asaka-machi, Saitama.
(11) Takinogawa, a stream-side exposure of the Shakujii-gawa, behind the Ikebukuro Commercial High School, 0.8 km of Itabashi Stn., Takinogawa-machi, Tokyo.

Narita formation
(12) Otake, 0.9 km NW of Manzaki Stn. (Narita Line), NW of Narita, Narita City.
(13) Kioroshi, 0.6 km S of Kioroshi Stn., Insei-machi, Imba-gun, Boso.
(14) Kamenari, 0.4 km E of Kamenari, S of Kioroshi Stn., Insei-machi.
(15) Shisui, a rail-road cut between Shisui and Owsakura (Keisei Line), 0.7 km SW of Shisui Stn., N of Shisui, Sakura City.
(16) Owsakura, 0.2 km E of Owsakura Stn. (Keisei Line), N of Shisui-machi.
(17) Owkawagishi, northern border of Imba-numa, 6 km N of Sakura, Sakura City.
(18) Iriyamazu, near the Primary School at Iriyamazu, 3 km S of Anegasaki Stn., Anegasaki City.
(19) Kamiizumi, near the bus-stop at Kamatayatsu, N of Kamiizumi, 5.5 km N of Makuta Stn., Fukuta-machi.
(20) Takinokuchi, 0.7 km N of Tahinokuchi, 1.2 km W of Yokota Stn., Fukuta-machi.
(21) Gion, 0.5km E of Gion Stn., E of Kisarazu City.

Table 1. Middle Pleistocene Fish-otoliths from the Boso and Miura Peninsulas.

Formation	Locality	Indeterminables	*Gobius copiosus*, n. sp.	*Gobius urbanus*, n. sp.	*Gobius puellaris*, n. sp.	*Gobius ingens*, n. sp.	*Gobius* spp.	*Conger durus*, n. sp.	*Ot.* (*Congridarum*) *bellus*, n. sp.	*Conger* spp.	*Sardinops* cf. *melanosticta*	*Engraulis* cf. *japonica*	*Sillago* cf. *sihama*	*Sillago* sp. A	*Ot.* (*Crangidarum*) *calidus*, n. sp.	*Ot.* (*Sparidarum*) *babai*, n. sp.	*Platycephalus* cf. *indicus*	*Nibea gemma*, n. sp.
Numa	Numa						F											
Narita	Otake	R				R	R				R							
	Kioroshi													R				
	Kamenari	R					R				R							
	Shisui	F					F		F									
	Owsakura	F												F				
	Owkawagishi	R																
	Iriyamazu	A	VA	A			F	R	F	R	F	R			R	R	R	
	Kamiizumi	F	R	F				?R		R		F				R		
	Takinokuchi	R																
	Gion		F	R					?R			R		R		R		R
	Sakurai	A	VA	A	?F				?F	F	A	C		F	F	F	F	
Tokyo	Asaka	F		R		?R												
	Takinogawa	F					R			F		R		R				
Owtsu	Mabori	R																
	Horinouchi	F		F														
	Hebinuma		R	R														
Semata	Semata	F							R	R								
Yabu	Yabu	F							F	R								
Jizodo	Jizodo	VA	C	F				C		C								
Naga-numa	Toyoda		C	F														
	Nagayatsu		VA	C		F							F					
	Naganuma	R	C	F	C						R	R	R					

R: 1 specimen, F: 2-4, C: 5-9, A: 10-29: VA: more than 30 specimens.

(22) Sakurai, a sea-side cliff, S of Sakurai, S of Kisarazu.

Numa formation

(23) Numa, SW of Tateyama City, southern Boso.

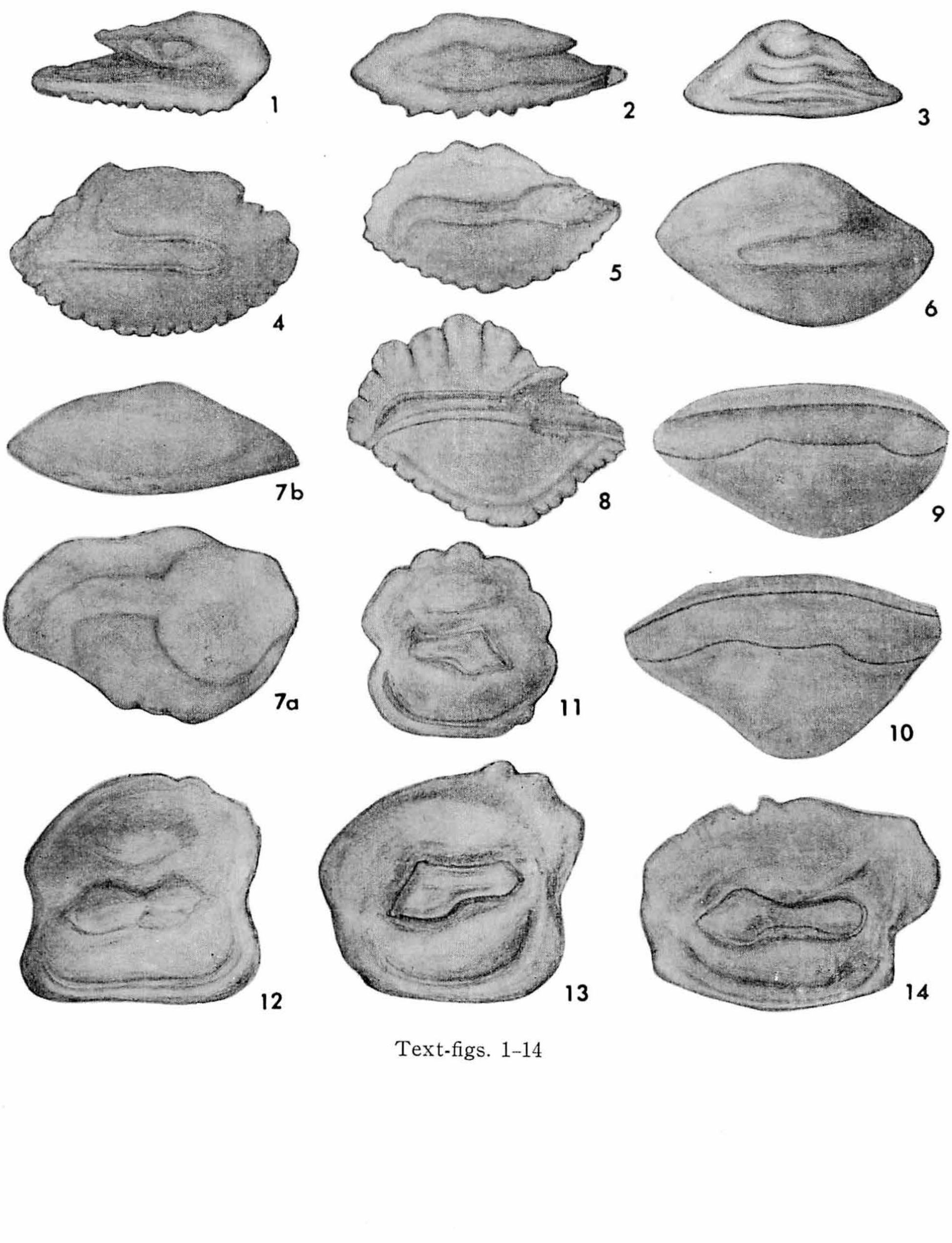
Description of Species

Sardinops cf. *melanosticta* (TEMMINCK & SCHLEGEL)

Text-fig. 1

The size and general morphology of the fossil otoliths are almost identical to those of *Sardinops melanosticta* (TEMMINCK & SCHLEGEL) (Japanese name: Ma-iwa-shi), a common living fish around the Japanese Islands, but positive identification is put off, because the otoliths of some related species are unavailable.

The otolith is typically a clupeoid form, having the straight dorsal and ventral margins which are parallel-sided or some-



Text-figs. 1–14

what anteriorly tapering, the elongate and projecting rostrum, the strongly notched excisura and the pointed antirostrum. The ventral margin is irregularly indented. The sulcus is deeply excavated, straight, elongate and wide. The area is distinct and wide.

Length of figured specimen 2.72 mm., height 1.20 mm., thickness 0.20 mm. Length ranges up to 3.0 mm.

20 specimens from Sakurai, Iriyamazu, Kamenari, Otake (Narita fm.) and Naganuma (Naganuma fm.).

Engraulis cf. *japonica* HOUTTUYN

Text-fig. 2

The fossil otolith is very similar to that of *Engraulis japonica* HOUTTUYN (Japanese name: Katakuchi-iwashi), a common living fish along the Japanese Islands. It is characterized by the lanceolate outline with the sharply birostrate anterior end and the acutely rounded posterior one, and by the sparsely spinose ventral margin.

Length of figured specimen 3.50+mm., height 1.38 mm., thickness ca. 0.50 mm. Length ranges from 2.2 to 3.5+mm.

14 specimens from Sakurai, Iriyamazu, Kamiizumi, Gion (Narita fm.), Takinogawa (Tokyo fm.) and Naganuma (Naganuma fm.).

Text-fig. 1. *Sardinops* cf. *melanosticta* (TEMMINCK & SCHLEGEL)
×12, from Sakurai, Kisarazu; Narita formation.

Text-fig. 2. *Engraulis* cf. *japonica* HOUTTUYN
×10, from Sakurai, Kisarazu; Narita formation.

Text-fig. 3. *Platycephalus* cf. *indicus* (LINNÉ)
×12, from Iriyamazu, Anegasaki; Narita formation.

Text-fig. 4. *Otolithus (Congridarum) bellus* AOKI, n. sp.
×10, holotype, from Iriyamazu, Anegasaki; Narita formation.

Text-fig. 5. *Otolithus (Crangidarum) calidus* AOKI, n. sp.
×10, holotype, from Sakurai, Kisarazu; Narita formation.

Text-fig. 6. *Conger durus* AOKI, n. sp.
×7, holotype, from Jizodo, Makuta; Jizodo formation.

Text-figs. 7a, b. *Nibea gemma* AOKI, n. sp.
×7, holotype, from Gion, Kisarazu; Narita formation.

Text-fig. 8. *Otolithus (Sparidarum) babai* AOKI, n. sp.
×7, holotype, from Sakurai, Kisarazu; Narita formation.

Text-fig. 9. *Sillago* sp. A
×6, from Gion, Kisarazu; Narita formation.

Text-fig. 10. *Sillago* cf. *sihama* (FORSKAL)
×6, from Nagayato, Naganuma, Yokohama; Naganuma formation.

Text-fig. 11. *Gobium puellaris* AOKI, n. sp.
×15, holotype, from Naganuma, Yokohama; Naganuma formation.

