Paleontological Analysis of Omma Fauna from Toyama-Ishikawa Area, Hokuriku Province, Japan

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ABSTRACT

The Omma Formation, distributed in Toyama-Ishikawa area, Hokuriku province, is well known because the formation yields abundant and particular marine molluscan fossils which constitute the so-called "Omma-Manganzi" fauna of Northern Japan. The writer undertook detailed stratigraphic work on the Omma Formation in order to define precise stratigraphic positions of fossil beds from the unit in the Toyama-Ishikawa area. Abundant fossils were collected from more than 200 localities. As the first step in the study, the writer determined and described the thickness and lithology of the shell beds, feature of shell beds, state of shell preservation, number of species, specific composition and combination of species.

After compilation of the above data, an attempt was made to interpret the paleoecology and sedimentary environment of the Omma Formation based fundamentally upon the association of the dominant species and lithology of each fossiliferous bed. Analysis of the various fossiliferous beds of the Omma Formation indicated that five distinct assemblages could be recognzied. These assemblages and their associated lithologies are as follows: *Acila-Anadara-Nemocardium-Limopsis-Clinocardium-Venericardia-Macoma* assemblage of the silty sand facies; *Anadara-Clinocardium-Felaniella-Glycymeris-Thracia-Peronidia-Rexithaerus* assemblage of the fine grained sand facies; *Felaniella-Glycymeris-Peronidia-Clinocardium-Mercenaria-Pseudamiantis* assemblage of the medium grained sand facies; *Glycymeris-Felaniella-Peronidia-Anadara-Venericardia-Clinocardium* assemblage of the coarse grained sand facies; and *Callithaca-Peronidia-Glycymeris-Felaniella-Mercenaria-Dosinia* assemblage of the granule to pebble facies.

These assemblages are considered to correspond to one sedimentary cycle of marine transgression. Brief remarks on 80 representative species of the Omma Formation are made, among which one genus, four species and one subspecies are described as new to science.

CONTENTS

INTRODUCTION

It seems to the writer that in undertaking paleoecologic interpretations, it is important to recognize those fossil assemblages which can, with substantial probability, indicate the environmental conditions in which they lived.

Molluscs are believed to be one of the most useful groups for the interpretation of habitat and/or environmental conditions, because most molluscan species are benthic living within rather restricted bottom conditions. The information on habitats and habits of living molluscan species which has been abundantly accumulated for the past several decades, affords one of the most important bases for the interpretation and reconstruction of fossil molluscan assemblages, especially those of late Cenozoic age.

The Plio-Pleistocene Omma Formation yields well preserved abundant molluscan fossils which are generally referred to as the Omma-Manganzi (=Manganji) fauna because of the well developed occurrences of the fauna in the Manganzi area, Akita oil-field, Akita Prefecture, and near the town of Omma, Kanazawa City, Ishikawa Prefecture (Otuka, 1939). The formations yielding the Omma-Manganzi molluscan fauna are distributed along the Japan Sea borderland from Western Hokkaido southward to Kanazawa in Honshu. The fauna also occurs on Saishu (=Cheju) Island, Korea.

The most part of elements of the Omma-Manganzi fauna is thought to have been introduced into the Japan Sea borderland during the course of Pliocene transgression. Kaseno and Matsuura (1965) carried out detailed paleontological investigation on the fauna from the Omma Formation and recognized various types of molluscan assemblage in it. Tsuda *et al.*, (1972) studied the Pliocene molluscan assemblages from the Niigata oil-field and recognized several faunal elements which indicated various types of environments. Chinzei (1973) established the typical faunal sequences in the Pliocene formation of Futatsui area, Akita Prefecture based upon the detail study of its Omma-Manganzi molluscan assemblages.

In order to determin the molluscan faunal distribution within the Omma Formation, the writer undertook a detailed analysis of the Omma fauna based upon the specimens collected from about 200 fossil localities occupying various horizons and distributing in different lithologies in part of Ishikawa and Toyama prefectures. Then, the writer extended his study into recognition of the typical molluscan assemblage for the purpose of interpreting and reconstructing faunal habitats and paleoenvironments in which the Omma molluscan fauna lived and the Omma Formation was deposited.

In the Omma Formation, the molluscan shell remains were accumulated in and formed

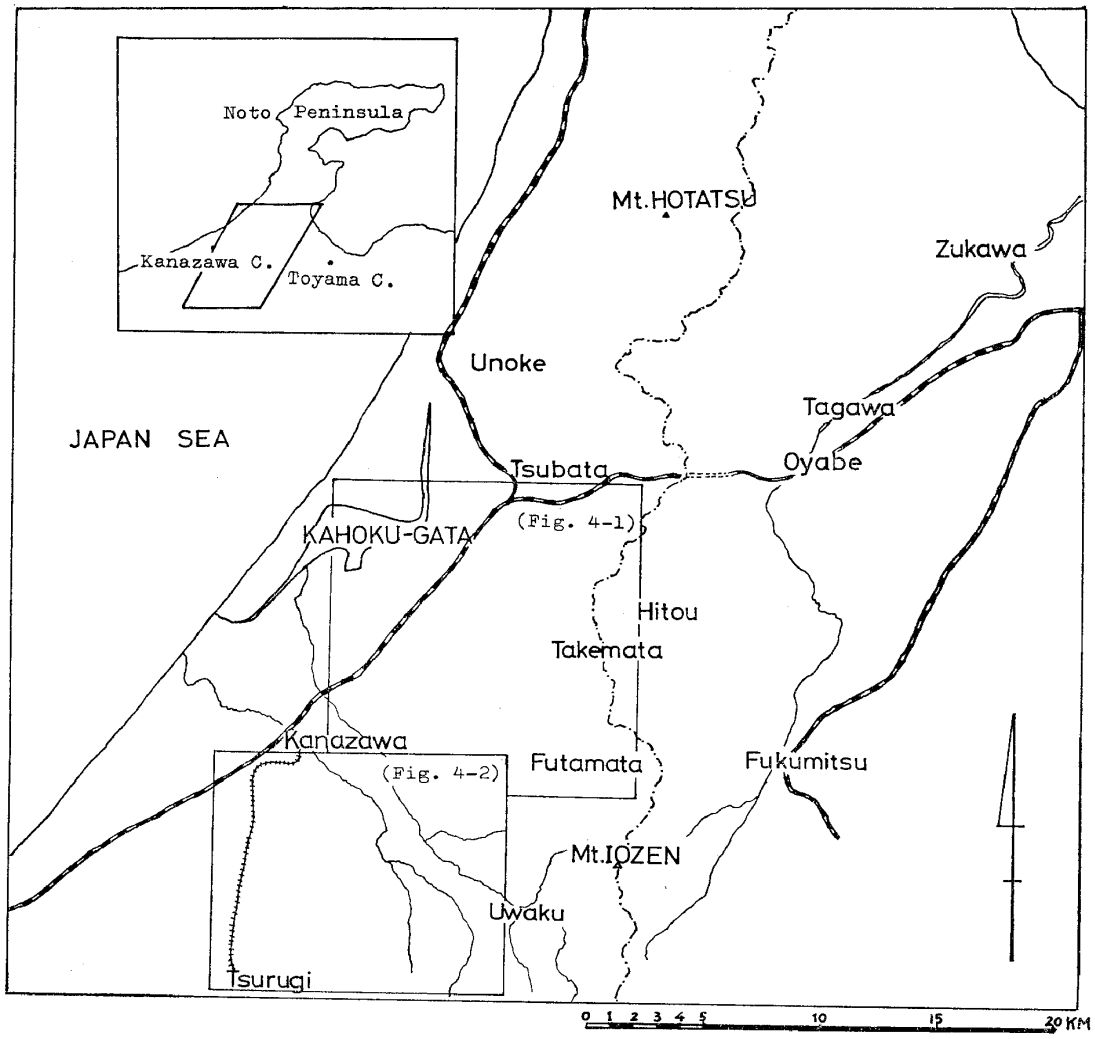

Fig. 1. Index map of the studied area

various types of so-called shell beds. According to Ijiri and Fujita (1949, 1952), Ogose (1953, 1956), Hirayama (1955), Kojima (1958) and Noda (1962), the so-called shell beds, in general, are composed of shell remains which were derived different from those in which the shell remains were deposited. These workers also discussed several problems, *e.g.*, on sedimentology, paleoenvironments, mechanism of constraction, fossilization, weathering, and so on.

The writer, after a careful examination of the specific composition and combination of dominant species in certain shell beds, concluded that successive changes in fauna and lithology might correspond to changes in environment and that certain dominant species or combinations of dominant species more or less directly indicate the ancient habitat in which they lived.

Accordingly, an analysis was made on the mode of fossil occurrence, number of composing species of each shell bed, state of shell preservation, type of enclosing sediments and combination of dominant species within each shell bed.

ACKNOWLEDGEMENTS

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HISTORICAL REVIEW ON THE STUDIES OF SO-CALLED "OMMA-MANGANZI" FAUNA

Plio-Pleistocene formations which yield abundant molluscan fossils, including the Omma-Manganzi fauna are widely distributed along the Japan Sea borderland from Western Hokkaido to Kanazawa and extend to Saishu (Cheju) Island, Korea. Many paleontological investigations have been carried out on these molluscan fossils.

Yokoyama (1927) studied the molluscan fossils of the Omma Formation developed around Kanazawa City and described 120 species including many new species, among which 67 species belong to Gastropoda, 50 species to Pelecypoda and 3 species to Scaphopoda. Based upon the faunal evidence, Yokoyama (*op. cit.*) concluded that the Omma Formation was Pliocene in age, and was correlated with the upper Musashino of the Kanto district (Yokoyama, 1920, 1922). Following the Yokoyama's pioneer work the studies on the fossil molluscs of the Omma Formation were published by Onoyama (1933a, 1933b and

1938), Oinomikado (1934) and Hatai and Nisiyama (1939).

On the other hand, Otuka (1936) who studied the molluscan fauna of Manganzi area, Akita Prefecture, discussed the Pliocene faunal province of Japan (1939) and proposed the name "Omma-Manganzi Fauna" based on the similarity of specific composition between the Omma and Manganzi fauna.

After Otuka's study, the name "Omma-Manganzian Fauna" was accepted by many paleontologists and geologists for a typical fauna indicating the Pliocene transgression along the Japan Sea borderland. The formations yielding the Omma-Manganzi fauna are tabulated in Fig. 2.

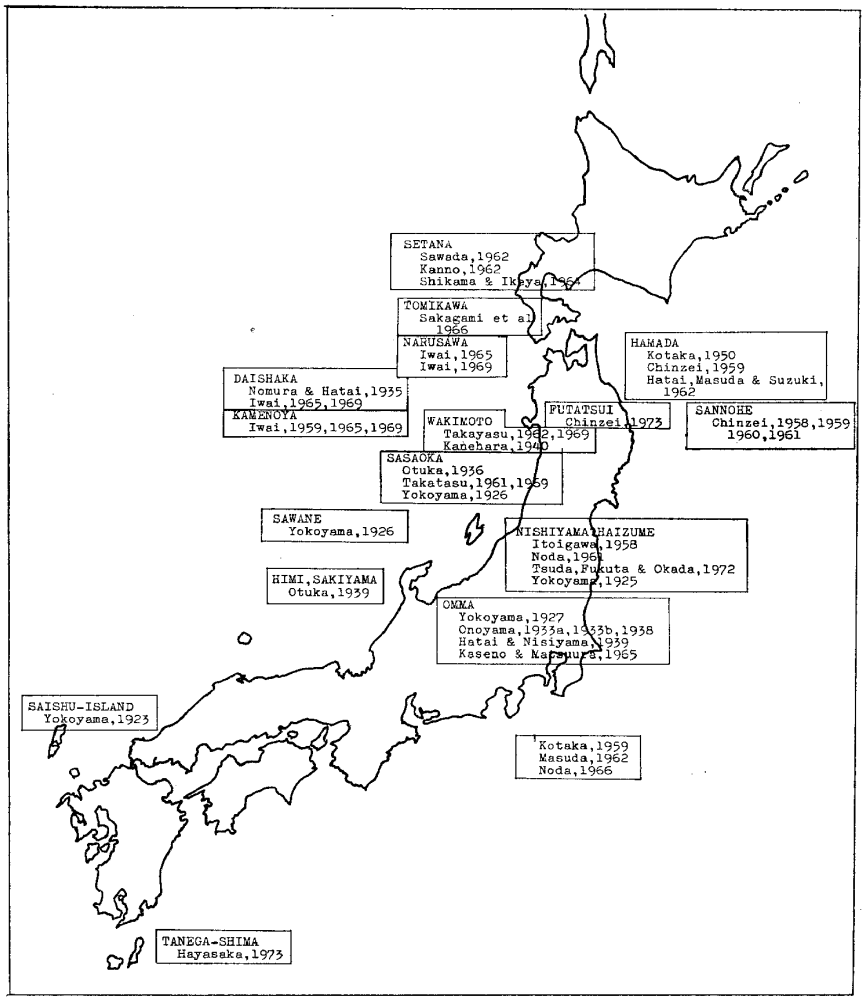


Fig. 2. Previous works on the Omma-Manganzi fauna.

They are the Setana and Tomikawa formations in Hokkaido, the Hamada, Daishaka, Narusawa and Higashimeya formations in Aomori Prefecture, the Wakimoto and Sasaoka formations in Akita Prefecture, the Sawane, Haizume and Nishiyama formations in Niigata Prefecture, the Himi Group of Toyama and Ishikawa prefectures and the sandy deposits exposed at western end of Seikiho, Saishu Island, Korea.

Since then, many geologically and geographically significant species of Omma-Manganzi fauna have been pointed out and discussed by Otuka (1936, 1939), Hatai and

Nisiyama (1939), Kotaka (1959), Masuda (1962, 1972, 1973), Chinzei (1963, 1973), Iwasaki (1963), Noda (1961, 1962) and others. These species are: *Turritella saishuensis* group, *Anadara amicula elongata*, *Anadara ommaensis*, *Limopsis tokaiensis*, *Clinocardium chikagawaense*, *Clinocardium fastosum*, *Yabepecten tokunagai*, *Chlamys daishakaensis*, *Chlamys cosibensis*, *Mizuhopecten yessoensis yokoyamae*, *Mizuhopecten tokyoensis hokurikuensis*, *Pecten naganumanus*, *Pseudamiantis tauyensis*, *Umbonium akitanum*, *Fulgoraria masudae*, *Cancellaria kobayashii*, *Antiplanes contraria* etc.

Recently, detailed studies on the Omma-Manganzi fauna have been done by Kaseno and Matsuura (1965), Tsuda *et al.*, (1972) and Chinzei (1973) from the paleoecological point of view. Kaseno and Matsuura (*op. cit.*) pointed out that the fauna of the Omma Formation was composed of more than 200 species which had lived on a sandy bottom from the upper sublittoral to eulittoral zones. Tsuda *et al.* (*op. cit.*) interpreted molluscan fauna from both deep and shallow habitats from the Haizume and Nishiyama formations, Niigata Prefecture. Chinzei (*op. cit.*) studied the relationship between the modes of fossil occurrence and type of sediments yielding fossils of a Pliocene molluscan fauna from Futatsui area, Akita Prefecture. He concluded that the fauna was classifiable into five typical assemblages in relation to the lithology, including; *Nuculana-Turritella nipponica* assemblage of fine grained sand facies; *Turritella saishuensis-Limopsis-Acila nakazimai* assemblage, *Turritella saishuensis-Macoma tokyoensis-Mercenaria* assemblage and *Felaniella-Thracia* assemblage medium grained sand facies; and *Umbonium-Glycymeris* assemblage of coarse grained sand facies. He concluded also that the combined occurrence of these assemblages was considered to be typical to the Omma-Manganzi fauna.

STRATIGRAPHY OF THE STUDIED AREA

1. GENERAL OUTLINE OF STRATIGRAPHY

The area where the molluscan fossils here treated were collected includes not only the area around Kanazawa City, Ishikawa Prefecture, but also extends from there to Nishi-Tonami district and Oyabe City, Toyama Prefecture. The type section of the Omma Formation was established in the south-eastern area of Kanazawa City, where a Neogene sequence is exposed. Detailed stratigraphic studies of this area have been carried out by many geologists as shown in Table 1.

The stratigraphic sequence in the area is divided into a series of formations as shown in Fig. 3. A summary of the stratigraphy of the studied area, including lithology and fossil content, are described below.

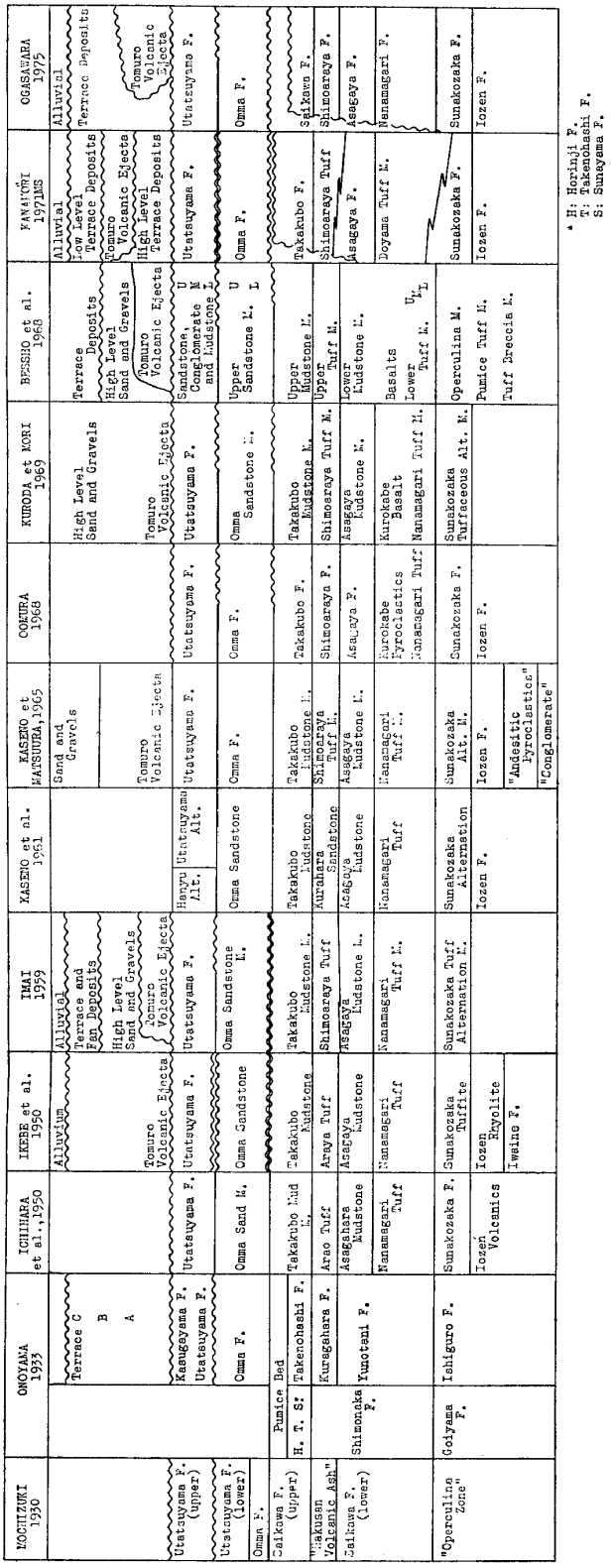
2. FORMATIONS OF PRE-OMMA STAGE

Neogene deposits of pre-Omma stage are classified into six lithological units including the Iozen, Sunakozaka, Nanamagari, Asagaya, Shimoaraya and Saikawa formations in ascending order. The Omma Formation rests unconformably on all the above formations except for the Iozen Formation. The stratgraphical relationship between the Omma and formations of pre-Omma stage can be observed mainly along the Asano-gawa between Choshi-machi and Higashi-Ichise, both of Kanazawa City, Ishikawa Prefecture. The pre-Omma stage formations, except for the Iozen, are briefly described as follows;

a. Sunakozaka Formation

The type locality is the north river-side cliff of Asano-gawa at Higashi-Ichise, Kanazawa City, Ishikawa Prefecture. The formation consists of an alternation of

Table 1. Correlation table in the southern area of Kanazawa City



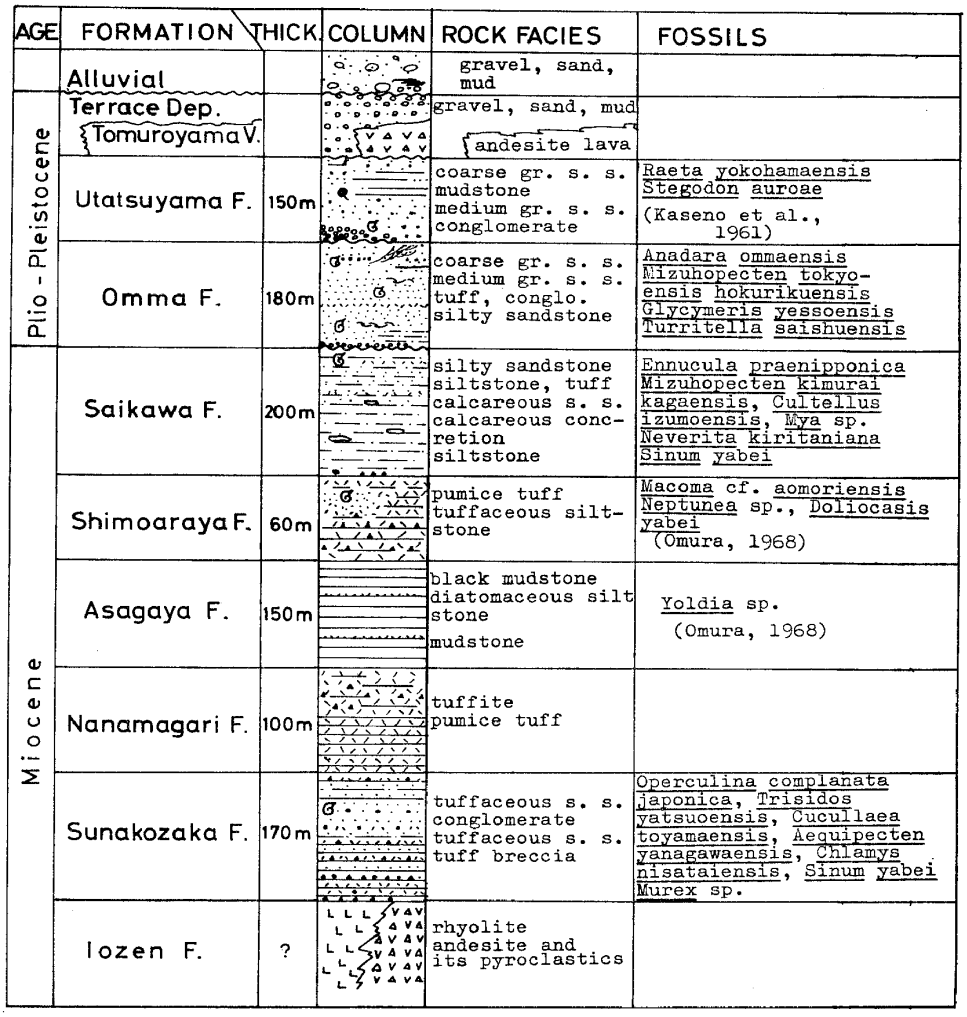


Fig. 3. Geologic columnar section around the area studied

andesitic lapilli tuffs or tuff breccias and tuffaceous sandstone. It attains about 170 meters in thickness. The Sunakozaka Formation yields abundant marine molluscs, larger foraminifera (*Operculina complanata japonica* Hanzawa), echinoids and shark teeth particularly from a thin interval of calcareous sandstones located about 10 meters below the contact of the overlying Nanamagari Formation. The molluscan fossils collected from the river side cliff of Asano-gawa at about 100 meters west of Higashi-Ichise bus stop, Higashi-Ichise, Kanazawa City are listed in Table 2. The Sunakozaka fauna, which is composed of more than 30 species, is characterized by sub-tropical elements. The geological age of the fauna is considered to be early Middle Miocene. It can be correlated with Higashi-Innai fauna of Noto Peninsula, Ishikawa Prefecture which has been described by Masuda (1966–1967) and the Kurosedani fauna reported by Tsuda (1959) from Kurosedani, Toyama Prefecture. A detailed study of the Sunakozaka fauna has already been published by the writer (1976).

b. Nanamagari Formation

This formation was defined by Ichihara *et al.*, (1950). The type locality of the formation is the river-side cliff along the Asano-gawa, Nanamagari-machi, Kanazawa City. The formation conformably overlies the Sunakozaka Formation and consists mainly of acidic, muddy and sandy tuffs. It is laminated and attains about 100 meters in thickness.

Table 2 Molluscan fossils from Sunakozaka Formation

Saccella cf. *confusa toyomaensis* Kamada
Anadara sp.
Trisidos (*Trisidos*) *yatsuoensis* Fujii
Cucullaea (*Cucullaea*) *toyamaensis* Tsuda
Pteria sunakozakensis Ogasawara
Aequipecten yanagawaensis (Nomura and Zinbo)
Chlamys (*Chlamys*) *nisataiensis* Otuka
Chlamys (*Chlamys*) *otukae* Masuda and Sawada
Chlamys sp.
Crassostrea sunakozakaensis Ogasawara
Anomia chinensis Philippi
Penicillus (*Warnea*) *kanazawaensis* Omura
Vasticardium ogurai (Otuka)
Leukomoides nipponicus Ogasawara
Cyclina hwabongriensis Yoon and Noda
Paphia (*Paphia*) *hirabayashii hirabayashii* Otuka
Clementia papyracea (Gray)
Lutraria (*Psammophila*) cf. *sieboldii* Reeve
Azorinus sp.
Solen sp.
Turritella (*Hataiella*) sp.
Calyptraea tubura Otuka
Tugurium matsuoi Ogasawara
Terebellum pseudodelicatum Ogasawara
Euspira meisensis (Makiyama)
Sinum yabei Otuka
Phalium (*Semicassis*) sp.
Murex sp.
Siphonalia sp.
Nassarius sp.
Sydaphera sp.
Chelyconus cf. *tokunagai* (Otuka)
Punctoterebra cf. *osawanoensis* (Tsuda)

Fossils have not been reported from the formation.

c. Asagaya Formation

The type locality of the formation is the river side cliff along the Asano-gawa, Asagaya-machi, Kanazawa City, Ishikawa Prefecture. This formation consists of so-called "Black mudstone" which are very hard and siliceous and intercalated with diatomaceous siltstones and tuffs. The formation attains about 150 meters in maximum thickness. *Yoldia* sp. and *Schizaster* sp. are reported by Omura (1968) but, generally, fossils are rare. The Asagaya Formation comformably overlies the Nanamagari Formation and conformably underlies the Shimoaraya Formation.

d. Shimoaraya Formation

The type locality of the formation is the river side cliff along the Asano-gawa, Asagaya-machi, Kanazawa City, Ishikawa Prefecture. This formation is mainly composed of massive pumice tuffs and occasional intercalations of tuffaceous siltstone. The formation is about 60 meters in thickness. Omura (1968) reported some molluscan

fossils such as *Macoma* cf. *aomoriensis*, *Neptunea* sp., *Doliocassis yabei*, *Fulgoraria striata* etc., from tuffaceous mudstones which occupy the upper part of the formation.

e. Saikawa Formation

The name Saikawa Formation was first used by Mochizuki (1930) for Miocene deposits distributed along the Sai-gawa and Asano-gawa. However, in the present study only the upper part of the Saikawa Formation of Mochizuki (*op. cit.*) is considered to correspond to the Saikawa Formation of the writer.

The name Takakubo has long been applied to the Saikawa Formation of the writer by several authors (Ichihara *et al.*, 1950, Imai, 1959, Kaseno and Matsuura, 1965, Omura, 1968 *etc.*). But the lithology and fauna of so-called Takakubo Formation distributed around Kanazawa City, especially the area along the Sai-gawa and Asano-gawa, cannot be correlated with the Takakubo Formation in its type area in Takakubo, Fukumitsu-machi, Nishi-Tonami-gun, Toyama Prefecture.

The type locality of the Saikawa Formation of the writer is the river side cliff along the Sai-gawa, about 1300 meters upstream from Okuwa Bridge (formerly pronounced Omma Bridge), Kanazawa City, Ishikawa Prefecture. This formation, at the type locality, consists mainly of massive siltstones with occasional intercalations of calcareous sandstones or concretions and attains 200 meters in maximum thickness. The formation conformably overlies the Shimoaraya Formation and is unconformably overlain by the Omma Formation. Fossil molluscs were collected from the siltstones or sandy siltstones which occupy the uppermost part of the formation at the type locality. They are listed in Table 3. The fauna is correlated with that of the Shimonaka Formation (Inoue, 1971 MS) which is destributed in the northern part of Kanazawa City. It is also comparable to the so-called Otokawa fauna of Sakamoto (1966) and Kaseno *et al.*, (1961) from Toyama Prefecture. The geological age of the Saikawa Formation is the Late Miocene.

Table 3 Molluscan fossils from Saikawa Formation

Ennucula praenipponica Kamada
Glycymeris cf. *nipponica* (Yokoyama)
Modiolus sp.
Mizuhopecten kimurai kagaensis Ogasawara
Crassostrea cf. *gigas* (Thunberg)
Lucinoma acutilineatum (Conrad)
Clinocardium sp.
Venus sp.
Solen sp.
Cultellus izumoensis Yokoyama
Panope cf. *nomurae* Kamada
Mya (*Arenomya*) *cuneiformis* (Böhm)
Dentalium (*Fissidentalium*) *yokoyamai* Makiyama
Minolia matsuoi Ogasawara
"*Epitonium*" sp.
Neverita kiritaniana (Yokoyama)
Sinum yabei Otuka
"*Phalium*" sp.
Siphonalia cf. *fusoides* (Reeve)
Phos iwakianus (Yokoyama)
Olivella omurai Ogasawara
Surculites sp.

3. FORMATIONS OF POST-OMMA STAGE

Deposits of post-Omma stage are divided into two lithological units including the Utatsuyama Formation and the Tomuroyama Volcanic Ejecta except for terrace and alluvial deposits.

a. Utatsuyama Formation

The type locality of the formation is a roadcut along the road from Tenjin-Bridge to Utatsu-Shrine, located southwestern part of Mt. Utatsu, Kanazawa City, Ishikawa Prefecture. The formation unconformably overlies the Omma Formation beneath a basal conglomerate which is a few meters in thickness. The formation consists mainly of coarse grained sandstones, an alternation of sandstones and mudstones, granule conglomerates and lignitic deposits. Carbonaceous detritus is common in the clastic rocks. It attains about 150 meters in maximum thickness. Fossils are few in number. However, Kaseno *et al.* (1961) reported the occurrence of *Raeta yokohamaensis*, *Pecten naganumanus* and *Macoma tokyoensis*.

b. Tomuroyama Volcanic Ejecta

It consists of two pyroxene andesitic lava flows and pyroclastics which are distributed mainly around Mt. Tomuro, in the eastern part of Kanazawa City, Ishikawa Prefecture.

4. OMMA (OR ONMA) FORMATION

Since Motiduki first used the name "Omma Formation" in 1930, revisions of the stratigraphy of the formation have been carried out by Ichihara *et al.* (1950), Imai (1959), Kaseno *et al.* (1960), Kaseno and Matsuura (1965), Omura (1968), Bessho *et al.* (1968), and Kanamori (1971 MS).

The type locality of the formation is the river floor of Sai-gawa, at Okuwa (formerly Omma), Kanazawa City, Ishikawa Prefecture. The Omma Formation unconformably overlies the Saikawa Formation and is unconformably overlain by the Utatsuyama Formation in the southern area of Kanazawa City. In the northern area of Kanazawa City, the formation conformably overlies pumice tuff which defines the top of the Takakubo Formation. The formation is widely distributed in Toyama and Ishikawa prefectures and consists mainly of fine to medium grained sandstones which grade laterally into silty and coarse grained sandstones. The formation attains 200 m in maximum thickness.

Because its lateral change in lithology is somewhat variable, the formation will be described by area from south to north. The stratigraphic position of fossil localities including shell beds are shown in Fig. 5–1 and Fig. 5–2. The geographical locations of fossil localities are shown in Fig. 4–1 and Fig. 4–2.

a. Lithology and distribution

a–1. Tsurugi (T) and Kanazawa-Yamashina (KY) Areas

The southwestern part of the Omma Formation is distributed within these two areas which occupy the southwestern part of Kanazawa City. Beds of the formation in these areas trend NE-SW with dip angles of 45° to 90° to the west. The base of the formation is generally defined by basal conglomerates of a few meters in thickness. Conglomerate bed consists of well rounded pebble to granule sized clasts and lies on stratified or massive pumice tuff or tuffaceous siltstone defining the top of the Saikawa Formation. Above the basal conglomerates, the formation is characterized by bluish-gray, fine grained sandstones

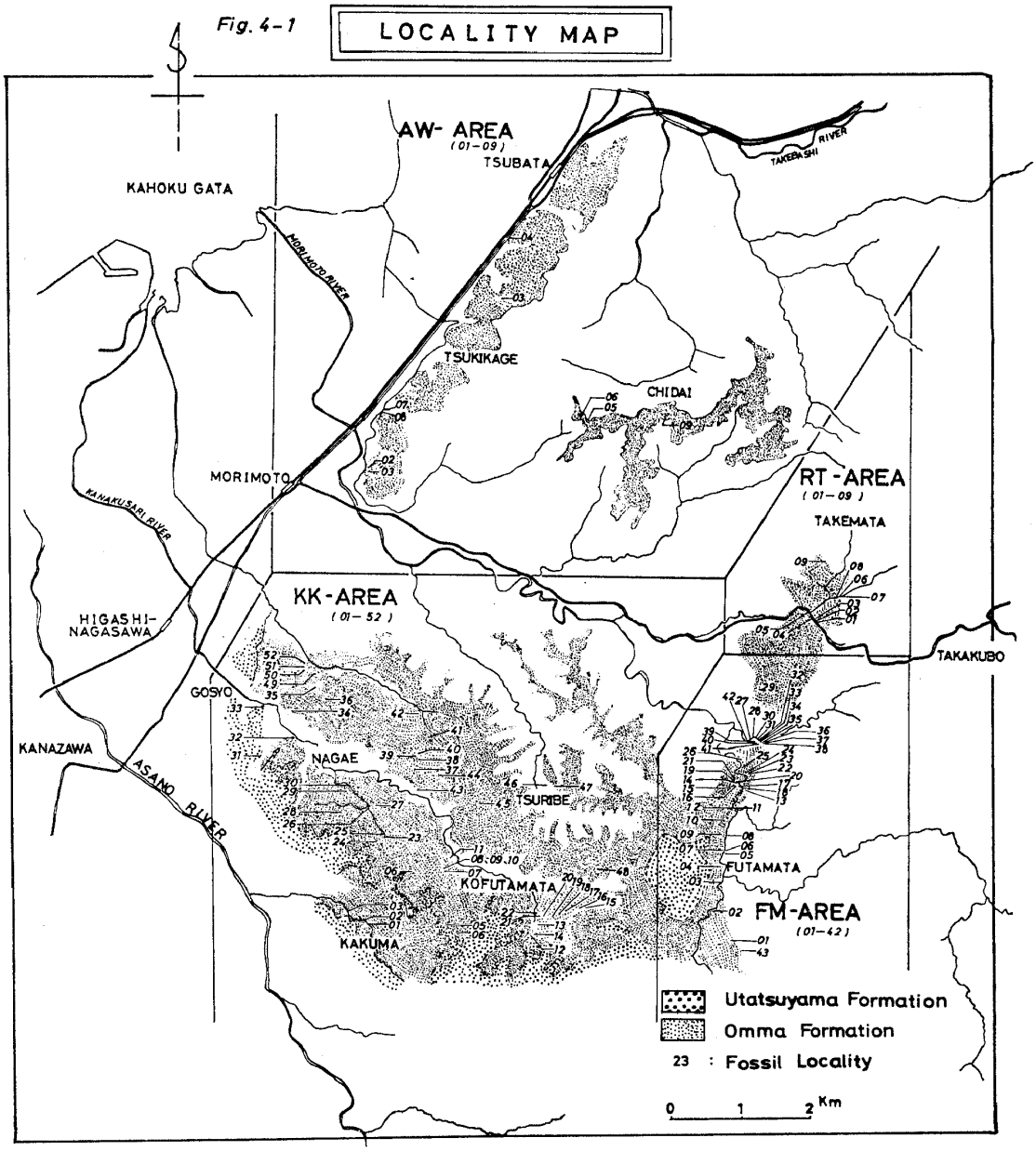


Fig. 4–1. Locality map

intercalated with two or three thin tuff layers. The middle and/or lower part of the formation in the areas consists of bluish-gray fine to medium grained sandstones. The upper part is composed of medium to coarse grained sandstones, occasionally intercalated with granule conglomerates and thin layers of mudstones. The formation in this area attains a maximum thickness of about 160 m. A typical columnar section of this area is shown by No. 13 section in Fig. 5–1.

Thirty-four fossil localities are recognized in the areas and, with few exceptions, they occur within the middle and lower parts of the formation.

a–2. **Kanazawa-Okuwa (KO) Area**

This area extends from the type locality of the Omma Formation to Higashi-Ichise,

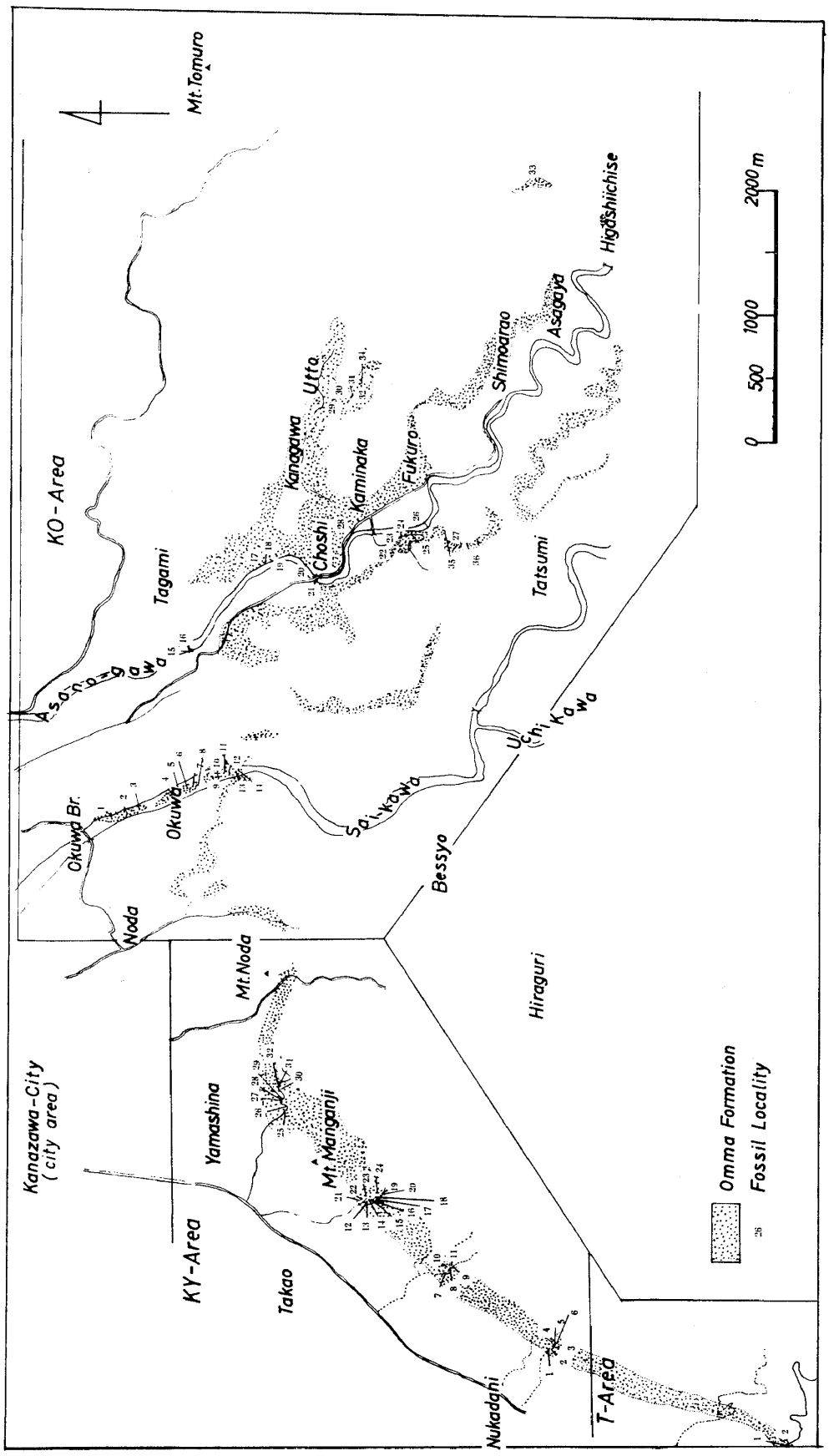


Fig. 4–2. Locality map

Kanazawa City.

The formation is sporadically distributed along the Asano-gawa and Sai-gawa with the beds having very low dip angles.

The formation, in this area, unconformably overlies five formations as mentioned above. Thirty-six fossil localities are recognized. The type section of the formation in the area is exposed along the river floor of Sai-gawa, and is represented by Section No. 16 of Fig. 5–1. In ascending order, the formation consists of silty, fine grained sandstones, fine grained sandstones with abundant mud-pipes, thin intercalations of white tuffs, tuffaceous sandstones and medium grained sandstones, coarse grained sandstones with intercalations of cross bedded granule conglomerates, stratified lignitic mudstone layers and medium grained sandstones. The lithologic succession described above indicates, in general, a gradual change from fine to coarse sediments in passing from the bottom to the top of the formation.

Along the southwestern margin of the area, the formation consists of weakly stratified, medium to coarse grained, yellowish brown-weathered sandstone which unconformably overlies the Sunakozaka, Nanamagari, Asagaya, Shimoaraya and Saikawa formations.

The formation, at the type locality, attains about 180 m in thickness. The fossil localities in the area occur mainly in the lower part of the formation, although a few localities, yielding well preserved shell remains, are found in the upper part.

a–3. **Kanazawa-Kanakusari-gawa (KK) Area**

The present area occupies the eastern border of Kanazawa City, and is extending mainly along the Kanakusari-gawa. It extends from Kakuma, Kofutamata to Gosho, all in Kanazawa City.

The formation is widely exposed with low dip of bedding of less than 10°. And it attains about 160 m in thickness. Abundant molluscan fossils were collected from 52 fossil localities in the present area. These localities occur mainly in the middle and lower parts of the formation.

The formation unconformably overlies massive siltstones and pumice tuffs of the uppermost part of the "Takakubo" Formation with a basal conglomerate. Although the basal conglomerate is poorly developed, it can be traced rather widely in the area. A typical stratigraphic sequence can be observed in a small roadcut in the southern part of Kofutamata-machi, Kanazawa City. Above the basal conglomerate, in ascending order, the formation is composed of (1) silty sandstones, (2) massive and clean, fine to medium grained sandstones with the intercalations of three thin tuff layers, and (3) well stratified and cross laminated coarse grained sandstones (section No. 26, Fig. 5–2).

The silty sandstones, which occupy the lower part of the formation, are widely developed in the area and contain abundant molluscan fossils. These sandstones attain about 20 m in maximum thickness and vertically grade upwards into fine grained sandstones.

In the upper part of the formatoin, on the contrary, coarse sedimentary rocks predominante, including coarse grained sandstones and conglomerates, which are distributed throughout the area.

Sandstones of the upper part occasionally reveal cross laminations and are intercalated with granule to pebbly conglomerate layers, in which mud-pipes and fossils are few.

Two thin tuff layers can be traced as the key beds in the middle and lower parts of the formation. One occurs about 6 to 10 m above the base of the formation and is 30 cm in constant thickness. The second one is found in the middle part of the formation, and also

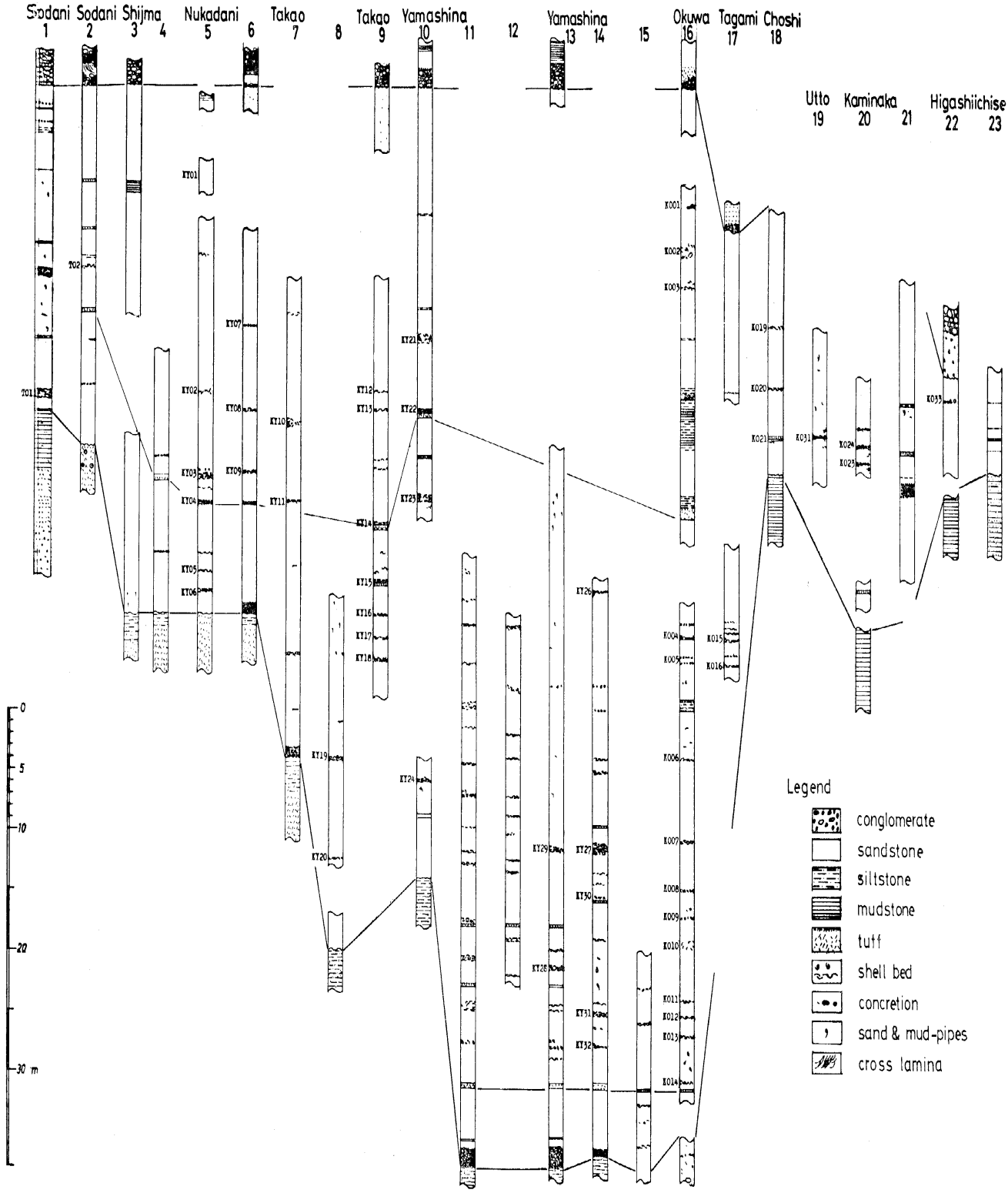


Fig. 5-1. Columnar section of the Omma Formation

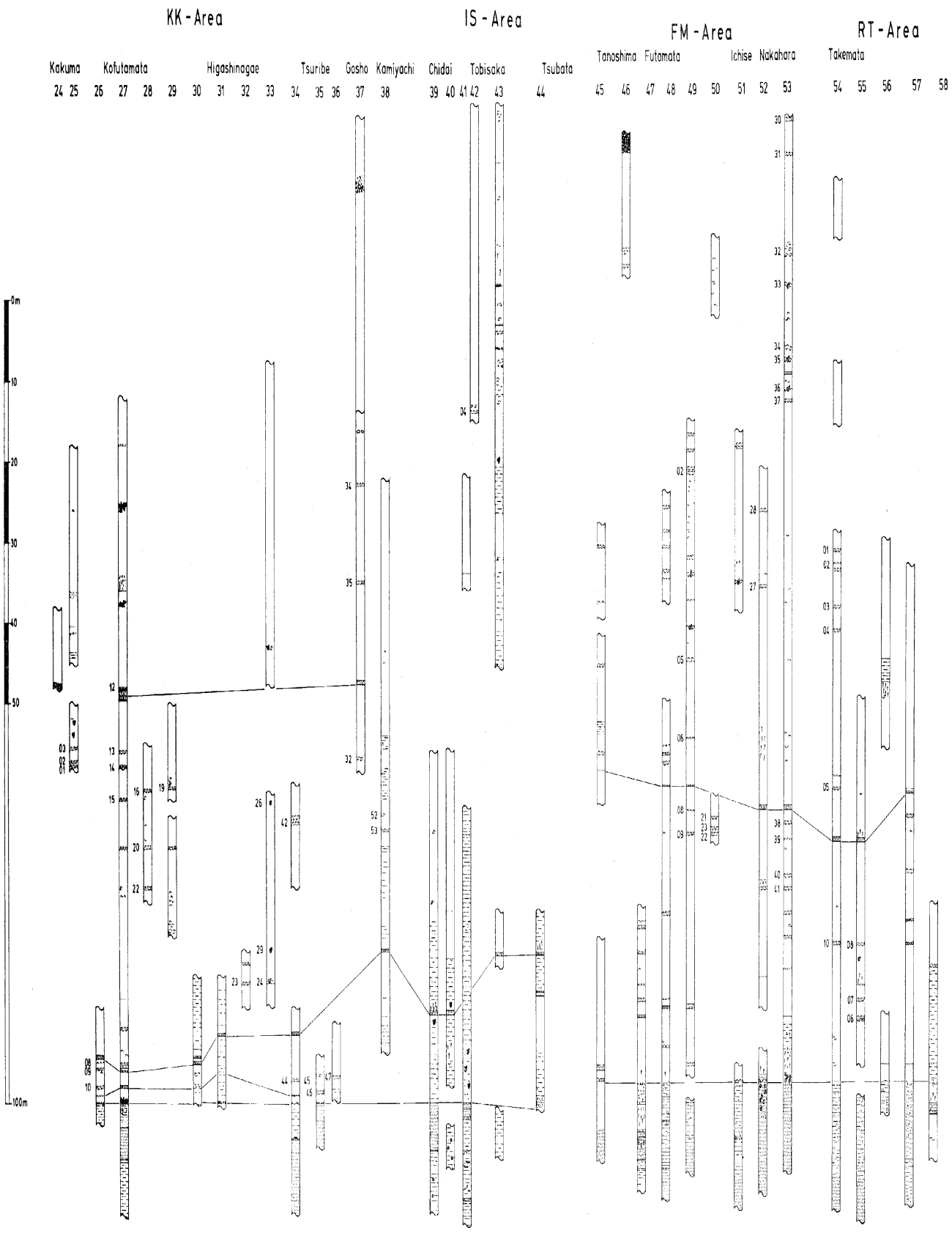


Fig. 5-2. Columnar section of the Omma Formation

about 30 cm thick. The lithologies of the two tuff layers are very similar in color to each other; both are well graded and contain sand-pipes at random orientations.