Text-fig. 12. *Gobius urbanus* AOKI, n. sp.
×15, holotype, from Toyoda, Naganuma, Yokohama; Naganuma formation.

Text-fig. 13. *Gobius copiosus* AOKI, n. sp.
×10, from Sakurai, Kisarazu; Narita formation.

Text-fig. 14. *Gobius ingens* AOKI, n. sp.
×6, holotype, from Nagayato, Naganuma, Yokohama; Naganuma formation.

Conger durus AOKI, n. sp.

Text-fig. 6

Sagitta large in size, transversely subovate, somewhat elongate rhomboidal in outline, height about 3/5 of the length of sagitta, highest at the middle or somewhat posterior and lowest at anterior 1/3 of the length, rather thick, thickness about 1/4 of the length; both dorsal and ventral margins broadly rounded and equally convex, antero-dorsal margin obliquely subtruncate, both anterior and posterior extremities bluntly pointed, whole margins smooth and entire; both faces moderately convex, edge subacute; inner face almost smooth except sulcus; sulcus centrally situated, nearly straight, horizontal, bordered with slightly raised and very narrow rim, extending from the antero-dorsal posteriorly to about 2/3 length of sagitta, its posterior end roundly closed, anterior end wider and open to the antero-dorsal margin; area absent; outer face smooth.

Length of holotype 5.16 mm., height 3.20 mm, thickness 1.32 mm. Length of paratypes ranges up to 9.0 mm.

Holotype from sample #9549, Jizodo, Makuta; Jizodo formation.

The otolith of *Conger durus*, n. sp., differs from that of *Astroconger myriaster* (BREVOORT) (HATAI, 1965, p. 64, pl. 15, f. 35-36. Japanese name: Ma-anago) in having the broadly elliptical outline.

About 15 specimens from Jizodo (Jizodo fm.), Yabu (Yabu fm.), Semata (Semata fm.), Iriyamazu and Kamiizumi (Narita fm.).

Otolithus (*Congridarum*) *bellus* AOKI, n. sp.

Text-fig. 4

Sagitta large in size, transversely ovate in shape, rather thick, height about 3/5 of the length, broadest at the middle, ventral margin very broadly arcuated, rather evenly crenulated, dorsal margin almost broadly rounded, but antero-dorsal part obliquely truncated, irregularly and very coarsely crenulated or wavy, anterior margin narrowly rounded, posterior end rather roundly pointed; inner and outer faces moderately convex, edge acutely rounded, surface somewhat lustrous; sulcus horizontal, more than 2/3 of the length of sagitta, bordered with very narrow elevated rim, its posterior end slightly bent down and roundly closed, its anterior end wider and open toward the anterior-dorsal margin; outer face corrugated with marginal crenumations.

Length of holotype 3.86 mm., height 2.36 mm., thickness 1.44 mm. (Largest specimen collected).

Holotype from sample #9047, Iriyamazu, Anegasaki; Narita formation.

The otolith of *Otolithus* (*Congridarum*) *bellus*, n. sp., differs from the previously known otoliths of the *Conger* species in having marginal crenulations; its precise systematic position is unknown.

About 7 specimens from Iriyamazu, Sakurai and Gion (Narita fm.).

Conger spp.

About 20 specimens from the Jizodo, Yabu, Semata, Narita and Tokyo formations.

Otolithus (*Crangidarum*) *calidus* AOKI, n. sp.

Text-fig. 5

Sagitta medium in size, elongate elliptical, height 3/5 of the length, equally convex dorsally and ventrally, broadest at the middle, posterior end narrowly rounded, anterior one subpointed, both dorsal and ventral margins broadly rounded, anterodorsal margin subtruncated obliquely, whole margins crenulated, finer at ventral and posterior margins, coarser or wavy at the middle of the dorsal margin; innerface weakly inflated; sulcus distinctly furrowed, horizontal in the central portion of sagitta, running almost the full length of sagitta, bordered with obscure ridges, divided into cauda and ostium, cauda relatively narrow and elongate, very slightly curved, its posterior portion bent down sharply, becoming shallower near the postero-ventral, ostium a half of cauda in length, wider, deeper, and open to the antero-dorsal; ridge present at the border of the middle part of sulcus, short and somewhat obscure; area slightly depressed and indistinctly marked; outer face concave, weakly corrugated with marginal crenulations.

Length of holotype 3.48 mm., height 2.08 mm., thickness ca. 0.65 mm. Length of paratypes ranges from 2.9 to 3.1 mm.

Holotype from sample #9522, Sakurai, Kisarazu; Narita formation.

The otolith of *Otolithus* (*Crangidarum*) *calidus*, n. sp., differs from those of the *Decapterus* species (Japanese name: Muro-aji and others) and of *Trachurus japonicus* (TEMMINCK & SCHLEGEL) (Japanese name: Ma-aji) in having the broadly elliptical outline, the more shallowly excavated sulcus and the different pattern of marginal crenulations.

5 specimens from Sakurai and Iriyamazu (Narita fm.).

Nibea gemma AOKI, n. sp.

Text-figs. 7a, b

Sagitta large in size, very thick, thickness 2/5 of the length, nearly plano-convex, roughly elliptical in outline, height 2/3 of the length; dorsal margin very broadly rounded with weak undulations, forming three low round-topped projections, one each in anterior, middle and posterior portions of the dorsal margin, anterior border broadly rounded, posterior one narrowly rounded, ventral margin broadly arcuated, projected downward at the anterior third, slightly concave in the posterior half of the margin, margins entire; inner face flat and curved outward; sulcus sciaenid-type, very shallowly and flatly impressed or almost flush, divided into ostium and cauda, ostium very large, suborbicular in outline, flat, bordered by dark-colored line, its diameter nearly 2/5 or slightly less than a half of the length of sagitta, cauda continued from the posterior portion of the ostinum, bordered by slightly depressed narrow grooves, relatively narrow, running horizontally for a short distance with parallel sides, sharply bent down and slightly widening at the posterior, becoming obscure to the postero-ventral; any other depression and ridge not present; outer face strongly convex, smooth, marked ornamentation absent.

Length of holotype 5.60 mm., height 3.78 mm., thickness 2.29 mm.

Holotype from sample #9505, Gion, Kisarazu; Narita formation.

The otolith of *Nibea gemma*, n. sp., is distinguishable from those of the species of Sciaenidae by the particular shape of the sulcus and the smoothness of the outer face. Only one specimen of this species was collected from Gion, east of Kisarazu, Narita formation.

Sillago cf. *sihama* (FORSKAL)

Text-fig. 10

The otolith specimens collected at Nagayato, Naganuma formation, are very similar to *Sillago sihama* (FORSKAL) (Japanese name: Kisu), a Recent species, and seem to slightly differ in outline and sulcus from that of *Sillago japonica* (TEMMINCK & SCHLEGEL) (Japanese name: Ao-gisu), a living fish commonly found in Tokyo Bay.

The diagnosis of *Sillago* cf. *sihama* is as follows: Sagitta large in size, triangular-shaped, with a very broadly arcuated dorsal margin and a strongly protruded ventral one, widest at the anterior, both anterior and posterior ends narrowly rounded, margins smooth; sulcus a broad band, very shallowly and flatly impressed, situated near the dorsal margin, broadly curved upward, nearly parallel to the dorsal margin, running the full length of sagitta, its both anterior and posterior portions sharply expand in width ventrally; outer face ornamented with weak and irregular corrugations, radially grooved at the margin.

Length of figured specimen 6.94 mm., height 4.10 mm., thickness ca. 1.80 mm. Length ranges from 2.7 to 7.5 mm.

5 specimens from Nagayato and Naganuma (Naganuma fm.).

Sillago sp. A

Text-fig. 9

The otolith of *Sillago* probably different from that of *Sillago* cf. *sihama* of this paper was collected from the Narita formation. The specimens are all ill-preserved, unabling a detailed comparison with the related species.

Length of figured specimen 6.45 mm., height 3.45 mm., thickness ca. 1.70 mm. Length ranges from 2.7 to 6.7 mm.

7 specimens from Sakurai, Owsakura, Gion and Kioroshi (Narita fm.), Takinogawa (Tokyo fm.).

Otolithus (*Sparidarum*) *babai* AOKI, n. sp.

Text-fig. 8

Sagitta large in size, curved slightly outward, transversely ovate and roughly rhomboidal in outline, eqally biconvex dorsally and ventrally, highest at the posterior and lowest at the anterior, height about 4/5 of the length of sagitta, ventral margin strongly convex or broadly rouned, distinctly and irregularly crenulated, dorsal margin broadly rounded, coarsely denticulated into short and wide radial ribs, which are not uniform in size, rostrum rather narrowly rounded; inner face slightly convex; sulcus elongate, situated centrally and horizontally, running almost the full length of sagitta, rather deeply excavated, very sharply bordered, divided distinctly into ostium and cauda, ostium wide and short, cauda more deeply incised, narrower, twice or more as long as ostium, straight and horizontal, its posterior end bent down and tapering, reaching the postero-ventral portion of sagitta; ventral furrow absent, but very narrow band of darker color running parallel to the whole length of ventral margin; outer face ornamented with short radial marginal ribs, central part weakly convex.

Length of holotype 5.35 mm., height 4.15 mm., thickness 1.12 mm.

Holotype from sample #9514, Sakurai, Kisarazu; Narita formation.

The otolith of this new species evidently belongs to those of spariform fishes and is somewhat similar to many of previously described otoliths of the *Otolithus* (*Sparidarum*) species, but an identical otoliths may have never been reported. The otolith of *Otolithus* (*Sparidarum*) *babai*, n. sp., is related closer to that of *Nemipterus virgatus* (HOUTTUYN) (Japanese name: Itoyori) than to any others available.

5 specimens from Sakurai, Gion, Kamiizumi and Iriyamazu (Narita fm.).

The proposed specific name of this new

species is dedicated to Mr. Katsuyoshi BABA, who collected a number of otolith specimens from the Boso Peninsula.

Gobius copiosus, AOKI, n. sp.

Text-fig. 13

Sagitta medium in size, plano-convex, thickness about 1/4 of the length, roughly quadrate in outline, height nearly equal to the length of sagitta or shorter, dorsal margin broadly rounded, antero-dorsal broadly rounded and slopes down to the anterior margin, postero-dorsal roundly projecting pos teriorly, having one or two low nodes, ventral margin very broadly arcuated, both antero- and postero- ventral corners rounded, anterior and posterior margins nearly vertically truncated, both incised at the middle, posterior more distinctly so; inner face nearly flat, edges subacute; sulcus distinctly depressed, centrally situated, nearly horizontal, both ends closed, its length about a half of the full length of sagitta, its anterior half slightly wider and obliquely bent down, usually constricted at the middle; area shallowly deressed, ridge above sulcus distinct, short and horizontal; ventral furrow distinct, narrow, broadly arched, running nearly parallel to the ventral margin; outer face moderately convex, slightly uneven, without any marked ornamentation.

Length of holotype 3.60 mm., height 3.24 mm., thickness ca. 1.00 mm. Length of paratypes ranges up to 4.2 mm.

Holotype from sample #9515, Sakurai, Kisarazu, Narita formation.

Gobius copisosus, n. sp., is characterized by the larger sized otolith for the genus having the broadly arcuated ventral margin and furrow.

About 170 specimens from Nagayato, Naganuma, Toyoda (Naganuma fm.), Sakurai, Iriyamazu, Gion, Kamiizumi (Narita fm.), Jizodo (Jizodo fm.), and Hebinuma (Owtsu fm.).

Gobius ingens AOKI, n. sp.

Text-fig. 14

Sagitta very large, transversely elongate and quadrate in outline, longer than height, height about 2/3 of the length or slightly less, both dorsal and ventral margins very broadly arcuated, a few weak projections present at the middle of the dorsal, both anterior and posterior margins almost vertical, but dorsal half of the posterior margin protruded posteriorly; sulcus large and horizontal, about a half the length of sagitta, gobioid type, its anterior half wider with bluntly pointed end, bent down a little, middle portion somewhat constricted, posterior end roundly closed; area broadly and distinctly depressed, ridge above sulcus distinct, short, curved a little along the upper border of sulcus; ventral furrow distinct, running close to and parallel to the ventral margin; lower portion of sagitta below sulcus somewhat flatly raised; outer face nearly smooth and weakly convex, slightly uneven without any distinct ornamentation.

Length of holotype 6.68 mm., height 4.82 mm., thickness 1.28 mm. Length of paratypes ranges from 4.5 to 5.5 mm.

Holotype from sample #4998, Nagayato, Naganuma, Yokohama; Naganuma formation.

The otolith of *Gobius ingens*, n. sp., is characterized by the very large size, and the transversely elongate quadrangle shape with a strongly protruded postero-dorsal margin and the elongate large sulcus.

4 specimens from Nagayato (Naganuma fm.), Otake (Narita fm.) and Asaka (Tokyo fm.).

Gobius puellaris AOKI, n. sp.

Text-fig. 11

Sagitta small in size, nearly orbicular in outline, height nearly equal to the length, dorsal and anterior margins broadly rounded or circular, crenulated very coarsely, ventral margin very broadly rounded or almost straight, posterior margin vertically truncated, distinctly excavated at the middle; inner face nearly flat; sulcus centrally situated, gobioid type, short and nearly horizontal, its anterior portion wider and bent down obliquely; area distinctly depressed, ventral furrow distinct, parallel to the broadly rounded ventral margin; outer face moderately or weakly convex, ornamented with radial marginal grooves.

Length of holotype 1.78 mm., height 1.73 mm., thickness ca. 0.55 mm. Length of paratypes ranges from 1.2 to 1.85 mm.

Holotype from sample #4999, Naganuma, Yokohama; Naganuma formation.

Gobius puellaris, n. sp., has the smaller-sized otoliths of nearly circular shape with coarsely crenulated dorsal and anterior margins, so that it is easily distinguishable

8 specimens from Naganuma (Naganuma fm.) and Sakurai (Narita fm.).

Gobius urbanus AOKI, n. sp.

Text-fig. 12

Sagitta medium in size, thin, plano-convex, roughly quadrate in outline, height nearly equal to the length or slightly less, dorsal margin broadly rounded, anteriorly sloping downward, ventral margin very broadly rounded or almost straight, postero-dorsal more or less protruded posteriorly, anterior and posterior margins nearly vertical, distinctly notched at the middle, antero- and postero- ventral corners narrowly rounded, all margins smooth and entire; inner face nearly flat; sulcus distinct, central and horizontal, its length about a half of the length of sagitta, both ends closed, somewhat constricted in the middle, its anterior half wider and somewhat bent downward; area distinctly impressed, rather wide; ventral furrow distinct, narrow, running parallel to the ventral margin; ridge above sulcus present, short and horizontal; outer face weakly inflated, marked ornamentation absent.

Length of holotype 2.18 mm., height 2.08 mm., thickness 0.70 mm. Maximum diamer of paratypes ranges up to 3.35 mm.

Holotype from sample #4997, Toyoda, Naganuma, Yokohama; Naganuma formation.

The otoliths of *Gobius urbanus*, n. sp., closely resembles those of *Gobius copiosus* AOKI, n. sp., from the Naganuma and Narita formations and of *Gobius notoensis* AOKI, (AOKI, 1967, p. 127, tf. 3–6) from the middle Pleistocene Hiratoko formation, but differs from the former in having more straight ventral furrow and from the latter in having the larger size (twice or more), the markedly developed area and more distinctly incised notches in the middle of the anterior and posterior margins.

About 60 specimens from Iriyamazu, Sakurai, Kamiizumi, Gion (Narita fm.), Nagayato, Toyoda, Naganuma (Naganuma fm.), Jizodo (Jizodo fm.), Horinouchi and Hebinuma (Owtsu fm.).

Gobius spp.

About 10 specimens are collected from the Narita, Tokyo and Numa formations.

Platycephalus cf. *indicus* (LINNÉ)

Text-fig. 3

Sagitta small in size, thick, elongate, nearly equilateral triangle of very low height in outline, ventral margin straight and long, dorsal margin strongly convex, anterior end sometimes truncated or notched a little, both faces moderately to weakly convex; sulcus deeply excavated, narrow, horizontal, weakly and somewhat sigmoidally curved, extending from the antero-dorsal margin posteriorly to about 2/3 of the total length of sagitta, its posterior end closed; area distinctly depressed and relatively restricted; ventral furrow elongate, distinctly grooved, slightly curved; outer face moderately convex and smooth.

Length of figured specimen 2.45 mm., height 1.10 mm., thickness ca. 0.42 mm. Length ranges from 2.2 to 2.45 mm.

The fossil otolith, which is very similar to that of *Platycephalus indicus* (LINNÉ) (Japanese name: Magochi), came from the two localities of the Narita formation. All of the fossil specimens are smaller and are half in size of the Recent ones. These were more or less eroded by currents before deposition.

5 specimens from Sakurai and Iriyamazu (Narita fm.).

Acknowledgements:—The author is much indebted to the following persons: Mr. Katsuyoshi BABA for collecting many fossil otolith specimens from various localities in the Boso and Miura Peninsulas, Toshiko AOKI and Masako NISHIKAWA for their aid in collecting otolith specimens of Recent fishes, Mr. Kenji KURIHARA and Prof. Wataru HASHIMOTO of the Tokyo University of Education for permission to use the laboratory facilities.

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Anegasaki	姉ヶ崎	Kimitsu	君津	Sambu	山武
Asaka	朝霞	Kioroshi	木下	Semata	瀬又
Boso	房・総	Kısarazu	木更津	Semata-no-seki	瀬又ノ堰
Fukuta	富来田	Mabori	馬堀	Shakujii-gawa	石神井川
Gion	祇園	Mabori-Kaigan	馬堀海岸	Shin-Owtsu	新大津
Hebinuma	蛇沼	Makuta	馬来田	Shisui	酒々井
Hiratoko	平床	Manzaki	松崎	Takinogawa	滝野川
Honda	誉田	Miharu	三春	Takinokuchi	滝ノ口
Horinouchi	堀ノ内	Miura	三浦	Tateyama	館山
Hossaku	発作	Naganuma	長沼	Toke	土気
Imbanuma	印幡沼	Nagayato	長谷	Tokyo	東京
Insei	印西	Narita	成田	Totsuka	戸塚
Iriyamazu	不入斗	Negishi	根岸	Toyoda	豊田
Itabashi	板橋	Numa	沼	Uchikoshi	打越
Jizodo	地蔵堂	Otake	大竹	Yabu	藪
Kaigara-sak	貝殻坂	Owkawagishi	大川岸	Yokohama	横浜
Kamatayatsu	鎌田谷	Owsakura	大佐倉	Yokosuka	横須賀
Kamenari	亀成	Owtsu	大津	Yokota	横田
Kamiizumi	上泉	Saitama	埼玉		
Keisei	京成	Sakurai	桜井		

Trans. Proc. Palaeont. Soc. Japan, N. S., No. 71, pp. 308-316, pls. 30, 31, Sept. 30, 1968

542. COCCOLITHOPHORIDS FROM THE CHŌJABARU FORMATION, IKI ISLAND, JAPAN*

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壱岐・長者原層のコッコリス： 壱岐島，長者原層（中新世）の珪藻土を処理し，電子顕微鏡によりその透過像を観察したところ，1ないし3ミクロンのコッコリス化石を含むことがわかった。それらを1新属，10新種として記載した。 西 田 史 朗

Introduction

After the discovery of coccolith by EHRENBERG in 1836, many investigations have been done on this fine organism. In 1858, HUXLEY described its occurrence in the North Atlantic recent deep sea oozes. The initial study of fossil calcareous nannoplankton was the work of ARKHANGELSKY written in 1912 on that in the Upper Cretaceous deposits in European Russia. Early in this century, KAMPTNER, DEFLANDRE, BRAARUD and BRAMLETTE began paleontological studies of nannoplanktons.

Biostratigraphic significance of nannoplanktons has been emphasized by BRAMLETTE et al., HAY et al. and STOVER in recent years.

In the early stage of the investigation and also in the recent times, the ordinary microscope has been used through the most course of it. Most coccoliths and other calcareous nannoplanktons ranges from less than 1 micron to more than 20 microns in their maximum diameter. Because of the small size and fine structures of the coccoliths, studies with ordinary microscope are not always satisfactory. In the works of DEFLANDRE and FERT (1952c, 1953a, 1953b and 1954), HALLDAL and MARKALI (1953), BLACK and BARNES (1959 and 1961), BLACK (1962, 1963, 1964 and 1965), HAY (1961 and 1965), HAY and SCHAUB (1961), HAY and TOWE (1962), COHEN (1964), BRAMLETTE and MARTINI (1964), HAY et al. and others, were introduced the electronmicroscope and the carbon replica technique in the study of nannoplanktons.