The formation is unconformably overlain in this area by the Utatsuyama Formation which is characterized by coarse grained carbonaceous sandstones and a basal conglomerate.

Coarse grained sandstones of the upper part of the Omma Formation can be distinguished from those of the Utatsuyama Formation, because the former has abundant mud-pipes, while the latter is characterized by abundant carbonaceous detritus.

The basal conglomerate of the Utatsuyama Formation is only a few meters thick but it can be traced widely throughout the area.

a–4. **Futamata-Morimoto-gawa (FM) Area**

This area is situated in the eastern border of the Kanazawa City, along the Morimoto-gawa, from Ichinose to Futamata and Tanoshima-machi. Although the lithological succession of the formation in the area resembles that of the Kanazawa-Okuwa Area, the formation in this area forms a synclinal structure with the general bedding strikes of N 10° W to N 10°E and dips ranging from 60°–80°. The axis of syncline extends from Takemata-machi to the southern part of Futamata-machi with a NNE-SSW trend. The formation unconformably overlies stratified pumice tuffs and/or siltstones with pumice patches of the "Takakubo" Formation.

At the vicinity of Higashi-Ichinose, Kanazawa City, the "Takakubo" tuffs attain more than 50 m in maximum thickness.

The base of the Omma Formation of this area consists mainly of widely distributed tuffaceous sandstones containing abundant angular granules and pebbles. These tuffaceous sandstones are a few meters in thickness and conformably overlie tuffs or siltstones of the "Takakubo" Formation.

The Omma Formation, in the present area, represents the lower to middle part of the Omma Formation. Above the basal tuffaceous sandstones, it consists mainly of silty sandstones and fine grained sandstones with intercalations of thin, white tuff layers. Total thickness is about 150 meters. The middle part of the formation yields not only abundant molluscan fossils but also sand-pipes and mud-pipes which are presumably of organic origin. In the present area, 42 fossil localities were studied.

The upper part of the formation is mainly distributed in the western border of the area along the Morimoto-gawa, and consists of coarse materials like cross-laminated, coarse grained sandstones, and medium to coarse grained sandstones with the intercalations of granules or pebbles bearing layer.

The stratigraphic sequence shows a gradual change in lithology from fine to coarse clastic materials in passing from the lower to upper part of the formation, and the similar relationship is found in other areas.

In the southern border of the present area, in the vicinity of Tanoshima-machi, Kanazawa City, the formation is composed of tuffaceous sandy siltstones containing various size of cobbles and granules and carbonaceous material. The formation is unconformably overlain by the Tomuroyama Volcanic Ejecta. This area represents an eastern marginal facies of the formation.

The Omma Formation, in the area, except for above mentioned area, is unconformably overlain by basal conglomerate of the Utatsuyama. This basal conglomerate consists of well rounded andesite, rhyolite, dacite and basaltic andesite cobbles and pebbles which are thought to be derived from the Iozen Formation. The conglomerate can not be traced to the northern part of the present area.

a–5. **Takemata (RT) Area**

The synclinal structure of the Futamata-Morimoto-gawa (FM) area extends north-

ward into the Takemata (RT) Area.

In this latter area, the Omma Formation lies unconformably upon stratified pumice tuff which defines the top of the "Takakubo" Formation. In the vicinity of southwestern part of Takemata-machi, the lower part of the formation consists of silty sandstones with intercalations of thin, white tuff layers and calcareous sandstones. The silty sandstones, which contain well preserved but sporadically distributed molluscan shell remains, attain a maximum thickness of about 50 m.

The silty sandstones gradually change upwards into fine grained sandstones in the middle part of the formation. The silty sandstones also tend to increase in thickness towards the northern part of the area.

The middle part of the formation is composed of fine grained to medium grained richly fossiliferous sandstones which are very similar to those of areas previously described. The upper part of the formation, which is about 30 to 50 m thick, consists of coarse grained sandstones which have well developed cross-bedding. These sandstones are overlain by Quaternary alluvial deposits. Nine fossil localities were studied.

a–6. **Awazaki-Tsubata (AW), Oyabe-Hitou (RH), Isurugi (IS) and Unoke (UK) areas.**

Sedimentary rocks of the Omma Formation are widely distributed from around Kanazawa City to the northern part of Isurugi-machi, Oyabe City, Toyama Prefecture and the western part of Mt. Hotatsu in the vicinity of Unoke-machi, Kahoku-gun, Ishikawa Prefecture. The lithological succession corresponds well to those of Oyabe-Hitou (RH) area and Isurugi (IS) area.

In the Awazaki-Tsubata (AW) area, the lower part of the formation is characterized by silty sandstones and siltstones which rest conformably on siltstones of the "Takakubo" Formation. The formation, in the (AW) area, along Route 7 of National Highway, reveals bedding strikes ranging from N to N 30°E and dip angles from 30° to 50° to the west. The lower part has a maximum thickness of 100 meters. These silty deposits which yield molluscan shells can be traced from the vicinity of Kannonji-machi, Kanazawa City to the east of Nose National Railway Station. The middle and upper parts of the formation are composed of fine to coarse grained sandstones which are lithologically very similar to comparable parts of the sequences located in other areas.

In the vicinity of the western part of Mt. Hotatsu, the formation contains only a few fossils and rests upon eroded granitic rocks. It seems to be very difficult to descriminate the Omma Formation from the younger Utatsuyama in the western part of Mt. Hotatsu, because of lithological similarity between these formations.

In the Oyabe-Hitou (RH) area, 22 fossil localities were studied. In this area, the strike of the beds ranges from N 10°E–N 30°E with dips ranging from 10–30°E. The formation attains about 200 m in thickness. The lower part is composed of silty sandstones, similar to the lithology of the lower part of the formation in the Awazaki-Tsubata (AW) area, and these gradual change into fine to coarse grained sandstones of the upper part. The formation in (AW) and (RH) areas is unconformably overlain by the Utatsuyama Formation.

In the vicinity of Yokotani, Oyabe City, the formation conformably overlies the "Takakubo" Formation and consists of silty pumiceous sandstones which contain rather common molluscan remains. The representative species of the area is *Turritella saishuensis*.

b. **Geological age and correlation**

The precise correlation of the strata within the Omma Formation developed in the separate areas is summarized in Fig. 6.

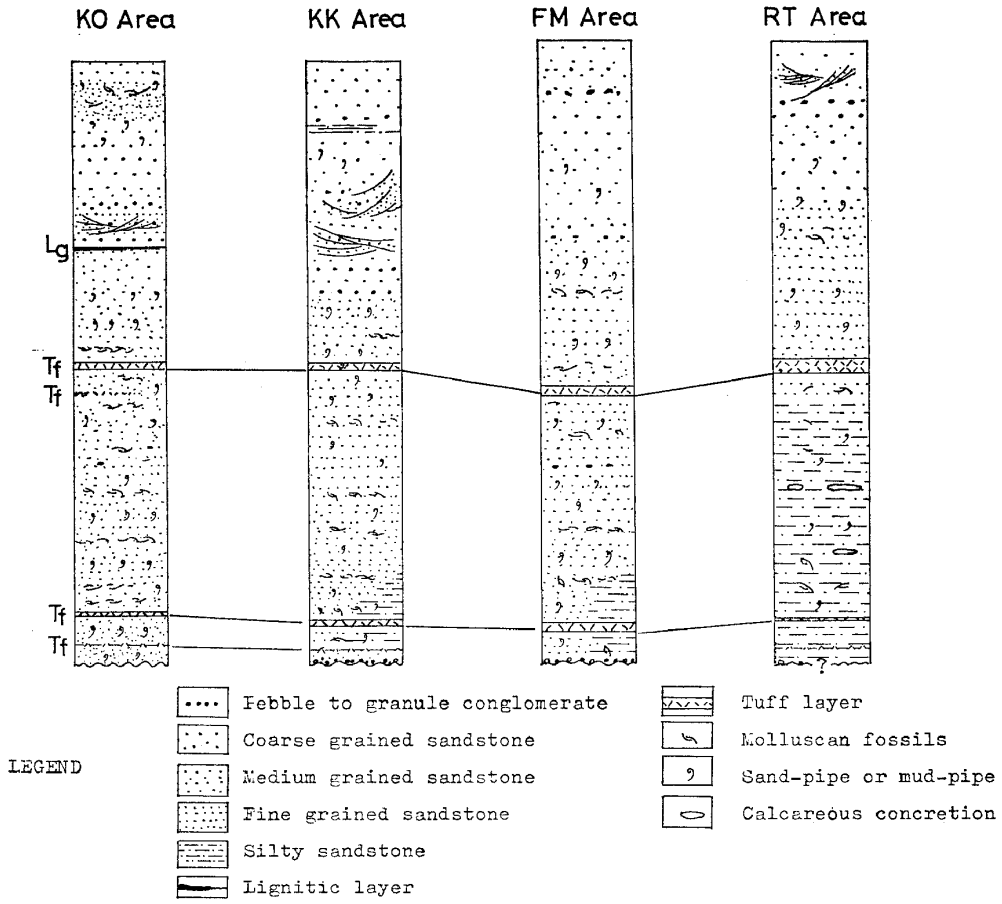


Fig. 6. Correlation within the Omma Formation among the separate areas

According to Ikebe *et al.* (1973), the Omma Formation is correlated with the following groups or formations; Himi Group (Noto and Toyama provinces), Haizume Formation (Niigata province), Sasaoka Formation (Akita province), upper Sannohe Group (Northern border of Kitakami Massif) and Setana Formation (Western Hokkaido), all of which are assigned to the Pliocene.

The molluscan assemblage from the Omma Formation is characterized by the following species: *Anadara amicula elongata*, *Mizuhopecten yessoensis yokoyamae*, *Mizuhopecten tokyoensis hokurikuensis*, *Chlamys cosibensis* and *Turritella saishuensis* (s. l.). Of these species, the bioseries of *Turritella saishuensis* is the most significant in the Omma fauna because of its importance in making age determinations and correlations.

According to Kotaka (1976) and Kotaka and Ogasawara (1977, in press), the *Turritella saishuensis* bioseries of the Omma Formation is shown as follows; *Turritella saishuensis motidukii* – *Turritella saishuensis* (s.s.) – *Turritella saishuensis etigoensis* in ascending order.

Based upon this bioseries, the Omma Formation can be correlated with the Sasaoka and Shibikawa formations in Oga Peninsula and Akita oil-field, Akita Prefecture.

Kotaka (1973 and 1976) inferred that the Pliocene-Pleistocene boundary might coincide with boundary between *Turritella saishuensis* (s.s.) zone and *Turritella saishuensis etigoensis* zone judging from the coincidence of the stage of parallel evolution of certain turritellid species in Italy which can be closely tied to Lyell's type localities for the Pliocene and Pleistocene.

PALEONTOLOGICAL ANALYSIS OF OMMA FAUNA

In the Omma Formation, the molluscan fossils generally occurred in the form of so-called "shell beds" or "shell enclosures". In order to avoid bias of observation and sampling of specimens in the field, the writer tried to obtain standardized data for each "shell bed" and other type of fossil occurrence according to the following steps:

1. DESCRIPTION OF LITHOLOGY, SHAPE, AND THICKNESS OF THE SHELL BED

The thickness of the shell beds ranges from 5 to 200 cm in the Omma Formation. Table 4 shows a thickness/modes of occurrence relationship; the table in the middle column indicates the number of assemblages or fossil localities. The order of occurrence is shown as 30 cm (38 localities), 20 cm (25 localities), 15 cm (21 localities) and 10 cm (20 localities).

The shell beds of 10 to 30 cm in thickness are most dominant in the studied area, and P-type (shell remains arranged nearly parallel to the bedding plane) assemblages are taken from about a half of these shell beds.

Table 4. Thickness and type of shell bed

Thickness of shell bed \ Type of shell bed	P	I	L	S	total
5 cm	—	—	1	2	3
10 cm	7	1	7	5	20
15 cm	8	3	9	1	21
20 cm	9	4	8	4	25
30 cm	20	8	4	6	38
40 cm	5	2	2	1	10
50 cm	4	3	1	2	10
60 cm	—	2	4	—	6
70 cm	—	—	—	1	1
80 cm	2	—	1	1	4
90 cm	—	—	—	—	0
100 cm	2	1	1	5	9
150 cm	—	—	—	1	1
200 cm	1	—	—	2	3
total	58	24	38	31	151

2. DETERMINATION OF MODES OF FOSSIL OCCURRENCE

a. Modes of occurrence

Although the molluscan fossils of the Omma Formation were enclosed in various types of sediments, the modes of occurrence of the shell bed can be classified into following four categories mainly by means of orientation of shell remains in the shell bed (see Pls. 3 and 4).

P-type: Shell remains arranged nearly parallel to the bedding plane.

I-type: Shell remains arranged irregularly to the bedding plane; occasionally the lower part or the base of the shell bed rests on an irregular surface of the underlying stratum.

L-type: Shell remains arranged irregularly in lenticular patch or enclosure.
S-type: Single shell occurring sporadically.

Among several assemblages in about 200 fossil localities, the modes of occurrence are summarized as follows; P-type: 58 localities, I-type: 24 localities, L-type: 38 localities, and S-type assemblage in several localities.

b. Abundancy and crowdedness

Most organic assemblages include not only molluscan shell remains, but also brachiopods, echinoids, bryozoans and foraminifers. In the present work, the relative abundancy and crowdedness of only the molluscan shell remains were measured, described, and classified into four types, in the field, as follows (see also Pls. 3 and 4);

AC: Molluscan assemblage composed of abundant numbers of individuals which are tightly crowded.
CC: Molluscan assemblage composed of a common number of individuals which are crowded.
CS: Molluscan assemblage composed of a common number of individuals which are sporadically scattered in the sediments.
RS: Molluscan assemblage composed of a rare number of individuals which are sporadically enclosed in the sediments.

AC type assemblages are found in 43 localities, CC type assemblages in 64 localities and CS type assemblages in 21 localities.

3. PRESERVATION OF SHELL REMAINS

The grades of preservation of shell remains are one of the most important lines of evidence for the interpretation of the history of molluscan shells after death. Preservation of the pelecypod shell remains can be classed into the following grades.

c: conjoined, i: isolated but perfectly preserved, w: isolated and rather well preserved,
b: isolated and partly broken, f: fragments but identical.

For gastropods:

p: perfectly preserved, w: well preserved, but imperfect, f: fragments but identical.

The assemblage from one shell bed, includes molluscan remains showing a mixture of several grades of preservation. The molluscan shell remains of c-, i- and w-grade of preservation (pelecypoda), and p-, w- grade preservation (gastropoda) are interpreted as not having transported any great distance from the place where they lived.

4. DETERMINATION OF THE TOTAL NUMBER OF SPECIES OCCURRING IN A SINGLE SHELL BED OR LENSE

The total numbers of species which constitute the assemblage are next examined. Each assemblage, in general, is composed of a few dominant species and a few to about 10 subordinate species (see Tables 5, 6). In a few exceptional localities, the assemblages consist of more than 20 species. Of course, the total number of constituent species of the assemblage becomes fewer as the shell bed thins.

The number of species, mostly, do not exceed 10, and the range lies mainly between 3 and 10. However, there are the cases of assemblages which are composed of more than 10 species and sometimes more than 20 species are found in AC and/or CC types of assemblages.

The shell bed of Loc. No. KO–04 was studied carefully as an example. The matrix sediments of this bed decrease gradually upwards in grain size. The shell bed, itself, can

Table 5. Number of species and type of shell bed

Number of species / Type of shell bed	2	3	4	5	7	8	9	10	11	12	17	19	22	24
P-type 30 cm			1	2	4	3	2	2	1	2	1	1		1
I-type 30 cm			1			3	1	1	1				1	
P-type 20 cm		1		3	1	1				1				
L-type 20 cm	1	1		3	1	1	1							
P-type 15 cm		2		1	1	1	1							
L-type 15 cm	1	1		2	1			1	2		1			

Table 6. Abundancy and number of species

Grade of abundancy	Number of localities																		
AC				2	4		3	4	2	2	2	4		2		1	1	1	5
CC	3	1	6	5	5	8	6	6	2	6	2	1	1	1		1	2		2
Number of species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20+

Range of number of species: AC-type 4–24, CC-type 1–59

Table 7 Molluscan fossils from the Omma Formation

Acila (*Truncacila*) *insignis* (Gould)
Acila (*Truncacila*) *nakazimai* Otuka
Sarepta speciosa A. Adams
Nuculana (*Thestyleda*) *yokoyamai* Kuroda
Portlandia (*Megayoldia*) *thraciaeformis* (Storer)
Portlandia (*Portlandella*) *hirosakiensis* Iwai
Saccella confusa (Hanley)
Yoldia (*Cnesterium*) *notabilis* Yokoyama
Limopsis tokaiensis Yokoyama
Limopsis creanta A. Adams

Arca (*Arca*) *boucardi* Jousseaume
Anadara (*Anadara*) *amicula elongata* Noda
Anadara (*Scapharca*) *ommaensis* Otuka
Anadara (*Hataiarca*) *pseudosubcrenata* Ogasawara n. sp.
Anadara (*Scapharca*) sp.
Glycymeris cf. *rotunda* (Dunker)
Glycymeris yessoensis (Sowerby)
Chlamys (*Chlamys*) *cosibensis* (Yokoyama)
Chlamys (*Chlamys*) *nipponensis* Kuroda
Pecten (*Notovola*) *albicans* (Schröter)

Pecten (*Notovola*) cf. *naganumanus* Yokoyama
Mizuhopecten tokyoensis hokurikuensis (Akiyama)
Mizuhopecten yessoensis yessoensis (Jay)
Mizuhopecten yessoensis yokoyamae (Masuda)
Crassostrea gigas (Thunberg)
Neopyconodonta musashiana (Yokoyama)

Table 7. (Continued)

Anomia chinensis Philippi
Monia umbonata (Gould)
Crenella sp.
Modiolus difficilis (Kuroda and Habe)

Mytilus grayanus Dunker
Thracia kakumana (Yokoyama)
Myadora japonica Habe
Pandora (*Heteroclidus*) *pulchella* Yokoyama
Astarte (*Astarte*) *hakodatensis* Yokoyama
Astarte (*Tridonta*) *borealis* (Schumacher)
Astarte (*Tridonta*) *alaskensis* Dall
Venericardia (*Cyclocardia*) *ferruginea complexa* Ogasawara n. subsp.
Venericardia (*Cyclocardia*) *ferruginea orbicularis* Yokoyama
Venericardia (*Cyclocardia*) *myogadaniensis* Itoigawa

Venericardia (*Megacardita*) *ferruginosa* (Adams and Reeve)
Venericardia (*Megacardita*) *ommaensis* Ogasawara n. sp.
Miodontiscus nakamurai (Yokoyama)
Felaniella usta (Gould)
Cycladicama cumingi (Hanley)
Lucinoma annulata (Reeve)
Pillucina (*Pillucina*) *psidium* (Dunker)
Pillucina (*Wallucina*) *striata* (Tokunaga)
Pillucina (*Wallucina*) sp.
Nemocardium (*Keenaea*) *samarangae* (Makiyama)

Clinocardium chikagawaense Kotaka
Clinocardium fastosum (Yokoyama)
Pitar ? sp.
Callista (*Callista*) *chinensis* (Holten)
Pseudamiantis tauyensis (Yokoyama)
Dosinia (*Phacosoma*) *japonica* (Reeve)
Mercenaria stimpsoni (Gould)
Callithaca (*Protocallithaca*) *adamsi* (Reeve)
Anomalocardia (*Veremopla*) *minuta* (Yokoyama)

Gomphina sp.
Paphia amabilis (Philippi)
Spisula (*Mactromeris*) *voyi* (Gabb)
Nipponopagia ommaensis Ogasawara n. gen et n. sp.
Macoma nipponica (Tokunaga)
Macoma praetexta (v. Martens)
Macoma tokyoensis Makiyama
Macoma cf. *calcarea* (Gmelin)
Macoma sp.
Rexithaerus sectior (Oyama)

Heteromacoma irus (Hanley)
Peronidia zyonoensis (Hatai and Nisiyama)
Fabulina nitidula (Dunker)
Siliqua cf. *alta* (Broderip and Sowerby)
Solen (*Solenarius*) *krusensterni* Schrenck
Panope japonica A. Adams
Anisocorbula sp.
Mya (*Mya*) cf. *japonica* Jay
Mya (*Mya*) *cuneiformis* (Böhm)
Umitakea japonica (Yokoyama)

Table 7 (Continued)

Dentalium (*Dentale*) *weinkauffii* Dunker
Dentalium sp.
Puncturella (*Puncturella*) *nobilis* A. Adams
Notoacmea asperulata (Yokoyama)
Notoacmea sp.
Lepeta cf. *abra* (Dall)
Collisella cf. *pelata shirogai* Habe and Ito
Turcica coreensis Pease
Calliostoma (*Tristichotrochus*) cf. *multiliratus* (Sowerby)
Calliostoma sp.
Umbonium (*Suchium*) *akitanum* Suzuki
Homalopoma amussitatum (Gould)
Turritella (*Neohaustator*) *saishuensis motidukii* Otuka
Turritella (*Neohaustator*) *saishuensis saishuensis* Yokoyama
Turritella (*Neohaustator*) *saishuensis etigoensis* Ida
Mesalia ommaensis Ogasawara n. sp.
Tachyrynchus venestellus (Yokoyama)
Architectonica sp.
Bittium cf. *yokoyamai* Otuka
"*Epitonium*" sp.
Spiniscala japonica (Dunker)
Tugarium (*Onustus*) *exutus* (Reeve)
Canarium (*Doxander*) *japonicus* (Reeve)
Neverita (*Glossaulax*) *reiniana* (Dunker)
Lunatia pila (Pilsbry)
Cryptonatica janthostomoides (Kuroda and Habe)
Semicassis japonica (Reeve)
Trophon kagaensis Hatai and Nisiyama
Ocenebra aduncum (Sowerby)
Mitrella (*Indomitrella*) *lischkei* (Smith)
Neptunea (*Barbitonia*) *arthritica* (Bernardi)
Siphonalia fusoides (Reeve)
Searlesia japonica Yokoyama
Nassarius (*Zeuxis*) *caelatus* (A. Adams)
Reticunassa spura (Gould)
Reticunassa sp.
Olivella cf. *japonica* (Stearns)
Oliva mustelina Lamarck
Fulgoraria masudae Hayasaka
Cancellaria (*Neadmete*) *japonica* Lischke
Cancellaria (*Merica*) *kobayashii* (Yokoyama)
Cancellaria (*Habesolatia*) *nodulifera* Sowerby
Sydaphera spengleriana (Deshayes)
Crithe (*Microvulina*) *comatago* (Yokoyama)
Antiplanes contraria (Yokoyama)
Paradrillia inconstans (Sowerby)
Suavodrillia declivis (v. Martens)
Inquisitor jeffreysii (Smith)
Inquisitor sp.
Crassispira pseudoprincipalis (Yokoyama)
Ophiodermella cf. *maekawaensis* Hatai, Masuda and Suzuki
Ophiodermella cf. *miyatensis* (Yokoyama)

Table 7. (Continued)

Ophiodermella ogurana (Yokoyama)
Propebela kagana (Yokoyama)
Mangelia sp.
Kuroshiodaphne ? sp.
Endemoconus sieboldii (Reeve)
Noditerebra (*Noditerebra*) *recticostata* (Yokoyama)
Punctoterebra (*Brevimyurella*) *lischkeana* (Dunker)
Leucotina dianae A. Adams
Odostomia (*Odostomia*) *hilgendorfi* Clessin
Odostomia (*Marignodostomia*) *subangulata* A. Adams
Odostomia sp. A
Odostomia sp. B
Syrnola (*Syrnola* ?) *cinnamomea* A. Adams
Turbonilla (*Paramormula*) *tokunagai* Yokoyama
Solidula (*Strigopupa*) *strigosa* (Gould)
Ringicula doliaris Gould
Rhizorus cylindrellus (A. Adams)
Rhizorus cf. *radiola* (A. Adams)
Adamnestia japonica (A. Adams)
Philine cf. *argentata* Gould

be subdivided into a lower (L), middle (M) and upper (U) units, each of which is composed mainly of shell remains. The species composition of each unit is shown in Table 9. The dominant species in each unit, especially, the infaunal elements, are the same. The writer infers from these facts that, firstly, the assemblages of three units were deposited under quite similar environmental conditions, secondly, careful check of preservation of shell remains which constitute each unit will be useful for the faunal change and its distribution in space and time reconstruction.

For the purpose of elimination of subordinate species and denoting dominant species combinations in each assemblage, constitutent species are arranged in the order of frequency.

5. COMPOSITION OF SPECIES

The molluscan fossils from the Omma Formation are listed up in Table 7. The number of specifically descriminated molluscan shell remains attains 151 species, including subspecies among which 38 species are extinct. There are 78 species of pelecypods, 71 species of gastropods and 2 species of scaphopods.

One genus of Tellinidae, four species and one subspecies are new to science.

Molluscan remains were collected from a block having a exposure surface of 15×30

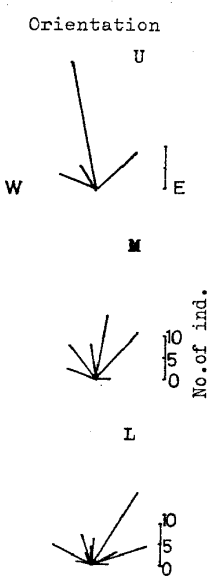
Table 8. Taxomomic composition of the Omma molluscs

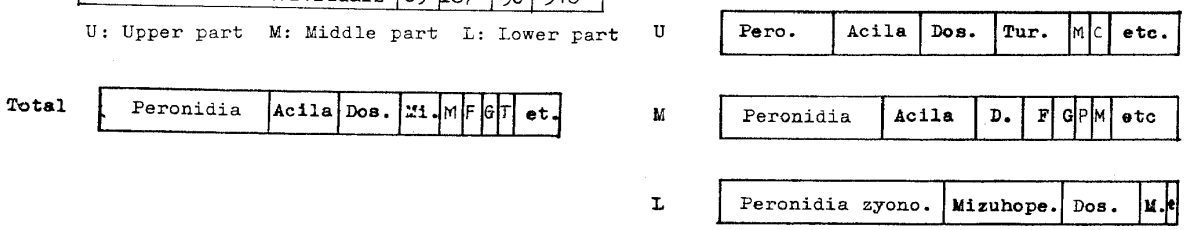
	Number of genera	Number of species			Total
		Indeterminant	Recent	Extinct	
Pelecypoda	53	9	50	19	78
Gastropoda	56	9	43	19	71
Scaphopoda	1	1	1	0	2
Total	110	19	94	38	151

Table 9. Faunal compostion among the graded three layers of fossil locality No. KO-04

Specific name \ Shell layer	Total number of individuals U	M	L	Total	No. of sp./Total ind.(%) U	M	L	Total
Peronidia zyonoensis	17	67	44	128	24.6	35.4	48.9	37.0
Acila insignis	13	39	-	52	18.8	20.9		15.0
Mizuhopecten yokoyamae		6	23	29		3.2	25.6	8.4
Dosinia japonica	11	20	15	46	15.9	10.7	16.7	13.3
Felaniella usta	2	12	-	14	2.9	6.4		4.0
Glycymeris yessoensis	2	10	-	12	2.9	5.3		3.5
Pandora pulchella	2	8	-	10	2.9	4.3		2.9
Mercenaria stimpsoni	3	8	6	17	4.3	4.3	7.8	4.9
Pseudamiantis tauyensis	-	6	2	8		3.2	2.2	2.3
Clinocardium fastosum	1	3	-	4	1.4	1.6		1.2
Clinocardium sp.	-	2	-	2		1.1		0.6
Chione sp.	3	-	-	3	4.3			0.9
Venericardia n. sp.	1	3	-	4	1.4	1.6		1.2
Solen sp.	1	3	-	4	1.4	1.6		1.2
Turritella saishuensis	11	-	-	11	15.9			3.2
Neptunea arthiritica	1	-	-	1	1.4			0.3
Propebela sp.	1	-	-	1	1.4			0.3
Total No. of species	14	13	5	17				
Total No. of individuals	69	187	90	346				

U: Upper part M: Middle part L: Lower part





cm (measured in the plane of bedding) and a thickness which is the same as that of the shell bed. Then, the number of species and individuals in each block were counted.

The specific composition are tabulated in the order of individual frequency of the species from each locality from the first largest to the fifth (Tables 10–1, 10–2, 10–3, 10–4).

In these tables, the specific names are abbreviated (see Table 10–1). This work shows that the species of first order (most dominant in the assemblage) exceeds 25 in number. They are as follows; Pelecypoda: *Anadara pseudosubcrenata, Anadara amicula elongata, Anadara ommaensis, Rexithaerus sectior, Acila insignis, Clinocardium fastosum, Peronidia zyonoensis, Mercenaria stimpsoni, Felaniella usta, Glycymeris yessoensis, Mizuhopecten yessoensis, Mizuhopecten yessoensis yokoyamae, Mizhuhopecten tokyoensis hokurikuensis, Venericardia ferruginea, Crenella* sp., *Mya* cf. *japonica, Yoldia notabilis, Crassostrea gigas, Callithaca adamsi, Nemocardium samarangae, Pandora pulchella, Limopsis tokaiensis*; Gastropoda: *Turritella saishuensis, Umbonium akitanum, Oliva mustelina* and Scaphopoda: *Dentalium* sp..

The combination of dominant species from the first to the fifth order were then calculated. From this calculation, for example, the associations which appear most frequently in several fossil localities of the Omma Formation are *Felaniella usta-Glycymeris yessoensis-Peronidia zyonoensis-Mizuhopecten yessoensis-Turritella saishuensis* group, *Anadara amicula elongata-Mizuhopecten yessoensis-Turritella saishuensis* group, *Rexithaerus sectior-Glycymeris yessoensis* and *Rexithaerus sectior-Acila insignis-Pandora pulchella-Mizuhopecten* sp..

Table 10–1. Simplified table of each locality showing thickness of shell bed, mode of occurrence, preservation of shell, number of species, and composition of species

Locality No.	Locality Name	Thickness of Shell bed (cm)	Facies	Mode of Occurrence								Preservation of Shell							No. of Species	Composition of Species
												Pelecy.					Gast.			
				P	I	L	S	AC	CC	CS	RS	c	i	w	b	f	p	w	f	
T-01	Sodani	40	MS	P					CC											3	Yol-Lim-Cli
T-02		50	MS	P						CS										2	Fel-Cli
KY-01	Nukadani	100	MS				S				RS									5	Fel-Gly-Cal-Dos-Pan
KY-02		30	MS		I			AC												8	Fel-Miz-Tur-Dos-Mer-Ana-Lim
KY-03		30	CS		I			AC												9	Tur-Gly-Cli-Per-Myok-Nas-Sip
KY-04		60	PC		I					CS										5	Ost-Per-Oph-(Tereb.)
KY-05		30	CS	P					CC											17	Tur-Gly-Cli-Ser-Oph-Psu
KY-06		20	CS	p				AC												8	Myok-Gly-Per-Ven-Ana-Nep-Oph
KY-07	Takao (South)	20	MS				S				RS									1	Turritella saishuensis
KY-08		30	FS			L			CC											10	Fel-Cli-Cry-Tur-Aci-Yol-Nep
KY-09		30	GC	P				AC												8	Fel-Per-Cal-Myok-Chl-Mtk-Ser
KY-10	Takao	60	FS			L				CS										7	Tur-Ana-Cry-Thr-Mac-Luc
KY-11		50	MS	P					CC											6	Gly-Pse-Cli-Mac-Ast
KY-12	Takao (North)	30	FS	P					CC											10	Cli-Tur-Cry-Mtk
KY-13		5	FS				S			CS										9	Fel-Per-Thr-Gly-Sol
KY-14		20	FS	P					CC											7	Fel-Gly-Mty-Per-Tur-Mer
KY-15		15	CS	P					CC											8	Gly-Ven-Ana-Cry-Mtk-Rin
KY-16		10	FS				S			CS										1	Ana
KY-17		50	GC	P					CC											4	Cli-Tur-Ana-Oph
KY-18		30	CS			L			CC											1	Spisula ?
KY-19		50	CS		I				CC											8	Gly-Ana-Ant-Tur-Ven
KY-20		20	FS			L				CS										5	Fel-Gly-Ana-Per
KY-21	Takao-Rindo	100	FS				S			CS										6	Cli-Per-Tur-Dos
KY-22		15	FS	P						CS										5	Fel-Per-Cli-Sol-Tur
KY-23		60	MS			L				CS										6	Gly-Ana-Ven-Myok-Mer-Chl
KY-24		15	GC		I				CC											6	Tur-Cli-Mer-Dos-Cry

Aci : Acila insignis
Ana : Anadara amicula elongata
Ana*: Anadara ommaensis
Ana+: Anadara pseudosubcrenata
Ant : Antiplanes contraria
Ast : Astarte borealis
Ast*: Astarte hakodatensis
Cal : Callista chinensis
Call: Callithaca adamsi
Chl : Chlamys cosibensis
Cli : Clinocardium fastosum
Cli*: Clinocardium chikagawaense
Con : Endemoconus sieboldi
Cre : Crenella sp.
Cry : Cryptonatica janthostomoides
Cyc : Cycladicama cumingi
Den : Dentalium weinkauffi
Dos : Dosinia japonica
Fel : Felaniella usta
Gly : Glycymeris yessoensis
Gom : Gomphina sp.
Lim : Limopsis spp.
Luc : Lucinoma annulata
Mac : Macoma sp.
Mack: Macoma tokyoensis
Macp: Macoma praetexta
Mer : Mercenaria stimpsoni
Mes : Mesalina ommaensis
Mod : Modiolus difficilis
Mtky: Mizuhopecten tokyoensis hokurikuensis
Mya : Mya spp.
Myad: Myadora japonica
Myes: Mizuhopecten yessoensis yessoensis
Myok: Mizuhopecten yessoensis yokoyamae
Nas : Nassarius caelatus
Nem : Nemocardium samarangae
Nep : Neptunea arthritica
Nev : Neverita reiniana

Oce : Ocenebra aduncum
Oli : Oliva mustelina
Oph : Ophiodermella ogurana
Ost : Crassostrea gigas
Pan : Panope japonica
Pand: Pandora pulchella
Pap : Paphia amabilis
Pec : Pecten albicans
Per : Peronidea zyonoensis
Por : Portlandia sp.
Psu : Pseudamiantis tauyensis
Rex : Rexithaerus sectior
Rin : Ringicula doliaris
Sac : Saccella confusa
Ser : Searlesia japonica
Sip : Siphonalia fusoides
Sol : Solen krusensterni
Spi : Spisula voyi
Thr : Thracia kakumana
Tug : Tugarium exutus
Tur : Turritella saishuensis
Umb : Umbonium akitanum
Ven : Venericardia ferruginea
Ven*: Venericardia spp.
Yol : Yoldia notabilis

Pelecy : Pelecypoda
Gast : Gastoropoda

Table 10–2. (Continued)

Locality No.	Locality Name	Thickness of Shell bed (cm)	Faies	Mode of Occurrence P	I	L	S	AC	CC	CS	RS	Preservation of Shell Pelecy. c	i	w	b	f	Gast. p	w	f	No. of Species Total ind.	Co.	Iso.	Composition of Species
KO-01	Okuwa	15	MS			L		AC												10	2	25	Ana-Oli-Con-Gly-Sac
KO-02		150	MS				S				RS									6	2	14	Oli-Gly-Ana-Sac-Pec
KO-03		20	MS				S				RS									6			Rex-Sol-Cli-Oph-Myos
KO-04		15	MS	P				AC												22	15	268	Per-Aci-Dos-Miz-Mer-Fel-Gly
KO-05		50	MS	P					CC											1			Tur
KO-06		10	MS				S				RS									6	1	10	Cli-Tur-Myes-Cry-Nep
KO-07		15	FS	P					CC											3	21	6	Ana±Myes±Myok
KO-08		15	FS	P					CC											9	1	18	Cli-Myes-Per-Gly-Aci-Gom
KO-09		50	MS		I				CC											10	5	62	Tur-Aci-Lim-Cal-Per
KO-10		70	FS				S			CS										7	3	11	Den-Ven-Rex-Gly-Pap-Oce
KO-12		100	FS				S			CS										12	2	17	Cli-Mtky±Oph-Rex-Yol-Pan-Ana+
KO-13		30	FS	P					CC											7	5	15	Ana+-Cry-Myes-Ant-Gly-Tur
KO-14		20	FS	P					CC											3	6	7	Ana+-Rex-Core

Locality No.	Locality Name	Thickness of Shell bed (cm)	Faies	Mode of Occurrence P	I	L	S	AC	CC	CS	RS	Preservation of Shell Pelecy. c	i	w	b	f	Gast. p	w	f	No. of Species	Composition of Species
KO-15	Tagami	15	MS	P				AC												21	Aci-Dos-Ven-Pand-Tur-Gly-Ast±Per
KO-16		10	MS	P					CC											7	Per-Gly-Fel-Myes-Aci
KO-17	Ghoshi	30	MS				S*				RS									5	Mer-Dos-Cli-Tur-Aci
KO-18		60	MS			L				CS										10	Mer-Aci-Gly-Per-Dos
KO-19		100	FS				S			CS										8	Tur-Aci-Psu-Mer-Per-Thr-Fel
KO-20		30	FS		I				CC											10	Fel-Gly-Per-Mer-Cli-Dos
KO-21		15	MS			L				CS										5	Gly-Lim-Myes-Ana-Cry
KO-22	Kaminaka	30	MS		I				CC											22	Ana-Mtok-Myes-Myad-Ven-Gly
KO-23		15	MS			L				CS										14	Fel-Gly-Per-Mer-Ven-Mtky-Psu
KO-24		30	MS	P				AC												11	Fel-Gly-Mer-Per-Ana
KO-25	Fukuro-Itaya	20	MS	P				AC												12	Tur-Aci-Fel-Den-Gly-Per
KO-26		20	MS			L			CC											16	Myok-Ana-Nas-Aci-Mtky-Cry-Tur
KO-27		30	MS	P				AC												12	Fel-Per-Gly-Ana-Mer-Tur
KO-28	Kaminaka	20	MS	P				AC												12	Gly-Fel-Psu-Per-Dos
KO-29	Utto	30	MS	P					CC											12	Fel-Per-Dos-Call-Mer
KO-30		40	MS	P				AC												17	Myes-Fel-Tur-Ven-Aci-Ven*
KO-31		15	MS	P				AC												12	Fel-Myok-Tur-Per-Cry
KO-32		40	MS	P				AC												14	Fel-Myok-Tur-Psu-Per-Cli
KO-33	Higashi-Ichise	10	MS			L*					RS									7	Umb-Nev-Cli-Nas-Ser-Tur
KO-34	Utto	40	MS	P					CC											10	Fel-Dos-Per-Gly-Tur
KO-35	Fukuro-Itaya	30	MS		I*				CC											8	Fel-Gly-Myok-Mer-Cli
KO-36		15	MS			L			CC											11	Fel-Per-Myok-Rex-Cli-Mer-Yol

6. MODEL OF SHELL BED

Based upon the standardized observations of the assemblages of shell beds described above, the features of assemblages and types of shell beds are summerized in Fig. 7.

Although the shell remains are found in various types of sediments in lithology, the majority of the shell beds in the Omma Formation are represented by P-AC and P-CC combination of modes of occurrence and abundancy. These types of assemblages are widely found in the middle to lower part of the formation which are generally composed of medium to fine grained sandstones.

Occasionally, one shell bed can be traced laterally about 1 km distance, but in most cases, shell beds thin over short distances. Certain shell remains, of course, might have been transported from other places after death by the result of hydrodynamic processes.

Table 10–3. (Continued)

Locality No.	Locality Name	Thickness of Shell bed (cm)	Facies	Mode of Occurrence P	I	L	S	AC	CC	CS	RS	Preservation of Shell Pelecy. c	l	w	b	f	Gast. p	w	f	No. of Species	Composition of Species
KK-01	Kakuma	10	MS	P				AC				-	-	-	-		-	-		23	Aci-Tur-Per-Cli-Fel-Thr-Mtky
KK-02		15	MS		I				CC			-	-	-	-	-	-	-	-	14	Aci-Rex-Mtky-Pand-Cry-Yol-Per
KK-03		40	FS		I				CC			-	-	-			-	-		59	Rex-Aci-Pand-Dos-Pan-Per-Sol
KK-04	Southern Maki	30	MS			L			CC			-	-	-			-	-		6	Tur-Fel-Aci-Pand-Mer-Cli
KK-05		30	FS	P				AC				-	-	-			-	-		7	Tur-Fel-Aci-Per-Cal-Cli
KK-06	Gohyakko-ku-dani Southern Maki	20	MS		I							-	-	-			-	-		19	Tur-Aci-Myok-Fel-Cli-Rex
KK-07		10	SS				S				RS	-	-							1	Ana
KK-08		10	FS			L				CS		-	-				-	-		3	Ana-Macp-Cry
KK-09		15	FS			L			CC			-	-				-	-		2	Ana-Cry
KK-10		10	FS	P				AC				-	-	-			-	-		7	Ana-Thr-Cli-Mod-Mac-Pand-Cry
KK-11																					
KK-12	Kofuta-Mata	20	MS	P				AC				-	-	-	-	-				5	Fel-Thr-Cli-Gly-Dos
KK-13		30	MS		I			AC				-	-	-	-	-	-	-	-	11	Tur-Myok-Fel-Aci-Mer-Cli-Cry
KK-14		20	CS			L			CC			-	-	-	-	-	-	-	-	7	Myok-Gly-Per-Thr-Nep
KK-15	Kofutama-ta-zawa	30	MS	P					CC			-	-	-			-	-		8	Fel-Gly-Per-Psu-Aci-Den
KK-16		100	MS		I			AC				-	-	-	-	-				16	Fel-Gly-Psu-Per-Thr-Cli
KK-17		20	MS	P					CC			-	-	-						6	Fel-Gly-Psu-Per-Mer
KK-18		30	MS	P				AC				-	-	-	-	-				9	Fel-Gly-Per-Psu-Thr
KK-19		30	MS	P				AC				-	-	-	-	-				7	Fel-Gly-Per-Psu-Pand
KK-20		20	MS		I				CC			-	-	-	-	-	-	-	-	10	Fel-Gly-Per-Cli-Dos-Psu
KK-21		20	MS		I				CC			-	-	-			-			8	Fel-Gly-Per-Psu-Cli
KK-22		30	MS	P				AC				-	-	-	-	-	-	-	-	24	Gly-Fel-Rex-Cry-Umb-Myok-Mer
KK-23	Gohyakko-ku-dani (Nagae)	10	MS		I					CS		-	-	-	-	-	-	-	-	5	Tur-Fel-Cli-Aci-Pan
KK-24		40	PC-FS	P				AC				-	-	-	-	-	-	-	-	23	Gly-Rex-Mtky-Dos-Mer-Per-Thr
KK-25		20	MS		I					CS		-	-	-						22	Gly-Rex-Thr-Per-Dos-Pan-Cli
KK-26		10	MS				S			CS		-	-	-			-			3	Tur-Thr-Cli
KK-27																					
KK-28		40	FS-GC		I-L				CC			-	-	-	-	-	-	-	-	5	Fel-Per-Myok-Cli-Tur
KK-29		20	MS	P						CS		-	-	-	-	-	-	-	-	5	Tur-Cli-Ana-Myok-Mac
KK-30		40	FS				S				RS	-	-	-			-	-		3	Tur-Mac-Tug
KK-31	Gosho	10	MS			L				CS		-	-	-	-		-	-		5	Per-Thr-Cli-Tur-Mac
KK-32		30	MS	P						CS		-	-	-			-			7	Gly-Fel-Thr-Sol-Mtky-Cry
KK-33		100	MS		I				CC			-	-	-			-	-		6	Tur-Cli-Ana-Thr-Mtky
KK-34		30	MS	P				AC				-	-	-	-	-	-	-	-	19	Mtky-Cli-Ana-Per-Yol-Cry
KK-35		10	MS	P					CC			-	-	-			-	-	-	13	Ven-Gly-Cry-Ana-Astb-Aci-Mod
KK-36		15	FS				S				RS	-	-	-			-	-		6	Cre-Mod-Gom-Yol-Tur-Cry
KK-37	Yuhidera	30	MS				S*				RS						-	-		1	Tur
KK-38		50	MS				S*				RS	-	-	-			-	-		3	Tur-Cli-Aci
KK-39		50	MS				S*				RS	-	-	-			-	-		2	Tur-Cli
KK-40		20	MS				S*				RS	-	-	-			-	-		4	Cli-Tur-Myad-Ost
KK-41		30	MS	P					CC			-	-	-	-	-	-	-		8	Cli-Pap-Dos-Tur-Thr
KK-42		100	FS	P				AC				-	-	-			-	-		14	Ven-Gly-Aci-Gom-Macp-Per-Ana
KK-43		5	SS				S				RS	-	-	-						1	Ana
KK-44		10	FS			L				CS		-	-	-						2	Ana-Nev
KK-45	Northern Maki Tsuribe	20	SS			L				CS		-	-	-						3	Ana-Thr-Tur
KK-46		30	MS				S*				RS		-	-				-		8	Gly-Cyc-Aci-Pap-Yol-Dos
KK-47		20	MS	P							RS	-	-	-			-	-		5	Mya-Ana-Tur-Myok-Gly
KK-48	Eastern Kofutama-ta	40	FS			L					RS		-	-						5	Gly-Ana-Mtky-Yol-Lim
KK-49		30	SS				S				RS	-	-	-						3	Nem-Cyc-Tur
KK-50	North-ta Gosho	20	SS				S				RS	-	-	-			-			4	Pan-Aci-Tur-Yol
KK-51		15	SS			L					RS	-	-	-			-			3	Nem-Mac-Tur
KK-52		20	SS			L				CS		-	-	-	-		-	-		6	Nem-Tur-Pap-Cyc-Thr

Table 10–4. (Continued)

Locality No.	Locality Name	Thickness of Shell bed (cm)	Facies	Mode of Occurrence P	I	L	S	AC	CC	CS	RS	Preservation of Shell Pelecy. c	i	w	b	Gast. f	p	w	f	No. of Species	Composition of Species
FM-01	Tanoshi-ma	15	MS			L			CC											7	Fel-Per-Cli-Mac-Myok-Tur
FM-02		30	MS		I			AC												4	Fel-Per-Mer-Tur
FM-03		20	MS			L*			CC											5	Gly-Fel-Ven-Dos-Cli
FM-04	Futamata Northern-Futamata	50	MS		I*				CC											7	Ven-Mer-Pan-Mac-Tur
FM-05		15	MS			L			CC											11	Gly-Ana-Mod-Mack-Cli-Luc
FM-06		100	MS	P					CC											17	Spi-Ana-Gly-Mac-Luc-Pec-Cli
FM-07		15	MS		I					CS										4	Gly-Aci-Mes
FM-08		10	MS				S				RS									3	Gly-Tur-Yol
FM-09																					
FM-10		30	FS				S				RS									7	Nem-Thr-Cli-Pap-Cal
FM-11		200	FS	P					CC											6	Myok-Fel-Gly-Ana-Thr-Tur
FM-12		20	FS			L			CC											5	Ana-Thr-Cli-Rex-Myok
FM-13		30	FS	P					CC											9	Ana-Rex-Thr-Pyok-Cli-Mya
FM-14		20	FS			L				CS										2	Myok-Mer
FM-15		30	FS	P				AC												5	Fel-Tur-Thr-Cal-Mer
FM-16		10	MS			L			CC											5	Tur-Myok-Fel-Cal-Rex
FM-17		10	MS			L		AC												5	Fel-Rex-Tur-Myok-Gly
FM-18		30	MS-PC	P				AC												4	Gly-Mer-Pyes
FM-19		80	MS	P					CC											6	Myok-Fel-Tur-Aci-Cre-Gom
FM-20		80	MS	P					CC											4	Myok-Cli-Tur-Cry
FM-21		30	MS	P				AC												10	Myok-Thr-Rex-Gly-Cli-Aci-Per
FM-22	Ishise	10	CS-PC	P					CC											3	Cal-Gly-Myok
FM-23		15	GC-PC	P					CC											3	Cal-Gly-Myok
FM-24		10	FS	P						CS										2	Cal-Myok
Fm-25		100	FS			L			CC											6	Tur-Fel-Myok-Mer-Yol
FM-26		60	FS			L				CS										5	Tur-Fel-Myok-Mer-Cal
FM-27		10	FS			L			CC											4	Fel-Per-Thr-Rex
FM-28		30	FS		I			AC												8	Fel-Gly-Thr-Ana-Mer
FM-29		15	SS			L					RS									5	Tur-Aci-Por-Yol-Cry
FM-30	Nakahara	30	SS				S			CS										4	Cli-Tur-Cry-Myes
FM-31		30	FS			L				CS										3	Cli-Mtky-Aci
FM-32		200	SS				S			CS										3	Cli-Tur-Myok
FM-33		80	FS			L			CC											3	Myok-Tur-Thr
FM-34		30	FS	P					CC											5	Tur-Cli-Mer-Fel-Myok
FM-35		80	SS				S			CS										3	Tur-Thr-Myok
FM-36		5	FS			L			CC											1	Tur
FM-37		10	FS	P				AC												5	Fel-Gly-Per-Thr-Mer
FM-38		100	FS				S			CS										2	Tur-Cli
FM-39		50	FS			L				CS										3	Ana-Tur-Myok
FM-40		40	FS		I				CC											4	Ana-Thr-Tur-Myok
FM-41		60	FS		I				CC											4	Ana-Thr-Cli-Tur
FM-42		200	SS				S			CS										5	Ptky-Aci-Ana-Pap-Sip

I* : Mold or cast

However, in the case of the Omma Formation, the majority of shell remains are generally in quite a good state of preservation, eventhough some of the remains were broken into fragments and water worn. The molluscan assemblage of each shell bed is mainly composed of a few dominant and representative species, but remarkable vertical change of the elements can be observed in the stratigraphic sequence of the Omma Formation. This vertical change is fairly clearly correspond to that of lithological change in the formation. On the other hand, the lateral change in composition of dominant species seems to be slight judging from field observations. Therefore, the composition of certain dominant species and their combination will be discussed without sedimentological consideration.

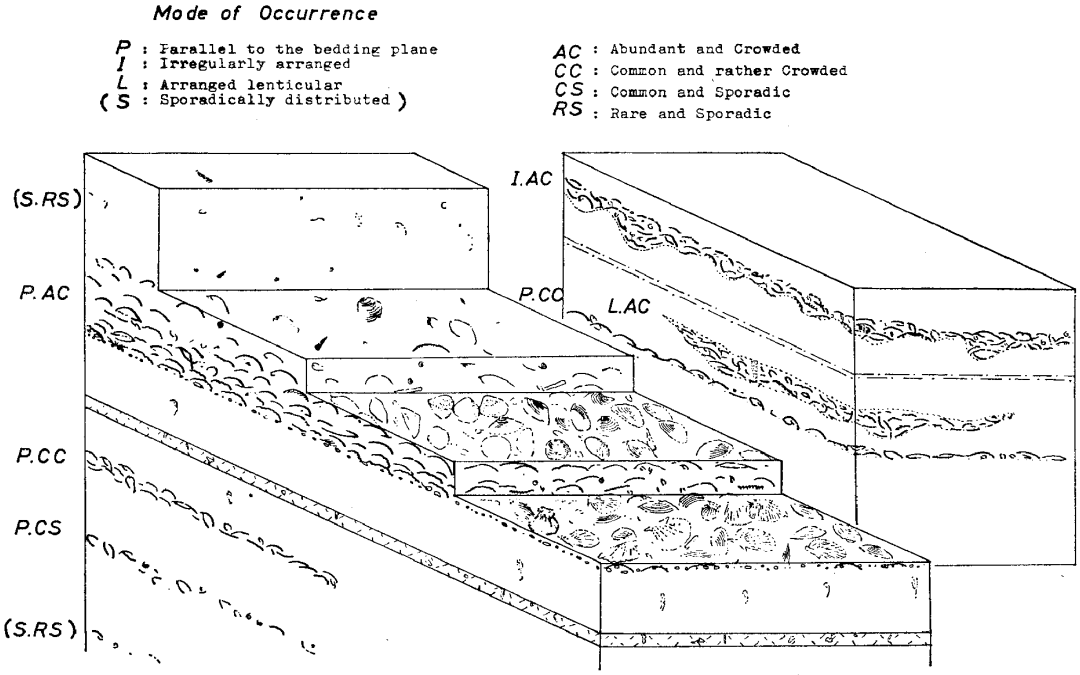


Fig. 7. Model of shell bed.

7. ANALYSIS OF MOLLUSCAN FAUNA

a. Relationship between lithology and fauna

Based upon the already mentioned data collected from each fossil locality, an analysis was made to determine the relationship between the lithology of strata yielding the molluscan fossils and the combination of dominant species in the assemblage. The lithology of strata in which the shell remains are enclosed are classified into five types, they are the pebble to granule conglomerate (PC-GC), coarse grained sandstone (CS), medium grained sandstone (MS), fine grained sandstone (FS) and silty sandstone (SS). The relationship between the lithofacies and faunal composition of each locality is shown numerically in Table 11. The molluscs dealt with in this analysis are restricted to certain dominant species in each shell bed, thus it is inferred that these species have a rather intimate relationship with the lithofacies of the shell bed.

In the course of calculation of abundancy or dominancy of the species, different weights are given according to the order of the individual frequency of species. That is, the species which has the largest frequency of all will be given five points, species of the next highest frequency four points and so on, with species of the fifth order having one point.

Species were then arranged in the order of relative frequency instead of by obsolete number of individuals in the assemblage.

From a study of Table 11, it can be inferred that the specific association found in the granule to pebbly conglomerate is *Callithaca adamsi-Peronidia zyonoensis-Glycymeris yessoensis-Felaniella usta-Dosinia japonica.* To these should be added, *Crassostrea gigas* and *Chlamys cosibensis* which, through field observation, are one of the characteristic species in the conglomeratic facies of the Omma Formation.

The representative combination of species in coarse grained sandstones is *Glycymeris yessoensis-Felaniella usta-Peronidia zyonoensis-Anadara amicula elongata-Venericardia ferruginea* subspp.–*Clinocardium fastosum.* The epifaunal species of *Mizuhopecten* spp. (including

Table 11. Relationship between lithofacies and molluscan assemblage

Total Number of Localities	7	11	48	54	14	total 134
Facies	PC-GC	CC	MS	FS	SS	
Specific Name						
Callithaca (Protocallithaca) adamsi	18					18
Mizuhopecten spp.	13	25	59	59		156
Turritella saishuensis subspp.	9	12	72	70	31	194
Peronidea zyonoensis	8	12	64	19	3	106
Glycymeris yessoensis	8	37	78	52		175
Crassostrea gigas	5					5
Felaniella usta	5	14	161	71		251
Mercenaria stimpsoni	3	4	24			31
Anadara amicula elongata	3	8	18	86	18	133
Dosinia japonica	2	2	23			27
Chlamys cosibensis	1					1
Venericardia ferruginea		7			11	18
Clinocardium fastosum		5	30	74	12	121
Acila insignis		4	53	10	19	86
Rexithaerus sectior		4	14	16		34
Pseudamiantis tauyensis			24			24
Thracia kakumana			13	44		57
Pandora pulchella			9			9
Limopsis spp.			7		12	19
Nemocardium samarangae				7	15	22
Macoma spp.				10	8	18
Crenella sp.				8		8
Modiolus difficilis				6		6
Paphia amabilis				3		3
Cycladicama cumingi					6	6
Panope japonica					5	5
Mya spp.					+	+

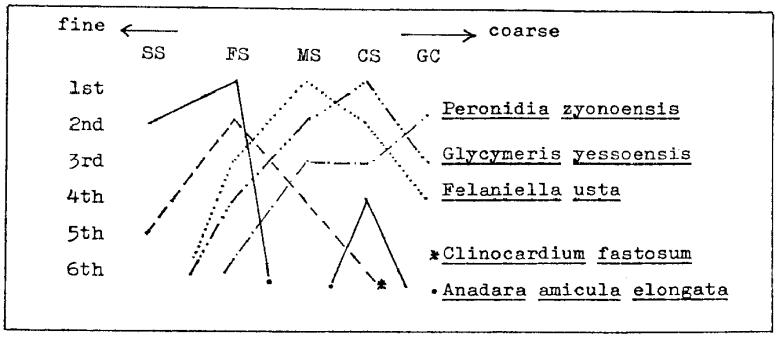
PC-GC facies
Infauna : Callithaca-Peronidea-Glycymeris-Felaniella-Mercenaria-Dosinia
Epifauna : Mizuhopecten-Turritella-Crassostrea-Chlamys
CS Facies
Infauna : Glycymeris-Felaniella-Peronidea-Anadara-Venericardia-Clinocardium
Epifauna : Mizuhopecten-Turritella-(Neptunea, Chlamys)
MS Facies
Infauna : Felaniella-Glycymeris-Peronidea-Clinocardium-Mercenaria-Pseudamiantis
Epifauna : Turritella-Mizuhopecten
FS Facies
Infauna : Anadara-Clinocardium-Felaniella-Glycymeris-Thracia-Peronidea-Rexithaerus
Epifauna : Turritella-Mizuhopecten
SS Facies
Infauna : Acila-Anadara-Nemocardium-Limopsis-Clinocardium-Venericardia-Macoma
Epifauna : Turritella-Mizuhopecten-(Mytilus)

Index: PC-GC; Pebble to granule conglomerate
CS ; Course grained sandstone
MS ; Medium grained sandstone
FS ; Fine graines sandstone
SS ; Silty sandstone

M. yessoensis s.s., *M. yessoensis yokoyamae* and *M. tokyoensis hokurikuensis*) and *Turritella* spp. (including *T. saishuensis* s.s., *T. saishuensis motidukii* and rarely *T. saishuensis etigoensis*) are rather commonly found in the coarse grained sandstones as they are in the granule to pebbly conglomeratic facies.

Table 12. Specific composition introduced by frequency study of species versus lithology

Order / Facies	1st	2nd	3rd	4th	5th	6th
PC-GC	Callithaca	Peronidia	Glycymeris	Felaniella	Mercenaria	Dosinia
CS	Glycymeris	Felaniella	Peronidia	Anadara	Venericardia	Clinocardium
MS	Felaniella	Glycymeris	Peronidia	Clinocardium	Mercenaria	Pseudamiantis
FS	Anadara	Clinocardium	Felaniella	Glycymeris	Thracia	Peronidia
SS	Acila	Anadara	Nemocardium	Limopsis	Clinocardium	Venericardia



LEGEND
PC-GC; Pebble to granule conglomerate
CS; Coarse grained sandstone
MS; Medium grained sandstone
FS; Fine grained sandstone
SS; Silty sandstone

Fig. 8. Frequency of some species in each classified lithology

The fauna from the medium grained sandstone facies are studied from 48 fossil localities. The dominant species in this facies is *Felaniella usta* (relative weighed frequency is 161 points). Although this species is known from the fine to coarse grained sandstones and occasionally from the pebbly to granule conglomerates of the Omma Formation, it can be inferred that the most preferable bottom condition of the species may be the medium grained sand as shown by the relative frequency.

The combination of *Anadara amicula elongata-Clinocardium fastosum-Felaniella usta-Glycymeris yessoensis-Peronidia zyonoensis-Rexithaerus sectior* represents the fine grained sandstone facies. Among which, *Thracia kakumana*, *Nemocardium samarangae*, *Macoma* spp. (including *M. tokyoensis*, *M. praetexta*, *M. nipponica* and *M.* sp.), *Modiolus difficilis* and *Paphia amabilis* are considered to be the characteristic species in the fine grained sandstone facies, because they are not found in the coarser sediments than the fine grained sandstone.

Relative frequency of species from the silty sandstone facies is *Acila insignis-Anadara amicula elongata-Nemocardium samarangae-Limopsis* spp. (including *L. tokaiensis* and *L. crenata*)-*Clinocardium fastosum-Venericardia* spp. (including *V. ferruginea orbicularis*, *V. f. complexa*)-*Macoma* spp., and from the field observation, *Mya* spp. (including *M.* cf. *japonica* and *M. cuneiformis*) seem to be common species in the silty sandstone facies.

The combinations, their ecological relationship and paleoenvironmental interpretation based upon the each combination of species will be discussed below.

b. Weighed frequency of species-lithofacies relationship

Some rock samples of the sandy sediments, yielding well preserved shell remains (p, i, and w type), were selected for grain size distribution analysis. The automatic grain size

Table 13. Specific composition and frequency curve of grain size distribution of the sediments

Locality	Max. (φ)	Mud-Cont. %	Character of Curve 1 2 3	Characteristic fauna
KY-03	3.15	9.7		^{15}Tur-^{6}Gly-^{4}Ser-^{2}Dos-^{2}Cli-^{1}Pseud-Fel-Pand-Rex
KY-05	3.05	8.6		Tru-Gly-Cli-Ser-Oph
KY-13	3.10	21.0		^{5}Aci-^{3}Tur-Mact-Mtky
KY-16	2.90	16.6		^{11}Ana
KY-30	3.20	16.3		^{15}Ana-^{3}Yol-^{1}Cli
KY-32	3.00	13.8		^{3}Ana-^{2}Gli-^{1}Cli
KO-15	3.10	13.7		^{26}Aci-^{16}Dos-^{12}Ven-^{10}Pand-^{9}Tur-^{7}Gly-^{7}Ast-^{6}Per-^{5}Rex-^{2}Thr
KO-21	2.95	13.9		^{10}Gly-^{5}Lim-^{3}Myes-^{2}Ana
KO-22	3.05	15.9		^{136}Ana-^{10}Mtok-^{9}Myes-^{6}Myad-^{3}Ven
KO-29	3.20	19.1		^{A}Fel-^{C}Per-^{C}Dos-^{R}Call-^{R}Mer
KK-02	3.10	12.6		^{8}Aci-^{5}Rex-^{4}Mtky-^{3}Pand-^{3}Cry-^{2}Yol-^{2}Per-^{2}Dos
KK-08	3.00	67.4		^{5}Ana-^{2}Macp-^{1}Cry
KK-10	2.90	16.3		^{12}Ana-^{5}Thr-^{4}Cli-^{3}Mod-^{3}Mac-^{2}Pand
KK-13	3.10	11.4		^{25}Tur-^{21}Myok-^{10}Fel-^{8}Aci-^{7}Mer-^{5}Cli-^{2}Per-^{2}Gly
KK-31	3.05	16.3		^{5}Per-^{3}Thr-^{3}Cli-^{3}Tur-^{1}Mac
KK-32	3.05	18.2		^{4}Gly-^{C}Pel-^{R}Thr-^{R}Sol-^{R}Mtky
KK-35	2.95	7.4		^{106}Ven-^{31}Gly-^{17}Cry-^{10}Ana-^{7}Astb-^{4}Aci-^{3}Mod
KK-36	3.20	10.4		^{7}Cre-^{5}Mod-^{3}Gom-^{2}Yol-^{1}Tur-^{1}Cry
KK-42	2.95	6.6		^{15}Ven-^{13}Gly-^{10}Aci-^{8}Gom-^{7}Macp-^{3}Per-^{2}Ana
KK-48	3.15	15.2		^{15}Gly-^{9}Ana-^{4}Mtky-^{1}Yol-^{1}Lim
KK-52	3.10	19.4		^{20}Men-^{7}Tur-^{7}Pap-^{5}Cyc-^{3}Thr
FM-05	3.00	12.3		^{30}Gly-^{14}Ana-^{6}Mod-^{4}Mtky-^{2}Cli-^{2}Luc
FM-06	3.00	48.3		Spi-Ana-Gly-Mac-Luc-Per-Cil
FM-07	3.05	44.5		^{34}Gli-^{4}Aci-^{2}Mes
IS-09	3.30			^{102}Lim-^{40}Mac-^{40}Cli-^{31}Yol-^{16}Aci-^{10}Tur
RO-14	3.10	7.87		^{A}Fel-^{13}Gly-^{3}Psu-^{2}Thr-^{2}Myok

0 1 2 3 4φ

Numbers above species abbreviation (e.g. Tur^{15}, Gly^{6}) indicate number of individuals of respective species.

analyser of Niitsuma (1971) was used. Mud contents of the samples ranged from 25.3% to 6.6%. Fine to medium grained sandstones which correspond to Maximal (M) of Niitsuma's range of 2.90 ϕ to 3.25 ϕ, were examined. The characteristic curves of grain size distribution and its well preserved fossil contents are shown in Table 13.

After careful examination of samples, the writer classified the sediment types of the Omma Formation into the following categories: (1) fine grained sandstone (FS) is characterized by the sand grains of Maximal of 3.1 to 3.2 in logalismic diameter, and has silt

fractions of approximately 15%, (2) medium grained sandstone is also characterized by the sand grains of Maximal of 2.9–3.1 ϕ with a silt fraction of about 10%.

Consequently, each species appears to be restricted to a particular sediment type represented by the limited values of mud contents and Maximal points. For example, the correlation between the mud contents and certain species is the most remarkable. These are: *Rexithaerus sectior*: 26.0–12.6%, *Nemocardium samarangae*: 19.9–19.2%, *Glycymeris yessoensis*: 18.0–5.4%, *Anadara amicula elongata*: 16.6–6.0%, *Venericardia ferruginea* subspp. : 7.4–6.6%, *Turritella saishuensis* subspp.: 11.4–8.6%, *Thracia kakumana*: 19.0–16.3%, *Clinocardium fastosum*: 20.0–9.2%.

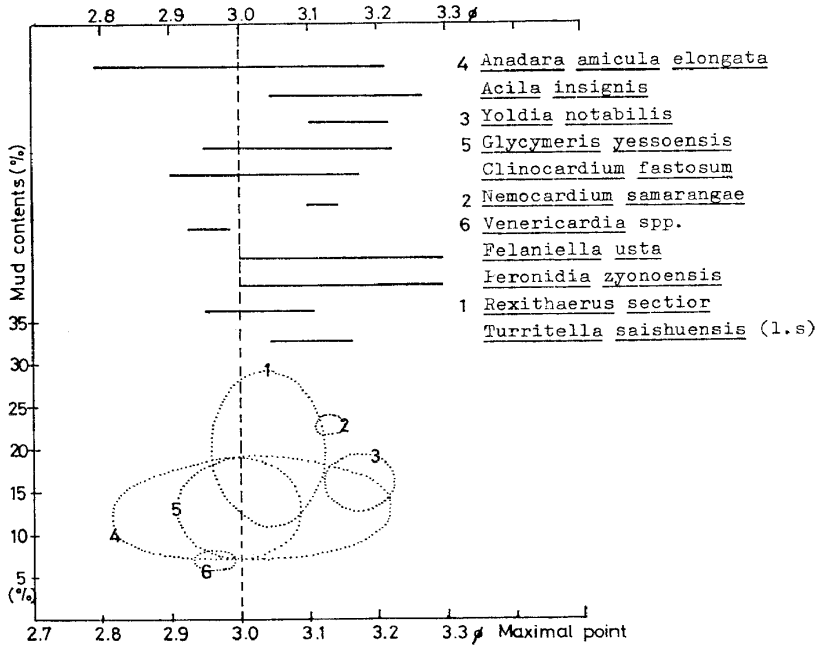


Fig. 9. Graph showing species-lithology relationship

Among them, *Clinocardium fastosum*, *Thracia kakumana*, *Glycymeris yessoensis*, *Acila insignis*, *Anadara amicula elongata* and *Felaniella usta* rather widely occur in sediments of Maximal range of 2.85 to 3.20 ϕ. Although the number of examined rock samples were not sufficient, it appears that the mud contents of the sediments might have exerted a stronger influence on the distribution of species than the Maximal of grain size does.

The weighed (or relative) frequencies of representative species in relation to the different lithology are summarized in Fig. 10. As pointed out in the preceeding page, two genera of the epifaunal *Mizuhopecten* spp., and *Turritella saishuensis* subspp. show rather abnormal distributions, and other dwellers have rather normal ones except for a few genera. For example, *Peronidia zyonoensis*, *Glycymeris yessoensis*, *Felaniella usta* have symmetrical distributional pattern in relation to the lithology, with Maximal falling in the medium grained sandstone (MS) category. *Mercenaria stimpsoni* and *Dosinia japonica* attain their peaks in the medium grained sandstone, even though their values are rather small.

Clinocardium fastosum, *Thracia kakumana* and *Anadara amicula elongata* have their peaks in the fine grained sandstone (FS) and *Nemocardium samarangae* tends to occur in silty sandstone.

The weighed frequency pattern of species is inferred to indicate the most optimum

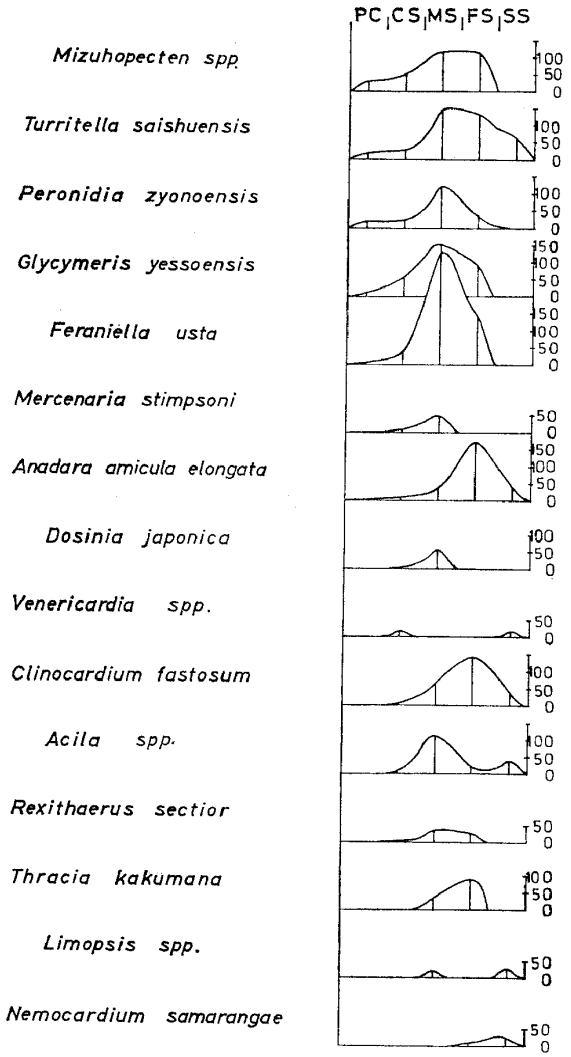


Fig. 10. Graph showing species-lithology relationship indicated by weighed frequency

bottom conditions for certain species.

In the cases of *Acila* spp., *Venericardia* spp., and *Limopsis* spp., they have two peaks in the different lithology, but one species, *Acila nakazimai*, is restricted in the silty facies, and another, *Acila insignis* in the sandy facies judging from the field observation of shell occurrence. *Limopsis* spp., including *Limopsis tokaiensis* and *Limopsis crenata*, might have lived in different bottom conditions. *Limopsis tokaiensis* seems to be limited in the sandy bottom and *Limopsis crenata* in the silty bottom.

The genus *Venericardia* includes several different species in the Omma Formation, the most of species except *Miotondiscus nakamurai* are occurring in sandy facies.

8. VERTICAL AND LATERAL DISTRIBUTION OF FAUNA

The idealized faunal distribution in the Omma Formation is shown in Fig. 11. Shell beds are found in various horizones in the Omma Formation, but they are restricted from place to place. Although more than 10 fossil localities can be plotted in each columnar section, shown in Figs. 5–1 and 5–2, most of them are restricted to the lower to middle part of the formation. Judging from the field data and faunal analysis, the vertical change in faunal elements of the assemblages is more remarkable than that of lateral. The Omma fauna can be divided into three vertical units.

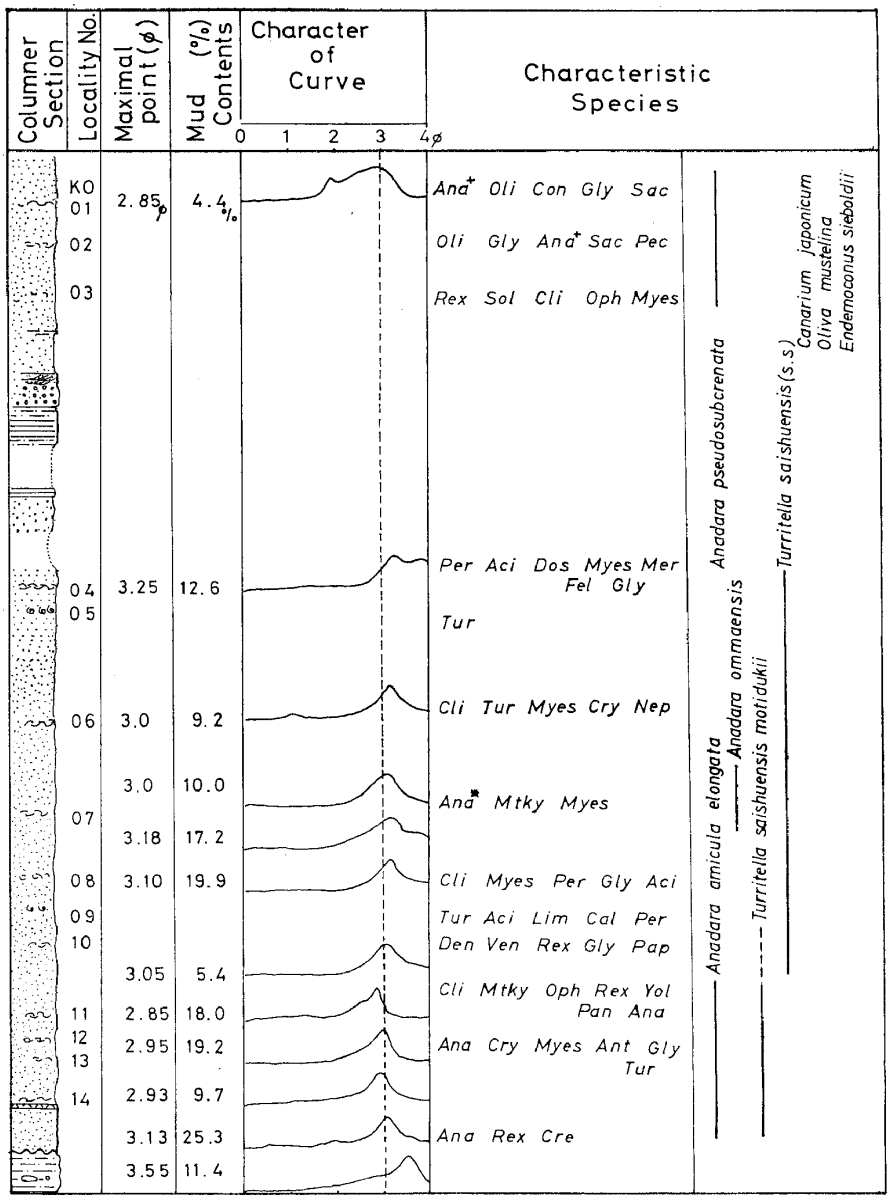
At the type locality of the formation, the lower part is represented by *Anadara amicula elongata* in association with *Rexithaerus sectior*, *Turritella saishuensis* (s. l.), *Glycymeris yessoensis* and *Acila insignis*. The assemblage of the middle part of the formation is shown by *Peronidia zyonoensis*, *Acila insignis*, *Dosinia japonica*, *Mizuhopecten yessoensis* and *Mizuhopecten tokyoensis hokurikuensis*. The upper part of the middle part of the formation consists of coarse grained sandstones intercalated with coarse sediments and lignitic bed without any molluscan remain.

The molluscan assemblage of the upper part is characterized by the occurrence of the genus *Anadara* as in the lower part. But the assemblage of the uppermost part is remarkably different from that of the middle and lower parts, because the species are of warm water elements, including *Canarium japonicus*, *Endemoconus sieboldii*, *Oliva mustelina* and *Saccella confusa*.

This is the first evidence in the Omma Formation, and noteworthy for the interpretation of paleoenvironment and paleogeography of the area.

In the northern part of Kanazawa City, the faunal change, from lower to upper part

Table 14. Composite diagram, showing typical faunal and lithological sequences in the Omma Formation



of the formation, is represented by (*Anadara amicula elongata-Nemocardium samarangae*) –(*Acila insignis-Glycymeris yessoensis-Felaniella usta*)–(*Clinocardium fastosum-Anadara amicula elongata-Yoldia notabilis*) in ascending order.

In the Takemata area, the change from lower to upper is rather distinct and shown as (*Anadara amicula elongata-Nemocardium samarangae-Mya cuneiformis* assemblage)–(*Glycymeris yessoensis-Felaniella usta* assemblage).

These changes in assemblage correspond quite well to the lithological change in the formation. That is to say, the lower part of the formation is represented by the assemblage of silty sandstone and fine grained sandstone (SS and FS's fauna, cited above), and the middle part are of the medium to coarse grained sandstone (MS and CS).

An interesting assemblage is found from the uppermost part of the Omma Formation

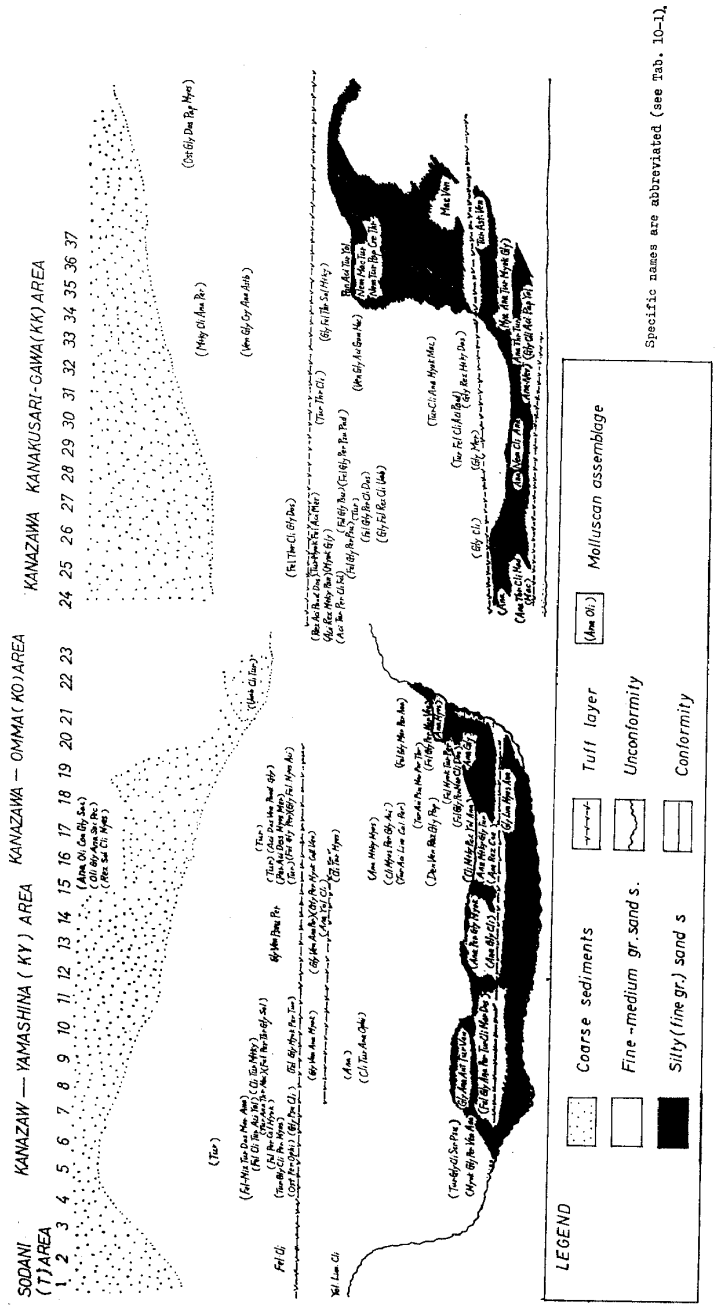


Fig. 11. Idealized faunal distribution

at the northern part of Oyabe City, it is represented by *Portlandia thraciaeformis, Macoma nipponica, Clinocardium chikagawaense, Turritella saishuensis etigoensis* (including specimens sculptured with *Turritella andenensis tsushimaensis* type cord) and *Limopsis crenata* etc.. Discussion on this assemblage will be postponed, because sufficient stratigraphic work has not been undertaken by the writer.

The characteristic assemblage of each lithofacies can be traced laterally fairly well. The assemblages represented by *Anadara* which have the largest weighed frequency are found close to the basal part of the lower Omma Formation, and their assemblages occasionally extend up to the lower middle part of the formation.

In Loc. No. KO–33, the assemblage is characterized by *Umbonium akitanum*, a shallow-bottom marine dweller. This fact coupled with lithological data, allows the inference that the area where the *Umbonium akitanum* assemblage is located might have been the marginal area of the Omma sedimentary basin.

Again in the western part of Mt. Hotatsu, the assemblage including *Acmaea, Puncturella, Arca, Heteromacoma, Mytilus* suggests that the area was the site of shallow marine environment with muddy and rocky bottoms.

9. CONCLUDING REMARKS ON PALEOENVIRONMENTS

Although individual fossil species seems to occur in various lithologies, in association with different species, certain definite combinations of species occur more frequently than others. Each has its own limitations with respect to the environment in which it lives and these limitations are reflected in its morphology, behavior, bottom sediment requirements, etc. As a general guide, the morphological and ecological data of the living species have been applied for the interpretation of those of fossil molluscan species.

The ecological data of some characteristic species of the Omma fauna which have living representatives on geographic distribution, bathymetry and bottom character are shown in Table 15.

Reconstruction of the paleoenvironment in which the Omma Formation was accumulated has already been discussed by Kaseno and Matsuura (1965). They have also made remarks on paleogeographic position, paleotemperature, depth and bottom sediments of the Omma basin.

The writer's results on paleoenvironmetal analysis, based on the typical combinations of species in the Omma Formation in relation to the different lithofacies are similar to the study of Kaseno and Matsuura (*op. cit.*). As pointed by Kaseno and Matsuura (*op. cit.*), the Omma fauna is characterized by the species which are living in shallow sea, littoral to 50–60 m in depth, where had been influenced by the cold to temperate current system except for a few species of upper part of the Omma Formation.

In the following pages, the writer describes and discusses a bathymetry and marine environment based upon the combination of species in each lithofacies and comparison within these assemblages.

a. Silty sandstone

The assemblage occurred in the silty sandstone (SS) lithofacies is considered to be the mixed faunal elements of off shore realm (*Acila, Nemocardium, Limopsis, Venericardia* etc.) and of embayed realm (*Anadara, Thracia, Clinocardium* etc.).

It is important fact that *Anadara* does not associate with *Nemocardium* in the silty sandstone. And the following three groups can be observed in the assemblage of silty sandstone. The first one is the *Anadara* dominant group, for example, *Anadara-Thracia-*

Turritella (Loc. No. KK–45), *Anadara*(KK–07), and the second one is the *Nemocardium* dominant group including *Nemocardium-Cycladicama-Turritella* assemblage (KK–49), *Nemocardium-Turritella-Paphia-Cycladicama-Thracia* assemblage (KK–52), and the third one is the *Clinocardium* dominant group (FM–32, FM–30).

Among these, the first and third groups can be inferred to belong to the assemblage of embayed realm, and the second group to an assemblage of off shore realm from the

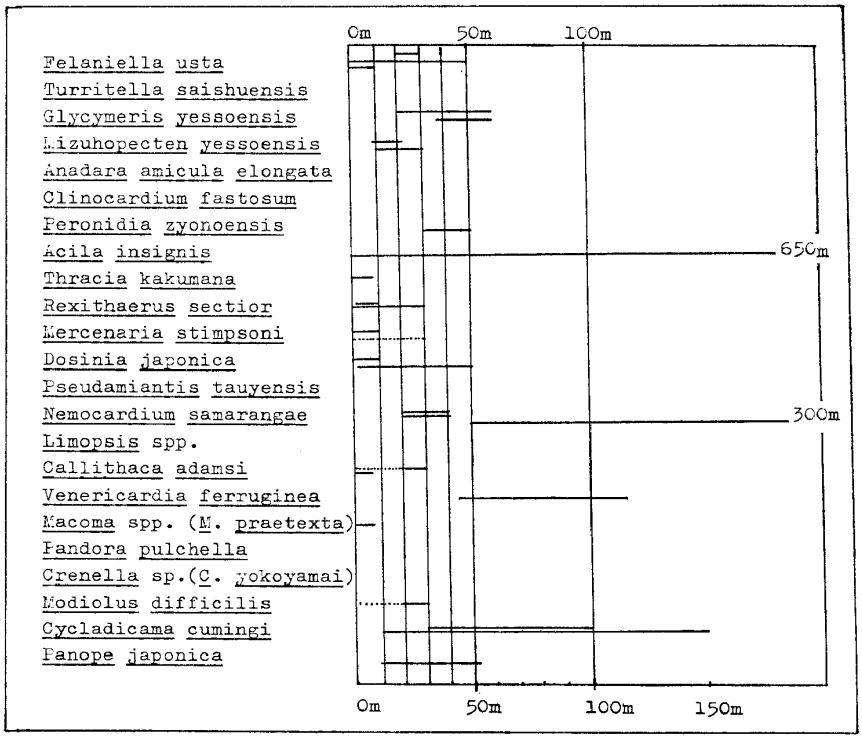
Table 15. Recent ecological data of some characteristic species

Specific Name		Geographical distribution	Bathymetric range	Bottom character
Felaniella usta	1.	P; 33°45°, J;37–46°	N1	S
	2	Northern part of Northeast Honshu	Littoral–5fsm	–
	3	Northern area of Boso Peninsula to Hokkaido,	Enkaishu	sandy bottom
	4	Honshu-Hokkaido-Chotsuku	10–50m	sandy bottom
Turritella saishuensis	1			
	2			
	3			
	4			
Glycymeris yessoensis	1	P;34°–44°, J;34°?–46°	N1–2	S
	2	Northern part of Northeastern Hokkaido	20–30fsm	sandy bottom
	3			
	4			
Mizuhopecten yessoensis spp.	1	P;35°–45°, J;36°–46°	N1	G,S,(sM)
	2	Northern area of Northeast Honshu	5–10fsm	
	3	Ibid.	10–30m	sandy and grabel
	4			
Anadara amicula elongata	1			
	2			
	3			
	4			
Clinocardium fastosum	1			
	2			
	3			
	4			
Peronidia zyonoensis	1			
	2			
	3	Boso-Hokkaido	30–50m	sandy bottom
	4			
Acila insignis	1	P;32°–42°, J;32°–43°	N1–4	mS
	2			
	3	Hokkaido-Honshu(Boso Pen.)-Kyushu	Littoral to 650m	fine grained sandy bottom
	4			
Thracia kakumana	1	P; 43°, J;40°–46°	N1	sM
	2	Northern part of Eastern Hokkaido	Littoral zone	–
	3			
	4			
Rexithaerus sectior	1	P;23°–41°, J; –46°	N1	S, M.
	2	Karafuto, Hokkaido	Littoral zone	
	3	Karafuto to Taiwan	embaymental shallow sea	mud bottom
	4	Hokkaido to Taiwan	embaymental 10–30m	fine grained sand to mud bottom
Mercenaria stimpsoni	1	P;37°–45°, J;34°–46°	N1	S
	2	Northern area of Northeast Honshu	Littoral to 5fsm	–
	3	Cold current area of Northern Japan	shallow sea	fine grained sand
	4			
Dosinia japonica	1	P;31°–42°, J; –43°	N1	M, S
	2	Southern area from Honshu	Littoral to 5fsm	–
	3	Southern Hokkaido, Kyushu, Korea	shallow sea	sandy bottom
	4	Southern Hokkaido to Chaina	Littoral to 50m	fine grained sand
Pseudamiantis tauyensis	1			
	2			
	3			
	4			
Nemocardium samarangae	1	P;32°–36°, J;32°–41°	N2	mS, S, sM
	2	Southern area of Honshu	10–20fsm	–
	3	Southern hokkaido to Kyushu, Korea	shallow sea	sandy bottom
	4	Southern area of Boso Pen. to Eastern Chaina Sea	50–300m	fine grained sand to muddy bottom
Limopsis spp.	1			
	2			
	3			
	4			

Table. 15. (Cotinued)

Callithaca adamsi	1 2 3 4	P;35°-45°, J;35°-46° Northeast Honshu, Hokkaido, Japan Sea	N1 Littoral zone	mS, sM sandy bottom
Venericardia ferruginea	1 2 3 4	P;33°-42°, J;32°-42°	N3-B	S
Macoma spp (M. praetexta)	1 2 3 4	P;23°-35°, J; -43° Southern area of Honshu Southern area of Boso to Kyushu	N1 Littoral zone Shallow sea	- - sandy bottom
Pandora pulchella	1 2 3 4			
Crenella sp. (C. yokoyamai)	1 2 3 4	P 35 ?		
Modiolus difficilis	1 2 3 4	P;35°-51°, J; -47°	N1	R
Cycladicama cumingi	1 2 3 4	P;23°- 35° , J; -41° Southern part from Boso Ibid.	30-100m 10-150m fine gr. N1-3	fine gr.sand sand-muddy bottom
Panope japonica	1 2 3 4	P; 34°- 43°, J; -46°		

Table 16. Depth range of some characteristic species



data on the Recent habitat in which these species are living. The assemblage of silty sandstone, therefore, is classified into the followings; the group of *Anadara-Thracia-Turritella* and *Clinocardium-Turritella-Mizuhopecten* which are flourished in the silty sand bottom of embayed shallow sea (littoral zone to about 10 m in depth), and *Nomocardium-Cycladicama-Turritella* in the silty sand bottom of off shore realm (about 50–60 to 150 m in depth)

b. Fine grained sandstone (FS)

The assemblage in the fine grained sandstone is shown by the group arranged according to the order of weighed frequency as a whole, *Anadara-Clinocardium-Felaniella-Turritella-Mizuhopecten-Glycymeris-Thracia-Peronidia-Rexithaerus-Acila-Macoma-Crenella-Nemocardium-Modiolus*, and this combination may be reclassified more clearly judging from the local character of assemblage in each fossil locality. They are shown by *Anadara-Clinocardium-Mizuhopecten-Thracia-Rexithaerus-Macoma-Crenella-Modiolus* group (for example, from Loc. Nos. KK–08, 09, 10, FM–12, 13, 39, 40, 41) and *Felaniella-Turritella-Mizuhopecten-Glycymeris-Peronidia-Acila-Nemocardium* group (for example, from Loc. Nos. KY–13, 14, 20, KO–08, FM–10, 27, 37). These fossil combinations well correspond to those of Recent ones idealized based on the ecological distribution of living forms. It can be inferred that the former group represented by the combination of major elements of *Anadara-Clinocardium-Thracia* might have lived in fine grained sand bottom of embayed realm and very shallow (littoral to about 10 m in depth) sea judging from the data shown in Table 15. On the other hand, the latter group represented by the combination of *Felaniella-Glycymeris-Peronidia*, may correspond to the group now flourished in fine sand bottom of open shallow sea (20 to 50–60 m in depth).

In conclusion, the fossil assemblage which is thought to be flourished in the fine grained sand bottom of embayed realm is also common to that of silty sandstone.

The frequency curve of the fine and medium grained sandstones of the Omma Formation can be compared with Niitsuma and Mekata's Sand 6 (1972) of the Recent sediment analysis of Mutsu Bay, Aomori Prefecture which has its Maximal between 3.2 ϕ and 4 ϕ, because frequency curves of both sediments in the Omma Formation and Mutsu Bay show very intimate correlation. They classified this sand type (Sand 6) into the off shore sand, and pointed out that Sand 6 was characteristic sediments of the bottom deeper than 20 m. Most of the fine and medium grained sandstones of the Omma Formation, therefore, may correspond to that of off shore bottom of about 20 m in depth.

The faunal analysis of the fine and medium grained sandstone of the Omma Formation, and the evidence on grain analysis mentioned above indicate very strong coincidence.

c. Medium grained sandstone (MS)

The fossil assemblage of the medium grained sandstone shows the generic combination in order of weighed frequency as follows; *Felaniella-Glycymeris-Turritella-Peronidia-Mizuhopecten-Acila-Clinocardium-Mercenaria-Pseudamiantis-Dosinia-Anadara-Rexithaerus-Thracia*. This chain of weighed frequency of genera is considered to be more definite than those of silty sandstone (SS) and fine grained sandstone (FS). Except for certain localities (Loc. Nos. KO–01, 02, 22, 26 etc.), the combination of *Felaniella-Glycymeris-Turritella-Peronidia-Mizuhopecten-Acila* are rather solid (for example, Loc. Nos. KY–01, KO–04, 16, 20, 23–25, 27–29, 31–33, 35, 36, KK–12, 15–22, 32, FM–01–03).

It is noticeable that the genera, *Anadara*, *Clinocardium*, *Thracia* and *Rexithaerus*, the representative species in the silty sandstone and fine grained sandstone, are thought to

be minor elements of the fauna in the medium grained sandstone.

The habitat of the present assemblage can be summarized to be the medium grained sand bottom of off shore shallow environments (20～50–60 m in depth).

d. Coarse grained sandstone (CS)

Although the fossil localities are not sufficient in number in order to examine and establish a faunal feature as a whole, the fossil molluscan assemblage observed in the coarse grained sandstone is shown by the generic combination of *Glycymeris-Mizuhopecten-Felaniella-Turritella/Peronidia-Anadara-Venericardia-Clinocardium-Mercenaria/Acila/Rexithaerus*, in the order of weighed frequency. And it can be pointed out that most of the species, just mentioned, in higher frequency are considered to be of ones from off shore realm.

Glycymeris occurs in association with *Anadara* in Loc. nos. KY–15, 19 and *Clinocardium* in Loc. nos. KY–03, 05, which belong to ones of the silty sand (SS) and fine grained sands (FS) of embayed realm. Therefore, the assemblage in question can be defined as a transitional one of the coarse grained sand bottom in between off shore and embayment.

It should be emphasized that there is an apparent difference in combination of species in between the fine, medium and coarse grained sand facies and an inversion of order of weighed frequency.

According to Kuroda and Habe (1952), *Glycymeris yessoensis* and *Felaniella usta*, both Recent species, are restricted in sandy bottom of Euneritic (N_1) to Mesoneritic (N_2). And this fact may be one of reasons for delicate difference in combination of species in respective assemblage of the Omma Formation. And it is reasonable to summarize that the genus *Glycymeris* has favourable habitat of coarser sediments under stronger current than those of *Felaniella usta* judging from the difference in the order of weighed frequency shown in Table 12 and Fig. 8.

e. Pebbly to granule conglomerate (PC-GC)

Only seven fossil localities are studied. Even though the number of localities seems to be insufficient for a total faunal analysis, rough combination of species can be defined as follows; *Callithaca-Mizuhopecten-Turritella-Peronidia/Glycymeris-Crassostrea/Felaniella-Mercenaria/Anadara-Dosinia*, in the order of weighed frequency.

The assemblage may be considered to have been flourished in off shore shallow sea (littoral to 50–60 m in depth) on granules to pebbles based on the combination of species and their ecological distribution (*fide* Kuroda and Habe, *op. cit.*). Roughly speaking, the present faunal assemblage corresponds to that of the Recent rocky bottom of off shore shallow sea.

f. Summary of Assemblage/Habitat relationship

In the preceding pages, the writer has discussed the relationship between the habitat and faunal assemblage of the Omma Formation in each lithofacies based upon the data on Recent ecological distribution of the representative species. Table 13 is summarizing interrelationship between assemblage and habitat. In Table 13, specific or generic combination of *Anadara-Clinocardium-Thracia* and *Rexithaerus* are rather common in shallow sea bottom of the embayed realm, but *Felaniella-Glycymeris-Peronidia-Acila* chain is considered to be one of the important elements in the sandy bottom of off shore environment (20～50–60 m in depth).

As already mentioned, the epifaunal species of *Turritella* and *Mizuhopecten* occur

Table 17. Composite table, showing assemblage/paleohabitat relationship

Bottom character	Embayed realm ≈ Transitional ≈ Off shore realm
SS:silty sand	Anadara-Thracia-(Turritella) Clinocardium-(Turritella)-(Mizuhopecten) Nemocardium-Cycladicama-(Turritella)
FS:fine sand	Anadara-Clinocardium-Thracia Felaniella-Glycymeris-Peronidia
MS:medium sand	Anadara-Clinocardium-Thracia-Rexithaerus Felaniella-Glycymeris-(Turritella)-Peronidia-(Mizuhopecten)-Acila
CS:coarse sand	Glycymeris-(Mizuhopecten)-Felaniella-(Turritella)-Peronidia-Anadara-Venericardia-Clinocardium-Mercenaria-Acila-Rexithaerus
PC-GC:pebble to granule	Callithaca-(Mizuhopecten)-(Turritella)-Peronidia-Glycymeris-Crassostrea-Felaniella-Mercenaria-Anadara-Dosinia

more frequently in various lithofacies and their environments. This fact indicates whether these species had rather wide habitats than other endofaunal species, or these species changed their habitat from one to another according to their growth. Therefore, the size distribution of species in each locality should be examined for further study.

Generally speaking, there is not a time interval among these five assemblages which were originally introduced by weighed frequency study. However, it should be noted that *Anadara* dominant assemblages occupy the lower part; *Felaniella*, *Glycymeris* and *Peronidia* dominant assemblages, the middle part; and again, *Anadara* dominant assemblages, the upper part of the Omma Formation (see Fig. 11). These facts indicate that these assemblages correspond reasonably to a sedimentary cycle. That cycle is shown by embayed realm → off shore realm of open sea → embayed realm in ascending order, although the fossil assemblages of the upper part are rather poor in the Omma Formation.

The assemblages from the uppermost horizon of the Omma Formation (Loc. nos. KO-01, 02, 03) are noteworthy, for the assemblages include several species of warm water elements as mentioned above, and the writer would point out that the paleogeography and paleoenvironment of the last depositional stage of the Omma Formation should be reconsidered. And in order to reconstruct precisely the paleoenvironment in which the Omma Formation was deposited, it should be added that the cross-check studies are neccessary, for example, the inorganic contents, precise grain analysis of silt fraction, oxygen isotope analysis for paleotemperature and so on.

SYSTEMATIC DESCRIPTION

Phylum Mollusca
Class Pelecypoda
Family Nuculidae
Genus *Acila* H. & A. Adams, 1858
Subgenus *Truncacila* Schenck in Grant and Gale, 1931
Acila (Truncacila) insignis (Gould, 1861)

Pl. 5, Figs. 8, 11, 12.

Nucula insignis Gould, 1861, Otia Conchologia, p. 175 (fide *in* Tokunaga, 1906); Tokunaga, 1906, p. 56; Yokoyama, 1920, p. 179, pl. 19, figs. 7–8.
Acila insignis (Gould), Iwai, 1965, p. 22, pl. 14, fig. 2.
Acila (Truncacila) insignis (Gould), Schrenck, 1936, p. 99, pl. 11, figs. 1–2; Nagao and Huzioka, 1941, p. 120, pl. 29, figs. 22, 22a; Ozaki, 1958, p. 107, pl. 22, figs. 2–3; Yamamoto and Habe, 1958, p. 2, pl. 2, fig. 6; Habe, 1958, p. 243, pl. 12, fig. 8; Sawada, 1962, p. 62, pl. 6, figs. 30–31; Kaseno and Matsuura, 1965, pl. 14, fig. 2.
Acila (Truncacila) insignis Gould, Ohara, 1968, p. 54, pl. 1, figs. 17a–b.

Remarks:

Several specimens were collected from the fine grained sandstone. These are referable to *Acila insignis* (Gould), the Recent form distributed in the seas around Japanese Islands from Hokkaido to Kyushu, and is living on soft substratum of littoral zone to more than 600 m in depth. The divergent pattern of surface sculpture is variable from mono-trigonal to tetra-trigonal. The frequencies of divaricate pattern of specimens collected from one locality are as follows; mono-trigonal, 90 individuals, bi-trigonal, 32 ind., tri-trigonal, 14 ind., and tetra-trigonal, 1 ind.

This pattern may be of genetic problem.

Locality:

KO–04, 08, 09, 15, 16, 17, 18, 19, 25, 26, 30.
KK–01, 02, 03, 04, 05, 06, 13, 15, 23, 35, 38, 42, 46, 50.
KM–07, 19, 21, 29, 31, 42.
RO–17, 19, 20.

Family Nuculanidae
Subfamily Sareptinae
Genus *Sarepta* A. Adams, 1860
Sarepta speciosa A. Adams, 1860

Pl. 5, Fig. 13.

Sarepta speciosa A. Adams, 1860, p. 333; 1868 Jour. de Conchyl. 16, p. 41, pl. 4, fig. 1, 1; Kuroda, 1929, append. p. 13–14, sp. 54; Habe, 1951a, p. 24, text-figs. 18–19; Habe 1964, p. 161, pl. 48, fig. 22; Kuroda, Habe and Oyama, 1971, p. 319, pl. 66, figs. 15–16.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	Valve
95076–1	12.60 mm	9.60 mm	2.80 mm	left
95076–2	14.55	10.90	3.50	right

Description:

Shell small in size, slightly inflated, oblongly ovate in outline, nearly equilateral and

rather thin. Anterior dorsal margin nearly straight, slightly shorter than posterior one and decending into well rounded anterior end. Posterior end narrowly rounded. Ventral margin well convexed. Shell surface smooth but sculptured with indistinct fine concentric growth lines. Beak rather prominent. No lunule and no escutcheon. Short hinge with comb-like small teeth; 10 anteriorly and about 6 posteriorly in number. No crenulation on inner ventral margin.