The present author observed intact coccoliths directly under the electronmicroscope. By this investigation, a new genus and ten new species were found and described. They consist of calcium carbonate and are of disk form, and have some rings and central area ranging in diameter from 1 to 3 microns. They are named as follows: *Pseudococcolithus reticulatus, P. striatus, P. fusiformis, P. orbicularis, P. deltoides, P. rotundatus, P. oviformis, P. oblongus, P. biporosus, P. nodulosus*. These coccoliths discovered from the Chōjabaru formation are regarded presumably as of Miocene age.

* Received Feb. 29, 1968; read June 18, 1967, at Ōsaka.

Specimens studied and their stratigraphic positions

The geology of Iki Island has been investigated by Y. ŌTSUKI (1910), K. MATSUI (1958), S. CHIGI (1952) and others. According to K. MATSUI, the stratigraphic members of Iki Island, mentioned in the ascending order, are the Neogene Katsumoto formation, the Iki formation, andesites, rhyolite, hornblende rhyolitic andesite and some kind of Quaternary basalt. K. MATSUI included the Chōjabaru diatomite bed in the Katsumoto formation, but T. MATSUMOTO et al. has concluded that the Chōjabaru diatomite bed is separated from the Katsumoto formation by a basaltic flow, so that it must be an independent formation sepa-

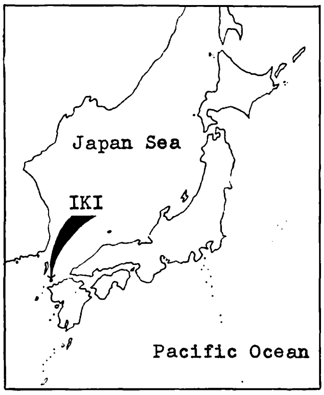


Fig. 1

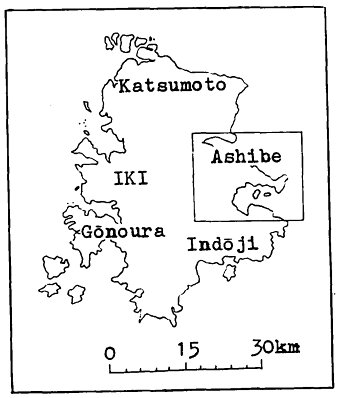
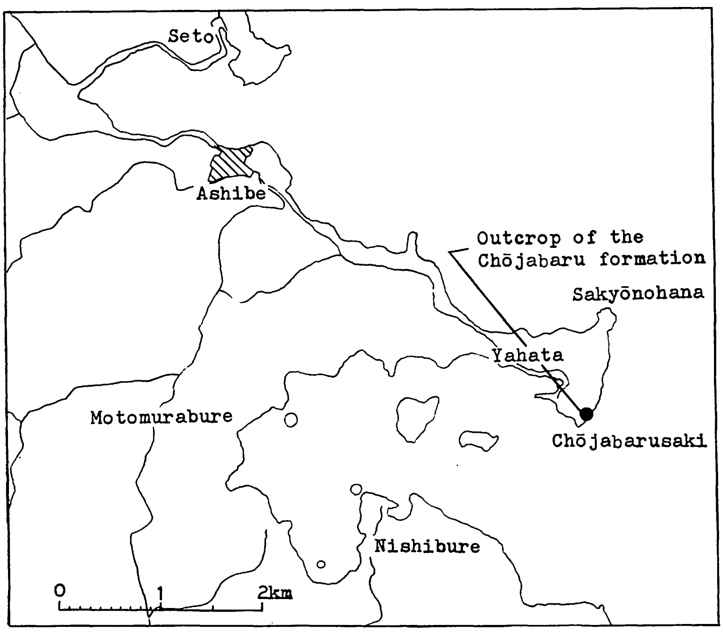


Fig. 2



Text-figs. 1–3. Map showing the location of Chōjabaru cape.

rated from the Katsumoto formation. The present author approves with the later opinion. The Chōjabaru formation is located at Chōjabaru Cape, Motomurabure, Moroyoshi, Ashibe-Chō, Iki-Gun, Nagasaki Prefecture, Japan. Fig. 1 shows the geographical position of Iki Island in the Far East and Fig. 2 shows an outline map of Iki Island. Outcrop of the Chōjabaru formation is shown in Fig. 3.

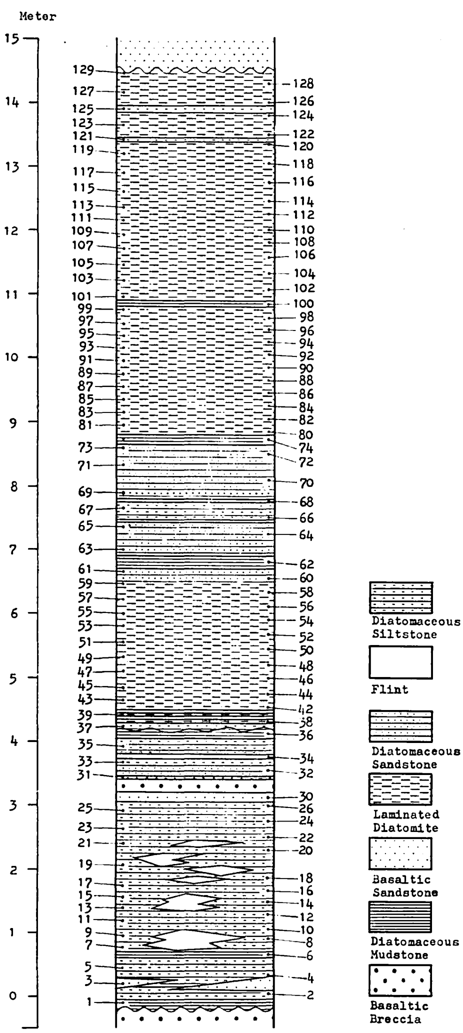


Fig. 4. Columnar Section of Chōjabaru Formation, Showing Stratigraphic Position of Samples.

Fig. 4 shows the columnar section at the Cape of Chōjabaru. This formation outcrops only in this place and its total thickness attains to about 15 meters. Its strike is E-W and dip is about 20 degrees southward. Most part of the formation consists of well laminated diatomite. In this formation some kinds of fossils, such as pisces, insects and plant leaves are found. Reported microfossils are *Coscinodiscus* cf. *haradai* PANNT. and others. The author's investigation has revealed that at the lower part of this formation *Melosira* sp. is abundant, but at the upper part *Coscinodiscus* sp. is conspicuous. Reported pisces are *Iquius nipponicus* JORDAN and others. Plant leaves are *Quercus* sp., *Cinnamomum* cf. *lanceolatum* HEER, *Liquidamber* sp., *Carpinus protojaponica* ENDO, *Ulmus parvifolia* JACQ, *Sterculia* cf. *tenuinervis* HEER and others. From these points, the Chōjabaru formation is supposed to be of Miocene age.

The selected specimen for electron-microscopy is No. Iki-97 in the columnar section in Fig. 4.

Method of study

At the field, diatomites are collected taking care to eliminate the contamination. In the laboratory, after the dispersion of a bulk sample of diatomite, the coccoliths are concentrated by hydraulic procedure, and repeatedly washed clean so as to be free from finer materials. Usually, in the course of the concentration of coccoliths, chemical treatment, especially with hydrofluoric acid, might be available, but in this case the weak coccoliths are apt to be destroyed during the procedure and also the replaced calcium fluoride are not transparent for regular electron beams. A smear is made on a carbon-coated collodion film immersed in a concentrated suspension of coccoliths in alcohol when it is taken out and allowed to dry. This is because the surface tension of alcohol is smaller than that of water. Commonly heavy metal shadowing is used to catch up the details of surface sculpture, and also to provide a shadow by means of which the thickness of the coccoliths may be measured, but the present author could'nt use this technique. Electronmicrographs were taken, using the Japan Electron Optics Laboratory JEM-SS electronmicroscope. In the normal mode of this operation, acceleration voltage was 30 kV and filament current was 70 μA. Prints made directly from the original negative reproduce the appearance of the coccoliths as seen on the fluoresent screen of the microscope with clear shadows which appear white on the print.

Taxonomic problem

Taxonomic problems of calcareous nannoplankton were taken up by BRAMLETTE and SULLIVAN (1961), BRAMLETTE and MARTINI (1964) and others. Especially, concerning to electronmicroscopical investigation, BLACK and BARNES (1959) made suggestion to these reports as following: " The selection of type specimen for species of fossil coccoliths present certain difficulties. Material preserved in permanent mounts, for example in Canada balsam, has been used in the past, but is unsatisfacotory because surface details, which are essential for the diagnosis of most species, cannot be seen in such mount. In the preparation of carbon replica, the specimen itself is destroyed in order to leave a transparent replica, and is thus not available for preservation as a type. Since the actual specimen cannot be used, it seems most satisfactory to base the species upon the photographic plate used in writting the description, rather than upon the carbon replica, which is more difficult to handle and to store safely." The present author observed the intact coccoliths on the carbon-coated collodion film. These observed specimens cannot easily be handled and safely preserved. In the following descriptions, therefore, the holotype and the paratype observed are those in micrographed negative films, preserved by the Department of Earth Science, Nara University of Education, Nara, Japan. Numbers on the plate are not equal to those of the electronmicrographed negative film on which serial numbers are given. Their relationship is shown in Table 1.

Systematic descriptions

Family Coccolithophoridae LOHMANN

Genus *Pseudococcolithus* NISHIDA, gen. nov.

Coccoliths consist of a single thin plate having a single rim or more rims without any sculpture. Generally speaking, coccoliths and allied calcareous nannofossils are opaque for regular electron beans with an acceleration voltage of less than 100 kV. For example, Deflandre and Fert published a number of transmission electronmicrographs of coccolithophorids which were not satisfactory to show the structural details clearly. But the present *Pseudococcolithus* is transparent to the electron beams even with 30 kV of acceleration voltage. Marginal form of the coccoliths is variable, being circular to oval, elliptical, and even deltaic, and outer margins of them are not serrated. Central area of a species of *Pseudococcolithus* is of perforated mesh structure, or has fine zigzag striae or knobs in surface sculpture.

Type species.—Pseudococcolithus reti-

culatus NISHIDA, sp. nov.

Pseudococcolithus reticulatus NISHIDA, sp. nov.

Pl. 30, figs. 1-4

Description.—The circular plate consists of three rims and a central area. Distal two rims are thick. The proximal rim is very narrow, but electron density is very high. The central area is meshed and perforated. Some of these coccoliths have etched design on the surface of rims, but normally their surface is supposed to be very smooth. Distribution of perforations in the central area is very regular.

Dimension of holotype.—2.60-2.55μ; second ring 1.50-1.45μ; inner ring 1.30-1.25μ; central area 1.10-1.05μ.