Remarks:

The genus *Sarepta* is rare in Tertiary of Japan. Only three species have hitherto been reported. The first one is *Sarepta* sp. recorded by Shikama in 1954 from Miocene Yonekawa Formation in Nagano Prefecture, the second is *Sarepta shimokawarae* Kanno and Ogawa, 1964 from Miocene Takinoue Formation in Hokkaido, and the third is *Sarepta fujiyamai* Masuda, 1970 from the Oligocene Taishu Formation, Tsushima Island, Nagasaki Prefecture.

The present species can easily be distinguished from the above mentioned species in shell form and size, and short hinge with weak comb-like teeth.

Locality:

Loc. no. IS–09

Genus *Nuculana* Link, 1807
Subgenus *Thestyleda* Iredale, 1929
Nuculana (Thestyleda) yokoyamai Kuroda, 1934

Pl. 5, Fig. 2.

Leda ramsayi Yokoyama, 1920, p. 176, pl. 19, fig. 3.
Nuculana (Thestyleda) yokoyamai (Kuroda), Itoigawa, 1958, pl. 1, fig. 1.
Nuculana (Thestyleda) yokoyamai Kuroda, Hatai, Masuda and Suzuki, 1961, pl. 1, figs. 3a–4; Habe, 1964, p. 161, pl. 48, fig. 17; Kaseno and Matsuura, 1965, pl. 7, fig. 10; Kuroda, Habe and Oyama, 1971, p. 320, pl. 66, fig. 14; Oyama, 1973, p. 73, pl. 21, fig. 6.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	H/L	Valve
95077	IS–09	12.20 mm	5.85 mm	48.0%	right

Remarks:

The species is characterized by strongly elongated shell outline and strongly marked coarse concentric lines.

Locality:

Loc. no. IS–09.

Genus *Saccella* Woodring, 1925
Saccella confusa (Hanley), 1860

Pl. 5, Figs. 1a-b, Pl. 22, Fig. 6.

Leda confusa Hanley, *in* Sowerby, 1860, p. 119–120, pl. 228, fig. 85; Yokoyama, 1922, p. 195–196, pl. 17, fig. 4; Kuroda, 1929, append. p. 10, sp. 26.
Nuculana confusa (Hanley), Nomura and Zinbo, 1935, p. 6, pl. 1, fig. 12.
Saccella confusa (Hanley), Tanaka, 1959, p. 68, pl. 1, figs. 2, 3, 8; Takayasu, 1961, pl. 1, fig. 1; Ohara, 1968, p. 53, pl. 1, figs. 5a-b; Hirayama, 1973, p. 169, pl. 15, fig. 1; Oyama, 1973, p. 74, pl. 21, fig. 4.
Saccella (Saccella) confusa (Hanley), Kuroda, Habe and Oyama, 1971, p. 322, pl. 117, fig. 7.

Measurements:

IGPS coll. cat. no.	Length	Height	H/L
95078–1	6.80 mm	3.35 mm	49.3%
95078–2	10.90	5.55	50.9
95078–3	13.80	7.80	56.5
95078–4	13.60	7.60	55.9
95078–5	14.90	8.45	56.7

Remarks:

More than five perfect specimens were collected from the medium grained sandstones and examined. They are safely identified with *Saccella confusa*, Recent species which is mainly distributed in the seas south of the Boso peninsula, Chiba Prefecture. This species belongs to one of the warm water elements of Japanese Recent molluscan fauna and is now living in the seas occupied by the warm Kuroshio current on the sandy bottom of 5 to 30 m in depth.

Locality:

Loc. nos. KO–01, 02, 03.

Genus *Portlandia* Mörch, 1857
Subgenus *Megayoldia* Verrill and Bush, 1897
Portlandia (*Megayoldia*) *thraciaeformis* (Storer, 1838)

Pl. 5, Fig. 4.

Nucula thraciaeformis Storer, 1838, Boston Jour. Nat. Hist., v, 2, p. 122. (*fide* Sowerby, 1866)
Leda (*Yoldia*) *thraciaeformis* (Storer), Hanley *in* Sowerby, 1866, p. 39, sp. 66, pl. 1, figs. 4, 13.
Yoldia thraciaeformis Storer, Sowerby, 1871, *Yoldia* sp. 1, pl. 1, figs. 1a-c; Otuka, 1934, p. 609, pl. 47, fig. 16; Minato & Uozumi, 1951, pl. 11, figs. 103–104.
Yoldia thraciaeformis Storer var. *scapha* Yokoyama, Kanehara, 1937b, p. 20, pl. 5, fig. 4.
Portlandia (*Megayoldia*) *thraciaeformis* (Storer), Uozumi, 1955, pl. 23, figs. 189a-b; Uozumi, 1957, p. 574–576, pl. 1, figs. 5, 5a, 7, 8, 8a, pl. 7, figs. 23, 28; Aoki, 1959, p. 263, pl. 1, figs. 5, 7: Kanno, 1960, p. 197, pl. 31, fig. 29; Kamada, 1962, p. 53, pl. 2, figs. 6a-b; Iwai, 1965, p. 23, pl. 12, fig. 2.
Portlandia thraciaeformis (Storer), Takayasu, 1962, pl. 1, figs. 15–16.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	Valve
95079–1	13.70 mm	8.45 mm	2.5 mm	61.7%	left
95079–2	34.00	20.40	7.0	60.0	left
95079–3	28.20	17.50	5.1	62.1	right
95079–4	ca. 40.0	25.90	7.6	64.8	right
95079–5	34.3	20.40	ca. 7.0	59.5	left
95079–6	ca. 35	21.10	–	60.3	right
95079–7	ca. 28	20.30	–	–	left
95079–8	ca. 35	23.00	7.5	65.7	right
95079–9	31.70	19.5	–	61.5	left
95079–10	35.70	22.15	6.0	62.0	right
95079–11	ca. 33	20.40	–	61.8	left

Remarks:

The small specimens of the present species are very similar to *Portlandia hirosakiensis*

Iwai, 1959 which was originally described as the subspecies of *P. scapha* based upon the specimens from the Pliocene Higashimeya Formation in Aomori Prefecture. At that time, Iwai (1959) pointed out that the Yokoyama's species from the Sawane Formation, Sado Island, Niigata Prefecture is synonymous with *P. hirosakiensis*. However the shell of the present species which attains more than 14 mm in length, and can be distinguished from *Portlandia hirosakiensis* Iwai, 1959 in having two weak but distinct keels running from beak to posterior ventral margin. But it seems to be difficult to the writer to discriminate the smaller specimens from *P. hirosakiensis* of Iwai.

According to Uozumi (1957), the ratio of height to length of the present species ranges from 60 to 70 per cent.

Locality:

Loc. no. IS–09.

Subgenus *Portlandella* Stewart, 1930

Portlandia (*Portlandella*) *hirosakiensis* Iwai, 1959

Pl. 5, Fig. 3.

Yoldia scapha Yokoyama, 1926d, p. 309, pl. 35, fig. 6.

Portlandia scapha hirosakiensis Iwai, 1959, p. 53–54, pl. 2, figs. 10–12; Iwai, 1965, p. 23, pl. 14, figs. 5(?), 6, 7.

Measurements:

IGPS coll. cat. no.	Length	Height	H/L
95080	24.40 mm	15.80 mm	64.80%

Remarks:

The present species was proposed by Iwai based upon the specimens from the Pliocene Higashimeya Formation, Hirosaki Basin of Aomori Prefecture including Yokoyama's species (1926) from the Pliocene Sawane Formation, Sado Island, Niigata Prefecture. The present one is characterized by inflated shell, except rather distinct growth lines, and no development of ridges on the posterior margin of shell.

The species closely resmebles *Portlandia japonica* (Adams and Reeve, 1850) in general outline, but the former can be distinguished from the latter by having small shell, more convex ventral margin, well developed posterior extermity and conspicuous growth lines.

Portlandia (*Portlandella*) *hirosakiensis* resembles also *Portlandia lischkei* (Smith, 1885), Recent species of the seas of Japan where the Kuroshio current is flourishing, but *hirosakiensis* differs from the latter in having higher shell, well rounded ventral margin and well developed posterior area of shell. The species can be assigned to subgenus *Portlandella* Stewart, 1930 from its shell outline and smooth shell surface.

Locality:

Loc. no. UK–01.

Genus *Yoldia* Möller, 1842

Subgenus *Cnesterium* Dall, 1898

Yoldia (*Cnesterium*) *notabilis* Yokoyama, 1922

Pl. 5, Figs. 5, 6.

Yoldia notabilis Yokoyama, 1922, p. 196–197, pl. 17, fig. 10.; Yokoyama, 1927, p. 170; Kuroda, 1929, p. 11, sp. 40; Yokoyama, 1929, p. 395, pl. 75, fig. 8.

Yoldia cooperi ochotensis Otuka, 1934, p. 609, pl. 47, figs. 18, 17.
Yoldia (Cnesterium) keppeliana notabilis Yokoyama. Otuka, 1936, p. 728–729, pl. 41, figs. 4–5.
Cnesterium notabilis (Yokoyama), Habe, 1955, p. 2–3.
Yoldia (Cnesterium) notabilis Yokoyama, Uozumi, 1957, p. 555–556, pl. 6, figs. 3, 3a-5; Kaseno and Matsuura, 1960, pl. 4, fig. 3; Iwasaki, 1970, p. 388, pl. 1, figs. 12, 13; Oyama, 1973, p. 74, pl. 21, fig. 5; Shibata, 1974, pl. 2, figs. 15–17, 19–20.

Remarks:

The present species originally described by Yokoyama from the Upper Musashino Formation in 1922. The present species is distinguished from *Yoldia johanni* Dall, 1925 in having narrowly pointed and somewhat turned upward posterior end and rather high shell.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	Anterior length/L
95081–1	29.70	14.95	–	50.3%	0.362
95081–2	33.10	15.35	–	46.4	0.397
95081–3	30.65	16.15	–	52.6	0.387
59081–4	31.50	16.20	–	51.4	0.381
95081–5	34.10	16.50	–	48.4	0.499
95081–6	35.60	18.20	7.60	51.1	0.371
95081–7	28.15	14.15	–	50.3	0.408
95081–8	24.30	12.25	–	50.4	0.385
95081–9	30.75	15.30	–	49.8	0.358
95081–10	25.00	12.05	–	48.2	0.350
95081–11	13.85	7.00	–	50.5	0.404
95081–12	24.55	12.80	–	521.	0.407

Locality:

Loc. nos. T–01, KY–08
KO–12, 36.
KK–02, 03, 34, 36, 46, 48, 50.
FM–09.
IS–09.
AW–02.

Family Limopsidae
Genus *Limopsis* Sacco 1827
Limopsis tokaiensis Yokoyama, 1910

Pl. 5, Figs. 7, 9a–b.

Limopsis tokaiensis Yokoyama, 1910, p. 1, pl. 9, figs. 1, 3, 5–7; Yokoyama, 1920, p. 172, pl. 18, figs. 14–16; Yokoyama, 1926d, p. 307; Makiyama, 1927, p. 28; Ozaki, 1958, p. 11, pl. 11, fig. 6; Iwai, 1959, p. 55–56, pl. 2, figs. 8a–9b; Iwai, 1960b, pl. 1, figs. 4a–b; Takayasu, 1961, pl. 1, figs. 2a–b, pl. 2, figs. 4a–b; Hatai, Masuda and Suzuki, 1961, pl. 1, figs. 10a–b; Sawada, 1962, p. 65, pl. 6, figs. 7–8; Hatai and Masuda, 1962, pl. 40, figs. 9–11; Kanno, 1962, pl. 3, figs. 5a–b; Iwai, 1965, p. 24, pl. 14, figs. 8a–11b; Sakagami *et al.*, 1966, pl. 2, figs. 16a–b; Shikama and Masujima, 1969, pl. 7, figs. 6–7; Chinzei, 1973, pl. 14, fig. 8.
Limopsis tokyoensis Yokoyama, Takayasu, 1962, pl. 1, figs. 11a–b.

Remarks:

Since Yokoyama (1910) described the present species from the Pliocene Koshiba Formation, Kanagawa Prefecture, many paleontologists have reported its occurrence from southern Hokkaido to Hokuriku and Kanto regions. Geologic distribution of the present

species is fairly narrowly restricted, it therefore, represents one of representative species in the Japanese Pliocene.

This species is mainly found in the silty sandstone of Omma Formation.

Locality: Loc. nos. T–01, KY–02, KO–04, 09, 21, UK–02

Family Arcidae

Genus *Arca* Linné, 1758

Subgenus *Arca s.s.*

Arca (Arca) boucardi Jousseaume, 1894

Pl. 6, Figs. 3, 4a–b.

Arca boucardi Jousseaume, 1894, The humming Bird 4, fig. 14 (*fide* Yamamoto and Habe, 1958); Kanehara, 1942, p. 130, pl. 3, figs. 9a–b; Yamamoto and Habe, 1958, p. 4, pl. 4, fig. 6; Hayasaka, 1961, p. 24, pl. 2, figs. 1–5; Sawada, 1962, p. 63–64, pl. 6, figs. 3–4; Iwai, 1965, p. 24.

Arca kobeltiana Pilsbry, 1904, p. 559, pl. 40, figs. 16–19.

Arca miyatensis Oyama, Kaseno and Matsuura, 1965, pl. 7, fig. 15.

Arca navicularis Bruguiere, Iwai, 1965, p. 24–25, pl. 14, figs. 12a–b.

Arca rectangularis Tokunaga, 1906, p. 61, pl. 3, figs. 23a–b.

Arca (Arca) boucardi Jousseaume, Noda, 1966, p. 55–57, pl. 6, figs. 12, 19; Noda, 1973, p. 35, pl. 4, fig. 7.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L
95086–1	17.15 mm	8.75 mm	4.8 mm	51.0%
95086–2	29.40	14.60	7.35	49.7
95086–3	46.00	21.20	10.0	46.1
95086–4	39.35	22.10	11.40	56.2
95086–5	24.2	16.2	8.40	66.9

Remarks:

The present species is characterized by well developed posterior extremity bounded by strong ridge running from beak to posterior corner, and sculptured with distinct radial ribs, about five in number, on the posterior extremity. The present one is very similer to *Arca miurensis* Noda, 1966 which was proposed for the Yokoyama's specimen named *Arca boucardi miyatensis* Oyama in shell outline and sculptures on the shell surface. But it can be distinguished from *miurensis* in having less number of radial ribs, strong ridge running from beak to posterior corner and rather strong, distinct five or six radial ribs on the posterior extremity.

The Pliocene and Recent specimens of *A. boucardi* have been recorded from various localities in Japan, and Noda (1966) cited complete references of distribution of the present species.

Locality: Loc. nos. KO–22, UK–04.

Subfamily Anadarinae

Genus *Anadara* Gray, 1847

Subgenus *Anadara* s.s.

Anadara (Anadara) amicula elongata Noda, 1966

Pl. 6, Figs. 9a–b, 10, 12–15.

Anadara amicula (Yokoyama), Hatai and Nisiyama, 1939b, p. 145–148, pl. 9, figs. 1–2; Iwai, 1965,

pl. 14, figs. 13a–b; Kaseno and Matsuura, 1965, pl. 7, figs. 16–17; Chinzei, 1973, pl. 4, fig. 1.
Arca trilineata amicula Yokoyama, Kanehara, 1935, p. 275, pl. 13, figs. 7–8.
Anadara (*Anadara*) *amicula* (Yokoyama), Iwai, 1959, p. 54, pl. 2, figs. 4a–b.
Anadara (*Anadara*) *amicula elongata* Noda, 1966, p. 84–85, figs. 2–7.

Measurements:

IGPS coll. Loc. no.	cat. no.	Length	Height	Width	H/L	Valve
95082	IS–06	(17.90 mm	16.40 mm	6.40 mm	91.6%	left
95083–1	KO–12	42.95	33.20	15.3/2	77.3	left
95083–2	–	43.30	32.30	15.3	74.6	right
95084–1	KO–22	62.20	51.80	19.6	83.3	conjoined
95084–2	–	55.80	44.10	37.0/2	79.0	conjoined
95084–3	–	51.40	43.10	15.8	83.9	left
95084–4	–	55.30	44.60	17.10	80.7	left
95084–5	–	44.00	37.40	14.2	85.1	left
95084–6	–	27.60	23.00	7.6	83.3	left
95084–7	–	22.50	18.50	7.4	82.2	right
95084–8	–	11.00	9.65	3.7	87.7	left
95085	KY–16	62.70	46.50	37.15/2	74.2	conjoined

Remarks:

Several perfect specimens were collected mainly from the fine grained sandstones of the Omma Formation. This subspecies was proposed by Noda (1966) from the Omma Formation, and can be distinguished from *A. amicula amicula* described from the Shigarami Formation, Nagano Prefecture in having more wide and high ligamental area, and more produced posterior ventral corner.

The present subspecies was also recorded from the Takikawa Formation in Hokkaido, Higashimeya Formation in Aomori Prefecture, Nishiyama Formation, Haizume Formation in Niigata Prefecture, Wakimoto Formation in Akita Prefecture, and Dainenji Formation in the environ of Sendai.

The ratio of height to length of shell is variable from 74.2% to 91.6% among the present specimens, and according to measurements of the present specimens, there is remarkable change in the ratio at the point where shell exceeds 30 mm in length.

Locality:

Loc. nos. KY–02, 06, 10, 15, 16, 17, 19, 20, 23.
KO–12, 13, 14, 21, 22, 24, 26.
KK–07, 08, 09, 10, 34, 35, 42, 43, 44, 45, 47.
FM–05, 06, 11, 12, 13, 28, 39, 40, 41, 42.
RT–03.
AW–04.
IS –06

Subgenus *Scapharca* Gray, 1847
Anadara (*Scapharca*) *ommaensis* Otuka, 1936

Pl. 6, Figs. 7, 8, 11, 16.

Anadara satowi ommaensis Otuka, 1936a, p. 729–730, pl. 41, figs. 3, 8a–b.
Anadara ommaensis Otuka, Hatai and Nisiyama, 1939b, p. 148.
Anadara (*Scapharca*) *satowi ommaensis* Otuka, Kaseno and Matsuura, 1965, pl. 7, fig. 19.
Anadara (*Scapharca*) *ommaensis* Otuka, Noda, 1966, p. 108–109, pl. 3, figs. 10–12, pl. 8, fig. 10.

Measurements:

IGPS coll. cat. no.	Loc. No.	Length	Height	Width	H/L	Valve
95087–1	KO–07	54.80 mm	42.30 mm	16.3 mm	77.2%	left
95087–2	–	37.60	30.85	22.4/2	82.0	conjoined
95087–3	–	38.20	32.30	13.1	84.6	right
95089	FM–05	64.20	50.10	23.0/2	78.0	conjoined

Remarks:

The present species is characterized by its radial ribs which are rather strongly granulated on the left valve, while they are rather smooth on the right valve, and about 38 in number on both surface.

The species was originally proposed by Otuka from the Omma Formation in 1936, at that time, he also recorded the occurrence of the present species in the Manganzian fauna of Akita oil-field.

The present species is one of the most important representatives to consider the faunal provinces in the Pliocene time along the Japan Sea coast. The species has been reported from the followings; Omma Formation in Ishikawa Prefecture, Haizume Formation in Niigata Prefecture, Wakimoto Formation in Akita Prefecture and Hamada Formation in Aomori Prefecture. The specimens of the species, in general, were found in the silty sandstone or fine grained sandstone of the Omma Formation, but rather rare in its occurrence.

Locality:

Loc. nos. KO–07, 22.
FM–05.

Subgenus *Hataiarca* Noda, 1966

Anadara (*Hataiarca*) *pseudosubcrenata* Ogasawara n. sp.

Pl. 6, Figs. 1, 2a–b, 5a–b, 6.

Description:

Shell medium in size, inequilateral and subequivalve. Anterior margin narrowly rounded and posterior one broadly truncated. Ventral margin smoothly rounded, and shell height rapidly becomes low on anterior side of shell.

External surface of right valve sculptured with 28–29 flat topped, smooth radial ribs squarish in cross section. Interspaces nearly equal to radial ribs in width, and sculptured with concentric growth lines. Posterior depressed area with 7–8 radial ribs.

External surface of left valve sculptured with similar radial ribs to right valve, but radial ribs except on posterior depressed area have five granules on surface. Beak strongly incurved forward, and situated anteriorly on nearly one-third of shell length. Crescent ligamental area with 2 or 3 irregular chevron-like grooves. Small comb-like teeth oblique to straight hinge line, and convergent at both extremities. Inner ventral margin crenulated corresponding to external radial ribs. Inner side with smooth pallial lines, very fine striation and opposite undulation of radial ribs recognized according to external radial ribs.

Dimensions:

Number of radial ribs	Number of Individuals		
	right	left	total
26	1	0	1
27	0	0	0
28	0	2	2
29	3	8	11
30	0	1	1
31	0	1	1

IGPS coll. cat. no.	Length (mm)	Height (mm)	Width (mm)	H/L (%)	No. of rad. rib.	Valve
95070 (Holotype)	37.75	33.10	14.4	87.7	29	left
95071–1 (Paratype)	39.10	33.10	14.8	84.7	29	right
95071–2 (Paratype)	35.70	30.60	13.65	85.7	29	left
95071–3 (Paratype)	39.00	32.90	14.05	84.4	29	right

Comparison and Affinity:

The present new species is characterized by having about 29 nodulous radial ribs on left valve, and smooth one on right valve with posterior depressed area.

Anadara (*Hataiarca*) *subcrenata* (Lischke) is one of allied species to the present one, but the former has 32 radial ribs. *Anadara* (*Hataiarca*) *troscheli* (Dunker) is another allied species in its inclination of beak and narrow anterior margin, but the former has 24 radial ribs constantly. *Anadara subcrenata* and *Anadara troscheli* have been recorded from the Pleistocene deposits to the Recent. *Anadara* (*Hataiarca*) *kogachiensis* Noda described from Okinawa Prefecture is characterized by 26–27 radial ribs, and resembles younger shell outline of the present new species. The present species could be assumed the ancestor of *Anadara subcrenata*, the Recent species.

Locality:

Loc. nos. KO–01, 02, 03.

Family Glycymeridae

Genus *Glycymeris* Da Costa, 1778

Subgenus *Glycymeris* s.s.

Glycymeris (*Glycymeris*) *yessoensis* (Sowerby, 1886)

Pl. 5, Figs. 14, 15, 18a–b, 19, 20a–b, 21, 22.

Complete synonym lists before 1935 were cited by Nomura and Hatai, 1935 (p. 93–95) and those from 1920 to 1962 by Sawada, 1962 (p. 64).

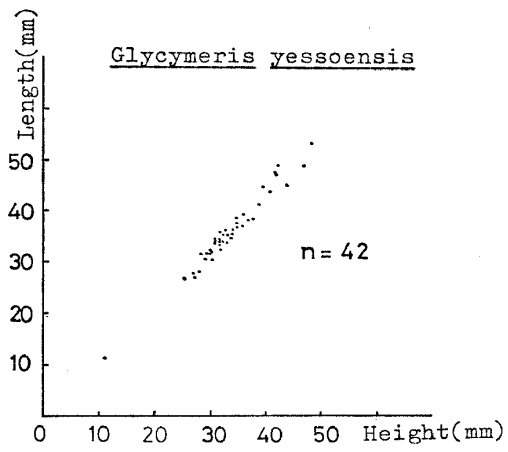
Pectenculus yessoensis Sowerby, 1886, Proc. Zool. Soc. London, no. 38, p. 570, pl. 28, fig. 19. (*fide* Yokoyama, 1922)

Glycymeris yessoensis (Sowerby), Iwai, 1960b, pl. 1, figs. 6a–b; Takayasu, 1961, pl. 1, fig. 7; Hayasaka, 1962; pl. 45, figs. 1a–b; Kaseno and Matsuura, 1965, pl. 6, fig. 16; Sakagami *et al.*, 1966, pl. 4, figs. 5a–b.

Glycymeris (*Glycymeris*) *yessoensis* (Sowerby), Iwai, 1959, p. 55, pl. 2, figs. 5a–b; Hatai, Masuda and Suzuki, 1961, pl. 1, fig. 8; Sawada, 1962, p. 64, pl. 4, figs. 12–13; Iwai, 1965, p. 26, pl. 14, figs. 18–24; Oyama, 1973, p. 76–77, pl. 23, figs. 3, 5, 6, 8, pl. 24, figs. 3, 5, 6, 8.

Locality:

Loc. nos. KY–01, 03, 05, 06, 11, 13, 14, 15, 19, 23, 32.
KO–01, 02, 04, 08, 10, 13, 22, 23, 24.



KK–11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 32, 35, 42, 46, 47, 48.
FM–03, 05, 07, 08, 11, 17, 18, 21, 22, 23, 28, 37.
RT–04, 05.
RO–03, 04, 07, 08, 13, 14, 17, 20.
IS –01.
AW–04.

Fig. 12. Relationship of height to length of *Glycymeris yessoensis*

Family Pectinidae
Subfamily Chlamyinae
Genus *Chlamys* Röding, 1798
Subgenus *Chlamys* s.s.
Chlamys (*Chlamys*) *cosibensis* (Yokoyama, 1911)

Pl. 7, Figs. 2, 4, Pl. 9, Figs. 2a–b,

Complete references cited by Masuda 1973a
Pecten cosibensis Yokoyama, 1911, p. 4, pl. 1, figs. 3, 4.
Chlamys (*Chlamys*) *cosibensis cosibensis* (Yokoyama), Masuda, 1962, p. 162–163.
Chlamys cosibensis (Yokoyama), Sawada, 1962, p. 68, pl. 6, fig. 24, Kaseno and Matsuura, 1965, pl. 6, fig. 20; Masuda, 1973a, p. 110–113, pl. 8, figs. 1–15, pl. 9, figs. 1–14; Masuda, 1973b, pl. 2, figs. 2–5; Noda, 1973, p. 36, pl. 5, figs. 3, 7.
Chlamys cosibensis cosibensis (Yokoyama), Iwai, 1965, p. 28, pl. 14, figs. 25–26, pl. 15, figs. 1–3.
Chlamys (*Chlamys*) *cosibensis* (Yokoyama), Krishtofovich, 1969, p. 230, pl. 1, figs. 1, 1a.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	Valve	Loc. no.
95090	20.60	22.00	4.2	right	IS–09
95091	20.10	22.50	4.0	right	KK–03
95092–1	36.80	42.50	5.8	right	UK–04
95092–2	51.7	56.9	7.4	right	–
95092–3	47.8	55.0	11.4	right	–

Locality:
Loc. nos. KY–09.
RO–21.
UK–04.
KK–03.
IS –09.

Chlamys (*Chlamys*) *nipponensis* Kuroda, 1932

Pl. 7, Figs. 1a–b, 3, 5.

Pecten laetus Gould, Lischke, 1869, p. 169, pl. 12, figs. 6, 7; Küster and Kobelt *in* Martini and Chemnitz, 1888, p. 134, pl. 37, figs. 4, 5; Tokunaga, 1906, p. 65, pl. 4, fig. 2; Yokoyama,

1920, p. 152, pl. 14, figs. 1, 2 (non Gould, 1861).
Chlamys farreri nipponensis Kuroda, 1932, append. p. 91 sp. 288; Kuroda, 1933, p. 55, fig. 37.
Chlamys farreri akazara Kuroda, 1932, append. p. 92, sp. 288a, fig. 105.
Chlamys nipponensis Kuroda, Taki *in* Hirase, 1951, pl. 13, fig. 4; Kira, 1955, p. 99, pl. 49, fig. 11; Oyama, 1957, 1, figs. 3–4, figs. 2, 4–6: Sawada, 1962, p. 70–71, pl. 1, figs. 8–9; Kaseno and Matsuura, 1965, pl. 6, figs. 21–22; Sakagami *et al.*, 1966, pl. 5, figs. 5a–b.
Chlamys (*Chlamys*) *nipponensis* Kuroda, Ozaki, 1958, p. 115, pl. 20, fig. 2; Masuda, 1962, p. 181, pl. 20, fig. 10.
Chlamys (*Chlamys*) *farreri nipponensis* Kuroda, Kuroda, Habe and Oyama, 1971, p. 362, pl. 80, fig. 7.

Measurements:

IGPS coll. cat. no.	Length	Height	Valve	Loc. no.
95093–1	16.30 mm	20.00 mm	right	KK–03
95093–2	19.80	23.70	right	–
95093–3	29.40	35.20	left	–
95094	ca. 52	ca. 56	left	UK–02

Locality:
Loc. nos. KK–03.
UK–02.

Genus *Pecten* Müller, 1776
Subgenus *Notovola* Finlay, 1926
Pecten (*Notovola*) *albicans* (Schröter, 1802)

Pl. 8, Figs. 4, 6, 7a–b, 9.

Ostrea albicans Schröter, 1802, Arch. f. Zool., 3, p. 135. (*fide* Yamamoto and Habe, 1958)
Pecten laqueatus Sowerby, 1842, p. 46, pl. 15, fig. 101; Reeve, 1853, pl. 30, sp. 135; Lischke, 1871, p. 157, pl. 12, figs. 1, 2; Küster and Kobelt *in* Martini and Chemnitz, 1888, p. 79, 137, pl. 20, fig. 5, pl. 38, fig. 1; Yokoyama, 1920, p. 160, pl. 14, figs. 9, 10; Kuroda, 1932, append. p. 102, fig. 111.
Pecten excavatus Anton, Yokoyama, 1922, p. 183, pl. 15, figs. 5, 6.
Pecten (*Pecten*) *laqueatus* Sowerby, Kinoshita, 1937, p. 22, pl. 7, fig. 40.
Pecten albicans (Schröter), Taki *in* Hirase, 1951, pl. 14, fig. 2; Rehder, 1944, p. 54.
Pecten (*Notovola*) *albicans* (Schröter), Omori and Utashiro, 1953, figs. 1–7; Ozaki, 1958, p. 116, pl. 20, fig. 1; Oyama, 1958, 1, figs. 7–9; Yamamoto and Habe, 1958, p. 15, pl. 5, figs. 1–2; Noda, 1961, p. 11–14, pl. 3, figs. 1–4; Kaseno and Matsuura, 1965, pl. 8, figs. 1–4.
Pecten (*Pecten*) *albicans* (Schröter), Masuda, 1962, p. 201–202, pl. 23, fig. 9.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	Valve	No. of ribs
95095	72.85 mm	62.90 mm	–	left	8
95096–1	19.80	18.20	–	left	9
95096–2	46.50	44.90	–	left	9
95096–3	54.00	48.80	13.00	right	10
95096–4	ca. 69.0	64.00	–	right	10

Locality:
Loc. nos. KO–04.
KK–03.
AW–04

Pecten (*Notovola*) cf. *naganumanus* Yokoyama, 1920

Pl. 8, Fig. 8.

Compared with:

Pecten naganumanus Yokoyama, 1920, p. 160–161, pl. 13, figs. 4–6.

Remarks:

Only one fragmental shell of right valve was collected from the medium grained sandstone. Although, the specimen lacks the anterior half of shell, it is characterized by flat-topped about 12 major ribs and a few minor ribs on the posterior side. The present form can be identical with *Pecten naganumanus* Yokoyama from above mentioned character, but left cf. *naganumanus* untill well preserved specimens are obtained.

Locality:

Loc. no. RO–17.

Repository:

IGPS coll. cat. no. 95284.

Genus *Mizuhopecten* Masuda, 1963

Mizuhopecten yessoensis yokoyamae (Masuda, 1962)

Pl. 8, Figs. 1–2, Pl. 9, Figs. 3, 5, Pl. 10, Fig. 6.

Pecten sp., Takahashi, 1922, p. 155, pl. 9, fig. 2. (*fide* Masuda, 1962).
Pecten kurosawaensis Yokoyama, 1927a, p. 180, pl. 49, figs. 1–2.
Patinopecten (s.s.) *kurosawaensis* (Yokoyama), Itoigawa, 1958, pl. 1, figs. 7–9.
Patinopecten yessoensis yokoyamae Masuda, 1962, p. 215–216, pl. 25, figs. 2–3, pl. 26, fig. 7, pl. 27, fig. 12.
Patinopecten yessoensis yokoyamae Masuda (MS), Hatai, Masuda and Suzuki, 1961, pl. 1, fig. 17.
Patinopecten kurosawaensis (Yokoyama), Takayasu, 1961, pl. 2, figs. 2–3; Kaseno and Mastuura, 1965, pl. 8, fig. 6, pl. 9, fig. 3.
Patinopecten cf. *kurosawaensis* (Yokoyama), Sakagami *et al.*, 1966, pl. 6, fig. 2.
Patinopecten (*Patinopecten*) *poculum* subsp. *a*, Akiyama, 1962, p. 102, pl. 4, fig. 1, pl. 6, figs. 1, 2, 5.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Hinge length	Apical angle	No. of ribs
95098	FM–17	111.0 mm	104.6 mm	58.0 mm		26
95099–1	KK–22	47.8	45.2	24.15	114°	29
95099–2	–	32.2	32.4	18.3	107°	26
95100–1	HH–01*	58.75	61.6	32.7	109°	22
95100–2	–	56.40	55.35	–	106°	27
95100–3	–	34.60	37.25	ca. 19	103°	26
95100–4	–	63.90	66.80	–	104°	26
95100–5	–	74.50	75.45	ca. 38	103°	30
95100–6	–	105.6	95.40	–	110°	29
95100–7	–	49.80	53.20	–	–	26

Comparison and Affinity:

The present species was established by Masuda in 1962 upon the characteristic form

* Loc. no. HH–01; Small road side cutting at Hotta, Himi City, Toyama Prefecture, Zukawa Formation.

of ribs on the right valve which are squarish, 25 to 30 flately-topped. This subspecies is distinguished from *Mizuhopecten yessoensis yessoensis* (Jay) in having larger number of radial ribs. The present subspecies is also different from *Mizuhopecten poculum poculum* (Yokoyama) by its rather flat right valve, less number of radial ribs and smaller auricules.

According to Masuda (1962), the original specimens of *kurosawaensis* of Yokoyama (1926) from Akita City is conspecific with *poculum* of Yokoyama. The present writer agrees with Masuda's view.

Yokoyama (1927) and Kaseno and Matsuura (1965) recorded *kurosawaensis* from the Omma Formation, but judging from the shell character, their species could be synonymous with the present subspecies *yokoyamae*.

Remarks:

The present subspecies has been reported from the following formations; Setana and Tomikawa formations in Hokkaido, Hamada and Narusawa formations in Aomori Prefecture, Sasaoka Formation in Akita Prefecture, Nishiyama and Haizume formations in Niigata Prefecture, and Omma Formation in Ishikawa Prefecture.

Locality:

Loc. nos. KY–03, 06, 09, 23.
KO–04, 06, 26, 31, 32, 35, 36.
KK–06, 13, 14, 22, 28, 29, 47.
FM–12, 13, 14, 16, 17, 19, 20, 21, 22, 23, 24, 25, 26, 32, 33, 34, 35, 39, 40.
IS–01.

Mizuhopecten yessoensis yessoensis (Jay, 1857)

Pl. 8, Figs. 3a–b, Pl. 9, Fig. 1.

Pecten yessoensis Jay, 1857, p. 393, pl. 3, figs. 3–4, pl. 4, figs. 1–2; Schrenck, 1867, p. 484, pl. 20, figs. 1–4; Lischke, 1869, p. 165, pl. 10, figs. 3–4; Küster and Kobelt *in* Martini and Chemnitz, 1888, vol. 7, pt. 2, p. 139, pl. 38, fig. 7; Yokoyama, 1911, p. 2, pl. 1, figs. 13–14; Yokoyama, 1920, p. 159, pl. 13, figs. 14–15, Yokoyama, 1931, p. 195, pl. 11, fig. 9; Taki *in* Hirase, 1951, pl. 14, fig. 1.

Pecten (*Patinopecten*) *yessoensis* Jay, Kuroda, 1932, append. p. 99, fig. 110; Kinoshita and Isahaya, 1934, p. 14, pl. 11, fig. 77; Kubota, 1950, p. 13, pl. 8, fig. 50; Oyama, 1958, *Pecten*, figs. 3–11.

Patinopecten yessoensis (Jay), Habe, 1951a, p. 82, fig. 161; Kira, 1955, p. 99, pl. 49, fig. 16, Sawada, 1962, p. 75–76, pl. 3, fig. 5, pl. 7, fig. 10; Takayasu, 1962, pl. 1, figs. 13a–b; Kaseno and Matsuura, 1965, pl. 10, fig. 1, pl. 11, fig. 1, pl. 12, fig. 1, pl. 13, fig. 1.

Patinopecten (*Patinopecten*) *yessoensis yessoensis* (Jay), Masuda, 1962, p. 213, pl. 26, figs. 5–6.

Mizuhopecten yessoensis (Jay), Iwai, 1965, p. 30, pl. 15, fig. 13; pl. 16, fig. 2; Noda, 1973, p. 36, pl. 5, fig. 5.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Hinge length	Apical angle	No. of ribs
95097–1	KK–03	6.20 mm	6.50 mm	4.55 mm	101°	–
95097–2	–	7.60	7.60	–	103	–
95097–3	–	7.20	7.65	5.10	99	26
95097–4	–	7.05	7.10	4.95	100	–
95097–5	–	8.35	8.50	5.50	101	–
95097–6	–	9.20	9.60	6.10	103	–
95097–7	–	9.00	9.00	–	100	27

95097–8	–	9.70	10.00	6.75	102	23
95097–9	–	9.40	9.60	6.20	98	22
95097–10	–	12.95	–	ca. 8.0	105	23
95097–11	–	16.85	18.10	ca. 10	105	21
95097–12	–	25.20	28.35	ca. 17	106	23

Locality:

Loc. nos. KY–02.
KO–03, 04, 06, 07, 08, 13, 16, 21, 22, 30, 31.
KK–03, 13, 14, 15, 16, 24, 25, 34.
FM–30.

Mizuhopecten tokyoensis hokurikuensis (Akiyama, 1962)

Pl. 8, Figs. 4, 5a–b, Pl. 9, Figs. 4, Pl. 10, Figs. 1a–b.

Patinopecten tokyoensis kimurai (Yokoyama), Otuka, 1935c, p. 887, pl. 57, fig. 212.
Patinopecten hokurikuensis Ogose (MS), 1956, p. 110. (*fide* Akiyama, 1962)
Patinopecten taiwanus (Nomura), Shuto, 1960, p. 125, pl. 12, figs. 2, 10, 11, pl. 14, figs. 7, 15 (?).
Patinopecten tokyoensis (Tokunaga), Aoki, 1960, pl. 34, figs. 10–11; Takayasu, 1961, pl. 1, figs. 23–24.
Patinopecten (*Patinopecten*) *tokyoensis hokurikuensis* Akiyama, 1962, p. 94, pl. 7, figs. 1, 3, 5.
Patinopecten (*Patinopecten*) *tokyoensis hokurikuensis* Masuda, 1962, p. 211, pl. 25, fig. 6, pl. 27, figs. 6–7.
Patinopecten tokyoensis hokurikuensis Akiyama, Kaseno and Matsuura, 1965, pl. 9, figs. 1–2.
Mizuhopecten tokyoensis hokurikuensis (Akiyama), Hayasaka, 1973, p. 102, pl. 1, figs. 1a–b.

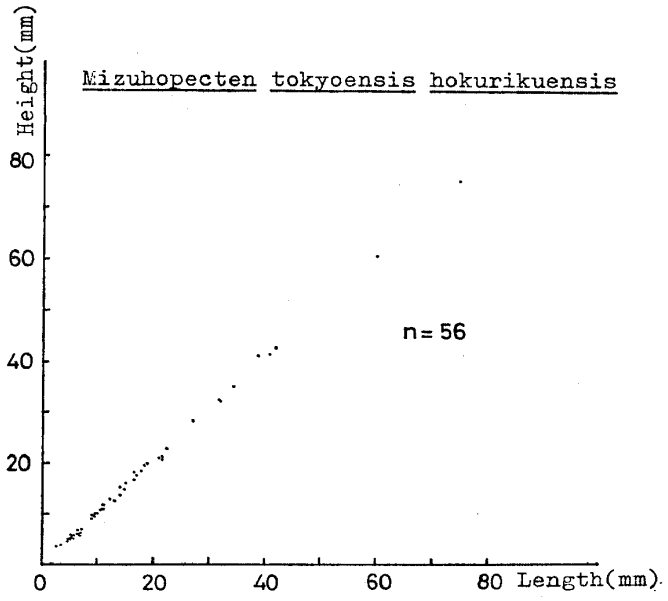


Fig. 13. Relationship of height to length of *Mizuhopecten tokyoensis hokurikuensis*

Description:

Shell large in adult, moderately thick, nearly equilateral, inequivalved and orbicular with large ears in outline. Shell nearly equal in height and length. Anterior dorsal margin

slightly concaved and descending into well rounded dorsal end as like as posterior. Ventral margin well concaved. Right valve rather well inflated and sculptured with fine concentric growth line and 6 or 7 radial ribs; ribs are roundly topped on the umbonal area and gradually become to flat and wide to ventral margin. And surface sculptured also with some riblets, it is rather distinct on the both extremities. Left valve flat and sculptured with 6 or 7 narrowly elavated radial ribs and numerous fine concentric growth lines. The main radial ribs, three, in number occupying central part of disk are distinct. Hinge line long and nearly straight. Ears trianguler in outline and nearly equal in size with wide and shallow byssal notch. Six radial threads on the anterior ear are sculptured. Cardinal crura is simple and shallow resirifer pit is setted. Inner surface is folded, corresponing to surface sculpture.

Remarks:

Mizuhopecten tokyoensis (Tokunaga, 1906) has been divided into three subspecies as *tokyoensis* s.s., *tokyoensis sematensis* (Akiyama, 1962) and *M. tokyoensis hokurikuensis* (Akiyama, 1962).

According to Akiyama (1962) and Masuda (1962), their subspecies are distinguished from each other in the convexity of shell, the shape of radial ribs, presence or absence of riblets on the surface of right valve. The writer agrees with the classifications of Akiyama (1962) and Masuda (1962) concerning subspecies.

Foutunatelly, many well preserved specimens were collected from several exposures of the Omma Formation, and examined from the view point of ontogenetic study. The result of observation on some specimens collected are shown in the following lines.

Right valve: (shell length in mm)

3 mm: Shell flat, and few threads on the ears become distinct.

5.6 mm: Radial ribs on the shell surface indistinct.

7.0 mm: Three roof-like elevated radial ribs become distinct.

9.5 mm: Four radial ribs with few riblets are seen.

Left valve

5.6 mm: Five or six radial threads can be observed on the shell surface.

Generally, the ratio of height to length of disk is constant, and apical angle is variable from 90° to 110°. The largest one attains more than 170 mm in length, 150 mm in height and about 100 mm in hinge length among the specimens from the Omma Formation.

The present subspecies is one of representatives of the Omma fauna from its geological and geographical distributions.

Locality:

Abundant specimens were collected from Loc. nos. KK–03, KK–21, KO–15, 22.

Family Gryphaeidae

Subfamily Pycnodonteinae

Genus *Neopycnodonta* Stenzel, 1971

Neopycnodonta musashiana (Yokoyama, 1920)

Pl. 7, Figs. 7, 8.

Ostrea musashiana Yokoyama, 1920, p. 161, pl. 16, figs. 1–5; Yokoyama, 1922, p. 185, pl. 15, fig. 5.

Notoostrea musashiana (Yokoyama), Kaseno and Mastuura, 1965, pl. 12, fig. 3; Hayasaka, 1973, pl. 6, figs. 10a–b.

Pycnodonta musashiana (Yokoyama), Habe, 1964, p. 176, pl. 54, fig. 15, Habe and Kosuge, 1970, p. 138, pl. 51, figs. 15–16; Kuroda, Habe and Oyama, 1971, p. 379, pl. 85, figs. 1–2.

Ostrea hiranoi Baker and Spicer, 1930, p. 175, pl. 18, figs. 1–3.
Neopycnodonta hirasei (Spicer and Baker), Stenzel *in* Treatise, p. N1109–N1113, figs. J86, 1a–d, 2a–c.
Ostrea (*Pycnodonta*) *musashiana* Yokoyama, Kuroda, 1931, append. p. 57, figs. 61–62.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	Valve
95101–1	36.4 mm	48.8 mm	ca. 15 mm	right
95101–2	24.3	31.7	13.4	conjoined
95101–3	20.6	28.8	9.8	conjoined

Locality:
Loc. nos. KO–04.
FM–25.
AW–04.

Family Anomiidae
Genus *Monia* Gray, 1850
Monia umbonata (Gould, 1861)

Pl. 7, figs. 9a–b.

Placunanomia umbonata Gould, 1861, p. 39. (*fide* Habe, 1953)
Anomia radulina A. Adams, 1861, p. 142.
Anomia pustulata A. Adams, 1861, p. 142.
Placunanomia radiata Sowerby, 1914, p. 33, pl. 2, fig. 15.
Anomia sematana Yokoyama, 1922, p. 177, pl. 14, figs. 20–21.
Anomia lunulata Yokoyama, 1922, p. 177, pl. 14, figs. 22–23.
Pododesmus (*Monia*) *radiatus* (Sowerby), Nomura and Zinbo, 1936, p. 238, pl. 11, figs. 5a–b.
Monia radiata (Sowerby), Habe, 1951, p. 90, figs. 182–184.
Monia umbonata (Gould), Habe *in* Kuroda, 1953, p. 199, pl. 27, fig. 14; pl. 28, fig. 19; Yamamoto and Habe, 1958, p. 19, pl. 3, fig. 9; Habe, 1958a, p. 271, pl. 12, figs. 12, 19; Hatai, Masuda and Suzuki, 1961, pl. 1, fig. 21; Hayasaka, 1961, p. 33–34, pl. 3, fig. 6; Sawada, 1962, p. 78, pl. 1, figs. 13–14; Iwai, 1965, p. 32, pl. 16, figs. 9–10; Kaseno and Matsuura, 1965, pl. 10, figs. 2, 3.

Measurements:

IGPS coll. cat. no.	Height	Length	Valve	Loc. no.
95102	ca. 36	31.6	right	KK–03
95103–1	18.7	16.1	right	AW–04
95103–2	24.6	24.4	right	–
95103–3	33.6	29.6	right	–
95104	23.35	24.00	right	IS –01

Locality:
Loc. nos. KK–03. KO–05.
AW–04.
IS –01.

Family Mytilidae
Genus *Mytilus* Linné, 1758
Mytilus grayanus Dunker, 1853

Pl. 7, Fig. 10

Mytilus grayanus Dunker, 1853, p. 84; Lischke, 1871, pl. 145; Dunker, 1882, p 221; Clessin *in* Martini and Chemnitz, 1890, v. 8, pt. 3, p. 68, dl. 7, figs. 1–2; Yokoyama, 1925a, p. 25, pl. 2, fig. 10;

Yokoyama, 1925b, p. 15, pl. 2, fig. 1; Yokoyama, 1926a, p. 135, pl. 20, fig. 1; Nomura and Hatai, 1935, p. 109; Taki *in* Hirase, 1951, pl. 17, fig. 4; Kira, 1959, p. 116, pl. 45, fig. 22; Sawada, 1962, p. 66, pl. 2, fig. 22.

Mytilus giganteus Holmberg, Yokoyama, 1920, p. 145, pl. 11, fig. 20.

Mytilus (*Crenomytilus*) *grayanus* Dunker, Habe, 1960, p. 4, pl. 1, figs. 14–15.

Crenomytilus grayanus (Dunker), Habe and Ito, 1965, p. 112, pl. 36, fig. 5.

Measurements:

IGPS coll. cat. no.	Length	Height
95105	163.0 mm	ca. 97 mm

Locality: Loc. no. UK–02.

Genus *Modiolus* Lamarck, 1799

Modiolus difficilis (Kuroda and Habe, 1950)

Pl. 7, Figs. 6, 11a–b.

Modiola modiolus Linné, Yokoyama, 1920, p. 145, pl. 11, fig. 21; Yokoyama, 1925a, p. 15, pl. 2, fig. 2.

Volsella difficilis Kuroda and Habe, 1950, pl. 30; Taki *in* Hirase, 1951, pl. 18, fig. 9; Habe, 1955, p. 4, pl. 4, figs. 1–2; Ozaki, 1958, p. 119–120, pl. 21, fig. 2; Takayasu, 1961, pl. 1, fig. 18.

Volsella (*Volsella*) *difficilis* Kuroda and Habe, Habe, 1951, p. 50; Taki and Oyama, 1954, pl. 12, fig. 21; Itoigawa, 1958b, pl. 1, fig. 10.

Modiolus difficilis (Kuroda and Habe), Kira, 1959, p. 116, pl. 45, fig. 21; Habe, 1960, p. 3, pl. 1, fig. 11, pl. 5, fig. 5; Sawada, 1962, p. 66.

Modiolus difficilis Kuroda and Habe, Kaseno and Matsuura, 1965, pl. 6, fig. 18; Sakagami *et al.*, 1966, pl. 5, figs. 1a–2b.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	Loc. no.
95106	71.6 mm	42.9 mm	26.00 mm/2	KO–13
95107	25.9	15.15	5.6	UK–04

Remarks:

The present form is characterized by narrow and rounded posterior to ventral margins, and well convexed shell compared with type specimen. And this one from the Omma Formation is most allied to the specimen reported from the Tomikawa Formation in Hokkaido (Sakagami *et al.*, 1966, pl. 5, fig. 2) in general shape of shell. The present specimen and Kaseno and Matsuura's one (1965, pl. 6, fig. 18) are slightly different from the type specimen of the species in having strongly inflated shell and narrowly rounded posterior corner.

Locality:

Loc. nos. KO–13.
UK–04.

Family Pholadidae

Genus *Umitakea* Habe, 1952

Umitakea japonica (Yokoyama, 1920)

Pl. 17, Fig. 1.

Pholadomya japonica Yokoyama, 1920, p. 106–107, pl. 6, figs. 30a–b.

Barnea (*Umitakea*) *japonica* (Yokoyama), Habe, 1952a, p. 241–242, text-figs. 632–634.

Umitakea japonica (Yokoyama), Oyama, 1973, p. 117, pl. 56, figs. 4, 9.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	Valve
95108	59.60 mm	33.70 mm	10.1 mm	56.5%	right

Remarks:

Only one specimen was collected from silty sandstone, upper part of the Omma Formation, at small river side cliff of Wakamatsu-machi, Kanazawa City. The present species is characterized by its peculiar sculptures of shell surface. It consists of roof-like coarse concentric striae and comb-like, about 14 radiating ribs of which anterior part are sharply granulated.

After Yokoyama (1920) first proposed the present species based upon the fossil specimen from the Upper Musashino deposits under the name of *Pholadomya*, this species was recognized by Habe in living.

This may be second report in fossil record in Japan.

Locality:

Small river side cliff, about 1000 m ESE from the Wakamatsu Bridge, Wakamatsu-machi, Kanazawa City, Ishikawa Prefecture.

Family Thraciidae

Genus *Thracia* Blainville, 1824

Thracia kakumana (Yokoyama, 1927)

Pl. 17, Figs. 8, 13.