Range of dimensions.—major axial diameter 2.60-2.15μ; minor axial diameter

Table 1. Type specimen.

Relationship between the figured numbers in the plates and the serial numbers given on the electronmicrographed negative film.

Plate 30		Plate 31	
Fig. No.	Nega. film No.	Fig. No.	Nega. film No.
1	IKI 97-268	1	IKI 97-335
2	018	2	334
3	219	3	311
4	339	4	338
5	035	5	369
6	309	6	341
7	015	7	380
8	364	8	300
9	337	9	010
10	324	10	117
11	026	11	021
12	009	12	051
13	347	13	314
14	321	14	025
15	336	15	325
16	119	16	340
17	210	17	069
18	299	18	266
19	290	19	017
20	351	20	327
21	223	21	209
22	132	22	318
		23	368
		24	033
		25	012
		26	365

2.55-1.90μ.

Remarks.—This coccoliths is easily distinguished by its wide three rims and perforated central area.

Holotype.—Pl. 30. fig. 1.

Paratypes.—Pl. 30, figs. 2-4.

Pseudococcolithus striatus NISHIDA, sp. nov.

Pl. 30, figs. 5-10

Description.—Oval to elliptical in form, consisting of a rim and a finely striated central area. No design is sculptured on the rim. Fine zigzag striae on the central area are counted from 21 to 25 lines. These striae of some specimens are not so distinct. The boundary between the rim and central area is not conspicuous with regard to electron density.

Dimension of holotype.—1.55-1.10μ; central area 1.35-0.65μ.

Range of dimensions.—Major axial diameter 2.10-1.45μ; minor axial diameter 1.30-1.10μ.

Remarks.—Fine zigzag striae on the central part are distinct.

There exists no part specially high in electron density.

Holotype.—Pl. 30, fig. 6.

Paratypes.—Pl. 30, figs. 5 and figs. 7-10.

Pseudococcolithus fusiformis NISHIDA, sp. nov.

Pl. 30, figs. 11-16

Description.—Oval to elliptical in form, consisting of a rim and a spindle-shaped central area. The rim is very thick and electron density becomes higher towards the boundary between the rim and central area. The central area is spanned by one third of the shorter diameter and closed. No sculpture exists on the surface of the rim and central area.

Dimension of holotype.—1.55-1.20μ; central area 0.90-0.45μ.

Range of dimensions.—Major axial diameter 1.80-1.40μ; minor axial diameter 1.35-1.05μ.

Remarks.—This coccolith is characterized by a thick rim and a spindle-shaped central area.

Holotype.—Pl. 30, fig. 12.

Paratypes.—Pl. 30, fig. 11 and figs. 13-16.

Pseudococcolithus orbicularis NISHIDA, sp. nov.

Pl. 30, figs. 17-21

Description.—Coccoliths of this genus are usually large with nearly circular outer shape. *P. orbicularis* consists of a rim and a central area. At the boundary between the rim and central area, electron density becomes higher. No figure exists both on the rim and central area. Central area is closed.

Dimension of holotype.—1.85-1.75μ; central area 1.20-1.05μ.

Range of dimensions.—Major axial diameter 1.95-1.20μ; minor axial diameter 1.80-1.15μ.

Remarks.—Nearly circular outer shape and the wide central area make this species distinct from others.

Holotype.—Pl. 30, fig. 20.

Paratypes.—Pl. 30, figs. 17-19 and fig. 21.

Pseudococcolithus deltoides NISHIDA, sp. nov.

Pl. 30, fig. 22

Description.—With round-cornered deltaic appearance, consisting of a rim and a central area. Shape of the central area is similar to the external form. No sculptured design is seen on its surface. Towards the boundary between the rim and central area, electron density becomes higer.

Dimension of holotype.—Base 1.65μ; height 1.55μ; base of central area 0.90μ; height of central area 0.90μ.

Remarks.—This coccolith can easily be distinguished by its deltaic external form.

Holotype.—Pl. 30, fig. 22.

Pseudococcolithus rotundatus NISHIDA, sp. nov.

Pl. 31, fig. 1

Description.—Of large circular form, consisting of double rim and a central part. The distal rim is thinner in width and somewhat lower in electron density than proximal one. Boundary between the rim and central part, and the rims themselves are obscure. No sculptured pattern is seen on its surface.

Dimension of holotype.—2.40-2.25μ; central area 1.5-1.06μ.

Remarks.—The diagnostic features of this coccoliths are its large circular form, double rims and a central area.

Holotype.—Pl. 31, fig. 1.

Pseudococcolithus oviformis NISHIDA, sp. nov.

Pl· 31, fig. 2

Description.—With large elliptical appearance, consisting of a thick rim and a central area. Boundary between the rim and central area is obscure, but in central area electron density is somewhat lower. Both rim and central area are not sculptured.

Dimension of holotype.—2.75-2.10μ; central area 1.65-1.00μ.

Remarks—This coccolith is [distinguished by large elliptical form, being consisted of a thick rim and central area.

Holotype.—Pl. 31, fig. 2.

Pseudococcolithus oblongus NISHIDA, sp. nov.

Pl. 31, figs. 3-11

Description.—Oval to elliptical in form, consisting of a rim and a wide central area. On the surface of the coccolith any distinct sculptured figure is not seen. Some specimens have etched surface which is supposed to have been smooth originally. Electron density becomes higher towards the boundary between the rim and central area.

Explanation of Plate 30

All electronmicrographs are magnified to the size of about 2000 times.

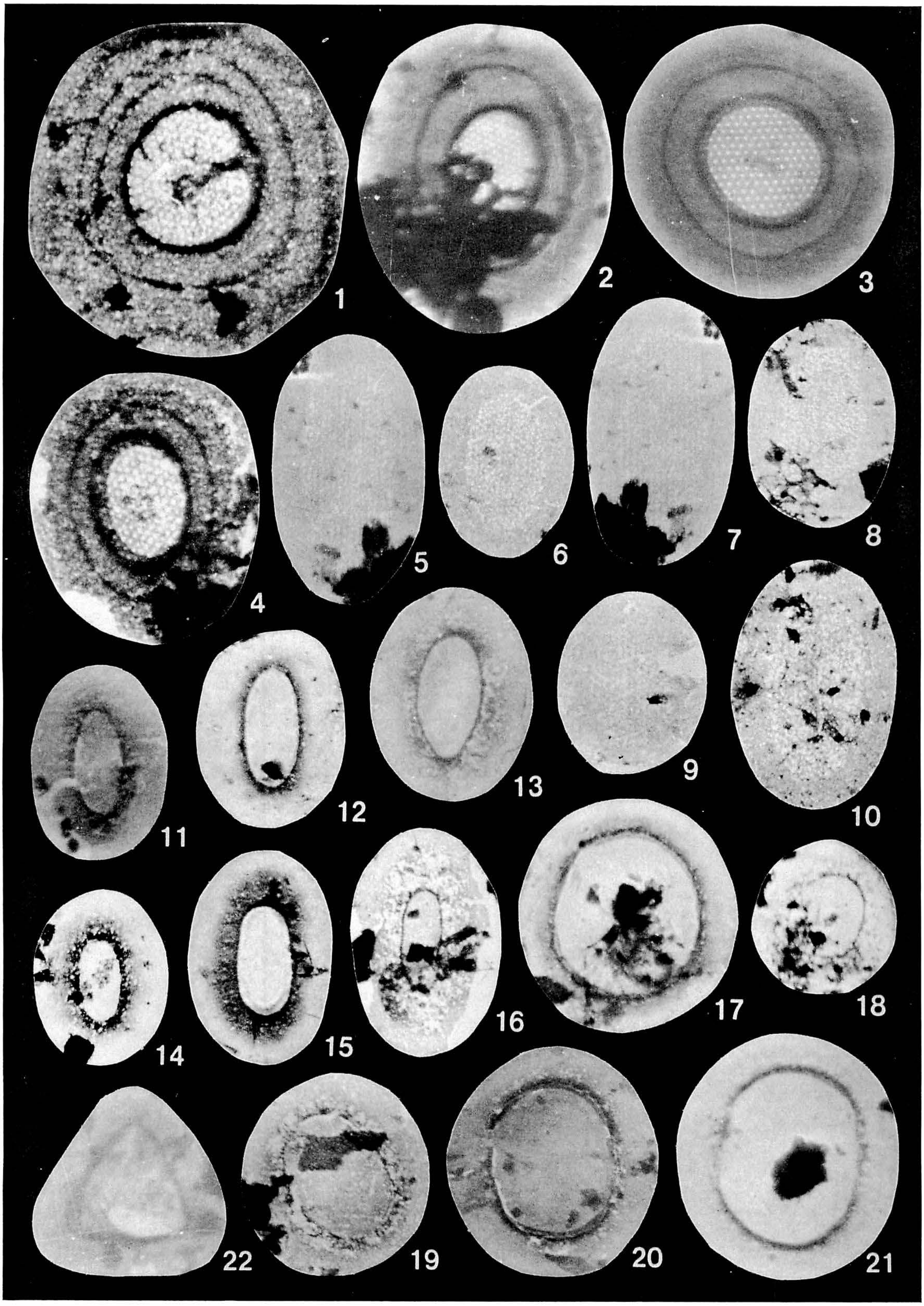
Figs. 1-4. *Pseudococcolithus reticulatus* NISHIDA, sp. nov.
1: Holotype; 2-4: Paratypes.

Figs. 5-10. *Pseudococcolithus striatus* NISHIDA, sp. nov.
6: Holotype; 5 and 7-10: Paratypes.

Figs. 11-16. *Pseudococcolithus fusiformis* NISHIDA, sp. nov.
12: Holotype; 11 and 13-16: Paratypes.

Figs. 17-21. *Pseudococoolithus orbicularis* NISHIDA, sp. nov.
20: Holotype; 17-10 and 21: Paratypes.

Fig. 22. *Pseudococcolithus deltoides* NISHIDA, sp. nov.
22: Holotype.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Dimension of holotype.—1.90-1.35μ; central area 1.15-0.65μ.

Range of dimensions—Major axial diameter 2.10-1.60μ; minor axial diameter 1.45-1.30μ.

Remarks.—This coccolith closely resembles *Pseudococcolithus fusiformis*, but its central area is wider than *P. fusiformis* and the thickness of the rim is somewhat thinner.

Holotype.—Pl. 31, fig. 3.

Paratypes.—Pl. 31, figs. 4-11.

Pseudococcolithus biporosus NISHIDA, sp. nov.

Pl. 31, figs. 12-17

Description.—Coccoliths of this genus usually small in shape, with oval to elliptical forms. This coccolith consists of a rim and a central area. Around the boundary between the rim and central area, electron density is higher in the other part. In the central part, two distinct apertures exist. The bridges of them are broken in many specimens, but they are normally joined.