Thracia pubescens Yokoyama, 1923b, p. 6, pl. 1, fig. 1; Yokoyama, 1925c, p. 15, pl. 3, fig. 4.
Tellina kakumana Yokoyama, 1927, p. 177, pl. 47, fig. 14.
Thracia kakumana (Yokoyama), Habe, 1952a, p. 262, text-figs. 708–709; Kamada, 1955a, p. 4–6, pl. 1, fig. 11; Itoigawa, 1958, pl. 2, fig. 4; Kaseno and Matsuura, 1965, pl. 19, fig. 12; Kira, 1971, p. 164, pl. 61, fig. 24; Chinzei, 1973, pl. 14, fig. 6.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L	Valve
95109–1	KK–25	ca. 84.0 mm	65.1 mm	29.2 mm	77.5	conjoined
95109–2	–	48.50	34.70	15.70/2	71.5	conjoined
95110–1	KK–03	82.4+	70.50	29.0	86	conjoined
95110–2	–	69.00	ca. 47.30	ca. 20.0	69	conjoined

Remarks:

The present species was originally proposed by Yokoyama as a fossil species based upon the Omma specimens. But, Habe (1952) recognized the living form of the species from the sea of Hokkaido.

The present species is yielded in the medium or fine grained sandstone of the Omma Formation.

Locality:

Loc. nos. KK–01, 03, 10, 14, 24, 25, 31, 45, 52.
KY–13, 10.

Family Myochamidae
Genus *Myadora* Gray, 1840
Myadora japonica Habe, 1950

Pl. 17, Figs. 2a–b, 3–7.

Myadora fluctuosa Gould, Yokoyama, 1922, p. 170–171, pl. 14, figs. 6–7; Otuka, 1935c, p. 901, pl. 57, fig. 209.
Myadora japonica Habe, 1950, p. 27, pl. 4, figs. 4–6; Takayasu, 1961, pl. 1, figs. 22a–b; Kaseno and Matsuura, 1965, pl. 19, figs. 5–8.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	Valve
95111–1	KK–03	13.75 mm	11.30 mm	3.8 mm	left
95111–2	–	13.65	11.20	4.00	left
95111–3	–	12.45	9.80	–	right
95111–4	–	10.80	8.35	–	right
95112–1	KO–22	15.90	13.00	4.80	left
95112–2	–	12.10	10.00	3.40	left
95112–3	–	12.00	9.90	–	right
95112–4	–	11.90	9.25	–	right
95112–5	–	10.05	8.20	–	right
95113	IS–09	11.50	10.00	–	left

Remarks:

The present form resembles *Myadora proxima* (Smith, 1880), but the former can be distinguishable from the latter in having rather low and small adult shell in comparison with the *proxima*.

Locality:

Loc. nos. KO–22.
KK–03, 40
I S–09.

Family Pandoridae
Genus *Pandora* Chemnitz, 1795
Subgenus *Heteroclidus* Dall, 1903
Pandora (*Heteroclidus*) *pulchella* Yokoyama, 1926

Pl. 16, Figs. 2, 5, 6, 8.

Pandora pulchella Yokoyama, 1926b, p. 387, pl. 45, fig. 4; Kaseno and Matsuura, 1965, pl. 19, figs. 9–10.
Pandora (*Clidiophora*) *pulchella* Yokoyama, Kuroda, 1931, p. 44, pl. 4, fig. 19.
Pandora (*Kennerlia*) *pulchella* Yokoyama, Otuka, 1936a, p. 732, pl. 42, fig. 10; Makiyama, 1958, pl. 57, fig. 4.
Pandora (*Heteroclidus*) *pulchella* Yokoyama, Otuka, 1943, pl. 2, figs. 1–4.

Measurements:

IGPS coll. cat. no.	Length	Height	H/L	Valve
95114–1	42.80 mm	30.45 mm	71.1%	conjoined
95114–2	35.0	20.40	58.3	–
95114–3	30.20	20.70	68.5	–
95114–4	26.60	18.60	69.9	–

95114–5	26.40	15.85	60.0	conjoined
95114–6	33.30	19.40	58.2	–
95114–7	28.85	22.50	78.0	–
95114–8	27.40	18.70	68.2	–
95114–9	27.25	15.40	56.5	–
95114–10	28.65	17.60	61.4	–
95114–11	ca. 23.0	16.95	ca. 73.7	–
95114–12	29.00	20.40	70.3	–
95114–13	26.00	15.45	59.4	–
95114–14	ca. 20.0	ca. 13.5	–	–
95114–15	18.60	11.30	60.8	–

Locality:

Loc. nos. KY–01,
KO–03, 15, 22.
KK–02, 03, 04, 10, 19, 25, 35, 42.

Family Astartidae
Genus *Astarte* Sowerby, 1816
Subgenus *Astarte* s.s.
Astarte (*Astarte*) *hakodatensis* Yokoyama, 1920

Pl. 11, Figs. 5a–b.

Astarte hakodatensis Yokoyama, 1920, p. 140–141, pl. 11, figs. 5a–c, 6a–c; Yokoyama, 1922, p. 164; Yokoyama, 1926d, p. 299; Otuka, 1935c, p. 889, pl. 56, figs. 148–150.
Astarte (*Astarte*) *hakodatensis* Yokoyama, Oyama, 1973, p. 90, pl. 37, figs. 1–2.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L	Valve
95115–1	KO–15	10.70 mm	10.50 mm	3.20 mm	98.1%	right
95115–2	–	11.00	11.20	3.45	101.8	right
95115–3	–	11.30	10.75	3.15	95.1	right
95115–4	–	11.30	10.50	3.00	92.9	left
95115–5	–	12.50	11.60	3.35	92.8	right
95116–1	KO–04	10.10	9.70	2.60	96.0	right
95116–2	–	10.55	10.30	3.10	97.6	left
95116–3	–	10.35	10.25	3.35	99.0	left

Remarks:

The present species resembles *Astarte* (*Tridonta*) *bennetti* Dall (1903), living species in the Sea of Japan and Bering Sea, in its shell outline, but the present one can be distinguished from the latter in having crenulated ventral margin, and more prominent beak than those of *bennetti*. The fossil form of the species has been recorded from Koshiba Formation, Kanagawa Prefecture, Sawana Formation in Sado Island, Niigata Prefecture, and at Shimazaki (Himi beds of Otuka, 1935), Himi City, Toyama Prefecture.

Locality:

Loc. nos. KO–04, 15.
KK–04, 22, 35, 42.

Subgenus *Tridonta* Schumacher, 1817

Astarte (*Tridonta*) *borealis* (Schumacher, 1817)

Pl. 11, Figs. 8, 9, 13a–b.

Tridonta borealis Schumacher, 1817, Essai nov. Syst. Vers test., p. 147–148, pl. 15, fig. 4. (*fide* Otuka, 1936)

Astarte borealis (Chemnitz), Yokoyama, 1922, p. 163, pl. 10, fig. 11.

Astarte borealis (Schumacher), Yokoyama, 1926d, p. 298, pl. 37, figs. 9, 10; Nomura and Hatai, 1935, p. 114, pl. 10, figs. 1–2, 7; Otuka, 1936a, p. 730; Iwai, 1959, p. 57, pl. 2, figs. 3a–b; Iwai, 1960b, pl. 1, figs. 11a–b; Takayasu, 1961, pl. 1, figs. 3a–b; Hatai, Masuda and Suzuki, 1961, pl. 2, fig. 5.

Astarte borealis Schumacher, Kanehara, 1942, p. 130, pl. 3, figs. 10a–b; Iwai, 1965, p. 34, pl. 17, figs. 7a–b, 9a–b, 10–11.

Astarte (*Tridonta*) *borealis* (Schumacher), Sawada, 1962, p. 79, pl. 3, figs. 2–3, pl. 6, fig. 29, pl. 7, figs. 8–9; Kaseno and Matsuura, 1965, pl. 8, fig. 8.

Astarte (*Tridonta*) *borealis* Schumacher, Sakagami *et al.*, 1966, pl. 2, figs. 9a–b.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	Valve
95117–1	13.65 mm	12.40 mm	3.10 mm	90.8%	right
95117–2	13.65	12.40	3.10	90.8	left
95117–3	22.30	20.30	4.45	91.0	conjoined
95117–4	11.80	10.75	3.40	91.1	left
95117–5	13.25	12.00	4.00	90.6	right

Locality:

Loc. nos. KY–11.
KO–04, 15.
KK–35.
UK–01, 02.

Astarte (*Tridonta*) *alaskensis* Dall, 1903

Astarte alaskensis Dall, 1903, p. 944, pl. 63, figs. 2; Otuka, 1935c, p. 890, pl. 57, fig. 195; Nomura and Hatai, 1935, p. 113, pl. 7, figs. 6–7, Iwai, 1959, p. 57, pl. 2, figs. 1a–b; Iwai, 1965, p. 34, pl. 17, figs. 8a–b; Sakagami *et al.*, 1966, pl. 2, figs. 18a–b.

Astarte (*Tridonta*) *alaskensis* Dall, Itoigawa, 1958, pl. 2, fig. 2; Hatai, Masuda and Suzuki, 1961, pl. 2, fig. 4; Sawada, 1962, p. 79, pl. 6,fig. 8.

Astarte sulcata (Dacosta), Yokoyama, 1926d, p. 298–299, pl. 37, figs. 9–10.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	Valve
95118	25.60 mm	20.65 mm	6.15 mm	right
95119	8.35	6.55	1.75	right

Remarks:

Thick and less inflated shell and more strong concentric growth-lines of the present species can be easily descriminated from those of *Astarte borealis* (Schumacher, 1817).

Locality:

Loc. no. IS–09.

Family Carditidae
Genus *Venericardia* Lamarck, 1801
Subgenus *Megacardita* Sacco, 1899
Venericardia (Megacardita) ferruginosa (Adams and Reeve, 1850)

Pl. 11, Figs. 4a–b.

Cardita ferruginosa Adams et Reeve, 1850, Zool. Voy, "Samarang", Moll., p. 76, pl. 21, fig. 21. (*fide* Oyama, 1973)
Venericardia cipangoana Yokoyama, 1920, p. 137–139, pl. 11, figs. 2a–c; Yokoyama, 1922, p. 162, pl. 13, fig. 4.
Venericardia (Megacardita) ferruginosa Adams et Reeve, Uozumi, 1953, p. 28, pl. 21, fig. 165.
Venericardia (Megacardita) ferruginosa (Adams et Reeve), Shuto, 1957b, p. 86, pl. 31, fig. 13; Habe, 1949, p. 108, text-figs. 216–217.
Venericardia (Megacardia) ferruginosa (Adams et Reeve), Hayasaka, 1973, pl. 6, fig. 6 (?).

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	No. of ribs	Valve
95120–1	15.70 mm	13.00 mm	3.40 mm	82.8%	15	left
95120–2	29.85 mm	24.85	7.00/2	82.6	13	conjoined
95120–3	15.75	12.30	4.00	78.3	14	left
95120–4	17.30	12.85	4.00	74.3	15	right

Locality:
Loc. no. UK–04.

Venericardia (Megacardita) ommaensis Ogasawara n. sp.

Pl. 10, Figs. 2a–b, 5a–b, Pl. 13, Fig. 3.

Venericardia (Megacardita) kiiensis cipangoana Yokoyama, Kaseno and Matsuura, 1965, pl. 11, fig. 2.

Description:
Shell small, rather thick, moderately inflated, nearly ovoidal in outline, longer than height and nearly equivalved. Anterior dorsal margin short and slightly concave, and decending into well rounded dorsal end. Posterior dorsal margin long, well arched and connected with somewhat truncated posterior dorsal end. Ventral margin slightly curved. Surface sculptured with 17 to 20, mainly 18 or 19, broad, rather smooth, low, round-topped radial ribs and numerous fine growth lines. The radiating ribs tend to become flat, indistinct and wide toward ventral margin. Interspaces of radial ribs distinct in younger specimen and umbonal area of adult ones, but become indistinct at the ventral margin in adult specimens. Beak small, rather weak and situated anteriorly. Lunule small, cordate in outline and well marked. Escutcheon weakly defined. Hinge plate rather broad and solid with two strong cardinal teeth. Teeth heavy and thick; posterior cardinal teeth about 3 times longer than that of anterior. Muscle scars ovately round in outline, and nearly equal in size. Inner surface of ventral margin strongly crenulated.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L	No. of Ribs	Valve
95122 (Holotype)	KO–15	20.35 mm	18.75 mm	5.45 mm	92.1%	19	left
95123–1 (Paratype)	–	20.00	16.90	5.10	84.5	18	right
95123–2 (Paratype)	–	19.80	17.45	5.20	88.1	20	right

95123–3 (Paratype)	–	19.60	16.80	4.75	85.7	17+(1)	right
95123–4 (Paratype)	–	17.45	15.10	4.30	86.5	19	left
95123–5 (Paratype)	–	14.70	12.50	3.80	85.0	17+(1)	left
95123–6 (Paratype)	–	13.05	11.00	3.45	84.3	19	right
95123–7 (Paratype)	–	12.60	11.15	3.40	88.5	17+(1)	left
95124–1	KO–04	26.10	23.00	7.70	88.1	17+(1)	right
95124–2	–	26.40	22.70	7.70	86.0	19	right
95124–3	–	25.70	22.00	8.00	85.6	18	right
95124–4	–	21.40	18.70	6.20	73.8	18	right
95124–5	–	17.60	15.15	4.80	86.1	19	left
95125	RO–07	28.00	25.05	7.50	89.5	19	left

Comparison and Affinity:

The present species is very similar to *Venericardia cipangoana* Yokoyama described and recorded by Yokoyama in 1920 from the Pliocene and Pleistocene deposits of Kanto Region, but the present one can be distinguished from the Yokoyama's species by having larger number of radial ribs and slightly high shell outline. According to Yokoyama (1920) *Venericardia cipangoana* has 14 to 16 wide and rounded radial ribs and trianglar shell outline. The characters pointed out by Yokoyama are found in *Venericardia ferruginosa* except for broad radial ribs.

The present species is allied to *Megacardita corrensis* (Deshayes) in shell outline and number of radial ribs, but the former can be descriminated from the latter by having more arched ventral margin and weak umbonal area. And the present new species resembles also *Cyclocardia paucicostata* (Krause) in broad ribs and shallow interspaces among them, but the present new species can be distinguished from the latter because the present one has less convexed ventral margin and rather low shell form.

Locality:

Loc. nos. KO–04, KO–15 (type locality).
RO–07.

Subgenus *Cyclocardia* Conrad, 1867

Venericardia (*Cyclocardia*) *ferruginea complexa* Ogasawara n. subsp.

Pl. 11, Figs. 3a–b, Pl. 12, Fig. 4.

Description:

Shell small, largest one attains 27.50 mm in length, rather thick and well inflated, nearly orbicular in shell outline, inequilateral and equivalve. Anterior margin slightly arched and decending into well rounded dorsal end. Posterior dorsal margin also slightly convex and somewhat longer than that of anterior, and connected with rather narrowly rounded end. Ventral margin slightly arched.

Surface sculptured with 24 to 30, broad, round topped radial ribs, and numerous fine concentric growth-lines. Ribs are separated by narrow and shallow radial fullows. Hinge plate with strong two cardinal teeth. Anterior muscle scar slightly larger than posterior one, and nearly ovoidal in outline. Ventral margin distinctly crenulated.

Measurements:

See Table 18 and Figure 14.

Comparison and Affinity:

The present new subspecies is mostly allied to *Cyclocardia ferruginea* from its shell-outline and surface sculptures. But the number of radial ribs of the subspecies is slightly

Table 18. Measurements of *Venericardia (Cyclocardia) ferruginea complexa* Ogasawara n. subsp.

Locality No.	IGPS coll. cat. No.	Length (mm)	Height (mm)	Width (mm)	H/L (%)	No. of Rad. Ribs	Valve
KK-42	95200-1	14.70	13.65	7.6/2	92.9	25	conjoined
	-2	19.80	17.00	5.00	85.7	27	left
	-3	23.30	20.65	6.00	88.6	27(+1)	left
	-4	19.60	18.30	5.65	93.4	27	left
	-5	22.00	20.00	ca.6.5	90.9	26(+1)	right
KO-22	95199-1	12.00	11.20	3.00	93.3	24	left
	-2	12.60	11.70	3.80	92.9	26	right
	-3	14.20	13.30	4.90	93.7	25	right
	-4	15.00	14.10	5.44	94.0	24(+1)	left
	-5	16.30	15.20	5.25	93.3	24(+1)	left
	-6	16.00	14.40	4.15	90.0	25	left
	-7	16.30	16.20	5.80	99.4	26	right
	-8	17.70	16.90	5.30	95.5	26	right
	-9	18.65	17.65	5.60	94.6	25	left
	-10	16.70	15.45	4.75	92.5	26	left
	-11	19.65	17.90	5.55	91.1	25	right
	-12	18.45	16.65	5.80	90.2	29	left
	-13	20.20	18.80	5.90	93.1	25	left
	-14	19.00	17.25	5.40	90.8	26	left
	-15	20.30	18.85	6.15	92.9	24	right
	-16	21.90	19.80	7.00	97.3	27	left
	-17	22.10	21.50	7.15	97.3	28	left
	-18	24.80	20.10	7.35	81.1	27	right
	-19	23.35	21.10	7.55	90.4	30	left
KO-22 (Paratype)	95128-1	13.00	12.10	3.95	93.1	24	right
(Paratype)	95128-2	14.00	12.90	4.00	92.1	26	left
-	95128-3	15.25	13.85	4.65	90.8	28	right
-	-4	16.25	15.00	4.30	92.3	24	left
-	-5	16.00	14.70	4.55	91.9	26	right
-	-6	16.20	15.15	5.00	93.5	27	right
-	-7	18.50	16.95	5.35	91.6	27	right
-	-8	18.40	18.00	6.25	97.8	26(+1)	right
-	-9	19.00	17.40	6.25	91.6	26	right
-	-10	19.20	17.40	6.45	90.6	25	right
-	-11	20.05	18.80	5.95	93.8	26	right
-	-12	20.00	19.60	6.60	98.0	26	left
-	-13	19.00	17.70	5.10	93.2	27	left
(Holotype)	95127	24.80	22.15	7.80	89.3	26	right
(Paratype)	95128-14	28.80	27.20	9.00	94.4	27	left
KK-35	95198-1	5.30	4.85	-	91.5	24	right
	-2	6.70	6.40	2.00	95.5	24	right
	-3	6.60	6.00	2.00	90.9	27	right
	-4	7.25	6.40	2.00	88.3	24	right
	-5	8.50	7.65	2.10	90.0	26	left
	-6	8.15	7.60	2.10	93.3	26	left
	-7	8.60	7.80	2.30	90.7	27	right
	-8	8.70	7.90	2.40	90.8	28	right
	-9	9.25	8.50	2.45	91.9	26	right
	-10	9.80	9.00	2.60	91.8	25	left
	-11	10.25	9.10	2.70	88.8	26	right
	-12	10.25	9.10	2.75	88.8	28	right
	-13	10.45	9.30	2.90	89.0	26	right
	-14	10.25	9.35	2.80	91.2	25	right
	-15	10.45	9.40	2.90	90.0	26	right
	-16	11.00	10.10	3.05	91.8	25	right
	-17	10.80	10.00	2.75	92.6	25	right
	-18	10.75	9.85	2.85	91.6	26	left
	-19	11.10	10.00	3.00	90.1	25	right
	-20	11.10	10.00	3.10	90.1	27	right
	-21	11.85	10.55	3.10	89.0	27	left
	-22	11.75	10.70	3.25	91.1	26	right
	-23	13.10	11.70	3.10	89.3	25	right
	-24	13.15	12.10	3.40	92.0	27	left
	-25	16.05	14.55	4.25	90.7	26	right
	-26	16.25	14.90	4.00	91.7	28	left
	-27	15.00	13.70	4.15	91.3	24(+1)	right
	-28	16.65	14.70	4.25	88.3	28	left
	-29	16.30	14.75	4.25	90.5	27	right
	-30	17.20	16.10	5.00	93.6	26	right
	-31	19.00	16.95	5.20	89.2	26	right
	-32	18.70	16.70	4.75	89.3	27	left
	-33	18.95	17.40	5.35	91.8	27	right
	-34	21.40	18.50	5.80	86.5	28	right
	-35	20.00	18.30	5.10	91.5	27	right
	-36	23.20	20.70	6.05	89.2	27	left
	-37	27.50	24.25	7.80	88.2	26	right
KY-15	95197-1	14.00	13.00	4.10	92.9	25	left
	-2	14.25	13.65	4.80	95.8	25(+1)	right
	-3	15.30	14.55	4.60	95.1	25	left
	-4	ca.20.0	18.90	5.70	94.5	27	left
	-5	18.15	16.30	5.00	89.8	25	right
	-6	22.50	21.50	7.15	95.6	26	left

bigger than that of the species and the size of shell is somewhat smaller than that of *C. ferruginea*.

The new subspecies resembles *Cyclocardia crassidens* (Broderip and Sowerby, 1829) in shell outline, but the former can be easily distinguished from the latter in having larger number of wider radial ribs. This subspecies is also similar to *Cyclocardia crebicostata* (Krause, 1885) in number of radial ribs and its shape except for shell outline which is characterized by concaved anterior dorsal margin and slightly arched ventral margin.

Remarks:

The present new subspecies is mainly yielded in the medium grained sandstone of Omma Formation.

Locality:

Loc. nos. KO–15, KO–22 (type locality).
KK–35, 42.

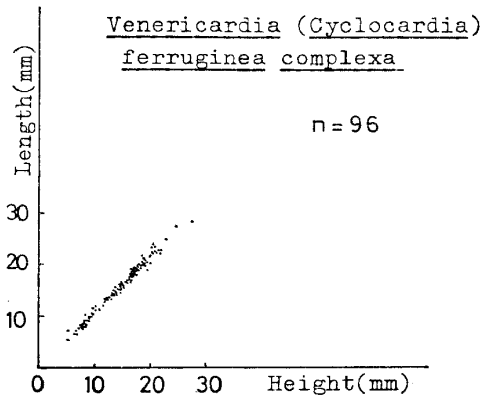


Fig. 14. Relationship of height to length of *Venericardia* (*Cyclocardia*) *ferruginea complexa* n. subsp.

Venericardia (*Cyclocardia*) *ferruginea orbicularis* Yokoyama, 1923

Pl. 10, Figs. 4a–b.

Venericardia ferruginea (Adams) var. *orbicularis* Yokoyama, 1923a, p. 5, pl. 1, fig. 6.
Venericardia ferruginea (A. Adams), Yokoyama, 1926d, p. 297.

Description:

Shell nearly orbicular in outline, moderately thick and inflated. Anterior dorsal margin well rounded and gradually ascending into its rounded end. Posterior dorsal margin slightly longer than the anterior one, and slightly arched. Both posterior and anterior dorsal ends well rounded. Ventral margin rather well convexed.

Surface sculptured with weakly granuled radial ribs and numerous fine concentric growth lines; radial ribs range from 19 to 21 in number, round topped and slightly wider than their interspaces.

Beak small but pointed. Hinge plate small and solid with two cardinal teeth. Muscle scars small and nearly ovoidal in outline and nearly equal in size. Ventral margin distinctly crenulated.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	No. of ribs	Valve
95121–1	9.45 mm	8.95 mm	2.85 mm	95.2%	21	right
95121–2	8.90	8.55	3.10	96.1	20	left
95121–3	9.10	8.65	3.10	95.1	20	right
95121–4	8.30	7.80	2.75	94.0	20	right
95121–5	7.50	7.00	2.45	93.3	10	right
95121–6	7.20	6.90	2.50	95.8	21	right
95121–7	7.45	6.90	2.30	92.6	20	left
95121–8	7.00	6.70	2.35	95.7	21	left
95121–9	6.40	6.30	2.25	98.4	20	right
95121–10	6.40	6.15	2.25	96.1	20	left

Locality:
Loc. no. KO–15.

Venericardia (*Cyclocardia*) *myogadaniensis* Itoigawa, 1958

Pl. 10, Fig. 7.

Venericardia (*Cyclocardia*) *myogadaniensis* Itoigawa, 1958, p. 261, pl. 1, fig. 7; Hatai, Masuda and Suzuki, 1961, pl. 2, figs. 8a–b.
Venericardia (*Cyclocardia*) *ferrugenea* (Clessin), Iwai, 1959, p. 58, pl. 2, figs. 7a–b.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	No. of ribs	Valve
95126–1	25.00 mm	22.90 mm	6.20 mm	91.6%	24	right
95126–2	23.00	24.00	6.30	104.3	23+(1)	left
95126–3	22.20	21.70	6.00	97.7	21+(2)	left
95126–4	19.40	20.60	7.00	106.2	23	left
95126–5	16.35	16.80	6.00	102.8	23	left
95126–6	13.40	13.70	5.10	102.2	24	right
95126–7	12.60	12.60	4.45	100.0	22	right

Remarks:
The present species is characterized by somewhat higher shell than its length, small but pointed beak slightly incurved to anteriorly, and 22 to 24 flat-topped broad radial ribs. Although the radial ribs of the present form range from 22 to 24 in number in comparing with 24 to 26 of Itoigawa's types, this can be safely allowed to include in the specific variation. The present species has been recorded from Nishiyama and Haizume formations, both in Niigata Prefecture, Hamada Formation at Chikagawa, Mutsu-City, Aomori Prefecture.
Locality:
Loc. no. IS–01.

Subfamily Carditamerinae
Genus *Miodontiscus* Dall, 1903
Miodontiscus nakamurai (Yokoyama, 1923)

Pl. 10, Figs. 3a–b, Pl. 11, Figs. 1a–b, 2a–b.

Venericardia nakamurai Yokoyama, 1923b, p. 5–6, pl. 1, fig. 9; Yokoyama, 1926d, p. 298, pl. 36, fig. 3.
Venericardia (*Miodontiscus*) *prolongata* (Carpenter) var. *nakamurai* (Yokoyama), Uozumi, 1953, p. 29, pl. 21, figs. 162a–b.
Venericardia (*Miodontiscus*) *prolongata nakamurai* Yokoyama, Itoigawa, 1958, pl. 2, fig. 7.
Venericardia (*Miodontiscus*) *prolongata nakamurai* (Yokoyama), Kaseno and Matsuura, 1965, pl. 11, fig. 6.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	No. of ribs	Valve
95129–1	5.30 mm	5.15 mm	1.45 mm	12+(1)	left
95129–2	6.10	6.00	1.55	11+(1)	right
95129–3	6.35	6.50	1.70	11+(1)	left
95129–4	6.85	7.40	2.15	12	right
95129–5	5.50	6.40	2.00	9+(1)	left
95129–6	5.40	6.40	1.85	10	right

95129–7	5.15	5.95	2.00	10	left
95129–8	4.25	4.80	–	9	right

Remarks:

The present species was originally proposed by Yokoyama in 1923 based upon the specimens from the Pliocene deposits of Saishu (Cheju) Island, Korea, and its description is as follows:

"Shell small, rather thick, compressed, subequilateral. Anterior and posterior margins rounded, both passing without any angle into the broadly arcuate ventral margin; anterior dorsal nearly straight, posterior somewhat excavated. Surface ornamented with ten coarse, flatly rounded, radiating ribs separated by very narrow valleys. Beak pointed. Lunula present, though not very distinct, short. Hinge with an anterior lateral tooth. Height 5.4 mm. Breadth 5 mm. Depth 1.5 mm".

The specimens from the Omma Formation is characterized in the following way: Shell small, rather thick, moderately inflated, obliquely oblong in outline, inequilateral and nearly equivalve. Anterior dorsal margin long, slightly concave, and descending rather sharply into well rounded anterior dorsal end. Posterior dorsal margin slightly curved, nearly equal in length to anterior one, and gradually connected with its broadly rounded end. Ventral margin slightly arched. Surface sculptured with smooth, broad, rather low, and round-topped radial ribs 9 to 12 or 13 in number, and with ribs crossed by distinct concentric growth lines, about 10 in number and several fine growth lines. Interspaces between each rib shallow and become gradually indistinct from beak to ventral margin as radial ribs do. Beak pointed, conspicuously prosogyrated, and situated near the center of shell length. Hinge plate small and not heavy with distinct two cardinal teeth. Lunule slightly depressed, narrow and lanceolate in outline. Escatcheon rather large for shell size, cordate and well marked. Muscle scar small and oval in outline, and nearly equal in size. Inner surface of ventral margin distinctly crenulated.

Although the present species has been described under the genus *Venericardia*, this species can be separated from the genus *Venericardia* because of its peculiar form as mentioned above. So, the present species is referred to *Miodontiscus* Dall, 1903 depend upon the Treatise (Keen, 1939). According to Uozumi (1953), Itoigawa (1958) and Kaseno and Matsuura (1965), the present species was reported in subspecies of *prolongatus* (Carpenter), but the shape of the ribs of the present species distinctly differs from that of *prolongatus*, being fine riblets and not so distinct crossed by concentric growth lines.

The present species has been recorded in Pliocene to Recent in Japan and Korea, and geological distribution is as follow; Pliocene deposits of Saishu (Cheju) Island, South Korea; Omma Formation, Kanazawa City, Ishikawa Prefecture; Sawane Formation, Sado Island, and Nishiyama Formation in Niigata Prefecture, Setana Formation in Hokkaido.

Locality:

Loc. nos. KO–04, 22.
KK–03.
UK–02.

Family Ungulinidae

Genus *Cycladicama* Valenciennes, 1854

Cycladicama cumingi (Hanley, 1884)

Pl. 11, Fig. 17.

Cyrenoida Cumingi Hanley, 1844, Cat. Rec. Biv. Shells, p. 353, pl. 15, fig. 5. (*fide*, Lamy, 1920)
Joannisiella cumingi Hanley, Lamy, 1920, p. 383.

Diplodonta semiaspera Philippi, Yokoyama, 1922, p. 160, pl. 14, fig. 2; Nomura, 1932, p. 78.
Joannisiella cumingi (Hanley), Habe, 1951b, p. 124, text-figs. 258–259; Kaseno and Matsuura, 1965, pl. 11, fig. 8.
Cyclodicama cumingi (Hanley), Shikama and Masujima, 1969, pl. 7, fig. 15; Masuda and Shibata, 1971, pl. 4, fig. 3; Habe and Kosuge, 1970, p. 145, pl. 54, fig. 1; Kuroda, Habe and Oyama, 1971, p. 388, pl. 87, fig. 15.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L	Valve
95130–1	KK–52	30.20 mm	26.60 mm	9.0 mm	88.1%	right
95130–2	–	35.80	31.45	12.0	87.8	left
95130–3	–	28.00	24.40	–	87.1	left
95131–1	KK–46	33.20	27.50	9.20	81.8	right
95131–2	–	ca. 31.5	28.20	ca. 10.0	89.5	left
95131–3	–	26.2	25.20	17.90/2	96.2	conjoined
95131–4	–	29.25	25.50	17.40/2	87.2	conjoined

Locality:
Loc. nos. KK–46, 52.

Genus *Felaniella* Dall, 1899
Felaniella usta (Gould, 1861)

Pl. 11, Figs. 7, 18.

Mysis (*Felania*) *usta* Gould, 1861, Proc. Boston Soc. Nat. Hist., v. 13, p. 32 (*fide* Gould, 1862); Gould, 1862, Otia Conch., p. 170–171. (*fide* Yokoyama, 1920)
Diplodonta usta (Gould), Yamakawa, 1909, p. 14, figs. 1–10; Yokoyama, 1920, p. 130–131, pl. 9, figs. 14–16; Yokoyama, 1922, p. 159, pl. 13, fig. 3.
Diplodonta (*Felaniella*) *usta* (Gould), Kuroda, 1931, aprend. p. 49, pl. 5, fig. 27; Taki and Oyama, 1954, pl. 10, figs. 14–16; Oyama, 1973, p. 94, pl. 39, figs. 7–10.
Felaniella usta (Gould), Habe, 1951a, p. 124, text-figs. 256–257; Itoigawa, 1956, pl. 1, fig. 8; Kira, 1959, p. 132, pl. 52, fig. 31; Habe, 1960, p. 6, pl. 4, figs. 12–13; Takayasu, 1961, pl. 1, fig. 12; Hatai, Masuda and Suzuki, 1961, pl. 2, fig. 14; Sawada, 1962, p. 81, pl. 6, figs. 25–26; Kaseno and Matsuura, 1965, pl. 11, fig. 9; Kanno, Ohara and Kaiteya, 1968, pl. 1, fig. 7; Iwasaki, 1970, p. 401, pl. 4, fig. 5; Chinzei, 1973, pl. 14, fig. 4; Hayashi and Miura, 1973, pl. 2, figs. 9–10; Itoigawa, 1974, p. 75, pl. 19, fig. 4.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L	Valve
95132–1	KO–24	20.95 mm	19.60 mm	– mm	93.6%	left
95132–2	–	22.15	20.55	10.80/2	92.8	conjoined
95132–3	–	22.15	21.00	10.85/2	94.8	–
95132–4	–	22.55	21.00	–	93.1	–
95132–5	–	20.00	18.50	10.45/2	92.5	–
95132–6	–	20.60	18.40	10.90/2	89.3	–
95132–7	–	18.75	17.00	9.34/2	90.7	–
95132–8	–	18.40	17.85	9.80/2	97.0	–
95132–9	–	19.05	17.65	–	92.7	right
95132–10	–	17.25	16.10	7.95	93.3	conjoined
95132–11	–	15.65	14.95	–	95.5	left
95132–12	–	17.60	15.95	8.15/2	90.6	conjoined

95132–13	–	ca. 16.0	15.45	7.75/2	96.6	–
95132–14	–	16.40	15.30	–	93.3	left
95132–15	–	17.20	15.75	8.55/2	91.6	conjoined
95132–16	–	15.75	14.40	–	91.4	left
95132–17	KO–24	14.35	14.00	–	97.6	right
95132–18	–	16.00	14.85	7.65	92.8	conjoined
95132–19	–	13.55	12.00	6.20	88.6	–
95132–20	–	14.80	13.40	7.00	90.5	–
95132–21	–	15.00	14.00	–	93.3	left
95133–1	KK–16	23.00	21.50	–	93.5	–
95133–2	–	23.45	22.40	–	95.5	–
95133–3	–	27.00	25.50	–	94.4	–
95133–4	–	20.05	18.40	–	91.8	–
95133–5	–	35.85	33.65	–	93.9	–
95133–6	–	27.30	23.85	–	87.4	–
95133–7	–	16.40	15.25	–	93.0	–
95133–8	–	22.40	20.35	–	90.8	–
95133–9	–	17.45	16.60	–	95.1	–
95134	KO–32	20.35	19.30	10.20/2	94.8	conjoined
95135	KK–17	27.45	24.70	ca. 14.0/2	90.0	–

Locality:

Loc. nos. T–01.
KY–01, 02, 08, 09, 13, 14, 20, 22.
KO–04, 16, 19, 20, 23, 24, 25, 27, 28, 29, 30, 31, 32, 34, 35, 36.
KK–01, 04, 05, 06, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 28.
FM–01, 02, 03, 11, 15, 16, 17, 19, 25, 27, 28, 34.
RT –01, 02, 04.
RO–04, 12, 13, 14, 15, 16, 17, 18, 20.
IS –01, 09.
AW–01.

Family Lucinidae

Genus *Lucinoma* Dall, 1901

Lucinoma annulata (Reeve, 1850)

Pl. 11, Figs. 10, 14a–b.

Lucina annulata Reeve, 1850, v. 6, *Lucina*, pl. 4, fig. 17.

Lucinoma annulata (Reeve), Habe, 1951b, p. 129, figs. 277–278; Yamamoto and Habe, 1959, p. 90, pl. 6, figs. 24–25; Takayasu, 1961, pl. 1, fig. 16; Hatai, Masuda and Suzuki, 1961, pl. 1, figs. 23a–b; Kaseno and Matsuura, 1965, pl. 13, fig. 5; Iwasaki, 1970, p. 400, pl. 5, figs. 5–6; Shikama, 1973, pl. 17, fig. 11; Hayashi and Miura, 1973, pl. 2, fig. 2.

Lucinoma annulatum (Reeve), Oyama, 1960, *Lucinoma* (1), figs. 13–15; Sawada, 1962, p. 81, pl. 6, figs. 16–17.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	Valve
95136–1	KO–22	28.00 mm	26.95 mm	14.80/2 mm	conjoined
95137–1	KK–03	11.15	10.55	–	right
95137–2	–	17.10	15.50	6.70/2	conjoined
95137–3	–	16.90	15.50	3.40	right

Locality:
Loc. nos. KY–10.
KO–04, 22.
FM–06.
KK–03.

Family Cardiidae
Subfamily Protocardiinae Keen, 1951
Genus *Nemocardium* Keen, 1876
Subgenus *Keenaea* Habe, 1951
Nemocardium (*Keenaea*) *samarangae* (Makiyama, 1934)

Pl. 11, Figs. 11, 12.

Cardium modestum A. Adams et Reeve, Yokoyama, 1920, p. 128–129, pl. 9, figs. 12–13.
Cardium (*Nemocardium*) *samarangae* Makiyama, 1934, p. 143; Nomura and Zinbo, 1937, p. 162, pl. 22, fig. 6.
Cardium (*Nemocardium*) *modestum* Adams et Reeve, Nomura and Hatai, 1936, p. 125, pl. 16, fig. 10.
Nemocardium samarangae Makiyama, Hirayama, 1954a, p. 66, pl. 3, figs. 16–17.
Nemocardium (*Keenaea*) *samarangae* (Makiyama), Habe, 1951, p. 152, fig. 326; Shuto, 1960b, p. 214, pl. 25, figs. 1–6, 19, 23, 24; Kaseno and Matsuura, 1965, pl. 13, fig. 9.
Nemocardium samarangae (Makiyama), Takayasu, 1961, pl. 1, figs. 9–10b; Masuda and Takegawa, 1965, pl. 2, fig. 2; Ogasawara, 1973, pl. 12, fig. 15.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	Posterior ribs	Valve
95138–1	21.00 mm	18.55 mm	6.2 mm	88.3%	26+(3)	right
95138–2	21.00	19.20	6.5	91.4	29+(1)	right
95138–3	24.30	21.05	7.7	86.6	30+	left

Remarks:
The Omma specimens of the species have slightly lower shell in comparing with that of type and Shuto's specimens from the Miyazaki Group.

Locality:
Loc. nos. KK–03, 49, 51, 52.
FM–10.

Genus *Clinocardium* Keen, 1936
Clinocardium chikagawaense Kotaka, 1950

Pl. 11, Fig. 15.

Cardium shinjiense Yokoyama, Yokoyama, 1926d, p. 293, pl. 34, figs. 17–18.
Clinocardium chikagawaense Kotaka, 1950, p. 46–49, pl. 5, figs. 1–6; Iwai, 1960b, pl. 1, fig. 10; Hatai, Masuda and Suzuki, 1961, pl. 2, fig. 9; Kanno, 1962, pl. 5, fig. 6; Iwai, 1965, p. 38, pl. 17, figs. 18a–b, 20.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	No. of rad. ribs	Valve
95142	KK–42	56.60 mm	51.35 mm	ca. 16 mm	35+(1)	left
95143	IS–09	67.70	66.40	ca. 22	36+(1)	left

Remarks:

The present species is similar to *Clinocardium ciliatum* (Fabricius, 1870) in general shape of shell and roof-like radial ribs, about 35 in number, but the present one can be distinguished from *ciliatum* in having somewhat anteriorly situated beak, more sharply topped radial ribs, and thicker test.

After Kotaka's proposal of the present species from the Pliocene Hamada Formation, Aomori Prefecture, the species has been reported from Setana Formation of Hokkaido, Narusawa and Daishaka formations of Aomori Prefecture and Sawane Formation of Niigata Prefecture.

Locality:

Loc. nos. KK–42.
I S–09.

Clinocardium fastosum (Yokoyama, 1927)

Pl. 11, Figs. 16, 19.

Cardium fastosum Yokoyama, 1927a, p. 178, pl. 48, fig. 5.
Clinocardium fastosum (Yokoyama), Kaseno and Matsuura, 1965, pl. 13, fig. 11.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	No. of rad. ribs	Valve
95139–1	KO–04	ca. 75 mm	ca. 70 mm	ca. 19.5 mm	50+3	left
95139–2	–	89.0	86.4	ca. 26.0	50+2	left
95139–3	–	ca. 86.5	85.4	24.2	55±	right
95140	KK–03	27.8	24.1	7.6	50±	right
95141	KO–06	21.8	19.30	ca. 5.0	–	right

Remarks:

This species is characterized by large and thin shell, low and round topped radial ribs which are indistinct at posterior and anterior margins and about 55 in number.

The species was originally described by Yokoyama from the Omma Formation as follows: "Shell large, thin, inflated, roundly ovata in outline, oblique, somewhat longer than height. Radiately costate; costae rounded, separated by much narrower interstices, fifty to sixty in full grown specimens, crossed by a few periodic concentric ridges. Beaks small. Teeth comparatively small, with two teeth and an anterior and posterior lateral".

The present species is similer to *Clinocardium nuttallii* (Conrad, 1837), Recent species distributed mainly in the Northern Pacific, in general outline, but can be easily distinguished from the latter by having somewhat larger shell, larger number of rather smooth radial ribs, and well topped concentric ridges on shell surface.

Locality:

Loc. nos. T–01, 02.
KY–03, 05, 08, 11, 12, 17, 21, 22, 24.
KO–03, 04, 06, 08, 12, 17, 20, 32, 33, 35, 36.
KK–01, 03, 04, 05, 06, 10, 12, 13, 16, 20, 21, 23, 25, 26, 28, 29, 31, 33, 34, 38, 39, 40, 41.
FM–01, 03, 05, 06, 12, 13, 20, 21, 30,31, 32, 34, 38, 41.
RO–03, 04, 10, 15, 21.
I S–09.

AW–01, 02, 08, 09.
UK–02.

Family Veneridae
Genus *Callista* Poli, 1791
Subgenus *Callista* s.s.
Callista (Callista) chinensis (Holten, 1803)

Pl. 12, Fig. 5.

Venus chinensis Holten, 1803, Enum. Syst. Conchyl., p. 20. (*fide* Kuroda, Habe and Oyama, 1971)
Venus pacifica Dillwyn, 1817, Descrip. Cat., 1, p. 175. (*fide* Otuka, 1935)
Cytheraea sinensis Sowerby, 1855, v. 2, p. 624, pl. 131, figs. 80–81.
Dione chinensis Chemnitz, Reeve, 1864, v. 14, *Dione*, pl. 1, fig. 4.
Dione festiva Reeve, 1864, v. 14, *Dione*, pl. 1, fig. 2.
Cytherea chinensis Chemnitz, Pfeiffer *in* Martini and Chemnitz, 1869, v. 11, pt. 1, p. 31, pl. 11, fig. 2; Tokunaga, 1906, p. 46, pl. 3, figs. 4a–b.
Meretrix (Callista) chinensis (Chemnitz), Yokoyama, 1920, pl. 8, figs. 9–10; Yokoyama, 1922, p. 146, pl. 11, fig. 5.
Meretrix (Macrocallista) ezoensis (Yokoyama,) Yokoyama, 1928, p. 77, pl. 8, fig. 1.
Callista pacifica (Dillwyn), Otuka, 1935c, p. 895, pl. 56, fig. 181.
Callista(Callista) chinensis (Holten), Habe, 1951b, p. 164, text-figs. 372–373; Shuto, 1960, p. 131, pl. 13, fig. 2; Tanaka, 1961, p. 75, pl. 1, figs. 32–33; Hayasaka, 1961, p. 43–44, pl. 4, figs. 10a–b; Hayasaka, 1973, pl. 6, fig. 8.
Callista chinensis (Holten), Kira, 1959, p. 141, pl. 56, fig. 3; Kira, 1962, p. 157, pl. 57, fig. 3; Kaseno and Matsuura, 1965, pl. 14, fig. 2.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	Valve
95114	30.80 mm	20.95 mm	12.0/2 mm	68.0%	conjoined

Locality:
Loc. nos. KO–04, 22.
KK–03.

Genus *Pseudamiantis* Kuroda, 1933
Pseudamiantis tauyensis (Yokoyama, 1927)

Pl. 12, Fig. 1, Pl. 13, Figs. 1, 7, 8.

Meretrix tauyensis Yokoyama, 1927a, p. 178, pl. 48, figs. 1–2.
Pseudamiantis tauyensis (Yokoyama), Makiyama, 1959, pl. 59, figs. 1–2; Kaseno *et al.*, 1961, pl. 2, figs. 25, 32; Iwasaki, 1963, p. 91–101, pl. 14, figs. 1–5; Kaseno and Matsuura, 1965, pl. 16, figs. 1–3; Sakagami *et al.*, 1966, pl. 8, figs. 1a–c.
Saxidomus ezoensis Kanno, 1962, p. 60, pl. 5, figs. 7a–c.
Pseudamiantis sp. (n. sp. ?), Kaseno and Matsuura, 1965, pl. 16, fig. 4.

Measurements:

IGPS coll. cat. no.	Loc. Nos.	Length	Height	Width	H/L	Valve
95145–1	KO–28	78.45 mm	60.80 mm	23.00 mm	77.5%	left
95145–2	–	77.00	61.30	20.00	79.6	left
95145–3	–	74.65	60.30	22.30	80.8	left
95145–4	–	ca. 56	47.20	–	84.2	left
95145–5	–	48.00	39.40	–	82.1	right
95145–6	–	47.95	39.30	–	82.0	right

95145–7	–	55.25	47.00	17.40	85.1	left
95145–8	–	11.15	10.35	–	92.8	right
95146–1	KO–22	80.80	65.00	25.30	80.4	left
95146–2	–	71.05	56.55	20.25	79.6	right
95147–1	KO–16	ca. 72	ca. 60	–	83.3	left
95147–2	–	ca. 59	ca. 52	–	88.1	right
95148	KO–04	85.60	67.10	24.00	78.4	right
95149	KK–19	57.20	45.15	16.00	78.9	left
95150	KY–28	85.85	65.90	–	–	left

Remarks:

The present species was proposed by Yokoyama (1927) under the name of *Meretrix tauyensis* from the Omma Formation. Recently, Iwasaki (1963) has discussed about this genus and allied ones, and concluded that the occurrence of the genus *Pseudamiantis* is restricted in the Neogene. Up to date, the present species has only been known in the so-called "Omma-Manganzian" fauna distributed along the Japan Sea coast.

The ratio of height to length of shell is somewhat variable in the species, and ranges from 77.5% to 92.8% in the present specimens.

Kaseno and Matsuura's specimen (1965, pl. 16, fig. 4) indicates rather low shell outline, however, it seems to the writer their specimen could be a varietal form within the species.

All specimens were collected from medium grained sandstone of the Omma Formation in which they might have lived.

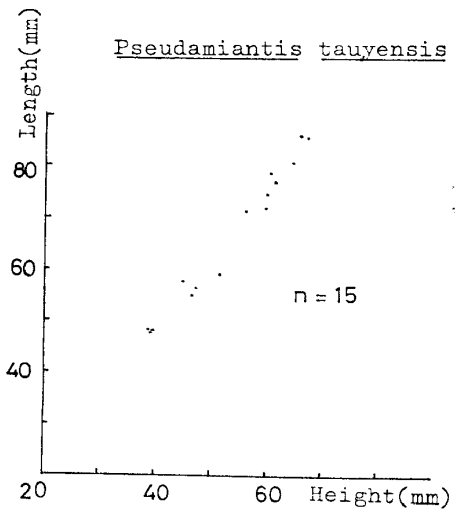


Fig. 15. Relationship of height to length of *Pseudamiantis tauyensis*

Locality:

Loc. nos. KY–05, 11.
KO–19, 28, 32.
KK–15, 16, 17, 18, 19, 20, 21.
RO–07, 08, 13.

Subfamily Dosiniinae
Genus *Dosinia* Scopoli, 1777
Subgenus *Phacosoma* Jukes-Browne, 1912
Dosinia (*Phacosoma*) *japonica* (Reeve, 1850)

Pl. 13, Figs. 2, 5, 6, Pl. 14, Fig. 1.

Artemis Japonica Reeve, 1850, *Artemis* sp. 17, pl. 3, fig. 17.
Dosinia troscheli Lischke, Yokoyama, 1920, p. 119, pl. 13, fig. 6; Yokoyama, 1926a, p. 133, pl. 16, fig. 16.
Dosinia (*Phacosoma*) n. sp., Taki and Oyama, 1954, p. 43, pl. 9, fig. 6.
Dosinia (*Phacosoma*) *japonica* (Reeve), Habe, 1951, p. 169, text-fig. 384; Kaseno and Matsuura, 1965, pl. 15, fig. 2.
Dosinia japonica (Reeve), Iwai, 1961, pl. 1, figs. 7a–c; Iwai, 1965, p. 41, pl. 18, figs. 5a–6.
Dosinia japonica Reeve, Sakagami *et al.*, 1966, pl. 4, figs. 4a–b.

Dosinia cf. *japonica* (Reeve), Chinzei, 1961, p. 113, pl. 3, fig. 8 (?).

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L
95151–1	KK–03	57.65 mm	57.30 mm	29.70 2/mm	99.4%
95151–2	–	57.35	57.15	ca. 29.0/2	99.6
95151–3	–	65.50	62.45	34.15/2	95.3
95151–4	–	50.00	50.25	26.40/2	100.5
95151–5	–	68.85	65.50	33.50/2	95.1
95151–6	–	55.00	52.60	–	95.6
95151–7	–	63.30	61.10	–	96.5
95152	KK–24	61.55	59.15	17.00	96.1
95153	KO–15	71.80	71.95	–	100.2

Remarks:

The fossil form of the present species is commonly found in the sediments of medium grained sandstones, and rarely found in the coarse or fine grained sandstones.

Locality:

Loc. nos. KY–01, 02, 21, 24.
KO–04, 15, 17, 18, 20, 29, 34.
KK–03, 12, 24, 25, 41, 46.
FM–03.
RO–04.
AW–04.

Subfamily Chioninae

Genus *Mercenaria* Schumacher, 1817

Mercenaria stimpsoni (Gould, 1861)

Pl. 12, Figs. 3a–b, 8, Pl. 14, Fig. 9.

Venus stimpsoni Gould, Tokunaga, 1906, p. 46; Makiyama, 1927, p. 47.

Venus (*Mercenaria*) *stimpsoni* Gould, 1861, Proc. Boston Soc. Nat. Hist., v. 8, p. 30; Gould, 1862, p. 169; Yokoyama, 1922, p. 148, pl. 11, figs. 11–12.

Mercenaria stimpsoni (Gould), Habe, 1951, p. 171–172, text-figs. 387–388; Ozaki, 1958, p. 129, pl. 20, fig. 6; Shuto, 1960, p. 144, pl. 13, fig. 9, text-fig. 12; Iwai, 1961, pl. 1, fig. 8; Chinzei, 1961, p. 115, pl. 2, figs. 5–6, pl. 3, fig. 5; Iwai, 1965, p. 42, pl. 18, fig. 11; Kaseno and Matsuura, 1965, pl. 14, figs. 3–4; Chinzei, 1973, pl. 14, fig. 5.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L	Valve
95154–1	KO–04	65.30 mm	57.30 mm	– mm	87.7%	rigth
95154–2	–	ca. 82	ca. 70	–	85.4	–
95155	KK–03	67.30	57.55	16.00	85.5	left
95156–1	KO–28	ca. 73	62.00	84.9	–	left
95156–2	–	100.50	82.90	22.20	82.5	left

Remarks:

The present species is found rather commonly in the Omma Formation, mainly from coarse grained or medium grained sandstones. The largest one is of more than 100 mm in length.