Dimension of holotype.—1.35-0.85μ; central area 0.90-0.35μ.

Range of dimensions.—Major axial diameter 1.40-1.05μ; miuor axial diameter 0.85-0.70μ.

Remarks.—This species can be readily separated from others by the perforated central area with two apertures.

Holotype.—Pl. 31, fig. 16.

Paratypes.—Pl. 31, figs. 12-15 and fig. 17.

Pseudococcolithus nodulosus NISHIDA, sp. nov.

Pl. 31, figs. 18-26

Description.—Oval to elliptical plate. The size of this species is varied. The distinction between the rim and central area is obscure. Under the electron-microscope, one or two knobs are seen in central area, but the feature in the photograph is not conspicuously demonstrated. Surfaces of some specimen are etched, but are supposed to be smooth in the normal state.

Dimension of holotype.—1.95-1.20μ.

Range of dimension.—Major axial diameter 2.05-0.95μ; minor axial diameter 1.50-0.85μ.

Remarks.—One or two obscure knobs observed in central area are the most characteristic features for this species.

Holotype.—Pl. 31, fig. 18.

Paratypes.—Pl. 31, figs. 19-26.

Acknowledgement

The author wishes to express his gratitude to Professor Misaburō SHIMAKURA of his department, not only for his interest and encouragement. Thanks are also due to Professor Kōshirō UMEDA of of his department for his constant encouragement and to Assistant Professor Naofumi KITAGAWA of the Biological department of his University for the suggestions made in the preparation of the manuscript.

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Chōjabaru	長者原	Nagasaki	長　崎
Gōnoura	郷ノ浦	Nishibure	西　触
Iki	壱　岐	Sakyōnohana	左京ノ鼻
Indōjo	印通寺	Seto	瀬　戸
Katsumoto	勝　本	Yahata	八　幡
Moroyoshi	諸　吉		

Explanation of Plate 31

All electronmicrographs are magnified to the size of about 20000 times.

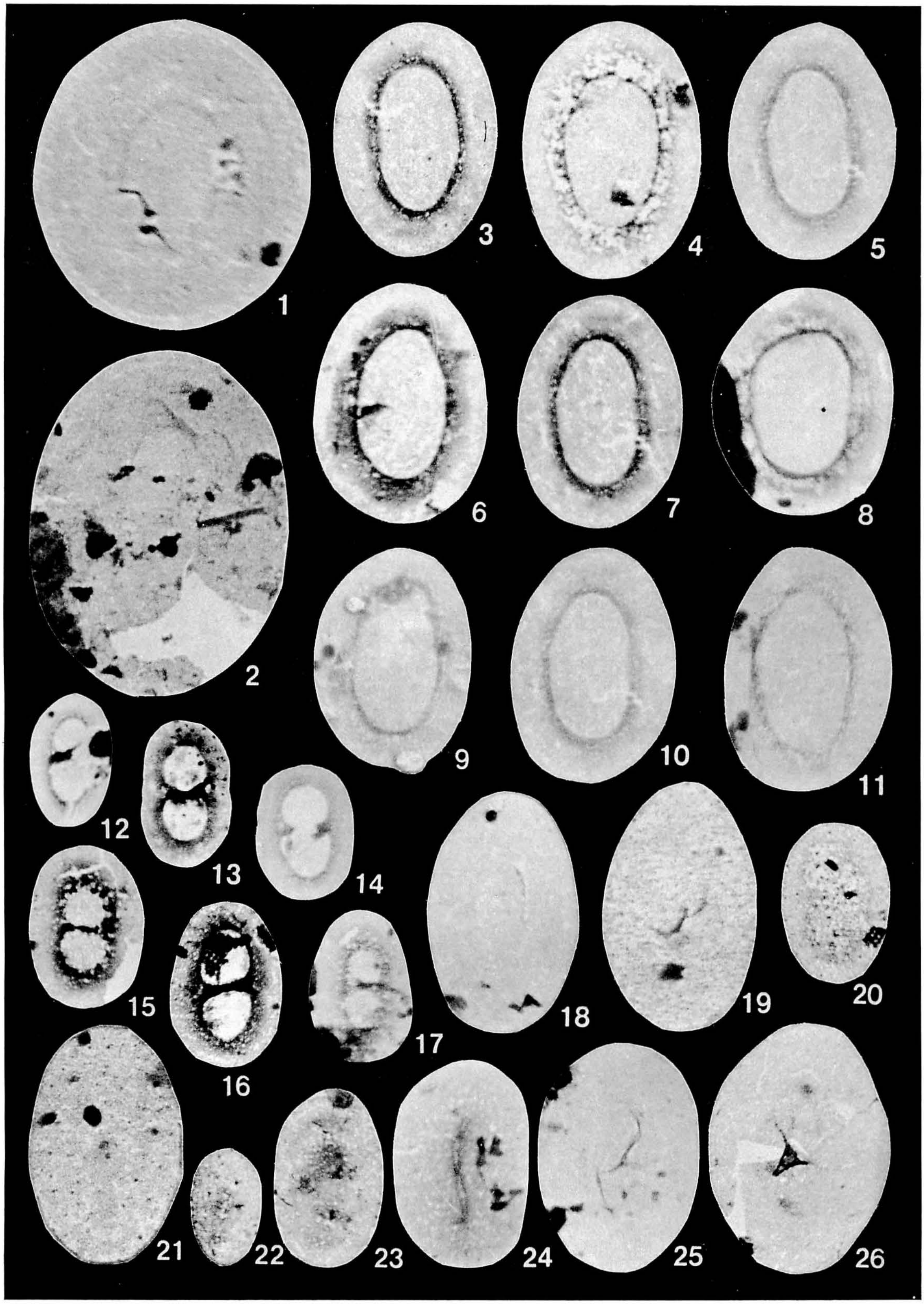
Fig. 1. *Pseudococcolithus rotundatus* NISHIDA, sp. nov.
1: Holotype.

Fig. 2. *Pseudococcolithus oviformis* NISHIDA, sp. nov.
2: Holotype.

Figs. 3–11. *Pseudococcolithus oblongus* NISHIDA, sp. nov.
3: Holotype; 4–11: Paratypes.

Figs. 12–17. *Pseudoccccolithus biporosus* NISHIDA, sp. nov.
16: Holotype; 13–15 and 17: Paratypes.

Figs. 18–26. *Pseudococcolithus nodulosus* NISHIDA, sp. nov.
18: Holotype; 19–26: Paratypes.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Trans. Proc. Palaeont. Soc. Japan, N.S., No. 71, pp. 317-325, pl. 32, Sept. 15, 1968

543. AN INTERESTING SPECIES OF *INOCERAMMS* FROM THE UPPER CRETACEOUS OF KYUSHU*

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九州上部白亜系産の興味あるイノセラムス：　大分県臼杵市南西に分布する上部白亜系田野層の上部から産したイノセラムスは，特異性があるので，ここに新種として記載する。これは *Inoceramus latus, I. incertus* などと類似するが，殻形生長の軸が前に凸の曲線を描くこと，小さい前耳をもつことなどで区別できる。同産地から *I. hobetsensis, Subprionocyclus neptuni* を産するので，田野層上部は上部チューロニアン（その比較的下部）に対比される。なお本種の記載に関連して，イノセラムスの若干種に存在する前耳の意義，また同じく前耳をもつ *I. (Platyceramus) mantelli* との類縁関係，ならびに本種の系統分類上の位置づけについて論及する。　　松本達郎・野田雅之

Introduction

Species of *Inoceramus* occur fairly commonly in the Upper Cretateous of central Kyushu. The principal rock-series which contain *Inoceramus* are the Himenoura Group in the west and the Onogawa Group in the east. The succession of species in the Coniacian to Campanian Himenoura Group has been clarified by UEDA (1962), with aid of MATSUMOTO, and TAKAI and MATSUMOTO (1961), while that in the Turonian to Santonian Onogawa Group was previously studied by one of us (MATSUMOTO, 1936) and is being restudied by the other of us (M.N.).

In the mean while, Y. TERAOKA of the Geological Survey of Japan has recently undertaken a precise geological mapping and stratigraphic work in the Onogawa area (TERAOKA, 1964, 68). He has kindly shown us his collections of *Inoceramus* specimens. The zonal sequence of the species in the Onogawa Group is *I. hobetsensis* NAGAO and MATSUMOTO, *I. teshioensis* NAGAO and MATSUMOTO, *I. uwajimensis* YEHARA, *I. mihoensis* MATSUMOTO, *I. naumanni* YOKOYAMA, and *I. amakusensis* NAGAO and MATSUMOTO in ascending order, as is described in another paper (NODA, 1968, written in Japanese). This is well correlated with the already established zonal sequence in Hokkaido (MATSUMOTO, 1954, 59).

The Turonian to Santonian Onogawa Group is distributed in the Onogawa basin, Oita Prefecture, which is demarcated in the southeast by a tectonic line called the Usuki-Yatsushiro Line,

* Received April 22, 1968; read June 22, 1968 at Sendai.

along which older rocks composed of sheared granite, gabbro, gneiss, mylonite, etc. are squeezed out. On the southeast side of this tectonic line Cretaceous strata are still distributed, although in patches. They were once studied by FUJII (1954), who called the Upper Cretaceous part the Tano Formation. The Tano Formation resembles the Onogawa Group, consisting of conglomerate, sandstone and shale, but is much thinner (about 920 m) than the extraordinarily thick Onogawa Group (about 4650 m in its lower half, the Turonian part).

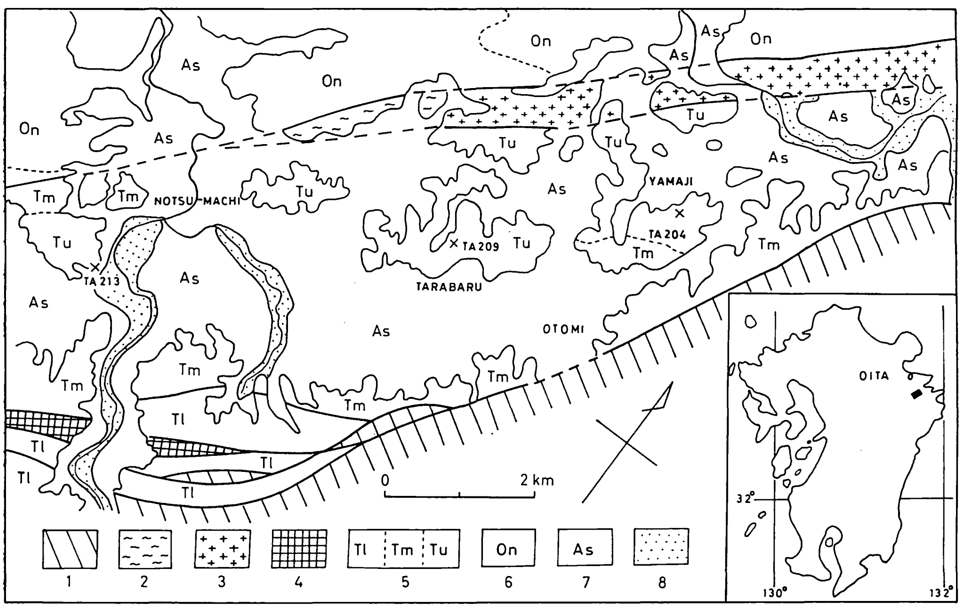
The upper, shaly part of the Tano Formation contains marine molluscan fossils, of which an ammonite species *Subprionocyclus neptuni* (GEINITZ) and *Inoceramus hobetsensis* NAGAO and MATSUMOTO are good guide fossils, indicating the middle part of Upper Gyliakian in the Japanese scale, approximately lower part of the Upper Turonian, if the Turonian is bipartite in the international scale.

Associated with these fossils, there are interesting specimens of *Inoceramus*, both in TERAOKA's and NODA's collections, which represent a new species. We describe it in this paper.

Before entering in the palaeontological description, a guide is given below for the localities from which the specimens have been obtained (Fig. 1).

Loc. TA 294 [=CF 14 of TERAOKA]: location, 33°4′19″N, 131°14′58″E, on a mountain path from Yamaji to Otomi, Usuki City, Oita Prefecture

Loc. TA 209: location, 33°3′19″N, 131°43′45″E, on the western flank of a hill, northern area of Tarabaru, Notsu-machi, Ono-



Text-fig. 1. Geological sketch map of the Tano area, Oita Prefecture, indicating localities of the described *Inoceramus*, with ×. 1: Upper Palaeozoic of the Chichibu belt; 2: Metamorphic rocks at Shonoharu; 3: Sheared granite, gabbro, and gneiss squeezed out along the Usuki-Yatsushiro Line; 4: serpentinite; 5: Tano Formation (including Tl, Tm, and Tu: lower, middle, and upper members), 6: Onogawa Group (indicating the formational boundary with a broken line); 7: Aso welded tuff (Quaternary); 8: Alluvium.

gun, Oita Prefecture

Loc. TA 213: location, 33°1′39″N, 131°41′ 22″E, on the eastern hillside near a bridge called Meijibashi, Ushirogawachi, Notsu-machi, Ono-gun, Oita Prefecture

Acknowledgements.—We thank Dr. Yasushi TERAOKA, Geological Survey of Japan, Mr. Mikio ICHII and Mr. Hiroshi SHIJO, who have kindly supplied us valuable specimens for our study. We are much indebted to Professor Dr. Otto SEIZ, Hannover, and also to Dr. Itaru HAYAMI, Kyushu University, for some problems in *Inoceramus*. Dr. HAYAMI and also Miss Yuko WADA have kindly assisted us in preparing the manuscript. The field work of one of us (M. NODA) was undertaken on a grant from the SHIMONAKA Commemorative Foundation.

Description of A New Species

Inoceramus teraokai sp. nov.

Pl. 32, Figs. 1–5; Text-fig. 2

Material.—Holotype: GK. H6833 (Pl. 32, Fig. 1; text-fig. 2), internal mould of a right valve, from loc. TA 204 [=CF 14 of TERAOKA] (Y. TERAOKA Coll.) Paratypes: GK. H6834 (Pl. 32, Fig. 2) and GK. H6835 (Pl. 32, Fig. 3), left valves (internal mould) in the same rock as the holotype; GK. H6836 (Pl. 32, Fig. 4a, b), internal and external moulds of a right valve, from loc. TA 209 (M. NODA Coll.); GK. H6837 (Pl. 32, Fig. 5), a left valve, from loc. TA 213 (H. SHIJO Coll.); GK. H6838, another left valve, from loc. TA 204 (M. NODA Coll.). Repository: Department of Geology, Kyushu University. There are more specimens in NODA's private cellection.

Specific characters.—Shell of moderate size, equivalve, very inequilateral, gently covex, in earlier stages somewhat longer than high, but in later stages slightly higher than broad and obliquely elongated from beak to the posteroventral margin. Hinge-line of moderate length, about two fifths of the shell length. The axis of growth gently curved, with the convex side facing anteriorly, forming angles of about 70° to 50° with the hinge-line, decreasing with growth.

Umbo subterminal and improminent, rising slightly above the hinge-line. Anterior margin of the main part of the flank gently curved or nearly straight, forming an apical angle of about 140°. Anterior part provided with a small ear.

Anteroventral margin broadly arcuate, passing gradually to the rounded ventral margin and then more broadly curved posteroventral one, which rather abruptly turns to the moderately long and nearly straight posterior margin. The angle between the posterior margin and the hinge-line about 130–140°. The postero-dorsal part flattened, passing gradually into posterior wing without sharp boundary.

Surface marked with major concentric ribs at rather irregular intervals and also with minor fine concentric rings. The major ribs are low but sharp-headed and ripple-like in cross section. The ribs and rings form an asymmetrically rounded curvature, following the outline of the shell.

Measurements.—

Dimensions in mm.

Specimen	H	L	h	l	HL
GK. H6833	50	35	42	39	16
	62(+)	40(?)	55.5	47.5	—
GK. H6834	53	41	43	50	20(?)
GK. H6836	53	41	46	52	20(+)

H = maximum dimension along the axis of growth

L = dimension along a line perpendicular to H

h = height (measured perpendicular to the hinge-line)

l = length (measured parallel to the hinge-line)
HL = length of the hinge-line
(see NAGAO and MATSUMOTO, 1939, p. 258, text-fig. 3 for the symbols.)

Change in the obliquity of the shell (angle between the axis of growth and the hinge-line) at 5 growth-stages.

Specimen	Length of growth axis in mm. 10	20	30	40	50
GK. H6833	73°	64°	55°	53°	51°
GK. H6836	69°	58°	50°	49°	47°
for comparison: Example of *I. incertus*	48°	50°	54°	60°	63°

Remarks.—The specimens before us are more or less secondarily compressed. The breadth of the valve is not accordingly measured. Although the original convexity is not precisely known, it does not seem high.

The outline of the shell as well as the proportion between height and length may have been modified by the secondary deformation. There is, however, variation to some extent, since the change in h/l may occur slowly or rapidly, depending on individuals.

Details of the surface ornamentation are better impressed on external moulds (e. g. GK. H6836b). Characters of the ribs, such as their strength, shape in cross-section, etc., may have been modified by the secondary deformation, too. From the synthetic judgement of several specimens the described characters are given.

In spite of the above situation, the specimens show distinctive characters which enable us to propose a new species.

Comparisons.—The present species is somewhat similar to *Inoceramus incertus* JIMBO, 1894 (see NAGAO and MATSUMOTO, 1940, p. 10, pl. 3, figs. 1-5; pl. 10, fig. 2), from the Upper Turonian (upper part of Upper Gyliakian) of Hokkaido, and also to *Inoceramus yubarensis* NAGAO and MATSUMOTO (1940, p. 11, pl. 6, fig. 1), from the upper Lower Urakawan (Coniacian) of Hokkaido. *I. incertus* is close to but not identical with *I. latus* SOWERBY for the reason mentioned below. *I. yubarensis* was at first regarded as a variety of *I. incertus*, but is now better separated as a distinct species, because of much higher outline of the shell and also of independent occurrence at higher stratigraphic level. It is very close to *I. mantelli* (MERCEY) BARROIS, 1879 (see SEITZ, 1962), from the Coniacian of Europe, but has a relatively shorter hinge-line. Anyhow, in these species the shell is more or less oblique postero-ventrally. However, if we carefully examine the change in growth stages, unmistakable differences are noticed. Namely in *I. teraokai* the shell becomes more oblique as it grows, in *I. incertus* it becomes slightly less oblique, and in *I. yubarensis* and *I. mantelli* it becomes remarkably less so. In other words, the axis of growth is convex to the anterior in *I. teraokai*, gently concave in *I. incertus*, and at first fairly concave and then nearly straight and upright in *I. yubarensis* and *I. mantelli*.

The ribs are apparently sharp-headed and rather irregular in *I. teraokai* as compared with low, broad, and regular ribs in *I. incertus* and *I. yubarensis*. The development of numerous, fine concentric rings in combination with the major ribs is common to the four species under consideration.

I. teraokai closely resembles *I. latus* SOWERBY, 1828 (see WOODS, 1911, p. 284, text-figs. 38, 40, 41, *non* text-fig. 39), from the Turonian of England, and also to *I. hercynicus* PETRASCHECK, 1904, from the Turonian of Germany and other regions, which, however, was regarded by SEITZ

(1921, p. 101) as a synonym of *I. latus* and later (SEITZ, 1934) as a variety of *I. labiatus*. *I. teraokai* is fairly allied to *I. labiatus* (SCHLOTHEIM, 1813) (see WOODS, 1911, p. 281, pl. 50; text-fig. 37 and also SEITZ, 1934), a world-wide index of the Lower Turonian.

I. latus has a nearly straight axis of growth which forms on the average a greater angle (70–80°) with the hinge-line. In these respects it is distinguished from *I. teraokai* on one hand and from *I. incertus* on the other. In the anteriorly convex curvature of the growth-axis and in the tendency to elongate posteroventrally, *I. teraokai* is somewhat similar to *I. labiatus*, but the latter is typically more oblique, still more elongated to the posteroventral extremity, has a smaller beak angle and relatively shorter hinge-line. Although SEITZ (1934) reported a great variability in shell form of *I. labiatus*, the collections from the upper member of the Tano Formation do not show such a variability and do not include the highly obliquely extended form. The ribs in *I. latus* and *I. labiatus* seem to be lower, more rounded on top, generally more crowded and covered with more distinctly marked concentric lines than those in *I. teraokai*.

The presence of the anterior ear is a particular character of the present species, while such a feature has not been reported with respect to any example of *I. labiatus*, *I. hercynicus*, *I. latus*, *I. incertus* and *I. yubarensis*. *I. mantelli* has the anterior ear, but is closer to *I. yubarensis* in the outline of the shell and in the surface ornamentation.