Locality:

Loc. nos. KY–02, 14, 23, 24.
KO–04, 17, 18, 19, 20, 23, 24, 27, 28, 29, 35, 36.
KK–03, 04, 13, 22, 24.
FM–02, 04, 14, 15, 18, 25, 26, 28, 34, 37.
RT–01, 04.
RO–07, 08, 16.

Genus *Callithaca* Dall, 1902
Subgenus *Protocallithaca* Nomura, 1937
Callithaca (*Protocallithaca*) *adamsi* (Reeve, 1850)

Pl. 12, Fig. 2.

Venus adamsi Reeve, 1850, v. 14, pl. 17, fig. 77.
Venus rigida Gould, Yokoyama, 1927a, p. 430, pl. 50, figs. 3, 4; Matsumoto, 1930, p. 96, pl. 39, fig. 3.
Protocallithaca adamsi (Reeve), Nomura, 1937, p. 10, pl. 3, figs. 4a-b.
Callithaca adamsi (Reeve), Habe, 1951, p. 180, text-figs. 391–392; Hatai, Masuda and Suzuki, 1961, pl. 2, fig. 11; Sakagami *et al.*, 1966, pl. 7, fig. 5.
Protothaca adamsi (Reeve), Taki *in* Hirase, 1951, pl. 41, fig. 2.
Protothaca (*Callithaca*) *adamsi* (Reeve), Taki and Oyama, 1954, p. 44, pl. 47, figs. 3–4; Ozaki, 1958, p. 129, pl. 22, fig. 1; Chinzei, 1961, p. 117, pl. 1, fig. 8; Oyama, 1973, p. 104–105, pl. 47, figs. 10–11.
Callithaca (*Protocallithaca*) *adamsi* (Reeve), Habe, 1955, p. 14, pl. 5, figs. 1–2; Kira, 1959, p. 143, pl. 56, fig. 19; Yamamoto and Habe, 1959, p. 98, pl. 7, fig. 16; Habe, 1960, p. 8, pl. 2, figs. 5–6; Sawada, 1962, p. 85, pl. 5, figs. 1–2; Kaseno and Matsuura, 1965, pl. 15, figs. 3–4.
Callithaca (*Protocallithaca*) *adamsi* (Reeve) var., Kaseno and Matsuura, 1965, pl. 15, fig. 5. (?)
Callithaca (*Protocallithaca*) *adamsi* Reeve, Noda, 1973, pl. 4, fig. 6.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L	Valve
95157	KK–24	61.45 mm	55.70 mm	16.0 mm	90.6%	left

Remarks:

This species is rare in the Omma Formation, but is one of the important elements of the Omma fauna found in the coarse sedimentary facies of the Formation.

Locality:

Loc. nos. KY–01.
KK–24.
FM–22, 23, 24, 26.

Subfamily Tapetinae
Genus *Paphia* Röding, 1798
Paphia amabilis (Philippi, 1847)

Pl. 14, Fig. 8.

Venus amabilis Philippi, 1847, Zeitscher, f. Malak., p. 90; Phillipi, 1849, Abbild. Beschr. Conchyl., 3, p. 75, fig. 2 (*non vide*).
Tapes amabilis (Philippi), Lischke, 1874, Jap. Meer. Conchyol., 3, p. 82, pl. 6, figs. 5–7.
Paphia amabilis (Philippi), Kira, 1962, p. 162, pl. 57, fig. 28; Kaseno and Matsuura, 1965, pl. 15, fig. 6; Habe and Kosuge, 1970, p. 150, pl. 56, fig. 16; Kuroda, Habe and Oyama, 1971, p. 424, pl. 92, fig. 1.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L	Valve
95158	KK–52	60.15 mm	36.35 mm	26.65/2 mm	60.4	conjoined
95159	RT–02	ca. 61.4	ca. 37.2	ca. 21.5/2	60.6	–

Remarks:

The present form is very similar to *Paphia naganumana* Otuka (1937), in its shell outline and surface sculptures. But *naganumana* can be distinguished from *amabilis* by having finer concentric growth lines than those of *amabilis*. The present form resembles also *Paphia takanabensis* Shuto (1957), proposed from the Takanabe Formation, Miyazaki Group, Miyazaki Prefecture in general outlines and fine concentric sculptures, but the former can be discriminated from the latter in having more large and low shell.

Locality:

Loc. nos. KK–52.
RT–02.

Family Mactridae
Genus *Spisula* Gray, 1837
Subgenus *Mactromeris* Conrad, 1868
Spisula (*Mactromeris*) *voyi* (Gabb, 1869)

Pl. 16, Figs. 7a, 7b.

Spisula voyi Gabb, Oldroyd, 1924, p. 193, pl. 23, figs. 1–2, Takeda, 1953, pl. 13, fig. 10.
Mactra (*Spisula*) *polynyma* Stimpson var *voyi* (Gabb), Grant and Gale, 1931, v. 1, p. 395.
Spisula (*Mactromeris*) *polynyma alaskana* Dall, Kuroda, 1931, p. 8, figs. 50–51.
Spisula (*Mactromeris*) *voyi* (Gabb), Nomura and Hatai, 1937, p. 139, pl. 20, fig. 8; Habe, 1951, p. 195, text-fig. 458; Habe, 1955, p. 15, pl. 2, fig. 8; Kanno, 1960, p. 293, pl. 43, fig. 4; Chinzei, 1961, p. 120, text-fig. 8; Kaseno and Matsuura, 1965, pl. 17, fig. 3; Kira, 1971, p. 151, pl. 58, fig. 13.
Spisula voyi (Gabb), Masuda and Takeyama, 1965, pl. 2, figs. 8a–b.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	Valve
95161–1	91.2 mm	63.0 mm	ca. 18.0 mm	61.9%	conjoined

Locality:

Loc. no. KO–04.

Family Tellinidae
Subfamily Macominae
Genus *Macoma* Leach, 1819
Macoma nipponica (Tokunaga, 1906)

Pl. 14, Figs. 4.

Tellina nipponica Tokunaga, 1906, p. 44–45, pl. 2, figs. 36, 36a.
Macoma (*Macoma*) *nipponica* (Tokunaga), Habe, 1952a, p. 220.
Macoma nipponica (Tokunaga), Taki and Oyama, 1954, pl. 9, figs. 3–4; Kaseno and Matsuura, 1965 pl. 17, fig. 12; Habe, 1970, p. 138, pl. 62, fig. 21.
Macoma (*Psammacoma*) *nipponica* Tokunaga, Ozaki, 1958, p. 133, pl. 22, fig. 4.
Macoma nipponica Tokunaga, Kuroda, Habe and Oyama, 1971, p. 458, pl. 99, fig. 4.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L	Valve
95162–1	IS–09	17.05 mm	11.80 mm	2.3 mm	69.2%	left
95162–2	–	18.30	12.75	–	69.7	left
95162–3	–	15.40	11.40	–	74.0	left
95162–4	–	17.40	12.60	–	72.4	right

Locality:

Loc. no. IS–09.

Macoma praetexta (v. Martens, 1865)

Pl. 14, Figs. 13a–b, Pl. 15, Figs. 2, 7.

Tellina praetexta Martens, 1865, Ann. Mag. Nat. Hist., 3rd Ser., v. 16, p. 430 (*non vide*); Lischke, 1871, p. 113, pl. 10, fig. 14.

Macoma praetexta (Martens), Yokoyama, 1922, p. 142, pl. 10, figs. 2–3; Taki *in* Hirase, 1954, pl. 45, fig. 2.

Macoma (*Macoma*) *praetexta* (v. Martens), Habe, 1952a, p. 220; Hayasaka, 1961, p. 58–59, pl. 7, figs. 10a–b; Noda, 1971, p. 457, pl. 99, fig. 10.

Macoma praetexta (v. Martens), Kira, 1963, p. 155, pl. 59, fig. 16; Kaseno and Matsuura, 1965, pl. 18, fig. 5; Habe and Kosuge, 1967, p. 163, pl. 61, fig. 23; Kira, 1971, p. 155, pl. 59, fig. 16; Kuroda, Habe and Oyama, 1971, p. 457, pl. 99, fig. 10.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	Valve
95163–1	28.60 mm	20.30 mm	8.6 mm/2	71.0%	conjoined
95163–2	20.65	14.55	2.8	70.5	left
95163–3	20.75	15.15	ca. 4.0	73.0	right
95163–4	13.10	9.45	2.2	72.1	left
95163–5	11.50	8.30	2.0	72.2	right

Remarks:

The specimens of *praetexta* from the Omma Formation have slightly higher shell, rather well rounded on its anterior dorsal end in comparing with the Recent specimens.

Locality:

Loc. nos. KK–03, 08, 32, 42.

Macoma tokyoensis Makiyama, 1927

Pl. 14, Fig. 12.

Tellina (*Macoma*) *dissimilis* Martens, *in* Martini and Chemnitz, 1888, v. 10, pt. 4, p. 232, pl. 44, figs. 12–14.

Macoma nasuta Conrad, Tokunaga, 1906, p. 45, pl. 3, figs. 2a–b.

Macoma dissimilis (Martens), Yokoyama, 1922, p. 143, pl. 10, fig. 4; Yokoyama, 1925c, p. 20, pl. 5, fig. 9; Yokoyama, 1925d, p. 9, pl. 1, fig. 19; Yokoyama, 1926a, p. 133, pl. 16, fig. 4; Yokoyama, 1926c, p. 221, pl. 28, fig. 10.

Macoma tokyoensis Makiyama, 1927, p. 50; Nomura, 1935a, p. 88, pl. 4, fig. 12; Taki *in* Hirase, 1951, pl. 45, fig. 1; Ozaki, Fukuta and Ando, 1954, p. 173, pl. 32, fig. 44; Shikama, 1954, pl. 5, fig. 8; Kira, 1955, pl. 59, fig. 19; Makiyama, 1957, pl. 20, fig. 9, pl. 22, fig. 19; Makiyama, 1958, pl. 34, fig. 4, pl. 39, fig. 10; Ozaki, 1958, p. 133, pl. 23, fig. 5; Yamamoto and Habe, 1959, p. 104, pl. 14, figs. 9–11; Kira, 1959, p. 155, pl. 59, fig. 19; Araki, 1960, p. 99, pl. 7, figs. 9a–b; Takayasu, 1961, pl. 1, fig. 14; Yamada, 1963, fig. 10; Itoigawa, 1964, pl. 1, fig. 8; Habe and Ito, 1965, p. 149, pl. 51, figs. 15–16; Hase, 1967, pl. 1, figs. 4, 4a, 8, 8a; Matsushima, 1969, pl. 11, fig. 8; Habe and Kosuge, 1970, p. 163–164, pl. 61, fig. 26;

Nagasawa, 1972, pl. 1, figs. 5–6; Zinbo, 1973, pl. 14, fig. 6; Itoigawa and Ogawa, 1973, pl. 5, fig. 12.

Macoma (*Macoma*) *tokyoensis* Makiyama, Habe, 1952, p. 220; Itoigawa, 1958b, pl. 2, fig. 3; Sawada, 1962, p. 87, pl. 7, figs. 22–23.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	Valve
95164	32.70 mm	23.00 mm	ca. 4.5 mm	70.3%	left

Locality:

Loc. nos. KO–25, 29.

Gneus *Rexithaerus* Tryon 1869
Rexithaerus sectior (Oyama, 1950)

Pl. 14, Figs. 5a–b, 7.

Macoma secta Conrad, Yokoyama, 1922, p. 143–144, pl. 10, fig. 1.

Macoma (*Rexithaerus*) *sectior* Oyama, 1950, p. 227; Habe, 1952, p. 220, text-figs. 566–567; Yamamoto & Habe, 1959, p. 106, pl. 9, figs. 1–2; Kira, 1962, p. 175, pl. 61, fig. 26; Kaseno and Matsuura, 1965, pl. 17, figs. 10–11; Habe and Kosuge, 1970, p. 163, pl. 61, fig. 24.

Rexithaerus sectior (Oyama), Kuroda, Habe and Oyama, 1971, p. 458–459, pl. 100, fig. 5; Oyama, 1973, p. 113, pl. 52, fig. 14.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L	Valve
95165–1	KK–03	39.90 mm	27.00 mm	ca. 6.5 mm	67.7%	right
95165–2	–	44.30	33.80	–	76.3	right
95165–3	–	39.85	29.45	12.30/2	73.9	conjoined
95165–4	–	45.25	31.70	13.40/2	70.1	–
95165–5	–	41.65	28.80	10.50/2	69.1	–
95165–6	–	43.00	31.70	12.35/2	73.7	–
95165–7	–	38.25	27.40	–	71.6	left
95165–8	–	40.15	28.00	–	69.7	left
95165–9	–	42.40	31.30	–	73.8	right
95165–10	–	34.00	22.65	9.40/2	66.7	conjoined
95165–11	–	33.00	23.00	ca. 9.0/2	69.7	–
95165–12	–	41.00	31.45	–	76.7	right
95165–13	–	35.30	25.00	ca. 10.0/2	70.8	conjoined
95165–14	–	41.00	27.75	–	66.5	right
95165–15	–	45.85	30.50	11.40/2	66.5	conjoined
95165–16	–	30.00	21.35	8.90/2	71.2	–
95165–17	–	39.00	27.85	–	71.4	–
95165–18	–	44.55	31.65	–	71.0	–
95165–19	–	29 (ca.)	19.0 (ca).	–	65.5	–
95165–20	–	42.00	29.20	14.00/2	69.5	conjoined
95165–21	–	40.75	27.80	12.00/2	68.2	–
95165–22	–	39.00	25.65	11.50/2	65.8	–
95165–23	–	42.65	30.45	13.00/2	71.4	–
95165–24	–	35.0 (ca.)	24.20	9.40/2	69.1	–
95165–25	–	37.75	26.20	–	69.4	–
95165–26	–	45.15	31.45	13.35/2	69.7	conjoined
95165–27	–	44.00	29.70	12.85/2	67.5	conjoined

95165–28	–	28.90	19.75	–	68.3	–
95165–29	–	40.50	27.6 (ca.)	12.95/2	68.1	conjoined
95165–30	–	33.50	23.4	9.25/2	70.0	–
95165–31	–	35.00	25.25	11.00/2	72.1	–
95165–32	–	28.0 (ca.)	19.0 (ca.)	–	67.9	–
95165–33	–	23.55	17.45	–	74.1	–
95165–34	–	39.0 (ca.)	26.0 (ca.)	–	66.7	–
95165–35	–	20.0 (ca.)	15.0 (ca.)	–	75.0	–
95166–1	KO–04	37.85	26.15	–	69.1	left
95166–2	–	41.20	28.25	–	68.6	left
95166–3	–	35.3 (ca.)	26.0 (ca.)	–	73.7	conjoined
95166–4	–	38.80	28.0	–	72.2	right
95166–5	–	32.85	24.20	–	73.7	conjoined
95167–1	KK–25	33.00	24.35	10.50/2	73.8	–
95167–2	–	27.80	20.0	–	71.9	right
95168	UK–04	34.00	23.10	ca. 4.0	67.9	left

Locality:

Loc. nos. KO–03, 04, 10, 12, 22, 36.
KK–02, 03, 06, 22, 24, 25.
FM–12, 16, 17, 21, 27.
RO–16, 19, 21.
UK–04.

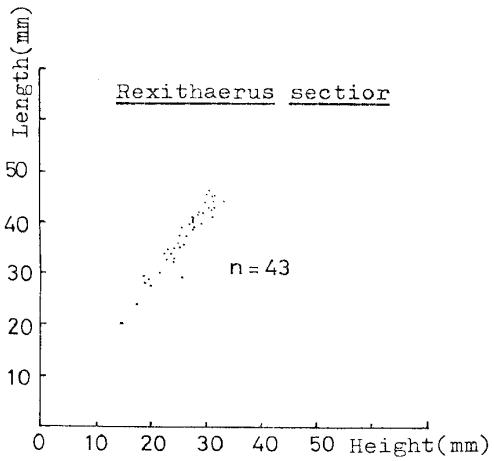


Fig. 16. Relation of height to length of *Rexithaerus sectior*

Genus *Heteromacoma* Habe, 1952

Heteromacoma irus (Hanley, 1845)

Pl. 15, Figs. 1a–b, 3, 5.

Tellina irus Hanley, 1845, Proc. Zool. Soc. London (1844), p. 166; Sowerby, 1868, *Tellina* sp., 229; Pilsbry, 1934, p. 85, pl. 12, figs. 7–8 (*non vide*).
Fragilia yantaiensis Crosse et Debeaux, 1863, Jour. de Conchyl., 11, p. 75, 255, pl. 9, fig. 2 (*non vide*).
Tellina yantaiensis (Crosse et Debeaux), Sowerby, 1868, *Tellina* sp., 295.
Lucina corrugata Dunker, 1882, Index Moll. Mar. Japon., p. 216, pl. 8, figs. 9–11.
Heteromacoma irus (Hanley), Habe, 1952, p. 218–219, text-figs. 542–543; Kira, 1962, p. 172, pl. 60, fig. 22; Habe and Ito, 1965, p. 149, pl. 51, figs. 13, 14; Habe and Kosuge, 1970, p. 163, pl. 61, fig. 25; Kira, 1971, p. 156, pl. 59, fig. 22; Kuroda, Habe and Oyama, 1971, p. 456–457, pl. 100, fig. 10.
Sinomacoma yantaiensis (Crosse et Debeaux), Yamamoto and Habe, 1959, p. 102–103, pl. 9, figs. 4–5.
Heteromacoma yantaiensis (Crosse et Debeaux), Kaseno and Matsuura, 1965, pl. 18, fig. 1.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	Valve
95169–1	49.50 mm	39.30 mm	10.90 mm	79.4%	left

95169–2	35.15	28.70	ca. 7.0	81.7	left
95169–3	39.05	30.90	ca. 7.5	79.1	right

Locality:
Loc. nos. UK–04.
RO–14.

Genus *Peronidia* Dall, 1900

Peronidia zyonoensis (Hatai and Nisiyama, 1939)

Pl. 14, Figs. 10a–b, Pl. 16, Figs. 1, 4.

Tellina venulosa zyonoensis Hatai and Nisiyama, 1939, p. 150, pl. 9, fig. 3.
Peronidia zyonoensis (Hatai and Nisiyama), Habe and Ito, 1965, p. 143, pl. 49, fig. 3; Habe, 1970, p. 138, pl. 62, fig. 20.
Peronidia lutea (Wood), Kaseno and Matsuura, 1965, pl. 18, fig. 6.

Measurements:

IGPS coll. cat. Number	Loc. no.	Length (in mm)	Height (in mm)	Width (in mm)	H/L (%)	Valve
95304–1	KK–03	85.00	50.00	11.3	58.8	left
95304–2	–	89.60	51.75	ca. 11.0	57.8	left
95304–4	–	ca. 84	51.20	–	61.0	–
95416–1	KO–28	71.80	41.55	–	57.9	–
–2	–	76.25	46.85	–	61.4	–
–3	–	75.05	45.00	–	68.0	–
–4	–	82.25	48.75	–	59.3	–
–5	–	80.75	49.00	–	60.7	–
95308–1	KK–21	88.80	48.90	17.9/2	55.1	conjoined
–2	KO–04	96.50	51.40	11.8	53.3	right
95417	–	86.30	47.20	11.9	54.7	right
–	KO–16	86.65	51.45	–	59.4	–
–	KO–34	93.85	56.45	25.0/2	60.1	conjoined
–	–	87.10	50.40	21.85/2	57.9	conjoined
–	KO–30	82.40	48.40	–	58.7	–
95304–3	KO–04	80.75	47.70	–	59.1	–
–	KO–31	78.20	46.45	–	59.4	–
–	KO–31	81.40	47.65	9.0	58.5	–
–	KK–19	78.70	43.90	–	55.8	–

Remarks:

The original description of the species is as follow; Shell resembling *Tellina venulosa* Schrenck, a common living and fossil species of Japan, but differs in the outline of the shell and length in regard to height; the important feature as follows: Shell measuring 67 mm. in length and 35.5 mm. in height, transversely elongate ovoid in shape, ventral margin straight, roundly angulate posteriorly, truncately angulate anteriorly; beak nearly central, antero-dorsal border straight postero-dorsal border arched shell very flat, compressed; surface with concentric growth lines which are strong and foliate in appearance.

The present forms from the Omma Formation are closely allied to *Peronidia zyonoensis* as described above.

The present species resembles *Peronidia lutea* (Wood) in general outline of shell, but the present one can be distinguished from the latter in having strongly sculptured rather coarse concentric growth lines and somewhat thick test.

Locality:

Loc. nos. KY–04, 06, 09, 13, 14, 20, 21, 22.
KO–04, 08, 15, 16, 18, 19, 20, 23, 24, 25, 27, 28, 29, 30, 31, 32, 34, 36.
KK–01, 02, 03, 05, 14, 15, 16, 17, 18, 19, 20, 21, 24, 25, 28, 31, 34, 42.
FM–01, 02, 06, 21, 37.

Genus *Fabulina* Gray, 1851

Fabulina nitidula (Dunker, 1860)

Pl. 14, Figs. 2, 3.

Tellina nitidula Dunker, 1860, Malacog. Bl., Bd. 6 (1859), p. 236 (*fide* Yokoyama, 1920); Dunker, 1861, p. 27, pl. 3, fig. 14; Yokoyama, 1920, p. 112–113, pl. 7, figs. 15a–b; Yokoyama, 1922, p. 139–140, pl. 8, fig. 11.

Fabulina nitidula (Dunker), Kira, 1954, pl. 60, fig. 7; Yamamoto et Habe, 1959, p. 107, pl. 9, fig. 14; Hatai, Masuda and Suzuki, 1961, pl. 1, fig. 25; Kira, 1962, p. 173, pl. 61, fig. 7; Habe, 1951, p. 223, text-figs. 556–557; Kaseno and Matsuura, 1965, pl. 18, fig. 25.

Nitidotellina nitidula (Dunker), Kuroda, Habe and Oyama, 1971, p. 453, pl. 99, fig. 13.

Fabulina (*Fabulina*) *nitidula* (Dunker), Oyama, 1973, p. 113, pl. 53, figs. 5, 10.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L	Valve
95170–1	KK–03	19.75 mm	12.00 mm	ca. 2.0 mm	60.8%	left
95170–2	–	22.00	14.00	–	63.6	right
95170–3	–	17.35	11.30	–	65.1	right
95170–4	–	14.90	9.35	–	62.8	left
95170–5	–	14.80	9.15	–	61.8	right
95170–5	–	14.80	9.15	–	61.8	right
95170–6	–	17.85	11.00	–	61.6	left
95170–7	–	ca. 22.0	12.25	–	55.7	right
95170–8	–	15.10	9.60	–	63.6	right
95170–9	–	11.75	7.10	–	60.4	left
95170–10	–	11.65	7.00	–	60.1	left
95170–11	–	11.00	6.60	–	60.0	right
95170–12	–	10.60	6.40	–	60.4	right
95170–13	–	ca. 15	8+	–	–	right
95171	FM–06	19.70	12.20	ca. 2.0	–	left

Locality:

Loc. no. KK–03.
FM–06.

Genus *Nipponopagia* Ogasawara n. gen.

Type species: *Nipponopagia ommaensis* Ogasawara, n. sp.

Diagnosis:

Shell moderate, thick, subtrigonal in outline, slightly inflated, nearly inequivalve and inequilateral. Posterior dorsal margin slightly longer than that of anterior, and weakly bend to right valve at its end. On the posterior shoulder conspicuously angled fold is observed on each valve. Sculpture consists of only concentric striae. Umbo is not prominent, obliqued and prosogyrated. Long and stout ligament is situated in a depressed ligamental groove. Two cardinals of each valve are small for shell size. Adductor muscle

scars are large, anterior scar is larger than posterior one. Pallial sinus is discrepant in two valves, and moderate for shell size, weakly ascending in right valve.

Comparison and Affinity:

The present new genus somewhat resembles *Arcopella*, the subgenus of *Arcopagia* according to Afsher (1969) in the shape of pallial sinus and sculpture on the shell surface, but it can be distinguished from the latter in having only one strong lateral tooth or flexture.

The genus *Heteromacoma* is one of the allied genus to the present new one, but the latter differs from the former in having anteriorly elongated shell outline, while *Heteromacoama* is slightly elongated posteriorly. The genus *Semele* is also allied to the present new genus in its thick shell and general outline of shell, but can be distinguished from it, because the genus *Semele* is characterized by concentric and radial striae. The present genus also resembles the genus *Macalina* in shell form, but the former is distinguished from the latter in having more prominant beak, not so orbicular shell outline, somewhat larger shell size, without radial striae and rather small pallial sinus in each valve. The new genus is also similar to *Macoma* in its shell outline, but the former differs from *Macoma* in having a strong lateral tooth on the posterior corner of shell surface and slightly higher shell.

Nipponopagia ommaensis Ogasawara n. sp.

Pl. 15, Figs. 4, 6a–b, 8a–b, Pl. 16, Fig. 3.

Description:

Shell moderately large, thick, sub-trigonal in outline, slightly inflated, nearly inequivalve and inequilateral. Anterior dorsal margin slightly convexed and connected with broadly rounded at its end. Posterior dorsal margin nearly straight and longer than anterior one, and decending into narrowly rounded posterior end.

Ventral margin slightly arched. Surface sculpture consists of fine concentric striae, alternately coarse and fine. Conspicuous flexure forms posterior shoulder of shell surface. Umbo not prominant, oblique and prosogyrated. Two cardinal teeth with stout and solid hinge plate rather small for shell size. Adductor muscle scras rather large, anterior one is elongate and somewhat larger than the posterior one. Short tongue-like pallial sinus of the right valve is rather small compared with one on left valve which is slightly ascending. Ventral margin smooth.

Measurements:

IGPS coll. cat. no.	Length	Height	Width	H/L	W/L	Valve
95072 (Holotype)	61.40 mm	56.85 mm	11.10 mm	92.6%	18.1%	right
95073–1 (Paratype)	61.50	58.20	12.25	94.6	19.9	left
95073–2 (Paratype)	63.10	58.95	11.35	93.4	18.0	right

Comparison and Affinity:

The present species is characterized by thick shell, slightly elongated anteriorly in shell outline, small and descrepant pallial sainus. The present one resembles *Heteromacoma irus* (Hanley) in thick shell and general outline, but the former differs from the latter in having flexture which running from beak to posterior corner, while *H. irus* is characterized by the existence of anterior flexture. This one is also similar to *Arcopagia* (*Macomona*) *liliana* (Iredale) illustrated by Afshar (1969, Pl. 21, Figs. 6–10) in general shape of shell, but the present new species can be distinguished from the latter in having poorly developed depressed area of posterior, small and remarkably discrepant pallial sinus.

The present new species is very unique among Tellinidae, in having thick test and sharply pointed beak.

Locality:

Loc. nos. KO–22. (type locality)
RO–17.

Family Solenidae

Genus *Siliqua* Megerle von Mühlfeldt, 1811

Siliqua cf. *alta* (Broderip and Sowerby, 1829)

Compared with:

Siliqua alta (Broderip et Sowerby), Habe, 1952, p. 230, text-figs. 583–585.
Siliqua alta (Broderip and Sowerby), Kaseno and Matsuura, 1965, pl. 18, fig. 8.

Remarks:

Three imperfect specimens are collected from medium grained sandstone of Omma Formation. The present species is characterized by strong ridge running from beak to ventral margin on inner surface, and small two lateral teeth. The specimens of the genus *Siliqua* from the Omma Formation are similar to *Siliqua alta* (Broderip and Sowerby, 1829) judging from its shell outline which is higher than that of *Siliqua pulchella* (Dunker, 1852). According to Habe and Ito (1965), *Cultellus costatus* Sowerby, 1874, *Siliqua intuspnrpurea* Pilsbery, 1905 and *Machaera sodalis* Gould are synonyms of the present species. The writer agrees with the classification of Habe and Ito.

Locality:

Loc. no. KK–03.

Repository:

IGPS coll. cat. no. 95172.

Genus *Solen* Linné, 1758

Subgenus *Solenarius* Dumeril, 1806

Solen (*Solenarius*) *krusensterni* Schrenck, 1867

Pl. 17, Figs. 14a, 14b.

Solen krusensternii Schrenck, Reis. u. Forsch. Amur-Lande, Bd. 2, p. 594–595, pl. 25, figs. 9–12 (*fide* Yokoyama, 1922); Tokonaga, 1906, p. 36, pl. 2, fig. 19; Yokoyama, 1922, p. 134–135, pl. 9, fig. 5; Kaseno et Masuura, 1965, pl. 18, fig. 9.
Solen krusensterni Schrenck, Kinoshita and Isahaya, 1934, p. 17, pl. 14, fig. 99; Taki and Oyama, 1954, pl. 29, fig. 5; Habe, 1955, p. 20, pl. 6, figs. 1–2; Chinzei, 1961, p. 124, pl. 3, fig. 4; Noda, 1973, pl. 4, fig. 13.
Solen stricta Gould, Habe, 1952, p. 232, figs. 594–595.
Solen bausensterni Habe, 1964, p. 14, pl. 1, fig. 1.
Solen (*Solenarius*) *krusensterni* Schrenck, Yamamoto and Habe, 1959, p. 109, pl. 11, fig. 7; Kira, 1962, p. 177, pl. 62, fig. 3; Kuroda, Habe and Oyama, 1971, p. 460, pl. 101, fig. 5.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L	Valve
95173–1	KK–03	82.7 mm	18.2 mm	ca. 11.0mm/2	22.0%	conjoined
95173–2	–	ca. 93.0	19.4	ca. 3.5	20.9	conjoined

Locality:

Loc. nos. KO–03, 04.

KK–03, 23, 24, 25, 32.
FM–9.

Family Hiatellidea
Genus *Panope* Menard, 1807
Panope japonica A. Adams, 1849

Pl. 17, Fig. 10.

Panope japonica A. Adams, 1849, Proc. Zool. Soc., p. 170, pl. 6, fig. 5 (*fide in* Nomura and Hatai, 1935); Kuroda, 1931, p. 65, pl. 8, fig. 56; Nomura and Hatai, 1935, p. 20, pl. 1, figs. 2a–b; Kanno, 1960, p. 312, pl. 45, figs. 1a–b (?); Kaseno and Matsuura, 1965, pl. 18, fig. 14.
Panope generosa (Gould), Yokoyama, 1922, p. 121, pl. 6, figs. 14–15; Yokoyama, 1925a, p. 16, pl. 6, fig. 6.
Panopea japonica A. Adams, Iwasaki, 1970c, p. 411, pl. 1, fig. 18; Oyama, 1973, p. 115, pl. 55, figs. 11, 14.

Measurements:

IGPS coll. cat. no.	Loc. no.	Length	Height	Width	H/L	Valve
95174–1	KK–03	110.0 mm	77.0 mm	ca. 21 mm	0.70	right
95174–2	–	107.6	68.3	41.0/2	0.63	left

Locality:
Loc. nos. KO–12.
KK–03, 23.
FM–04.
RO–12.

Family Myidae
Genus *Mya* Linné, 1758
Subgenus *Mya* s.s.
Mya (*Mya*) cf. *japonica* Jay, 1857

Pl. 17, Figs. 9a–b.

Compared with:
Mya japonica Jay, 1857, p. 293, pl. 1, fig. 7 (*non vide*); Iwai, 1961, pl. 1, fig. 11.

Remarks:
Although imperfect specimens were examined, the present form from the Omma Formation is rather well allied to *Mya japonica* Jay.
The present specimens were collected from silty sandstone.

Locality:
Loc. no. IS–09.

Repository:
IGPS coll. cat. no. 95160.

Class Gastropoda
Family Trochidae
Subfamily Gibbulinae
Genus *Turcica* H. and A. Adams, 1854
Turcica coreensis Pease, 1860

Pl. 18, Figs. 16a–b.

Turcica coreensis Pease, 1860, Proc. Zool. Soc. London, pt. 428, p. 189, pt. 425, pl. 51, fig. 2; Kira, 1962, p. 9, pl. 7, fig. 1; Habe, 1965, p. 14, pl. 5, fig. 8; Habe and Kosuge, 1970, p. 10, pl. 5, fig. 26; Kira, 1971, p. 11, pl. 6, fig. 1; Kuroda, Habe and Oyama, 1971, p. 28, pl. 9, fig. 1–2; Oyama, 1973, p. 12, pl. 2, figs. 12, 16.
Turcica imperialis A. Adams, 1863, Proc. Zool. Soc. London, no. 32, p. 507 (*non vide*); Yokoyama, 1920, p. 92–93, pl. 5, fig. 31; Yokoyama, 1922, p. 111–112, pl. 5, fig. 23.

Measurements:

IGPS coll. cat. no.	Loc. no.	Height	Diameter	D/H	Whorls
95175	IS–09	ca. 33.0 mm	27.40 mm	83.0%	3+

Remarks:

The present species is characterized by the surface sculptures of strong and fine nodulous striae on each whorl, and well concaved subsutural band.

The species has been recorded from the seas around Japanese Islands, from Hokkaido to Kyushu on the bottom of 50 m to 200 m in depth.

Locality:

Loc. nos. I S–09.
KK–02.

Subfamily Umboniinae
Genus *Umbonium* Link, 1807
Subgenus *Suchium* Makiyama, 1924
Umbonium (*Suchium*) *akitanum* Suzuki, 1934

Pl. 18, Figs. 11a–c, 12a–c.

Umbonium akitanum Suzuki, 1934, p. 69, text-fig. 1.
Umbonium (*Suchium*) *akitanum* Suzuki, Otuka, 1935c, p. 849, pl. 54, figs. 62–63; Sugiyama, 1935, p. 465–466, pl. 12, figs. 10a–15c; Kaseno and Matsuura, 1965, pl. 1, fig. 11–12; Chinzei, 1973, pl. 14, fig. 11.
Umbonium costatum (Kiener), Sakagami *et al.*, 1966, pl. 3, figs. 1a–b.

Measurements:

IGPS coll. cat. no.	Loc. no.	Height	Diameter	Whorls
95176–1	RO–06	16.40 mm	23.85 mm	6
95176–2	–	7.0	12.00	4+
95176–3	–	8.10	13.05	5

Remarks:

The present species is characterized by low spire, smooth and rather fine spiral cords. The species is one of the important representatives of "Omma-Manganzi" fauna which was named by Otuka in 1939 based upon the comparison of mollucan fauna between Omma, Kanazawa City and Manganzi, Akita Prefecture.

Umbonium (*Suchium*) *costatum* Yokoyama is very similar to the present species in

general aspects, but the present one can be distinguished from *costatum* in having no tubercles on the shell surface, and rather fine smooth, spiral ornamentation.

Locality:

Loc. nos. KO–27, 33.
KK–22.
RO–06, 07.
ZU–15.

Family Turritellidae
Subfamily Turritellinae
Genus *Turritella* Lamarck, 1799
Subgenus *Neohaustator* Ida, 1952
Turritella (Neohaustator) saishuensis saishuensis Yokoyama, 1923

Pl. 18, Figs. 19, 21, 24.

Turritella saishuensis Yokoyama, 1923, p. 3, pl. 1, fig. 2; Nomura, 1937, p. 174, pl. 26, figs. 10a–b; Iwai, 1960, pl. 4, figs. 15a–b; Hatai, Masuda and Suzuki, 1961, pl. 4, figs. 13, 17a–b, 18a–b; Takayasu, 1961, pl. 2, fig. 9, pl. 3, figs. 1a–b; Kaseno and Matsuura, 1965, pl. 1, fig. 20.

Turritella fortilirata saishuensis Yokoyama, Otuka, 1934, p. 622, pl. 51, fig. 103.

Turritella (Haustator) saishuensis Yokoyama, Otuka, 1938, p. 44, text-fig. 7; Otuka, 1939, p. 29, pl. 2, fig. 12.

Turritella (Neohaustator) saishuensis Yokoyama, Ida, 1952, p. 50, pl. 6, figs. 1, 4, 6; Kotaka, 1959, p. 76–78, pl. 3, fig. 9, pl. 6, figs. 2–4, 6, 7, pl. 12, fig. 9, pl. 14, fig. 7, pl. 15, fig. 7; Iwai, 1959, p. 46–47, pl. 1, fig. 6; Iwai, 1965, p. 49, pl. 19, fig. 12.

Remarks:

Many well preserved specimens of the species were collected from various localities of the silty sandstone to coarse grained sandstone of the Omma Formation. The present species has very wide variation in spiral sculpture on the whorl surface, and owing to the variation in sculpture, the species has been divided into three subspecies by different authors. They are *Turritella (Neohaustator) saishuensis motidukii* Otuka 1935, *saishuensis saishuensis* and *saishuensis etigoensis* Ida, 1952. And typical spiral cording of each subspecies is formulated by Kotaka (1959, p. 59–61, fig. 9) in the following way.

Turritella saishuensis motidukii (C B A)
T. saishuensis saishuensis (C B s A)
T. saishuensis etigoensis (....C....B..s....A....)
or (....C....B..s....A)

Kotaka (1959) applied K.A. Joysey's (1956) opinion on the fossil community in his paper, and explained the subspecies group of *T. saishuensis* as cited below.

Joysey, stated in his paper, as follows: "1) if there are gaps of sufficient magnitude for

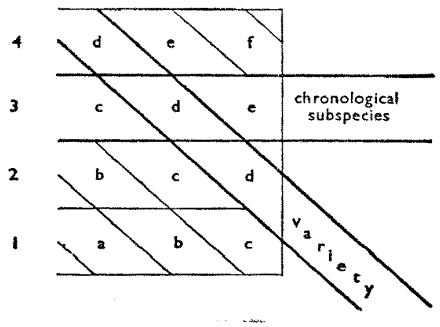


Fig. 17. Joysey's Fig. 1. Diagram to illustrate the two alternative directions in which a fossil lineage may be divided. Numbers 1–4 represent a series of geological horizons in ascenping order. At each horizon the middle letter represent less common extremes of variation.

the two communities to have no varieties in common (e.g., when the horizons 2 and 3 are represented by stratigraphical breaks), they would initially be distinguished as distinct species; 2) when the gap is partially filled by "missing links" from an intermediate horizon (*e.g.*, when the horizon 3 is lacked), it is surely better to modify the nomenclature, each community from the horizons 1, 3 and 4 is treated as subsp. b, c, and e, respectively than to use the completely different system of classification as a for subsp. a, b from horizon 1 and 2 for subsp. b, ... d from horizons 2, 3, and 4 for subsp. d, ... f from horizon 4 for subsp. f. And he suggested that the community from each horizon should be regarded as the basis for systematics in paleontology."

Joysey's opinion seems to be convenient for the case of the phylogenetic series of *Turritella* (*Neohaustator*) *saishuensis*. It is easily recognized by transfering Joysey's b, c, d and e to *Turritella* (*Neohaustator*) *saishuensis motidukii*, *saishuensis* (s.s.), *saishuensis etigoensis*, and *otukai*.

The species from the Omma Formation has also some variation of its spiral cords. They can be denoted as follow;

Loc. no.	Spiral cords (refer to Kotaka, 1959)
KO–05	u C t B. s. A
	u C. t. B. s . . A .
	. . C . . t B. s. . A .
	. .C. .t B s A
	. . . C . B. . . .A.
	. . . C . t. .B . s. . A . .
	. . . C . . B . s . A . . .
KO–22	C . . B s A.
	. . . C . B s . A . .
	. . . C . . . B . s . A . . . . .
	. . . . C . . B . s . A .
	. . . C . . B s A r
	. . . C . . B . . A r

The surface sculpture is nearly equal in the specimens from other localities. This species is very important one and representative species of the Omma-Manganzi fauna, since it has been recorded from the Pliocene formations along the Japan Sea.

Locality:

Loc. nos. KY–02, 03, 05, 07, 08, 12, 14, 17, 19, 22, 24.
KO–05, 06, 09, 13, 15, 17, 19, 22, 25, 26, 27, 30, 31, 32, 33, 34.
KK–01, 03, 04, 05, 06, 23, 26, 30, 31, 33, 36, 37, 38, 39, 40, 41, 45, 47, 49, 50, 51, 52
FM–01, 02, 04, 11, 15, 16, 17, 29, 20, 25, 26, 29, 30, 32, 33, 34, 35, 36, 38, 39, 40, 41.

Turritella (*Neohaustator*) *saishuensis motidukii* Otuka, 1935

Pl. 18, Fig. 22.

Turritella fortilirata subsp. *motidukii* Otuka, 1935a, p. 508; Otuka, 1935c, p. 856, pl. 45, fig. 53.
Turritella (*Neohaustator*) *saishuensis motidukii* Otuka, Ida, 1952, p. 51; Kotaka, 1959, p. 78–79, pl. 6, fig. 1; Iwai, 1959, p. 47, pl. 1, fig. 7; Iwai, 1965, p. 49–50, pl. 19, figs. 11, 13a–b.
Turritella saishuensis motidukii Otuka, Kotaka, 1954, p. 9.

Remarks:

Among 19 specimens of more than 10 mm in diameter collected from locality no.

AW–06, only four specimens have prominant secondary spiral cord *s*, situated between primary spiral cords A and B, but remainders exhibit typical *motidukii* formula (C B A), therefore, the specimens collected from above mentioned locality can be assigned to one of subspecies of *T. saishuensis*, that is *T. saishuensis motidukii*.

Locality:

Loc. nos. KY–10.
UK–01.
RO–12.
AW–05, 06.
KK–24.

Repository:

IGPS coll. cat. no. 95325–1～19

Turritella (*Neohaustator*) *saishuensis etigoensis* Ida, 1952

Pl. 18, Figs. 15, 20, 23.

Turritella saishuensis var. *etigoensis* Ikebe (MS), 1940a, and b, p. 336, 339, 367.
Turritella (*Neohaustator*) *saishuensis etigoensis* Ikebe, Ida, 1952, p. 51, pl. 6, figs. 2, 7, pl. 7, fig.. 4; Kotaka, 1959, p. 79–80, pl. 6, fig. 11.

Remarks:

The specimens from the Omma Formation at Loc. no. IS–09 are comparable to *T. saishuensis etigoensis* which was described by Ida (1952) from the Pliocene deposits of Niigata oil-field. Spiral cords of the present specimens are as follow:

Loc. no.	Spiral notation (refer to Kotaka, 1959)
IS–09	. . C . B . s . . A . . .
	. . . C t B . s . A . .
	. . . . C . . . B s . A . .
	. . . . C . t . B . s . . A . .
	. . . . C . . B s A . . .
	. . . . C . . . B . s . . . A r . .
	. . . . C . B . s . . . A r . .
	. . . . . C . . B . . . A .
	. . . . C . . . . B . . . . . A . r . .

They, therefore, can be assigned to *T. saishuensis etigoensis*.

Locality:

Loc. no. IS–01, 09.

Repository:

IGPS coll. cat. no. 95419, 95177, 95179–1～9.

Subfamily Pareorinae

Genus *Mesalia* Gray, 1847

Mesalia ommaensis Ogasawara n. sp.

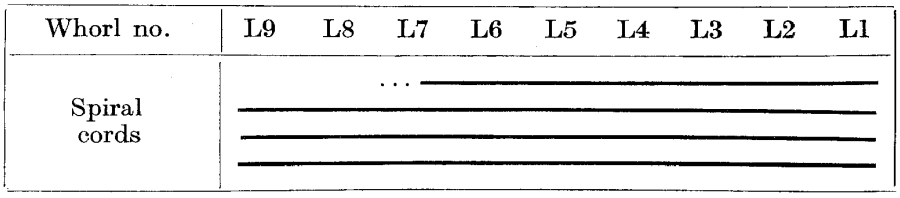
Pl. 18, Figs. 13a–b, 18.

Turritella (*Neohaustator*) *andensis* Otuka var, Kaseno and Matsuura, 1965, pl. 1, fig. 21.

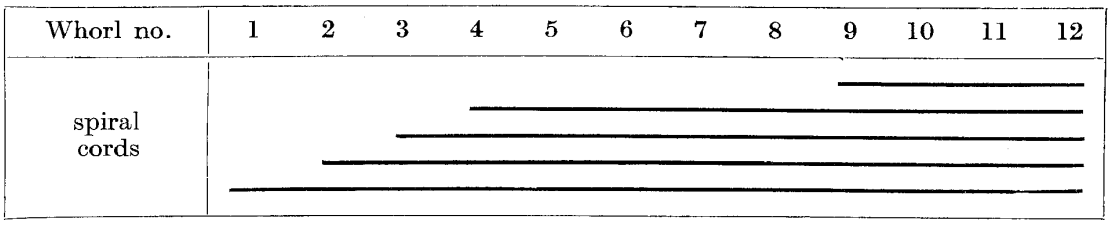
Description:

Adult shell medium in size, rather thick, spire conical and slightly convex in whorl profile. Suture distinct, weakly concave at just above suture line. Surface sculptured

with three broad, flat topped primarly spiral C B A and r or r_1 (see Kotaka, 1959) in adult stage as shown in Fig. 18. Interspaces of each spiral narrower than spirals. Surface ornamentation of body last whorl and periphery are of indistinct spiral costae and conspicuous longitudinal growth lines. Aperture ovately elongate in outline. Inner lip and outer lip are smooth.



Max. diameter of L7; measuring 6.80 mm



Max. diameter: 4th whorl; 3.15 mm, 9th whorl; 7.45 mm: L means the whorl number from the body whorl. (Spiral notation according to Kotaka, 1959)

Fig. 18. Diagram showing ontogenetic change in sculpture of *Mesalia ommaensis*

Measurements:

IGPS coll. cat. no.	Max. diameter	Height	Preserv. whorls
95074 (Holotype)	14.60 mm	50.60 mm(+)	8.5
95075 (Paratype)	–	–	12

Comparison and Affinity:

The present new species is characterized by flat-topped, broad three spirals which are divided by distinct, but narrow and very shallow spiral furrows, and strong columella.

The present species can be distinguished from turritellids in surface sculptures and by having columella.

According to Marwick (1957), the genus *Mesalina* is described as follows; "Influenced largely by the operculum, Finlay and Marwick (1937, 1942) favoured placing *Mesalina* in Potamididae, but the aperture does not support this. The columella, with its entering spiral ridge, is unlike any in the Turritellinae, but quite like that of *Parcora* and other genera here grouped in the Pareorinae."

Only two species of *Mesalina* were reported by Kotaka, they are *Mesalina yessoensis* Kotaka from the Piu Formation (Miocene) of Hokkaido and *Mesalina akitana* Kotaka from the Sasaoka Formation at Soto-Warita-mura, Yamamoto-gun Akita Prefecture.

The present new species can be easily distinguished from the above mentioned two species in having simple spiral cords, and a rather flat whorl profile compared with their strongly-convexed whorl profile.

Locality:

KO–22 (type locality).

FM–06.

Family Strombidae
Genus *Canarium* Schumacher, 1817
Subgenus *Doxander* Iredale, 1931
Canarium (Doxander) japonicus (Reeve, 1851)

Pl. 20, Figs. 11a–b.

Strombus japonicus Reeve, 1851, v. 6, *Strombus* sp. 42, pl. 17, fig. 42.
Strombus japonicus Reeve, Liscke, 1869, v. 1, pl. 5, fig. 7; Yokoyama, 1922, p. 70, pl. 3, fig. 12; Taki *in* Hirase, 1954, pl. 86, fig. 10.
Strombus (Labiostrombus) japonicus Reeve, Otuka, 1935c, p. 866, pl. 54, fig. 90.
Canarium (Labiostrombus) japonicus (Reeve), Taki and Oyama, 1954, p. 17, pl. 23, fig. 12; Hayasaka, 1961, p. 74, pl. 9, figs. 14–15.
Labiostrombus japonicus (Reeve), Kira, 1959, p. 36, pl. 15, fig. 13.
Strombus (Doxander) vittatus japonicus Reeve, Abbott, 1960, p. 113, pl. 17, fig. 8.
Doxander vittatus japonicus (Reeve), Kira, 1962, p. 35, pl. 16, fig. 13; Habe and Kosuge, 1970, p. 42, pl. 16, figs. 18–19.
Doxander japonicus (Reeve), Kuroda, Habe and Oyama, 1971, p. 127, p. 83, pl. 22, figs. 1–4.
Canarium (Doxander) japonicus (Reeve), Oyama, 1973, p. 34, pl. 10, fig. 4.

Measurements:

IGPS coll. cat. no.	Height	Diameter	D/H	whorls
95200–1	32.00 mm	11.40 mm	34.4%	7
95200–2	ca. 13	ca. 40	–	6+

Description:

Shell medium in size, fusiform with highly elevated spire and large body whorl. Spire consists of 6 whorls. Protochonch rather small and smooth, and consists of about 3 volutions. Surface sculptured with axial and spiral cords. Axial folds variable in number from 20 to 23 on each whorl, and conspicuous. Spiral cords rather fine and shallowly sculptured, about 7 on periphery and about 40 on last whorl. Surface sculptured with subsutural narrow and distinct band, and it becomes wider towards last whorl with growth. Aperture large and elongate in outline. Inner lip smooth.

Remarks:

Two imperfect specimens were collected from the medium grained sandstone of Omma Formation at about 200 meters up-stream from Okuwa Bridge, Okuwa, Kanazawa City. Even though the specimens at hand are imperfect, the morphological characters of the specimens agree with those of *Canarium (Doxander) japonicus* (Reeve). But the present Omma specimens are slightly different from the Recent form of the species in having rather outwardly expanded outler lip and higher spire.

Locality:

Loc. nos. KO–01, 02.

Family Muricacea
Genus *Ocenebra* Gray, 1847
Ocenebra aduncum (Sowerby, 1834)

Pl. 19, Figs. 8a–b, 11a–b, 12a–b, 13a–b, 15a–b, 17a–b.

Murex aduncus Sowerby, 1834, Conch. Illustr., part 62, pl. 5, fig. 35. (*fide* Oyama, 1973)
Ocinebra falcata Sowerby, Yokoyama, 1922, p. 65, pl. 3, fig. 4. (?)
Ocinebra spectata Yokoyama, 1922, p. 65–66, pl. 3, fig. 5.
Ceratostoma (Ocenebra) aduncum (Sowerby), Hatai, Masuda and Suzuki, 1961, pl. 3, fig. 6; Oyama,

1973, p. 39, pl. 2, figs. 9, 13.
Ocenebra adunca (Sowerby), Habe and Ito, 1965, p. 38, pl. 11, figs. 3–4.
Ocenebrellus adunca (Sowerby), Habe and Kosuge, 1970, p. 72, pl. 28, fig. 16.
Ocenebra (Ocinebrellus) adunca (Sowerby), Kira, 1971, p. 24, pl. 24, fig. 9.
Ceratostoma japonicum (Dunker), Iwai and Siobara, 1969, pl. 3, figs. 11a–b.
Ceratostoma (Ocenebra) japonica (Dunker), Kaseno and Matsuura, 1965, pl. 3, figs. 6–8.