Occurrence:—Common in the shaly part of the upper member of the Tano Formation, Notsu area, Oita Prefecture, eastern central Kyushu. The species is associated with *Inoceramus hobetsensis*, a zonal index of the middle part of the Upper Gyliakian, approximately lower Upper Turonian. *Subprionocyclus neptuni* (GEINITZ), a world-wide ammonite species of the Upper Turonian (precisely speaking lower Upper Turonian), occurs in the same bed. For some reason *Inoceramus teraokai* has not yet been found in the prolific Upper Cretaceous sequence of Hokkaido.

Notes on the Anterior Ear

Examples with anterior ear or wing-like area have been occasionally noted in certain Jurassic and Cretaceous species. According to HAYAMI (1960, p. 299), a small anterior wing-like area is usually present in the group of *Inoceramus polyplocus* ROEMER (i.e. subgenus *Mityloceramus* ROLLIER, 1914), from the Middle Jurassic of Europe and Japan and it is sometimes discernible in *Parainoceramus* VORONETZ, 1936 (see COX, 1954, p. 47), a primitive genus of the Inoceramidae ranging from Upper Triassic to Bajocian (abundant in Lower Jurassic).

In the description of *Inoceramus dunveganensis* MCLEARN, 1926, from the Upper Albian to Middle or Upper Cenomanian of northern Alaska, JONES and GRYC (1960, p. 159–160) mentioned that after the shell attains to 25 to 50 mm in height the anterior marginal area becomes flat and new shell material is added to form a broadly rounded skirt which, in turn, is in some specimens developed into an anterior wing. They consider that the development of the anterior wing is variable and that its presence or absence is not of specific importance in that species.

In the meanwhile SEITZ (1962) notified the presence of the anterior ear in *Inoceramus mantelli* (MERCEY) BARROIS, 1879, from the Coniacian of Europe, *I. expansus* BAILY, 1855, from the Senonian of South

Africa, and also *I. cordiinitialis ickernensis* SEITZ, 1961, from the Santonian of Germany. SEITZ, furthermore, remarked that a narrow opening is found between the anterior ears of both valves and that it probably worked as a byssal notch.

Prior to these works SOKOLOW (1914) described the presence of a small anterior ear, in addition to the distinct posterior wing, in *Inoceramus pilvoensis* SOKOLOW, from the Upper Cretaceous of north Sakhalin, which is apparently similar to *I. hercynicus* but actually dubious in its systematic position (see NAGAO and MATSUMOTO, 1940, p. 54). Similarly a small anterior and a longer posterior wings are distinctly demarcated from the main part of the valve in *Inoceramus kusiroensis* NAGAO and MATSUMOTO, from the Maastrichtian of eastern Hokkaido. In the last species, which is again taxonomically problematic, the ligamental pits are discernible along the inner margin of both the anterior and posterior wings. In other words the beak is not terminal. Accordingly the anterior wing in that species is not identical with the anterior ear or wing-like area under consideration.

The aforementioned idea of SEITZ can well be applied to the anterior ear of *I. teraokai*, although the secondarily flattened preservation of our specimens may not be adequate for restoring the byssal opening. In *I. teraokai*, as shown in Text-fig. 2, the ligamental pits are observed along the hinge-line, which does not extend to the dorsal margin of the anterior ear. The ear itself is short and narrow, showing an obtuse angle. The anteroventral margin of the ear passes gradually to the gently curved anteroventral margin of the main valve. Therefore a narrow gape must have existed between the anterior ears of both valves. The anterior ear is, thus, a distinctive character of the present species, although it may not be preserved in some specimens.

Many of inocerami species are indeed geographically widespread, being good index fossils for the interregional correlation, but in what way they have been distributed so widely needs special explanation. HAYAMI (oral communication, Sept. 25, 1967, in a lecture at Kyushu University) has suggested us an idea of the pseudoplanktonic distribution of certain inocerami species. In fact some specimens of *Parainoceramus dubius* SOWERBY, 1826, in the Holzmaden Posidonienschiefer, Germany, show a situation of the shell attached to a piece of drifted wood, as reported by JESSERIES et al. (1965). HAYAMI considers, as a working hypothesis, that such a pseudoplanktonic mode of life may have been kept only in an immature stage of numerous widespread species of later geological ages. His idea is indeed interesting

Text-fig. 2. *Inoceramus teraokai* sp. nov. GK. H6833, holotype, showing the hinge-line and the anterior ear (natural size). The same specimen in a different light is shown by Pl. 32, Fig. 1.

but awaiting further evidence.

We think that in a limited number of species the mode of the sessile and pseudoplanktonic life may have continued up to the mature stage. In such mytiliform species as *Inoceramus labiatus* the byssus might have been extruded through an apparently indiscernible slit as in the recent species of *Mytilus*. BÖHM (1915, 1920) has already recognized a byssal gape between the curved anterior margins in *Inoceramus* (*Sphaenoceramus*) *nasutus* WEGNER and *I.* (*S.*) *cardissoides* GOLDFUSS. In some other species a byssal opening is formed between the anterior ears, as SEITZ has pointed out. It is interesting to note that *Inoceramus teraokai* belongs to the same group as *I. mantelli*, which is provided with a distinct anterior ear.

Problem of Subgeneric Assignment

We do not intend to give in this paper comprehensive comments on the classification of the Inoceramidae. Only a short remark is given in connexion with the above described new species.

It is certain that *I. anglicus* WOODS, 1911, *I. crippsi* MANTELL, 1822, *I. reachensis* ETHERIDGE, 1881, *I. latus* SOWERBY, 1828, *I. incertus* JIMBO, 1894, *I. yubarensis* NAGAO and MATSUMOTO, 1940, and *I. mantelli* BARROIS, 1879, constitute a major evolutional series, as WOODS (1912) demonstrated and as one of us (MATSUMOTO, 1959) mentioned. In view of the affinity with the last four species, *I. cycloides* WEGNER, 1905, and *I. ezoensis* YOKOYAMA, 1890, probably represent the Santonian species of the same series. *I. labiatus* (SCHLOTHEIM, 1813) is referable to the same stock, but it may represent a specialized offshoot, as MATSUMOTO (1959, p. 85) has remarked. In our opinion *I. dunveganensis* MCLEARN, 1926, with which *I. athabaskensis* MCLEAN, 1945, is synonymous, belongs to the same subgroup as *I. anglicus—I. crippsi.*

These species are all subequivalve or equivalve and be can distinguished from another evolutional series which includes more distinctly inequivalve species, such as *I. lamarcki* PARKINSON, 1819 and *I. cuvieri* SOWERBY, 1814. To the latter group are referable the Japanese species *I. hobetsensis* NAGAO and MATSUMOTO, 1939. As one of us (MATSUMOTO, 1959, p. 84) briefly mentioned, we are inclined to seek the ultimate origin of this group in *I. concentricus* PARKINSON, 1819, and not in *I. anglicus* WOODS.

If the type-species of *Inoceramus* SOWERBY, 1814, is settled at *Inoceramus cuvieri* SOWERBY, 1814, the subgeneric name *Inoceramus* (*s. s.*) should be used for the latter group, and the species of the former series should come under another name or other names.

Although the validity of many of the generic and subgeneric names proposed by HEINTZ (1932, etc.) is nomenclatorially doubtful, because of lack of clear diagnosis and of *nomen nudum* situation of the designated type-species, some of them could be validated.

Platyceramus HEINTZ, 1932, was proposed with designation of the type-species *Inoceramus mantelli* (MERCY) BARROIS. HEINTS, however, gave no generic diagnosis nor distinction from other genera. SEITZ (1961, p. 54) used it as a subgeneric name, giving a clear diagnosis.

Should *Mytiloides* BRONGNIART, 1822, be restricted to the subgroup of *I. labiatus*, which is characterized by an extremely obliquely elongated form and is interpreted here as an offshoot from the main stock, the *Platyceramus* could be used as a subgeneric name for the subgroup of *I. mantelli*. However, if *I. latus* was interpreted as a mere variant of *I. labiatus*, *Platyceramus* might fall in a synonym of *Mytiloides*. We do not follow this interpretation.

Because *I. latus*, *I. incertus* and *I. yubarensis* are intimately related to *I. mantelli*, they are referable to *Platyceramus*. *I. ezoensis* has already been referred to subgenus *Platyceramus* by SEITZ (1961, p. 92). Since *I. teraokai* closely resembles *I. latus* and *I. incertus*, it can also be assigned to *Platyceramus*.

HEINTZ (1932, p. 6) proposed the generic name *Gneisioceramus** for *Inoceramus crippsi*. This generic name might have a page priority to *Patyceramus* HEINTZ (1932, p. 10), unless the distinction of subgeneric significance could be found between *I. crippsi* and *I. mantelli*. In *I. crippsi*, as well as in *I. anglicus*, the concentric ribs are more or less crowded but the concentric rings are undeveloped or indiscernible. *I. reachensis* and aforementioned Turonian and Senonian descendants, including *I. mantelli*, numerous, fine, concentric rings are clearly developed in combination with the major ribs. In this respect the two subgroups can be distinguished. The former subgroup seems to include subequivalve (i. e. slightly inequivalve) form, while the species of the latter group are all equivalve. Thus at least a subgeneric distinction is, in our opinion, warrantable between the subgroup of *I. crippsi* (i. e. *Gneisioceramus*) and that of *I. mantelli* (i. e. *Platyceramus*).

A question may arise whether the distinction between the series of *I. cuvieri* and that of *I. crippsi—I. mantelli* is evaluated as generic or subgeneric. To settle the problem we have to study more comprehensively. For the time being we describe the present new species under the generic name of *Inoceramus* in a broad sense. It can be called *Inoceramus* (*Platyceramus*) *teraokai*, if one wishes to tell the subgeneric assignment.

* *Gneisioceramus* HEINZ, 1932, is nomenclatorially invalid, because the type-species was not designated. *I. crippsi* was taken only as an example.

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Explanation of Plate 32

Inoceramus teraokai sp. nov. (all figures of natural size)

Fig. 1. GK. H6833, holotype, internal mould of a right valve, from loc. TA 204 [=CF 14 of TERAOKA].

Fig. 2. GK. 6834, paratype, incomplete internal mould of a left valve. A portion of the holotype at the upper right corner.

Fig. 3. GK. H6835, paratype, incomplete internal mould of another left valve, from the type-locality.

The above three specimens are on the same stratification plane of a siltstone.

Fig. 4. GK. H6836, paratype, internal mould of a left valve (a) and a rubber model taken from external mould of the same individual (b), from loc. TA 209.

Fig. 5. GK. H6837, paratype, iternal mould of a left valve, from loc. TA 204.

Kyushu University Photos, without whitening. GK.=Department of Geology, Kyushu University.

1

3

4a

4b

5

2

181-183.

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