Measurements:

IGPS coll. cat. no.	Loc. no.	Height	Diameter	D/H	Whorls
95180	KK–16	ca. 50.0 mm	29.40 mm	58.8%	5(+)
95181–1	KO–08	29.40	18.10	61.6	6
95182	KK–02	28.20	19.85	70.4	6
95183	KO–22	32.80	16.60	50.6	6(+)
95184	KK–03	ca. 35	ca. 24.0	68.6	6
95185	KK–25	22.00	12.10	55.0	5+
95181–2	KO–08	22.45	10.85	48.3	5

Remarks:

The present species has a fairly wide variation in its shell form, especially the developments of its axial folds are not shown on certain specimens, and is characterized by roundly ovate aperture, tube-like siphonal canal in adult stage, and winkle sort of surface sculpture. Generally, 8 to 9 axial folds are observed.

Ocenebra japonica (Dunker), the Recent froms, is similar to the present one in general aspects, but different from the present one in having smaller aperture for shell size and finer spirals.

Locality:

Loc. nos. KO–04, 08, 22.
KK–02, 03, 16, 25.

Family Buccinidae
Genus *Neptunea* Röding, 1798
Subgenus *Barbitonia* Dall, 1916
Neptunea (Barbitonia) arthritica (Bernardi, 1857)

Pl. 19, Figs. 9a–b, 16a–b, 18a–b.

Fusus arthriticus Bernardi, 1857, Jour. Conchyl, Tom. 6, p. 386–387, pl. 12, figs. 3, 3a. (*fide* Yokoyama, 1920)
Siphonalia diltata (Quay), Yokoyama, 1920, p. 52–53, pl. 2, fig. 12.
Chrysodomus arthriticus (Valenciennes) Bernardi, Yokoyama, 1922, p. 53–54, pl. 2, fig. 12.
Neptunea arthritica Bernardi, Nomura and Hatai, 1937, p. 1–5, pl. 1, figs. 1–7, pl. 2, figs. 1–7; Iwai and Siobara, 1969, pl. 3, figs. 19a–b.
Neptunea arthritica (Bernardi), Taki and Oyama (1954), pl. 22, fig. 12; Ozaki, 1958, p. 151, pl. 19, fig. 19; Iwai, 1965, p. 54, pl. 20, fig. 11; Habe and Ito, 1965, p. 61, pl. 20, fig. 3; Sakagami *et al.*, 1966, pl. 1, fig. 32; Habe and Kosuge, 1970, p. 77, pl. 30, fig. 2; Kira, 1971, p. 71, pl. 27, fig. 17; Nagasawa, 1970, p. 124, pl. 1, figs. 1–11, pl. 2, figs. 1–10, pl. 3, figs. 1–7.
Neptunea (Barbitonia) arthritica (Bernardi), Kaseno and Matsuura, 1965, pl. 3, fig. 13.

Measurements:

IGPS coll. cat. no.	Loc. no.	Height	Diameter	Whorls
95186	KK–25	65.00 mm	42.00 mm	5.5
95187	KO–04	17.25	9.55	2.5
95188	KO–22	17.75	ca. 8.0	3

Remarks:

The present specimens are very similar to *Neptunea arthritica hirosakiensis* proposed by Iwai, 1959 based upon the specimens from the Higashimeya Formation, Hirosaki City, Aomori Prefecture in general shape of spire, but the present form can be distinguished from *hirosakiensis* by having shorter shell, well developed spiral shoulder, and rather large protoconch.

The present species is well known in the seas along the Pacific and Japan Sea coast of Northern Japan.

The present species is comparable to the forma *narita* which was reported from the Narita Bed at Ozakura, Shimosa, Chiba Prefecture by Nomura and Hatai (1937).

Locality:

Loc. nos. KO–04, 22.
KK–25.
KY–06, 08.

Genus *Siphonalia* A. Adams, 1863
Siphonalia fusoides (Reeve, 1846)

Pl. 20, Figs. 1a–b, 13a–b.

Buccium Fusoides Reeve, 1846, v. 3, *Buccium* sp., 9, pl. 2, fig. 9. (non sp. 64, pl. 9, fig. 64)
Siphonalia trochulus (Reeve), Yokoyama, 1920, p. 54, pl. 2, fig. 14; Yokoyama, 1922, p. 56, pl. 2, figs. 15, 16, 18 (non 17).
Siphonalia stearnsii Pilsbry, Yokoyama, 1920, p. 54–55, pl. 3, fig. 3 (non fig. 4).
Siphonalia fusoides (Reeve), Kawamoto and Habe, 1956, pl. 14, fig. 134; Kira, 1962, p. 74, pl. 27, fig. 24; Kaseno and Matsuura, 1965, pl. 3, fig. 17; Habe and Kosuge, 1970, p. 81, pl. 31, fig. 15; Kira, 1971, p. 68, pl. 26, fig. 24; Kuroda, Habe and Oyama, 1971, p. 170, pl. 45, figs. 6, 7; Oyama, 1973, p. 43, pl. 12, figs. 2, 3, 10, 12, 14.

Measurements:

IGPS coll. cat. no.	Loc. no.	Height	Diameter	D/H	Whorls
95189–1	KK–03	33.30 mm	18.50 mm	55.6%	5
95189–2	–	47.60	23.70	49.8	6

Locality:

Loc. nos. KK–02, 03, 25.
KO–04, 22.
KY–03.

Genus *Searlesia* Harmer, 1915
Searlesia japonica Yokoyama, 1926

Pl. 21, Figs. 12, 13, 14a–b, 16, 17, 18.

Searlesia japonica Yokoyama, 1926d, p. 269, pl. 32, fig. 22; Kaseno and Matsuura, 1965, pl. 4, fig. 1.

Measurements:

IGPS coll. cat. no.	Loc. no.	Height	Diameter	D/H	Whorls
95193–1	KK–03	ca. 24.0 mm	9.80 mm	40.8%	6
95193–2	–	ca. 27.0	11.20	41.5	6
95193–3	–	ca. 27.5	11.60	42.2	6

95194–1	KO–04	21.95	9.40	42.8	5.5
95194–2	–	ca. 24	9.50	39.6	–
95194–3	–	ca. 25	11.60	46.4	–
95194–4	–	ca. 17.0	7.4	43.5	5
95194–5	–	ca. 17	7.5	44.1	5
59195	IS–09	22.55	9.60	42.6	6

Remarks:

The present species was reported by Yokoyama in 1926 from the Sawane Formation, Sado Island, Niigata Prefecture. And the Omma specimens are quite identical with Yokoyama's species.

The present form is allied to *Searlesia fuscolabiata* (Smith, 1860) in general outline, but the former differs from the latter in having more strong and wide spiral cords and less convexed whorl profile.

Locality:

Loc. nos. KK–03.
KO–04, 33.
KY–05, 09.
IS–09.

Family Ollividae

Genus *Oliva* Bruguiere, 1789

Oliva mustelina Lamarck, 1844

Pl. 20, Figs. 2, 3, 4, 5, 6.

Oliva mustelina Lamarck, 1844, Anim. sans. vert., ed. 2, 10, p. 616 (*fide* Reeve, 1851); Reeve, 1851, v. 6, *Oliva*, pl. 13, fig. 23; Weinkauff *in* Martini and Chemnitz, 1878, v. 5, pt. 1, p. 92, pl. 24, figs. 10–11; Sowerby, 1880, v. 4, *Oliva*, p. 22, pl. 7, figs. 272–273; Makiyama, 1927, p. 79, pl. 3, figs. 14–15; Otuka, 1935, p. 872, pl. 54, figs. 60a–b; Kanehara, 1938, p. 374, text-figs; Taki *in* Hirase, 1954, pl. 113, fig. 4; Kira, 1959, p. 80, pl. 31, fig. 5; Hayasaka, 1961, p. 87, pl. 12, figs. 14a–b; Kaseno and Matsuura, 1965, pl. 4, fig. 11; Habe and Kosuge, 1970, p. 90, pl. 35, fig. 10; Kira, 1971, p. 80, pl. 31, fig. 5.

Oliva (*Oliva*) *mustelina* Lamarck, Shuto, 1959b, p. 177, pl. 14, figs. 17, 19.

Measurements:

IGPS coll. cat. no.	Loc. No.	Height	Diameter	D/H
95196–1	KO–01	15.00 mm	7.85 mm	52.3%
95196–2	–	18.10	8.50	47.0
95196–3	–	22.60	11.70	51.8
95196–4	–	ca. 17.0	7.90	46.5
95196–5	–	17.60	8.30	47.2
95196–6	–	18.50	8.45	45.7
95196–7	–	19.05	8.60	45.1
95196–8	–	19.45	9.10	46.8
95196–9	–	20.10	9.80	48.8
95196–10	–	22.85	11.30	49.5
95197–1	KO–02	19.20	8.80	45.8
95197–2	–	18.75	9.30	49.6
95197–3	–	22.85	10.70	46.8
95197–4	–	23.15	11.15	48.2

Remarks:

Geologically the record of the present species ranges from the Pliocene to Pleistocene, and geographically it extends from the central Japan to Formosa. The living representative of the species is spread in the seas where the warm Kuroshio current is prevailing.

Locality:

Loc. nos. KO–01, 02, 03.

Family Volutidae
Genus *Fulgoraria* Schumacher, 1817
Fulgoraria masudae Hayasaka, 1958

Pl. 20, Figs. 17a–b, 22a–b.

Fulgoraria masudae Hayasaka, 1958, p. 24–27, pl. 1, figs. 1–3; Hatai, Masuda and Suzuki, 1961, pl. 3, fig. 9; Kaseno and Matsuura, 1965, pl. 4, figs. 12–13; Shikama, 1967, p. 89, pl. 16, figs. 4–5.
Fulgoraria cf. *masudae* Hayasaka, Iwai, 1965, p. 57, pl. 20, figs. 20–21.

Measurements:

IGPS coll. cat. no.	Loc. no.	Height	Diameter	D/H	Whorls
95198	KO–22	107.80 mm	40.45 mm	37.5%	5.5
95336	KO–23	37.20	15.30	41.1	3.5

Remarks:

The present specimens can be identical in every respect with *Fulgoraria masudae* Hayasaka proposed in 1958 from Pliocene Hamada Formation, Aomori Prefecture. The species is characterized by five, rather strong columellar plaits arranged irregularly in adult stage.

Locality:

Loc. nos. KO–22, 23.

Family Cancellariidae
Genus *Cancellaria* Lamarck, 1799
Subgenus *Merica* H. and A. Adams, 1854
Cancellaria (*Merica*) *kobayashii* (Yokoyama, 1927)

Pl. 21, Figs. 6, 10a–b.

Mitra kobayashii Yokoyama, 1927a, p. 173, pl. 47, fig. 5.
Cancellaria kobayashii (Yokoyama), Hatai and Nisiyama, 1940, p. 121, pl. 5, figs. 12–13; Iwai, 1960b, pl. 1, figs. 20a–b; Hatai, Masuda and Suzuki, 1961, pl. 4, figs. 4a–b.
Cancellaria (*Merica*) *kobayashii* (Yokoyama), Hatai and Nisiyama, 1952, p. 182; Makiyama, 1959, pl. 58, fig. 5; Hayasaka, 1961, p. 87–88, pl. 12, figs. 3a–b; Kaseno and Matsuura, 1965, pl. 4, fig. 14.

Measurements:

IGPS coll. cat. no.	Loc. no.	Height	Diameter	D/H	Whorls
95402	KO–25	37.00 mm	17.20 mm	46.5%	5
95350	KO–04	22.40	10.40	46.4	4.5

Remarks:

Cancellaria mutsuana Hatai, Masuda and Suzuki, 1961 recorded from the Pliocene Hamada Formation is somewhat similar to the present form, but differs from the present one in having higher shell and weak spiral cords.

The geological occurrences of the present species to date are as follows: Miocene Chiganoura Formation, Miyagi Prefecture, Pliocene Umegase Formation, Chiba Prefecture, Pleistocene deposits of Atsumi Peninsula, Aichi Prefecture and Omma Formation in Ishikawa Prefecture.

Locality:

Loc. nos. KO–04, 22, 25, 34.

Subgenus *Sydaphera* Iredale, 1929

Cancellaria (*Sydaphera*) *spengleriana* Deshayes, 1843

Pl. 20, Figs. 21a–b.

Complete synonym list is cited by Shuto, 1962, p. 72–73.

Cancellaria spengleriana Deshayes, 1843, Anim. San Vert. V. 9, p. 415; Sowerby, 1855, v. 2, p. 429, sp. 2; Reeve, 1856, v. 10, *Cancellaria*, pl. 3, sp. 11; Tokunaga, 1906, p. 11, pl. 1, fig. 15; Yokoyama, 1920, p. 44, pl. 2, fig. 15; Makiyama, 1927, p. 84; Otuka, 1934, p. 632, pl. 50, fig. 99; Hatai and Nisiyama, 1940, p. 128, pl. 5, fig. 6.

Cancellaria asprella var. *reeveana* Crosse, Yokoyama, 1922, p. 46, pl. 2, fig. 2.

Sydaphera spengleriana (Deshayes), Kuroda and Habe, 1952, p. 43; Kira, 1955, pl. 31, fig. 20; Hayasaka, 1961, p. 88–90, pl. 12, figs. 4a–5b; Habe and Kosuge, 1970, p. 90, pl. 35, fig. 16; Kira, 1971, p. 82, pl. 31, fig. 20.

Cancellaria (*Sydaphera*) *spengleriana* Deshayes, Taki and Oyama, 1954, p. 24, pl. 3, figs. 2–3; Shuto, 1962, p. 72–73, pl. 11, figs. 4, 8, pl. 13, figs. 13–14, text-fig. 14.

Cancellaria (*Sydaphera*) *spengleriana* Deshayes, Oyama, 1973, p. 48, pl. 15, figs. 18–20.

Measurements:

IGPS coll. cat. no.	Loc. no.	Height	Diameter	D/H	Whorls
95346–1	KO–22	37.80 mm	19.90 mm	52.6%	6
95346–2	–	23.35	12.55	53.7	5
95403	KO–04	25.35	13.30	52.5	5

Locality:

Loc. nos. KO–04, 22.

Subgenus *Habesolatia* Kuroda, 1965

Cancellaria (*Habesolatia*) *nodulifera* Sowerby, 1825

Pl. 20, Figs. 20a–b.

Cancellaria nodulifera Sowerby, 1855, v. 2, p. 440, pl. 94, fig. 57; Reeve, 1856, *Cancellaria* sp. 6; Dunker, 1882, p. 103, p. 6, figs. 24–25; Tokunaga, 1906, p. 12, pl. 1, fig. 16; Yokoyama, 1922, p. 45, pl. 2, fig. 1.

Cancellaria (*Narona*) *nodulifera* Sowerby, Taki and Oyama, 1954, p. 24, pl. 22, fig. 1.

Narona (*Solatia*) *nodulifera* (Sowerby), Kira, 1959, p. 82, pl. 31, fig. 19.

Narona nodulifera (Sowerby), Hayasaka, 1961, p. 90, pl. 12, figs. 15a–b.

Solatia (*Habesolatia*) *nodulifera* (Sowerby), Habe and Kosuge, 1970, p. 90, pl. 35, fig. 19.

Solatia nodulifera (Sowerby), Kira, 1971, p. 82, pl. 31, figs. 19.

Cancellaria (*Habesolatia*) *nodulifera* Sowerby, Oyama, 1973, p. 48, pl. 15, figs. 15a–b.

Habesolatia nodulifera (Sowerby), Kuroda, Habe and Oyama, 1971, p. 203, pl. 54, fig. 6.

Measurements:

IGPS coll. cat. no.	Height	Diameter	D/H	Whorls
95345	33.10 mm	21.60 mm	65.3%	4.5

Remarks:

The present species is characterized by low shell, large body whorl strongly sculptured 12 axial folds, and some distinct spiral cords compared with other cancellariids.

The species from the Omma Formation is somewhat thinner than the Recent form which is distributed along the Pacific coast of Eastern Japan.

Locality:

Loc. no. KO–22.

Family Turridae
Subfamily Turrinae
Genus *Antiplanes* Dall, 1902
Antiplanes contraria (Yokoyama, 1926)

Pl. 20, Figs. 12, 14, 15.

Pleurotoma contraria Yokoyama, 1926f, p. 383, pl. 44, figs. 2a–b.
Antiplanes kamchatica Dall, Otuka, 1935c, p. 873.
Antiplanes perversa contraria (Yokoyama), Otuka, 1936a, p. 734, pl. 42, fig. 11.
Antiplanes contraria (Yokoyama), Taki *in* Hirase, 1951, pl. 115, fig. 11; Itoigawa, 1958, pl. 2, fig. 15; Kira, 1959, p. 90, pl. 35, fig. 2; Iwai, 1959, p. 52, pl. 1, figs. 13a–b; Iwai, 1960, pl. 4, figs. 18a–b; Iwai, 1961, pl. 1, figs. 18a–b; Hatai, Masuda and Suzuki, 1961, pl. 3, figs. 11a–b; Takayasu, 1961, pl. 3, figs. 5a–b; Takayasu, 1962, pl. 1, figs. 24a–b; Sawada, 1962, p. 58–59, pl. 2, figs. 14–15; Iwai, 1965, p. 58, pl. 20, figs. 27–29; Kaseno and Matsuura, 1965, pl. 5, fig. 1.

Measurements:

IGPS coll. cat. no.	Loc. no.	Height	Diameter	Whorls
95342–1	KO–22	ca. 31.5 mm	9.25 mm	9
95342–2	–	23.50	8.10	8
95404	IS–02	43.00	13.40	9
95343	KO–04	ca. 36.0	11.10	9

Remarks:

The present species resembles *Antiplanes kamchatica* Dall, 1919 in general outline of shell, but the former can be distinguished from the latter in having finer and more consipicuous whorl sculpture.

Locality:

Loc. nos. KY–19.
KO–04, 13, 22.
AW–04.
IS–02, 09.

Family Marginellidae
Subfamily Mangeliinae
Genus *Ophiodermella* Bartsch, 1884
Ophiodermella ogurana (Yokoyama, 1922)

Pl. 21, Figs. 1a–b, 3, 4, 7a–b.

Genotia ogurana Yokoyama, 1922, p. 38–39, pl. 1, figs. 29, 29a.
Ophiodermella ogurana (Yokoyama), Kaseno and Matsuura, 1965, pl. 5, fig. 10; Oyama, 1973, p. 53, pl. 16, fig. 10.

Measurements:

IGPS coll. cat. no.	Loc. no.	Height	Diameter	D/H	Whorls
95405–1	KO–22	26.60 mm	10.00 mm	37.6%	7
95405–2	–	26.20	9.60	36.6	7
95411–1	KO–04	29.15	9.80	33.6	8
95411–2	–	ca. 25.0	9.20	36.8	–
95347	KK–03	25.60	9.20	35.9	7
95406	KK–22	22.65	8.55	37.7	7
95407	IS–09	15.25	5.30	34.8	7.5

Remarks:

The spire of the present specimens from the Omma Formation is slightly more slender than the type specimen of Yokoyama (1922). But, they are identical with *Ophiodermella ogurana* from their characters of inner and outer lips, and fine longitudinal striae on the whorls. The species is somewhat similar to *Ophiodermella miyatensis* (Yokoyama, 1920), but is different from *O. miyatensis* in having more slender shell and somewhat finer striae.

This species also resembles *Ophiodermella pseudopanus* (Yokoyama) in its shell outline, but the former can be distinguished from the latter, because *O. pseudopanus* is characterized by poor developments of shoulder and strongly marked axial keels or costae on the whorl.

Locality:

Loc. nos. KO–04, 22, 23.
KK–03, 22, 25.
IS–09.

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List of fossil localities

Tsurugi (T) Area

T–01: Road-side cliff, 900 m E of Sodani railway station, Tsurugi-machi, Ishikawa-gun, Ishikawa Prefecture, Lat. 36°29′15″ N, Long. 136°37′40″ E.

T–02: Road-side cliff, 650 m E of Sodani railway station. Lat. 36°29′15″N, Long. 136 37′31″ E.

Kanazawa-Yamashina (KY) Area

KY–01, KY–02, KY–03, KY–04, KY–05, KY–06: Road-side cliffs, 500 m ESE of Itadani-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°40′15″ N, Long. 136°38′10″ E.

KY–07, KY–08, KY–09, KY–10, KY–11: Road-side and river-side cliffs, 600 m S of Takao-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°40′42″ N, Long. 136°38′36″ E.

KY–12, KY–13, KY–14, KY–15, KY–16, KY–17, KY–18, KY–19, KY–20, KY–21, KY–22, KY–23, KY–24: Road-side and river-side cliffs, 600 m ESE of Takao-machi. Lat. 36° 40′56″ N, Long. 136°39′59″ E.

KY–25, KY–26, KY–27, KY–28, KY–29, KY–30, KY–31, KY–32: River-side cliffs, 500 m ESE of Yamashina-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°41′16″ N, Long. 136°40′37″ E.

Kanazawa-Okuwa (KO) Area

KO–01: River floor of Sai-gawa, 350 m SE of Okuwa bridge, Okuwa, Kanazawa City. Lat. 36°31′58″ N, Long. 136°41′03″ E.

KO–02: River floor of Sai-gawa, 450 m SE of Okuwa bridge. Lat. 36°31′54″ N, Long. 136° 41′03″ E.

KO–03: River floor of Sai-gawa, 500 m SE of Okuwa bridge. Lat. 36°31′53″ N, Long. 136°41′ 03″ E.

KO–04: River floor of Sai-gawa, 750 m SSE of Okuwa bridge. Lat. 36°31′45″ N, Long. 136° 41′08″ E.

KO–05: River floor of Sai-gawa, 875 m SSE of Okuwa bridge. Lat. 36°31′41″ N, Long. 136° 41′09″ E.

KO–06: River floor of Sai-gawa, 900 m SSE of Okuwa bridge. Lat. 36°31′41″ N, Long. 136° 41′09″ E.

KO–07: River floor of Sai-gawa, 925 m SSE of Okuwa bridge. Lat. 36°31′40″ N, Long. 136° 41′12″ E.

KO–08: River floor of Sai-gawa, 1050 m SSE of Okuwa bridge. Lat. 36°31′37″ N, Long. 136°41′03″ E.

KO–09: River floor of Sai-gawa, 1100 m SSE of Okuwa bridge. Lat. 36°31′35″ N, Long. 136° 41′03″ E.

KO–10: River floor of Sai-gawa, 1125 m SSE of Okuwa bridge. Lat. 36°31′35″ N, Long. 136° 41′03″ E.

KO–11: River floor of Sai-gawa, 1150 m SSE of Okuwa bridge. Lat. 36°31′34″ N, Long. 136°41′04″ E.

KO–12: River floor of Sai-gawa, 1225 m SSE of Okuwa bridge. Lat. 36°31′32″ N, Long. 136° 41′05″ E.

KO–13: River-side cliff of Sai-gawa, 1125 m SSE of Okuwa bridge. Lat. 36°31′35″ N, Long. 136°41′03″ E.

KO–14: River-side cliff of Sai-gawa, 1150 m SSE of Okuwa bridge. Lat. 36°31′35″ N, Long. 136°41′03″ E.

KO–15: River-side cliff of Asano-gawa, 400 m W of Tagami-hon-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°31′42″ N, Long. 136°41′42″ E.

KO–16: River-side cliff of Asano-gawa, 400 m W of Tagami-hon-machi. Lat. 36°41′41″ N, Long. 136°41′42″ E.

KO–17: River-side cliff, 300 m SE of Tagami-hon-machi. Lat. 36°41′33″ N, Long. 136°42′18″ E.

KO–18: River-side cliff, 350 m SE of Tagami-hon-machi. Lat. 36°41′31″ N, Long. 136°42′19″ E.

KO–19: River-side cliff, 425 m SE of Tagami-hon-machi. Lat. 36°41′29″ N, Long. 136°42′21″ E.

KO–20: Road-side cliff, 100 m E of Tate-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36° 41′17″N, Long. 136°42′23″ E.

KO–21: Road-side cliff, the south end of Tate-machi. Lat. 36°41′15″ N, Long. 136°42′16″ E.

KO–22: Cliff, distant from the road, 300 m W of Kaminaka-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°40′57″ N, Long. 136°42′25″ E.

KO–23: Road-side cliff, 250 m SW of Kaminaka-machi. Lat. 36°40′55″ N, Long. 136°42′27″ E.

KO–24: Road-side cliff, 250 m SW of Kaminaka-machi. Lat. 36°40′53″ N, Long. 136°42′28″ E.

KO–25: Road-side cliff, 100 m N of Kaminaka-machi, Lat. 36°40'43″ N, Long. 136°42′32″ E.

KO–26: River-side cliff, 200 m SW of Fukuroitaya-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°40′46″ N, Long. 136°42′38″ E.

KO–27: Cliff beside the river terrace, 400 m SW of Fukuroitaya-machi. Lat. 36°40′42″ N, Long. 136°42′23″ E.

KO–28: Road-side cliff, the north end of Kaminaka-machi. Lat. 36°41′05″ N, Long. 136°42′35″ E.

KO–29: Road-side cliff, 150 m S of Utto-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°41′09″ N, Long. 136°43′12″E.

KO–30: Road-side cliff, 300 m SSE of Utto-machi. Lat. 36°41′04″ N, Long. 136°43′16″ E.

KO–31: *Ibid.*

KO–32: *Ibid.*

KO–33: Road-side cliff, 600 m NNE of Higashi-ichise-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°40′23″ N, Long. 136°44′26″ E.

KO–34: Road-side cliff, 350 m SSE of Utto-machi. Lat. 36°41′03″″ N, Long. 136°44′18″ E.
KO–35: Cliff beside the river terrace, 450 m SW of Fukuroitaya-machi. Lat. 36°40′44″ N, Long. 136°42′31″ E.
KO–36: Cliff beside the river terrace, 550 m SW of Fukuroitaya-machi. Lat. 36°40′38″ N, Long. 136°42′28″ E.

Kanazawa-Kakuma (KK) Area

KK–01: Road-side cliff, 300 m N of Kakuma-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°32′50″ N, Long. 136°42′29″ E.
KK–02: Road-side cliff, 300 m N of Kakuma-machi. Lat. 36°32′50″N, Long. 136°42′49″ E.
KK–03: Cliff, distant from the road, 400 m N of Kakuma-machi, Lat. 36°32′52″ N, Long. 136°42′27″ E.
KK–04: Cliff of a branch of Kanakusari-gawa, 1500 m S of Maki-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°32′44″ N, Long. 136°43′19″ E.
KK–05: Cliff of a branch of Kanakusari-gawa, 1300 m S of Maki-machi. Lat. 36°32′52″ N, Long. 136°43′17″ E.
KK–07: Cliff of a branch of Kanakusari-gawa, 500 m S of Maki-machi. Lat. 36°33′17″ N, Long. 136°43′12″ E.
KK–08: *Ibid.*
KK–09: *Ibid.*
KK–10: *Ibid.*
KK–11: Cliff of the entrance of a branch of Kanakusari-gawa, 300 m S of Maki-machi. Lat. 36°33′24″ N, Long. 136°43′15″ E.
KK–12: Cliff of a branch of Kanakusari-gawa, 1100 m SSE of Kofutamata-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°32′45″ N, Long. 136°44′05″ E.
KK–13: Road-side cliff, 1000 m SSE of Kofutamata-machi. Lat. 36°32′51″ N, Long. 136° 44′06″ E.
KK–14: Road-side cliff, 950 m SSE of Kofutamata-machi. Lat. 36°32′51″ N, Long. 136°44′06″ E.
KK–15: Cliff of a branch of Kanakusari-gawa, 1250 m ESE of Kofutamata-machi. Lat. 36°33′00″ N, Long. 136°44′35″ E.
KK–16: Cliff of a branch of Kanakusari-gawa, 1150 m ESE of Kofutamata-machi. Lat. 36° 33′00″ N, Long. 136°44′32″ E.
KK–17: Cliff of a branch of Kanakusari-gawa, 1050 m ESE of Kofutamata-machi. Lat. 33° 32′57″ N, Long. 136°44′23″ E.
KK–18: Cliff of a branch of Kanakusari-gawa, 950 m SE of Kofutamata-machi. Lat. 36°32′56″ N, Long. 136°44′20″ E.
KK–19: Cliff of a branch of Kanakusari-gawa, 850 m SE of Kofutamata-machi. Lat. 36°32′56″ N, Long. 136°44′17″ E.
KK–21: Cliff of a branch of Kanakusari-gawa, 850 m SE of Kofutamata-machi. Lat. 36° 32′56″ N, Long. 136°44′09″E.
KK–22: Cliff of a branch of Kanakusari-gawa, 750 m SE of Kofutamata-machi. Lat. 36°32′56″ N, Long. 136°44′09″ E.
KK–23: Cliff of a branch of Kanakusari-gawa, 1400 m SE of Higashinagae-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°33′32″ N, Long. 136°42′33″ E.
KK–24: Cliff of a branch of Kanakusari-gawa, 1350 m SE of Higashinagae-machi. Lat. 36° 33′35″ N, Long. 136°42′34″ E.
KK–25: *Ibid.*
KK–26: Cliff of a branch of Kanakusari-gawa, 900 m SE of Higashinagae-machi. Lat. 36°33′45″ N, Long. 136°42′24″ E.
KK–27: Cliff of a branch of Kanakusari-gawa, 925 m SE of Higashinagae-machi. Lat. 36°33′49″ N, Long. 136°42′27″ E.
KK–28: Cliff of a branch of Kanakusari-gawa, 750 m SSE of Higashinagae-machi. Lat. 36°33′ 46″ N, Long. 136°42′07″ E.
KK–29: Cliff of a branch of Kanakusari-gawa, 500 m SE of Higashinagae-machi. Lat. 36°33′57″ N, Long. 136°42′15″ E.
KK–30: Cliff of a branch of Kanakusari-gawa, 450 m SE of Higashinagae-machi. Lat. 36° 33′59″ N, Long. 136°42′16″ E.

KK–31: Cliff of a branch of Kanakusari-gawa, 1000 m SSE of Gosho-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°34′13″ N, Long. 136°41′24″ E.
KK–32: Road-side cliff, 600 m NW of Higashinagae-machi. Lat. 36°34′04″ N, Long. 136°41′42″ E.
KK–33: Road-side cliff, 300 m SE of Gosho-machi. Lat. 36°34′40″ N, Long. 136°42′24″ E.
KK–34: Outcrop on a ridge, 600 m ESE of Gosho-machi. Lat. 36 34′38″ N, Long. 136 41′41″ E.
KK–35: Road-side cliff, 1000 m ENE of Gosho-machi. Lat, 36°34′50″ N, Long. 136°41′53″ E.
KK–36: Road-side cliff, 1150 m E of Gosho-machi. Lat. 36°34′44″ N, Long. 136°41′53″ E.
KK–37: Road-side cliff, 200 m N of Yuhidera-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°34′10″ N, Long. 136°42′50″ E.
KK–38: Road-side cliff, 350 m N of Yuhidera-machi. Lat. 36°34′15″ N, Long. 136°42′54″ E.
KK–39: Road-side cliff, 400 m N of Yuhidera-machi. Lat. 36°34′17″ N, Long. 136°42′53″ E.
KK–40: Road-side cliff, 450 m N of Yuhidera-machi. Lat. 36°34′18″ N, Long. 136°42′53″ E.
KK–41: Road-side cliff, 700 m NNE of Yuhidera-machi. Lat. 36°34′27″ N, Long. 136°42′59″ E.
KK–42: Road-side cliff, 1000 m N of Yuhidera-machi. Lat. 36°34′38″ N, Long. 136°42′54″ E.
KK–43: Outcrop, 100 m SE of Yuhidera-machi. Lat. 36°33′58″ N, Long. 136°42′55″ E.
KK–44: Outcrop of a branch of Kanakusari-gawa, 400 m ENE of Yuhidera-machi. Lat. 36° 34′05″ N, Long. 136°43′07″ E.
KK–45: Road-side cliff, 500 m NE of Maki-machi. Lat. 36°33′53″ N, Long. 136°43′29″ E.
KK–46: Road-side cliff, 200 m NNE of Tsuribe-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°34′03″N, Long. 136°44′10″ E.
KK–47: Road-side cliff, 350 m NE of Tsuribe-machi. Lat. 36°34′01″ N, Long. 135°44′18″ E.
KK–48: Outcrop of a branch of Kanakusari-gawa, 1100 m ESE of Konimata-machi. Lat. 36°33′10″ N, Long. 136°44′52″ E.
KK–49: Outcrop, 1000 m ENE of Gosho-machi. Lat. 36°34′56″ N, Long. 136°41′54″ E
KK–50: Outcrop, 950 m ENE of Gosho-machi. Lat. 36°34′58″ N, Long. 136°41′47″ E.
KK–51: Outcrop, 900 m ENE of Gosho-machi. Lat. 36°35′00″ N, Long. 136°41′47″ E.
KK–52: Outcrop, 1000 m ENE of Gosho-machi. Lat. 36°35′02″ N, Long. 136°41′47″E.

Futamata-Morimoto-gawa (FM) Area

FM–01: Outcrop of a branch of Tanoshima-gawa, 400 m E of Tanoshima-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°32′45″ N, Long. 136°45′57″ E.
FM–02: Outcrop of Tanoshima-gawa, 500 m N of Tanoshima-machi. Lat. 36°33′01″ N, Long. 136°45′48″E.
FM–03: Road-side cliff, near the post office of Futamata-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°33′15″ N, Long. 136°45′53″ E.
FM–04: Road-side cliff, NW end of Futamata-machi. Lat. 36°33′26″ N, Long. 136°45′46″ E.
FM–05: Outcrop, 150 m NNW of the police office of Futamata-machi. Lat. 36°33′33″ N, Long. 136°45′52″ E.
FM–06: *Ibid.*
FM–07: *Ibid.*
FM–08: Outcrop, 400 m N of the police office of Futamata-machi. Lat. 36°33′40″ N, Long. 136°45′55″ E.
FM–09: *Ibid.*
FM–10: Outcrop, 650 m N of the police office of Futamata-machi. Lat. 36°33′48″ N, Long. 136°45′52″ E.
FM–11: Outcrop, 825 m N of the police office of Futamata-machi. Lat. 36°33′54″ N, Long. 136°46′00″ E.
FM–12: Outcrop, 850 m N of the police office of Futamata-machi. Lat. 36°33′54″ N, Long. 136°45′59″ E.
FM–13: Road-side outcrop, 500 m S of Ichise-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°34′04″ N, Long. 136°46′03″ E.
FM–14, FM–15, FM–16, FM–17, FM–18, FM–19, FM–20: Outcrops, distant from the road, 450 m S of Ichise-machi. Lat. 36°34′06″ N, Long. 136°46′03″ E.
FM–21: Outcrop, 400 m S of Ichise-machi. Lat. 36°34′08″ N, Long. 136°46′01″ E.
FM–22: Outcrop, distant from the road, 200 m SSE of Ichise-machi. Lat. 36°34′13″ N, Long. 136°46′07″ E.

FM–23: *Ibid.*
FM–24: *Ibid.*
FM–25: Road-side cliff, 100 m S of Ichise-machi. Lat. 36°34′17″ N, Long. 136°46′05″ E.
FM–26: Road-side cliff of Ichise-machi. Lat. 36°34′20″ N, Long. 136°46′04″ E.
FM–27: Road-side cliff, 350 m NNE of Ichise-machi. Lat. 36°34′31″ N, Long. 136°46′06″ E.
FM–28: Road-side cliff, 400 m NNE of Ichise-machi. Lat. 36°34′32″ N, Long. 136°46′10″ E.
FM–29: Road-side cliff, 1000 m NNE of Ichise-machi. Lat. 36°34′50″ N, Long. 136°46′17″ E.
FM–30: Road-side cliff, 350 m NE of Ichise-machi. Lat. 36°34′31″ N, Long. 136°46′10″ E.
FM–31: Road-side cliff, 350 m NE of Ichise-machi. Lat. 36°34′30″ N, Long. 136°46′10″ E.
FM–32: Road-side cliff, 350 m NE of Ichise-machi. Lat. 36°34′30″ N, Long. 136°46′11″ E.
FM–33: Road-side cliff, 350 m NE of Ichise-machi. Lat. 36°34′29″ N, Long. 136°46′12″ E.
FM–34, FM–35, FM–36, FM–37, FM–38, FM–39, FM–40, FM–41: Road-side cliffs, 350 m NE of Ichise-machi. Lat. 36°34′28″ N, Long. 136°46′14″ E.
FM–42: Road-side cliff, 300 m NNE of Ichise-machi. Lat. 36°34′30″ N, Long. 136°46′05″ E.

Takemata (RT) Area

RT–01: Toad-side cliff, 900 m NW of Tohara-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°38′19″ N, Long. 136°46′41″ E.
RT–02: Road-side cliff, 925 m NW of Tohara-machi. Lat. 36°38′19″ N, Long. 136°46′41″ E.
RT–03: Road-side cliff, 950 m NW of Tohara-machi. Lat. 36°38′18″ N, Long. 136°46′42″ E.
RT–04: Road-side cliff, 1000 m NW of Tohara-machi. Lat. 36°38′22″ N, Long. 136°46′38″ E.
RT–05: Road-side cliff, 1150 m NW of Tohara-machi. Lat. 36°38′24″N, Long. 136°46′36″ E.
RT–06: Outcrop of a branch of a river, 1000 m SSE of Takemata-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°38′05″ N, Long. 136°46′55″ E.
RT–07: Outcrop of a branch of a river, 1000 m SSE of Takemata-machi. Lat. 36°38′05″ N, Long. 136°46′55″ E.
RT–08: Outcrop of a branch of a river, 1000 m SSE of Takemata-machi. Lat. 36°38′06″ N, Long. 136°46′54″ E.
RT–09: Outcrop of a branch of a river, 100 m W of Takemata-machi. Lat. 36°38′16″N, Long. 136°46′44″ E.

Awazaki-Tsubata (AW) Area

AW–01: Road-side cliff of Iwade-machi, 1150 m ENE of Morimoto railway station, Kanazawa City, Ishikawa Prefecture. Lat. 36°36′44″ N, Long. 136°42′19″ E.
AW–02: Road-side cliff of Iwade-machi, 1150 m ENE of Morimoto railway station. Lat. 36° 36′45″ N, Long. 136°42′20″ E.
AW–03: Artificial cliff, 800 m ESE of Togiya-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°38′12″ N, Long. 136°43′33″ E.
AW–04: Road-side cliff along the national road Route 8, 1000 m NE of Togiya-machi. Lat. 36°38′42″ N, Long. 136°43′37″ E.
AW–05: Road-side cliff, beside the entrance of a tunnel, 400 m WSW of Chidai-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°37′12″ N, Long. 136°44′27″ E.
AW–06: Road-side cliff, beside the entrance of a tunnel, 600 m WSW of Chideai-machi. Lat. 36°37′09″ N, Long. 136°44′19″ E.
AW–07: River-side cliff, 150 m W of Umeda-machi. Lat. 36°37′13″ N, Long. 136°42′29″ E.
AW–08: *Ibid.*
AW–09: Road-side cliff, 400 m WNW of Kaga-asahi-machi, Kanazawa City, Ishikawa Prefecture. Lat. 36°37′11″ N, Long. 136°45′09″ E.

Oyabe-Hitou (RH) Area

RH–01: Road-side cliff, 2000 m S of Komoridani, Fukumitsu-machi, Nishi-tomari-gun, Toyama Prefecture. Lat. 36°35′51″ N, Long. 136°50′46″ E.
RH–02: Road-side cliff, 1800 m S of Komoridani. Lat. 36°35′59″ N, Long. 136°50′47″ E.
RH–03: Road-side cliff, 500 m S of Hitou, Oyabe City, Toyama Prefecture. Lat. 36°36′13″ N, Long. 136°48′33″ E.
RH–04: Road-side cliff, 150 m S of Hitou. Lat. 36°36′27″ N, Long. 136°48′37″ E.
RH–05: Road-side cliff, 800 m NW of Hitou. Lat. 36°36′47″ N, Long. 136°48′08″ E.
RH–06: Road-side cliff, 550 m NW of Hotou. Lat. 36°36′45″ N, Long. 136°48′19″ E.
RH–07: *Ibid.*
RH–08: Road-side cliff, 600 m E of Hitou. Lat. 36°36′32″ N, Long. 136°49′01″ E.

RH–09: Outcrop of a branch of Goromaru-gawa, 300 m W of Goromaru, Oyabe City, Toyama Prefecture. Lat. 36°37′43″ N, Long. 136°49′11″ E.
RH–10: Road-side cliff of a branch of Goromaru-gawa, 1200 m WNW of Goromaru. Lat. 36° 38′09″ N, Long. 136°48′48″ E.
RH–11: Road-side cliff of a branch of Goromaru-gawa, 700 m WNW of Goromaru. Lat. 36°38′ 09″ N, Long. 136°49′07″ E.
RH–12: Outcrop of a branch of Goromaru-gawa, 800 m NW of Goromaru. Lat. 36°37′56″ N, Long. 136°48′58″ E.
RH–13: Outcrop of a branch of Goromaru-gawa, 650 m NW of Goromaru. Lat. 36°37′53″ N, Long. 136°49′02″ E.
RH–14: Outcrop of a branch of Goromaru-gawa, 550 m WNW of Goromaru. Lat. 36°37′52″ N, Long. 136°49′04″ E.
RH–15: Outcrop below a bridge, 500 m NW of Goromaru. Lat. 36°37′56″ N, Long. 136°49′08″ E.
RH–16: Outctop of a branch of Goromaru-gawa, 500 m WSW of Hakkoda, Oyabe City, Toyama Prefecture. Lat. 36°37′55″ N, Long. 136°49′12″ E.
RH–17: Road-side outcrop 500 m N of Hakkoda. Lat. 36°38′14″ N, Long. 136°49′42″ E.
RH–18: Outcrop of Umi-gawa, 1500 m WNW of Matsuo, Oyabe City, Toyama Prefecture. Lat. 36°38′40″ N, Long. 136°49′38″ E.
RH–19: Road-side outcrop of a branch of Umi-gawa, 250 m S of Yatate-yama, Oyabe City, Toyama Prefecture. Lat. 36°39′09″ N, Long. 136°50′00″ E.
RH–20: Road-side cliff, 600 m NE of Ishizaka, Oyabe City, Toyama Prefecture. Lat. 36°39′38″ N, Long. 136°50′34″ E.
RH–21: Road-side cliff, 700 m NE of Ishizaka. Lat. 36°39′40″ N, Long. 136°50′32″ E.

Isurugi (IS) Area

IS–01: Road-side cliff of Fukagawa, 2000 m NNE of Isurugi railway station, Oyabe City, Toyama Prefecture. Lat. 36°41′09″ N, Long. 136°52′30″ E.
IS–02: Road-side cliff, 500 m NW of IS–01 along the road. Lat. 36°41′23″ N, Long. 136°52′20″ E.
IS–03: River-side cliff, 300 m NW of Tagawa, Oyabe City, Toyama Prefecture. Lat. 36° 41′45″ N, Long. 136°53′00″ E.
IS–04: River-side cliff, 300 m NW of Tagawa. Lat. 36°41′46″ N, Long. 136°53′04″ E.
IS–05: Road-side cliff, 350 m NW of Tagawa. Lat. 36°41′48″ N, Long. 136°53′04″ E.
IS–06: Road-side cliff, 400 m NW of Tagawa. Lat. 36°41′49″ N, Long. 136°53′04″ E.
IS–07: Road-side cliff, 450 m NNW of Tagawa. Lat. 36°41′50″ N, Long. 136°53′04″ E.
IS–08: Road-side cliff, 500 m NNW of Tagawa. Lat. 36°41′54″ N, Long. 136°53′07″ E.
IS–09: Road-side cliff, 600 m ENE of Tagawa. Lat. 36°41′45″ N, Long. 136°53′37″ E.

Unoke (UK) Area

UK–01: Road-side cliff, 200 m ENE of Nakatsubata rialway station, Tsubata-machi, Kahoku-gun, Ishikawa Prefecture. Lat. 36°40′10″ N, Long. 136°34′44″ E.
UK–02: Road-side cliff, 250 m ENE of Nakatsubata railway station. Lat. 36°40′13″ N, Long. 136°34′45″ E.
UK–03: Road-side cliff, 1000 m ENE of Noze railway station. Lat. 36°41′35″ N, Long. 136° 34′00″ E.
UK–04: Cliff in a little valley, 1100 m ESE of Uedana, Unoke-machi, Kahoku-gun, Ishikawa Prefecture. Lat. 36°44′08″ N, Long. 136°34′58″ E.
UK–05: Road-side cliff, 220 m ENE of Nakatsubata railway station. Lat. 36°40′10″ N, Long. 136°34′44″ E.

Explanation of Plates (Plate 3—Plate 22)

Explanation of Plate 3

Figs. 1–6, Examples of the exposure of shell beds in the Omma Formation.

Fig. 1. Loc. No. KO–04; River floor of Sai-gawa at 750 m SSE from the Okuwa bridge, Okuwa, Kanazawa City. (P-AC*, 15 cm in thickness), white cards on the pictures measure 12.5×18 cm

Fig. 2. An exposure, 50 cm above that shown in Fig. 1.

Fig. 3. Loc. No. KO–09; River floor of Sai-gawa at 1100 m SSE from Okuwa bridge, Okuwa, Kanazawa City. (I-CC*, 50 cm in thickness)

Fig. 4. Loc. No. KO–07; River floor of Sai-gawa at 925 m SSE from Okuwa bridge, Okuwa, Kanazawa City. (P-CC*, 15 cm in thickness)

Fig. 5. Loc. No. KO–08; River floor of Sai-gawa at 1050 m SSE from Okuwa bridge, Okuwa, Kanazawa City. (P-CC*, 15 cm in thickness)

Fig. 6. Loc. No. KK–13; Road side cliff, 1000 m SSE from the Kofutamata-machi, Kanazawa City. (I-CA*, 30 cm in thickness)

*: means mode of occurrence, and abundancy and crowdedness (see text p. 60~61)


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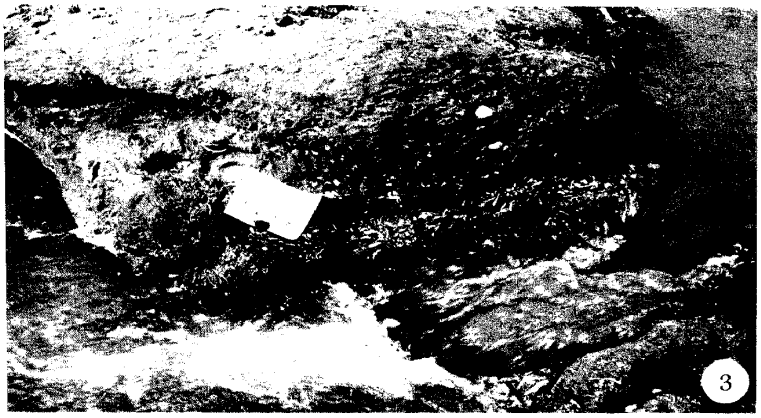
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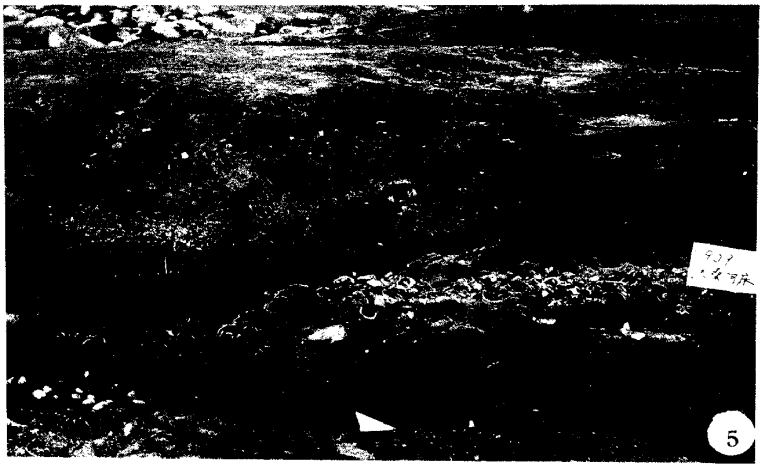
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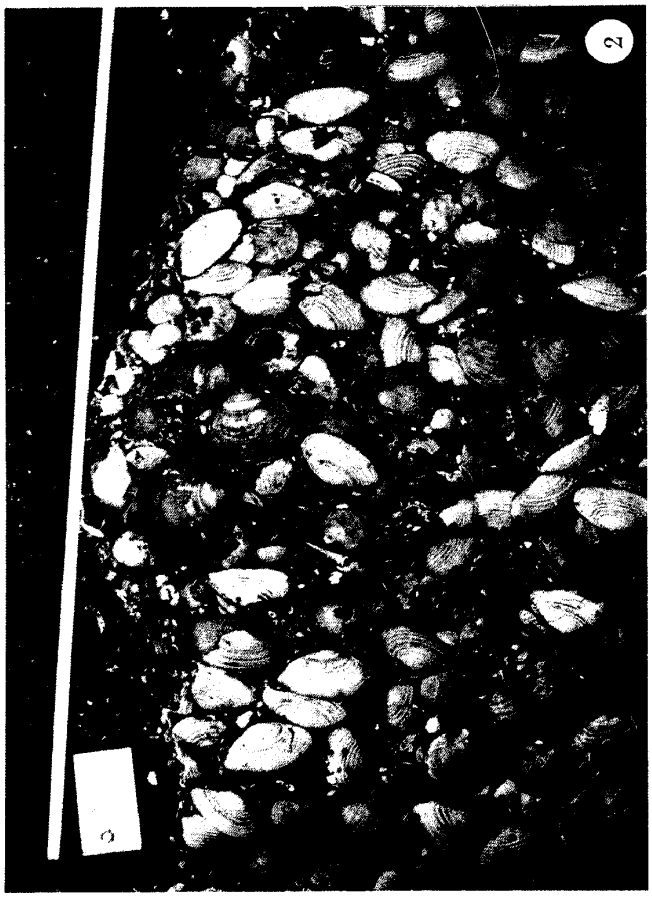
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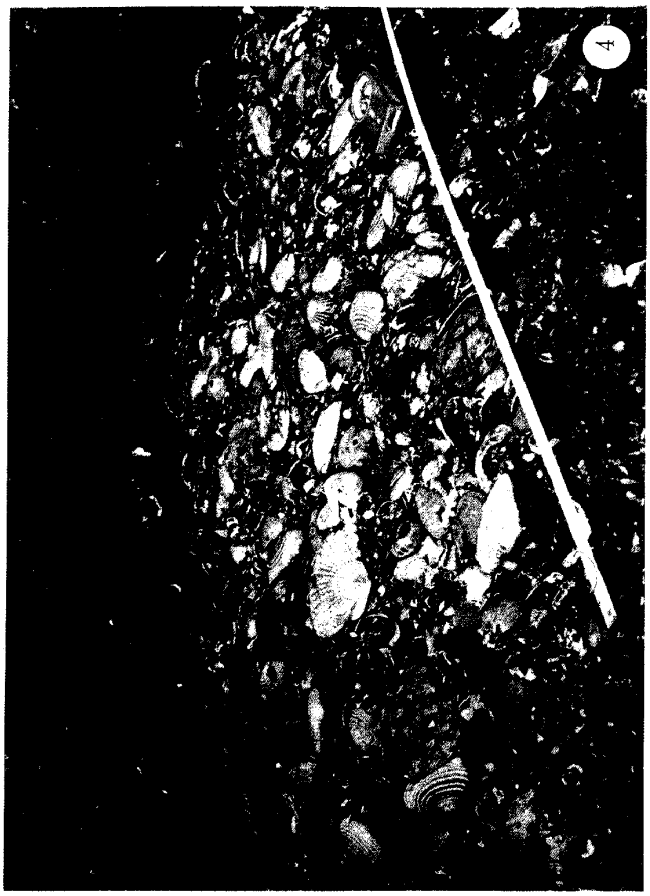
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Explanation of Plate 4

Figs. 1–4, Loc. KO–04, River floor of Sai-gawa 750 m SSE from the Okuwa bridge, Okuwa, Kanazawa City, (the thickness of shell bed measures 15 cm)

Fig. 1. Upper part; view vertical to the bedding plane.

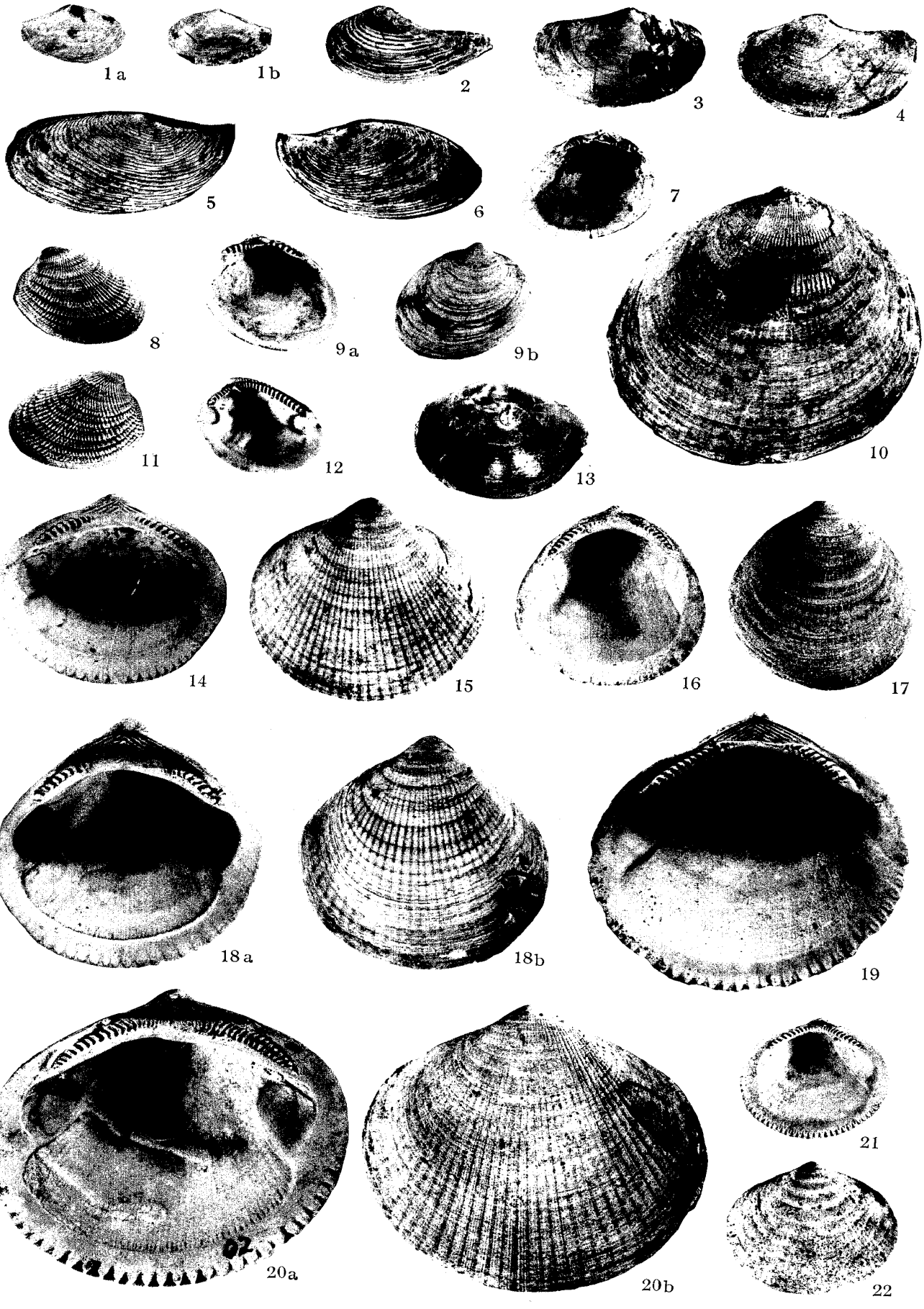
Fig. 2. Middle part; view vertical to the bedding plane.

Figs. 3, 4. Lower part, fig. 3; view vertical to the bedding plane, fig. 4; view about 45 degrees oblique to the bedding plane.

Explanation of Plate 5

(All figures in natural size, unless otherwise stated)

Figs. 1a. b. *Saccella confusa* (Hanley), × 2, IGPS coll. cat. no. 95078–5, Loc. no. KO–01.
Fig. 2. *Nuculana* (*Thestyleda*) *yokoyamai* Kuroda, ×2, IGPS coll. cat. no. 95077, Loc. no. IS–09.
Fig. 3. *Portlandia* (*Portlandella*) *hirosakiensis* Iwai, IGPS coll. cat. no. 95080, Loc. no. UK–01.
Fig. 4. *Portlandia* (*Megayoldia*) *thraciaeformis* (Storer), × 2, IGPS coll. cat. no. 95079–1, Loc. no. IS–09.
Figs. 5–6. *Yoldia* (*Cnesterium*) *notabilis* Yokoyama, IGPS coll. cat. nos. 95081–1, 95081–2, Loc. no. KK–03.
Figs. 7, 9a-b. *Limopsis tokaiensis* Yokoyama, × 3/2, IGPS coll. cat. nos. 95270–1, 95270–2, Loc. no. UK–02.
Figs. 8, 11–12. *Acila* (*Truncacila*) *insignis* (Gould), × 3/2, IGPS coll. cat. nos. 95271–1, 95271–2, 95271–3, Loc. no. KK–03.
Figs. 10, 16–17. *Glycymeris* (*Glycymeris*) cf. *rotunda* (Dunker), fig. 10, IGPS coll. cat. no. 95272, Loc. no. KK–14; fig. 16, IGPS coll. cat. no. 95273, Loc. no. KO–23; fig. 17, IGPS coll. cat. no. 95274, Loc. no. KO–28.
Fig. 13. *Sarepta speciosa* A. Adams, ×3, IGPS coll. cat. no. 95076, Loc. no. IS–09.
Figs. 14–15, 18–22. *Glycymeris* (*Glycymeris*) *yessoensis* (Sowerby), fig. 14, IGPS coll. cat. no. 95275–1, Loc. no. KY–32; fig. 15, IGPS coll. cat. no. 95276–1, Loc. no. KK–16; fig. 18, IGPS coll. cat. no. 95277–1, Loc. no. KO–24; fig. 19, IGPS coll. cat. no. 95278–1, Loc. no. KO–02; figs. 20a–b, IGPS coll. cat. no. 95279–1, Loc. no. KK–42; figs. 21–22; IGPS coll. cat. nos. 95280–1, 95280–2, Loc. no. KO–04.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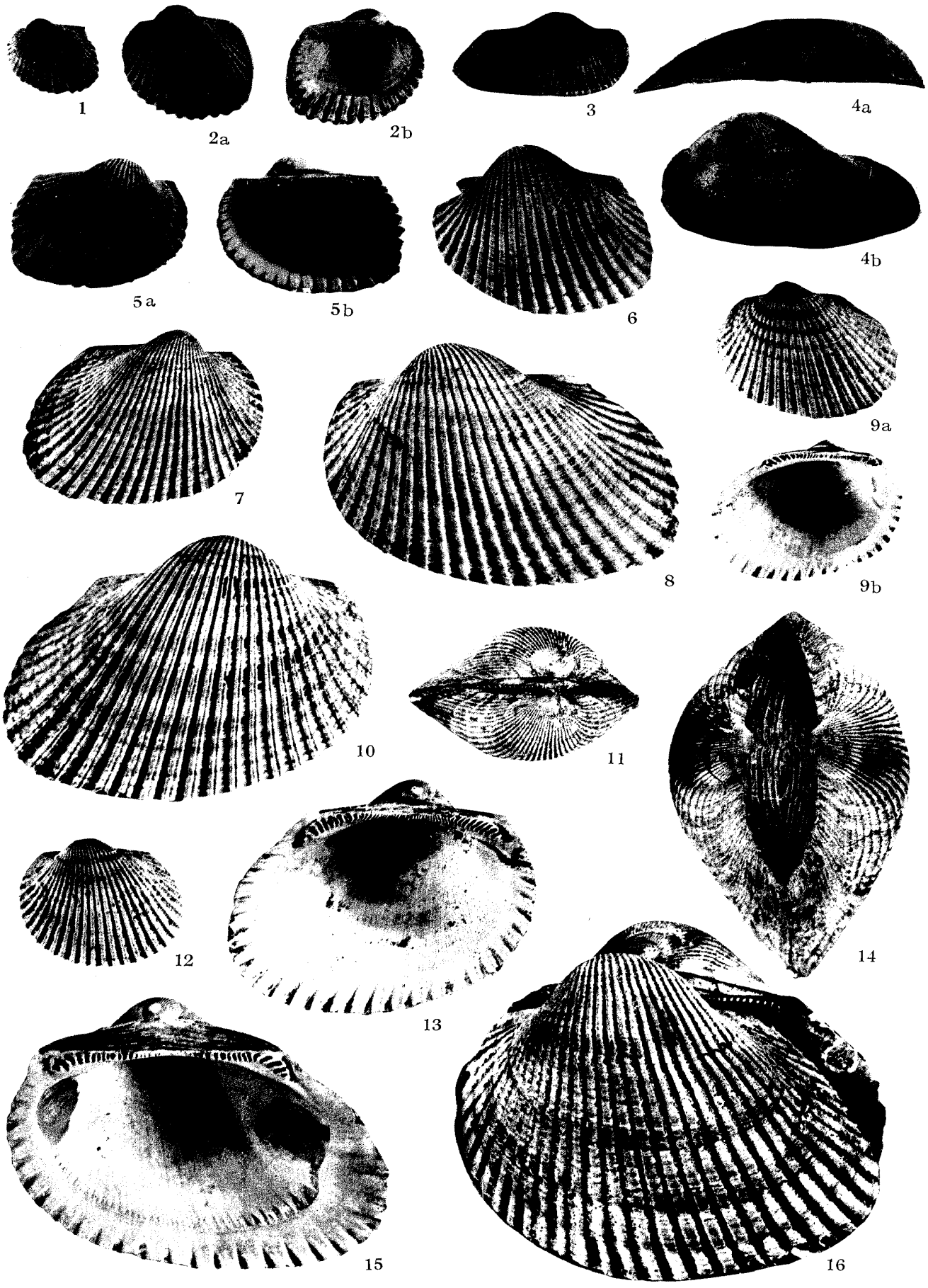
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Explanation of Plate 6

(All figures in natural size, unless otherwise stated)

Figs. 1–2, 5–6. *Anadara* (*Hataiarca*) *pseudosubcrenata* Ogasawara n. sp., fig. 1, IGPS coll. cat. no. 95071–1 (Paratype), Loc. no. KO–01; figs. 2, 5–6, IGPS coll. cat. nos. 75071–2, 75071–3, 75071–4 (Paratypes), Loc. no. KO–01.

Figs. 3–4. *Arca* (*Arca*) *boucardi* Jousseaume, fig. 3, × 3/2, IGPS coll. cat. no. 95086–1, Loc. no. UK–04; fig. 4, IGPS coll. cat. no. 95086–2, Loc. no. UK–04.

Fig. 7–8, 11, 16. *Anadara* (*Scapharca*) *ommaensis* Otuka, figs. 7–8, 11, IGPS coll cat. nos. 95087–1, 95087–2, 95087–3, Loc. no. KO–07; fig. 16, IGPS coll. cat. no. 95089, Loc. no. FM–05.

Figs. 9–10, 12–15. *Anadara* (*Anadara*) *amicula elongata* Noda, figs. 9–10, 13, 15, IGPS coll. cat. nos. 95084–1, 95084–2, 95084–3, 95084–4, Loc. no. KO–22; fig. 12, × 2, IGPS coll. cat. no. 95088, Loc. no. KO–22; fig. 14, IGPS coll. cat. no. 95085, Loc. no. KY–16.

Explanation of Plate 7

(All figures in natural size, unless otherwise stated)

Figs. 1, 3, 5. *Chlamys* (*Chlamys*) *nipponensis* Kuroda, figs. 1, 5, IGPS coll. cat. nos. 95093–1, 95093–2, Loc. no. KK–03; fig. 3, IGPS coll. cat. no. 95094, Loc. no. UK–02.

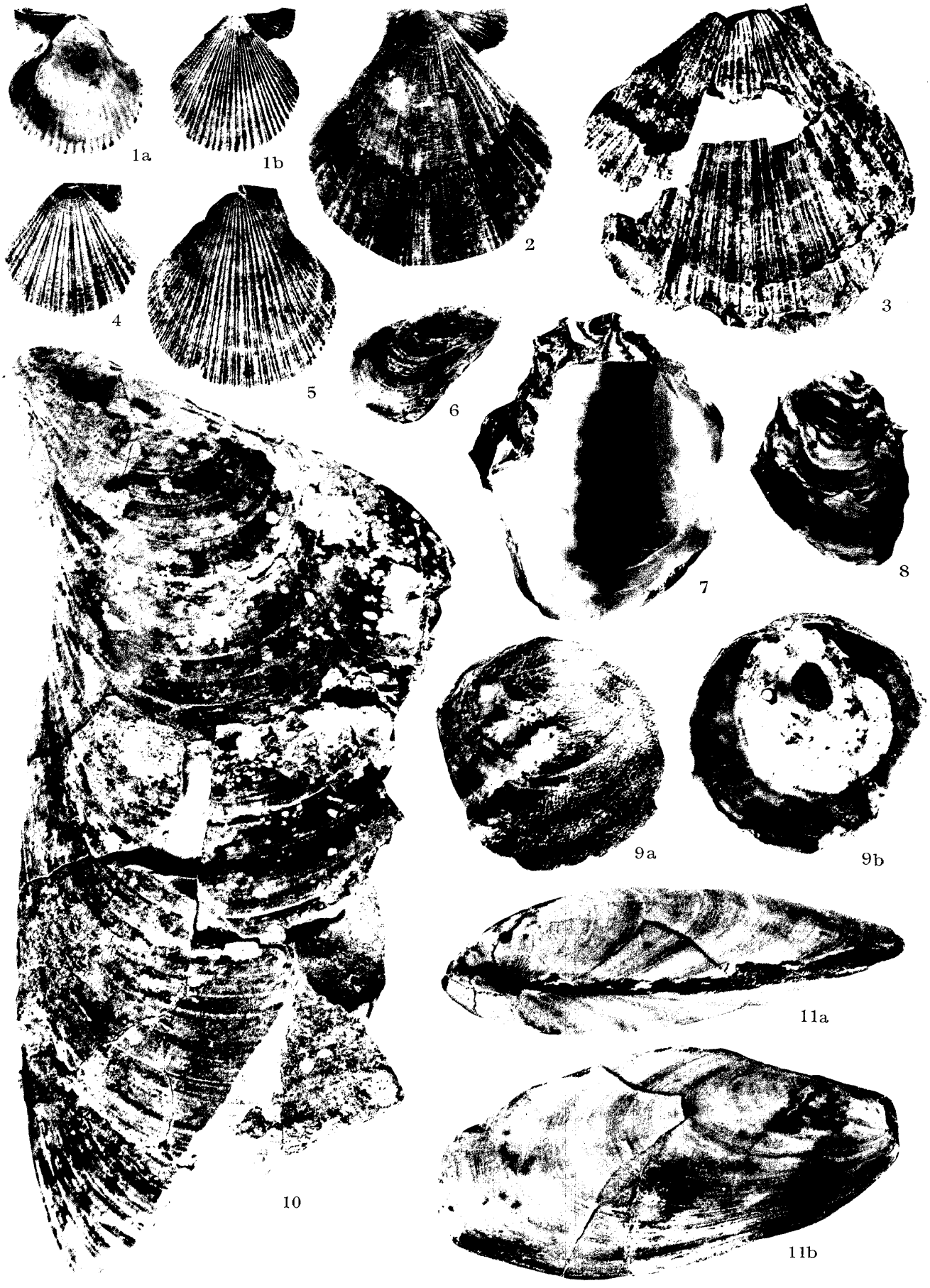
Figs. 2, 4. *Chlamys* (*Chlamys*) *cosibensis* (Yokoyama), fig. 2; IGPS coll. cat. no. 95092–1, Loc. no. UK–04; fig. 4, IGPS coll. cat. no. 95090, Loc. no. IS–09.

Figs. 7–8. *Neopycnodonta musashiana* (Yokoyama), IGPS coll. cat. nos. 95101–1, 95101–2, Loc. no. AW-04.

Figs. 9a–b. *Monia umbonata* (Gould), IGPS coll. cat. no. 95023, Loc. no. KO–05.

Fig. 10. *Mytilus grayanus* Dunker, IGPS coll. cat. no. 95105, Loc. no. UK–02.

Figs. 6, 11a–b. *Modiolus difficilis* (Kuroda and Habe), fig. 6, IGPS coll. cat. no. 95017, Loc. no. UK–04; fig. 11a–b, IGPS coll. cat. no. 95106, Loc. no. KO–13.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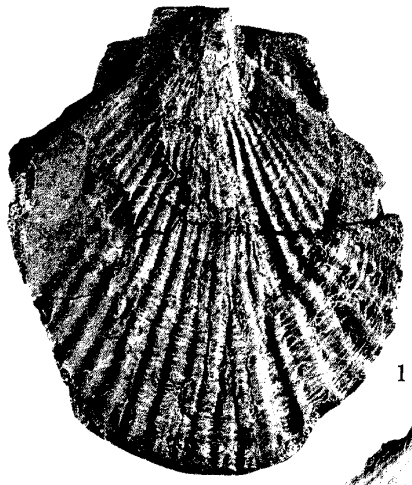
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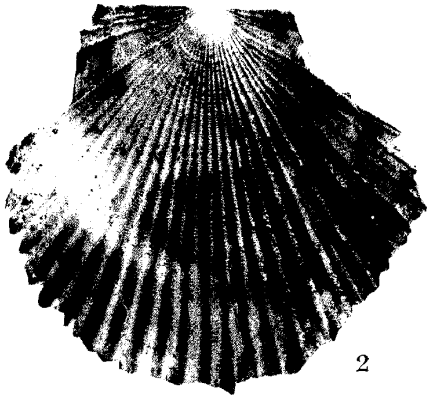
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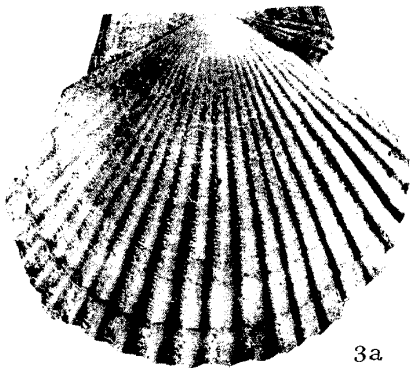
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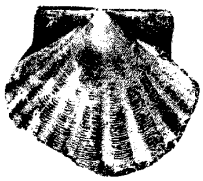
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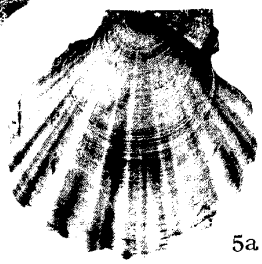
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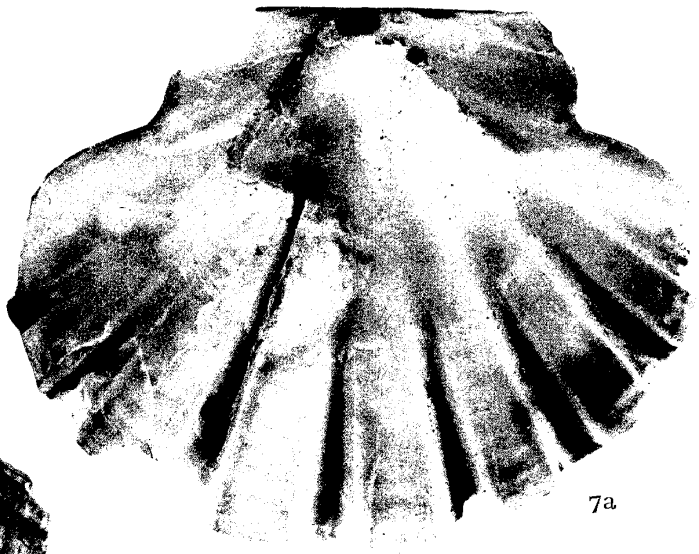
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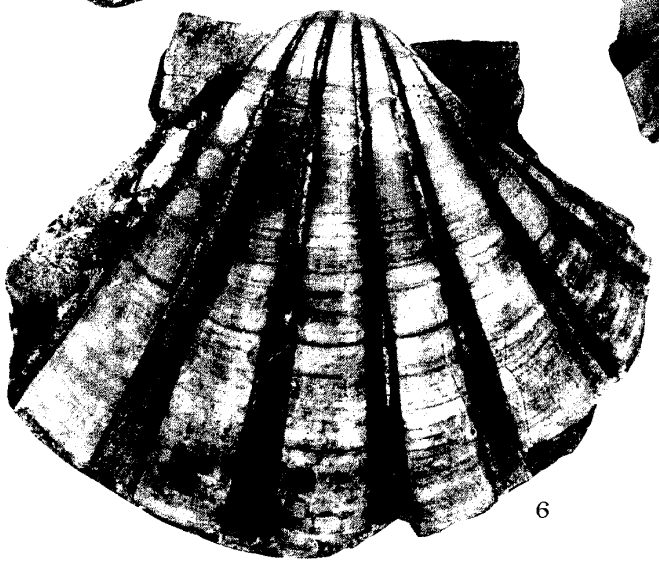
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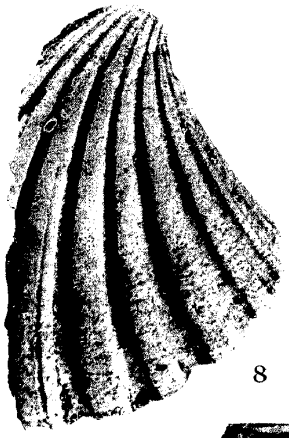
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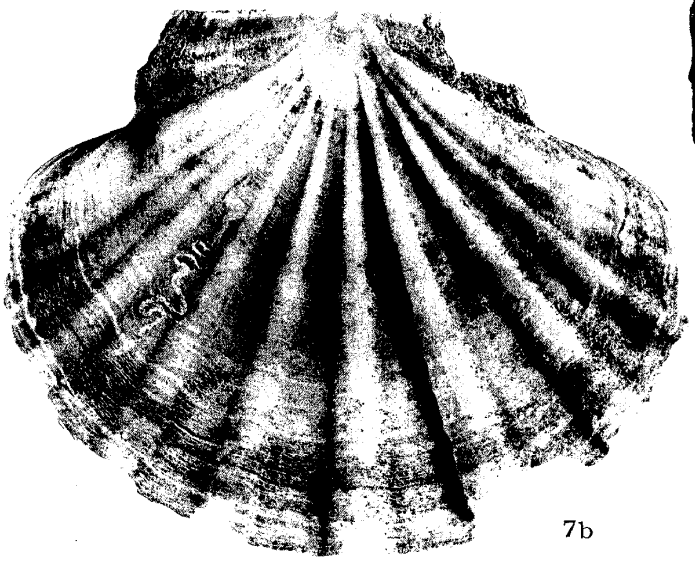
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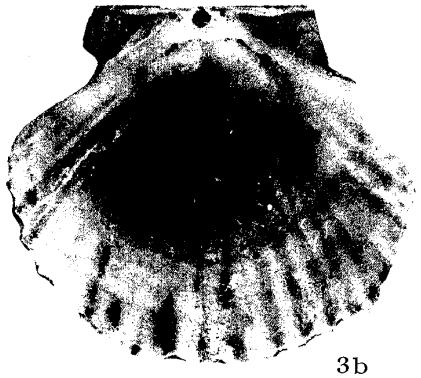
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Explanation of Plate 8

(All figures in natural size, unless otherwise stated)

Figs. 1–2. *Mizuhopecten yessoensis yokoyamae* (Masuda), fig. 1, IGPS coll. cat. no. 95098, Loc. no. FM–17; fig. 2, IGPS coll. cat. no. 95099–1, Loc. no. KK–22.

Figs. 3a–b. *Mizuhopecten yessoensis yessoensis* (Jay), IGPS coll. cat. no. 95281, Loc. no. KO–04.

Figs. 5a–b. *Mizuhopecten tokyoensis hokurikuensis* (Akiyama), fig. 5, IGPS coll. cat. no. 95283, Loc. no. KO–22.

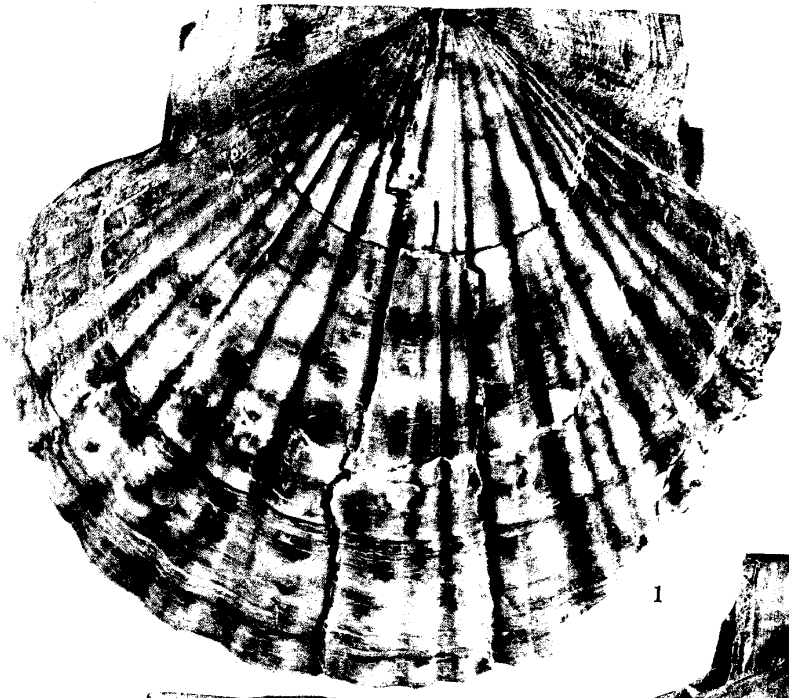
Figs. 4, 6, 7. *Pecten* (*Notovola*) *albicans* (Schröter), fig. 4, IGPS coll. cat. no. 95282–1, Loc. no. KK–03; fig. 6, IGPS coll. cat. no. 95096–1, Loc. no. KK–03; fig. 7, IGPS coll. cat. no. 95095, Loc. 1 m above of Loc. no. KO–04.

Fig. 8. *Pecten* (*Notovola*) cf. *naganumanus* Yokoyama, IGPS coll. cat. no. 95284, Loc. no. RO–17.

Explanation of Plate 9

(All figures in natural size, unless otherwise stated)

Fig. 1. *Mizuhopecten yessoensis yessoensis* (Jay), ×2/3, IGPS coll. cat. no. 95285, Loc. no. KO–04.
Figs. 2a–b. *Chlamys* (*Chlamys*) *cosibensis* (Yokoyama), IGPS coll. cat. no. 95092–3, Loc. no. UK–04.
Figs. 3, 5. *Mizuhopecten yessoensis yokoyamae* (Masuda), fig. 3, IGPS coll. cat. no. 95286, Loc. no. FM–20; fig. 5, × 2/3, IGPS coll. cat. no. 95287, Loc. no. KO–06.
Fig. 4. *Mizuhopecten tokyoensis hokurikuensis* (Akiyama), fig. 4, ×2/3, IGPS coll. cat. no. 95288, Loc. no. KO–15.



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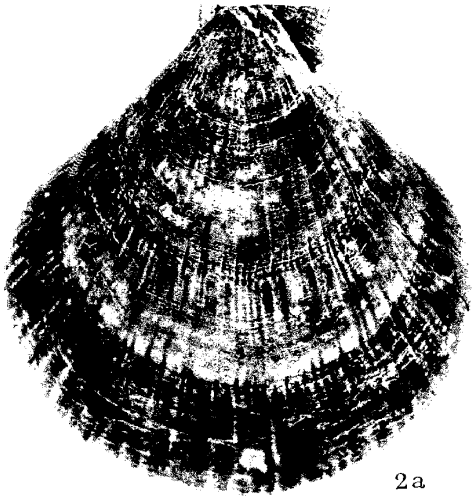

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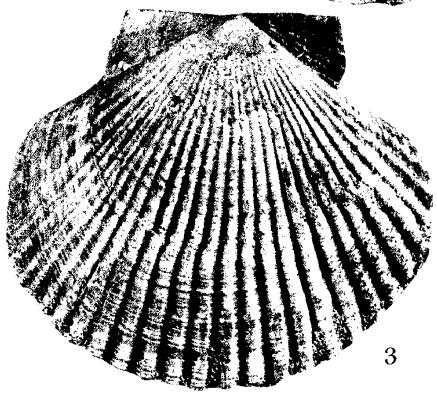

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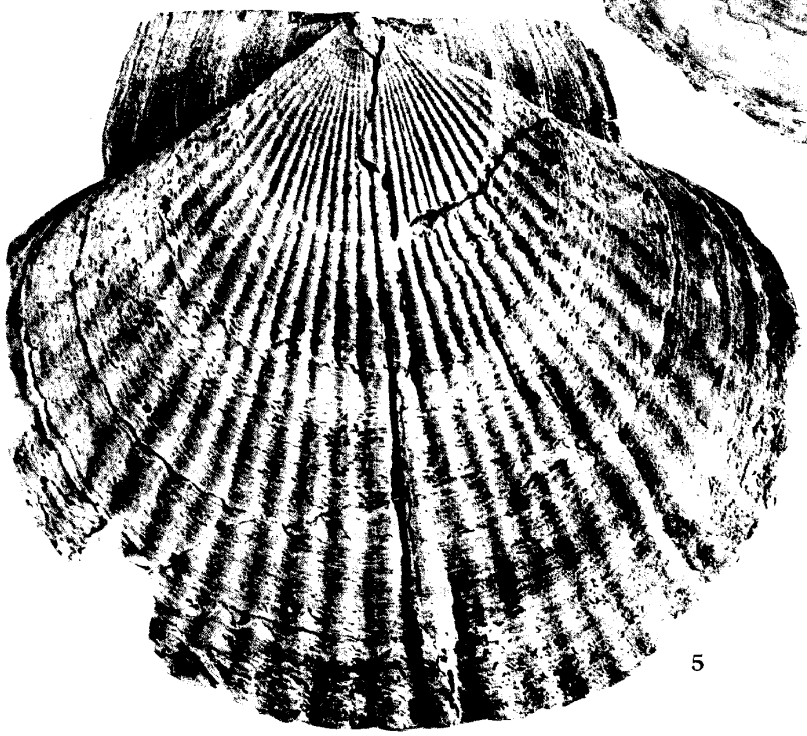

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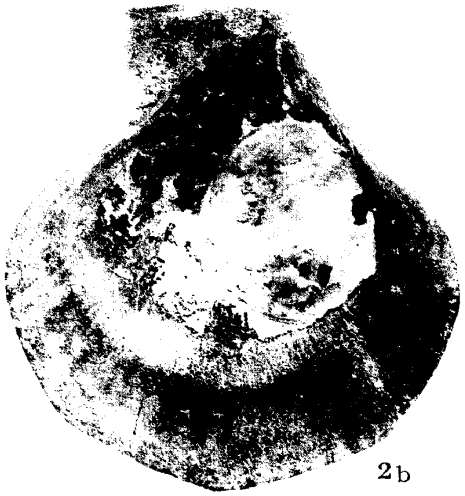

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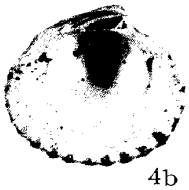
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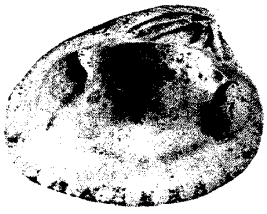
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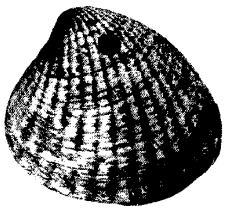
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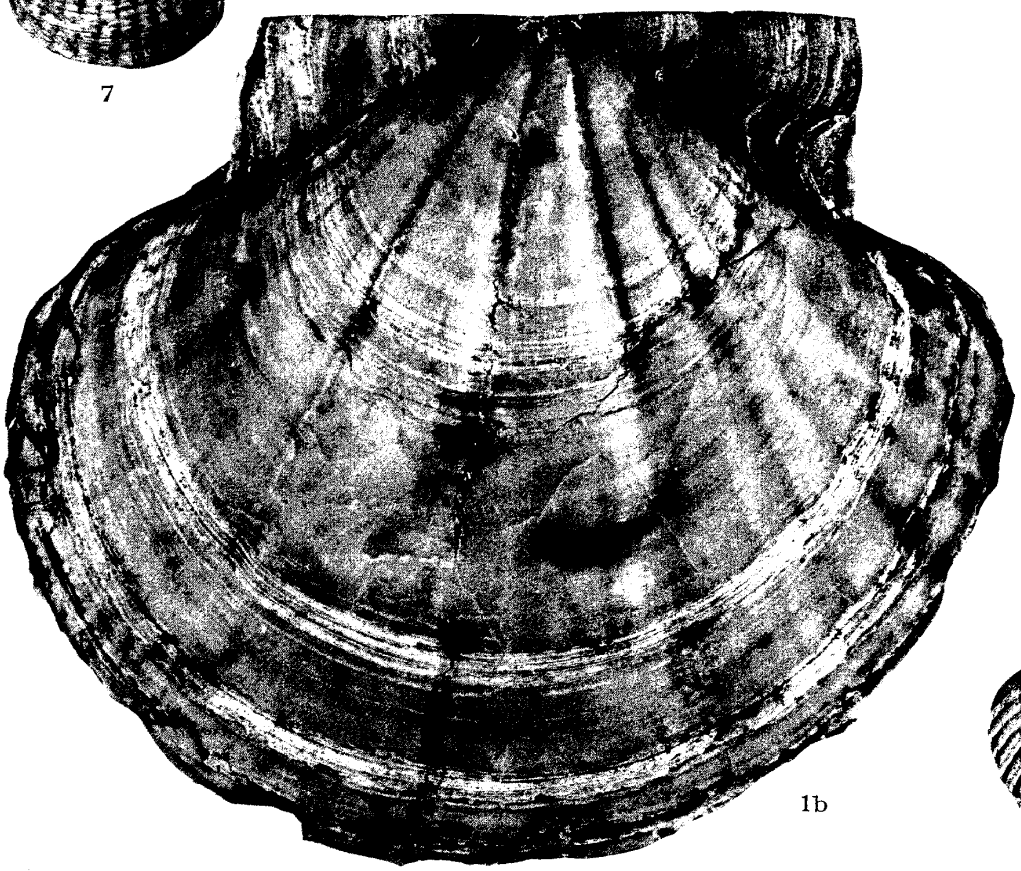
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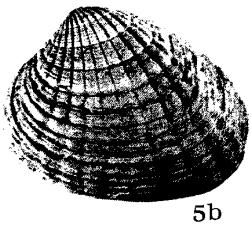
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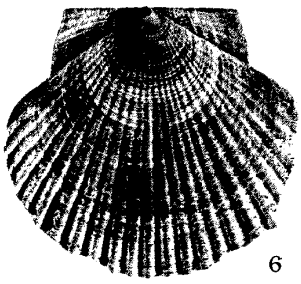
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Explanation of Plate 10

(All figures in natural size, unless otherwise stated)

Figs. 1a–b. *Mizuhopecten tokyoensis hokurikuensis* (Akiyama), ×2/3, IGPS coll. cat. no. 95289, Loc. no. KK–03.

Figs. 2a–b, 5a–b. *Venericardia* (*Megacardita*) *ommaensis* Ogasawara, n. sp, figs. 2a–b, IGPS coll. cat. no. 95122 (Holotype); figs. 5a–b, IGPS coll. cat. no. 95123–1 (Paratype), Loc. no. KO–15.

Figs. 3a–b. *Miodontiscus nakamurai* (Yokoyama), × 2, IGPS coll. cat. no. 95129–1, Loc. no. UK–02.

Figs. 4a–b. *Venericardia* (*Cyclocardia*) *ferruginea orbicularis* Yokoyama, × 2, IGPS coll. cat. no. 95121–1, Loc. no. KO–15.

Fig. 6. *Mizuhopecten yessoensis yokoyamae* (Masuda), IGPS coll. cat. no. 95290, Loc. no. KO–31.

Fig. 7. *Venericardia* (*Cyclocardia*) *myogadaniensis* Itoigawa, IGPS coll. cat. no. 95126–1, Loc. no. IS–01.

Explanation of Plate 11

(All figures in natural size, unless otherwise stated)

Figs. 1–2. *Miodontiscus nakamurai* (Yokoyama), × 2, IGPS coll. cat. nos. 95129–2, 95129–3, Loc. no. UK–02.

Figs. 3a–b. *Venericardia* (*Cyclocardia*) *ferruginea complexa* Ogasawara n. subsp., IGPS coll. cat. no. 95291, Loc. no. KK–42.

Figs. 4a–b. *Venericardia* (*Megacardita*) *ferruginosa* (Adams and Reeve), IGPS coll. cat. no. 95120–1, Loc. no. UK–04.

Figs. 5a–b. *Astarte* (*Astarte*) *hakodatensis* Yokoyama, IGPS coll. cat. no. 95292, Loc. no. UK–02.

Figs. 6a–b. *Pillucina* (*Wallucina*) sp., × 2, IGPS coll. cat. no. 95293, Loc. no. KO–22.

Figs. 7, 18. *Fellaniella usta* (Gould), fig. 7, IGPS coll. cat. no. 95294–1, Loc. no. KO–28; fig. 18, IGPS coll. cat. no. 95295–1, Loc. no. KK–15.

Figs. 8–9, 13a–b. *Astarte* (*Tridonta*) *borealis* (Schumacher), fig. 8, ×2, IGPS coll. cat. no. 95296–1, Loc. no. UK–02; fig. 9, IGPS coll. cat. no. 95297–1, Loc. no. KK–35; fig. 13, ×2, IGPS coll. cat. no. 95296–2, Loc. no. UK–02.

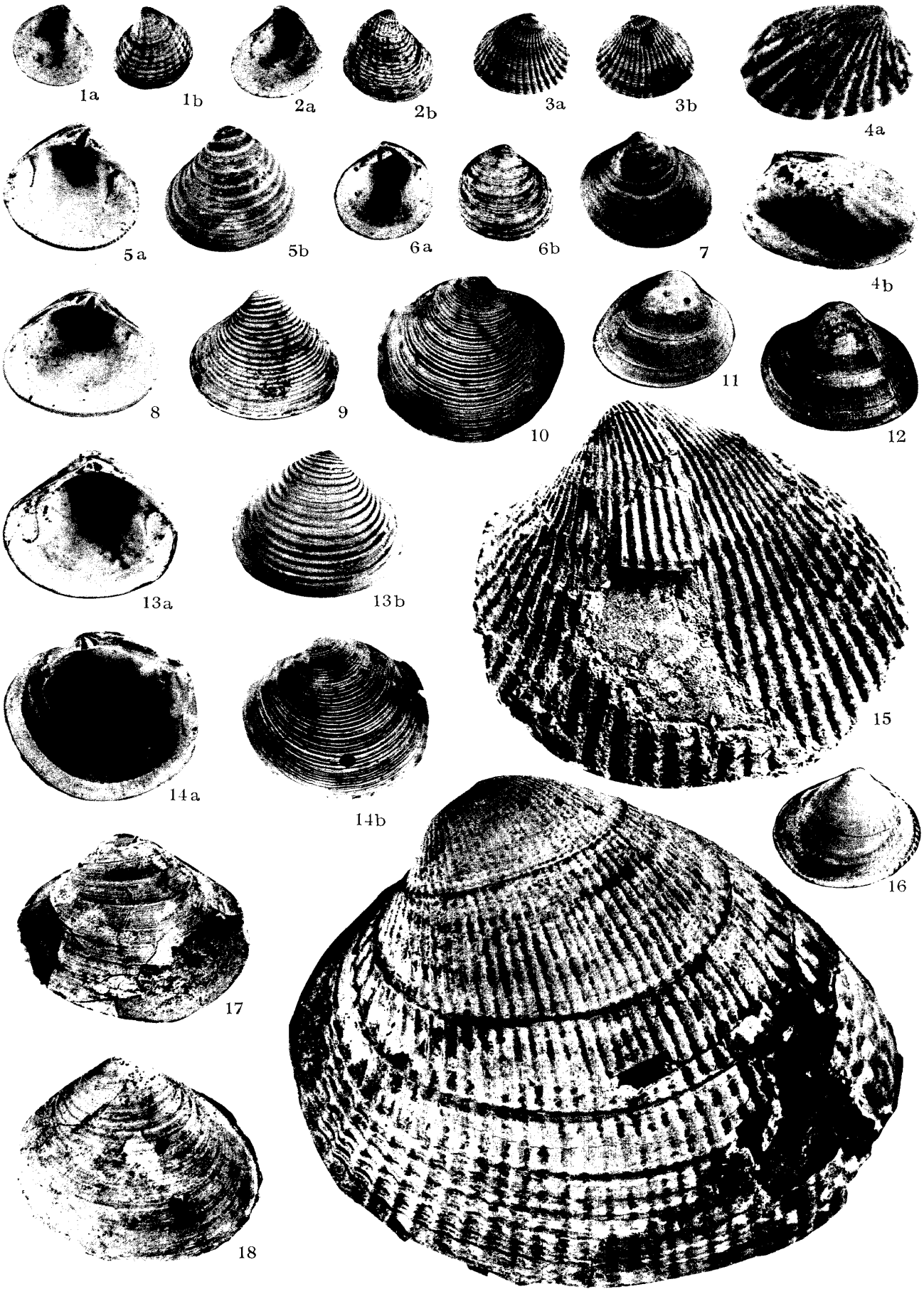
Figs. 10, 14a–b. *Lucinoma annulata* (Reeve), IGPS coll. cat. nos. 95136–1, 95136–2, Loc. no. KO–22.

Figs. 11–12. *Nemocardium* (*Keenaea*) *samarangae* (Makiyama), IGPS coll. cat. nos. 95298–1, 95298–2, Loc. no. KK–52.

Fig. 15. *Clinocardium chikagawaense* Kotaka, IGPS coll. cat. no. 95143, Loc. no. IS–09.

Figs. 16, 19. *Clinocardium fastosum* (Yokoyama), fig. 16, IGPS coll. cat. no. 95140, Loc. no. KK–03; fig. 19, IGPS coll. cat. no. 95141, Loc. no. KO–06.

Fig. 17. *Cycladicama cumingi* (Hanley), IGPS coll. cat. no. 95130–1, Loc. no. KK–52.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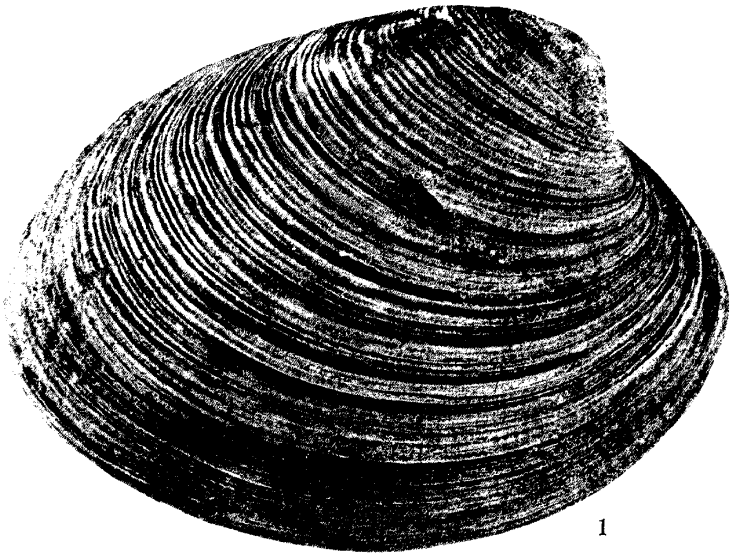

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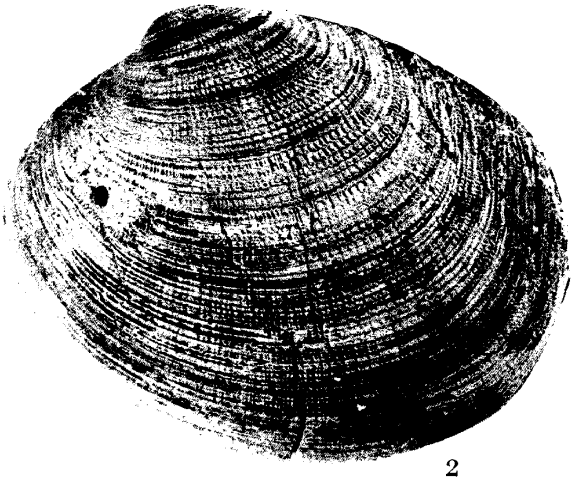

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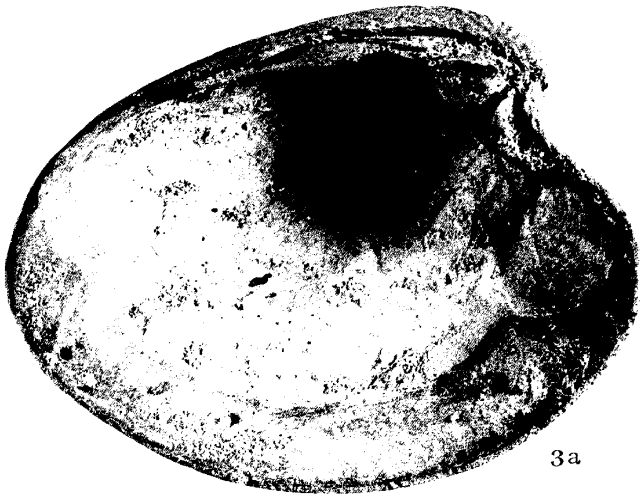

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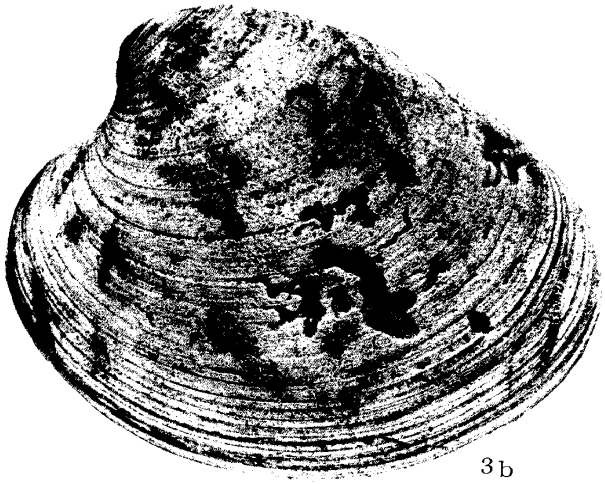

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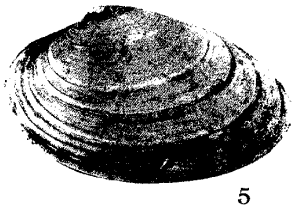

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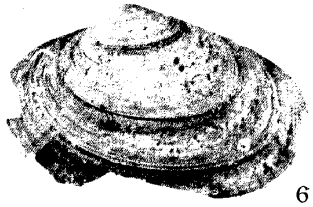

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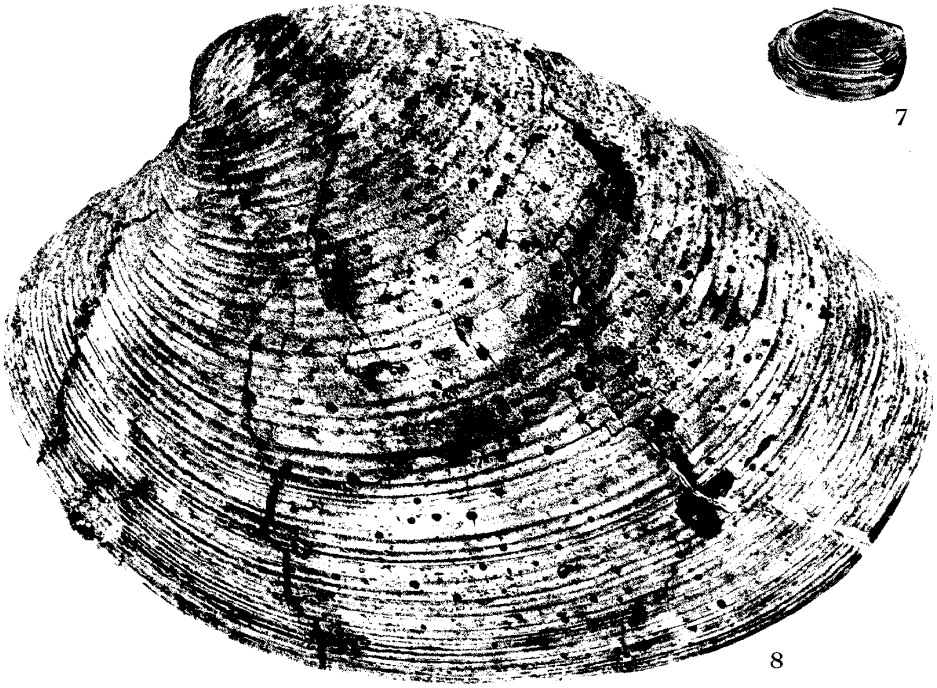

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Explanation of Plate 12

(All figures in natural size, unless otherwise stated)

Fig. 1. *Pseudamiantis tauyensis* (Yokoyama), IGPS coll. cat. no. 95145–1, Loc. no. KO–28.
Fig. 2. *Callithaca* (*Protocallithaca*) *adamsi* (Reeve), IGPS coll. cat. no. 95157, Loc. no. KK–24.
Figs. 3a–b, 8. *Mercenaria stimpsoni* (Gould), figs. 3a–b, IGPS coll. cat. no. 95156–1, Loc. no. KO–28; fig. 8, IGPS coll. cat. no. 95154–1, Loc. no. KO–04.
Fig. 4. *Venericardia* (*Cyclocardia*) *ferruginea complexa* Ogasawara n. subsp., × 2, IGPS coll. cat. no. 95127 (Holotype), Loc. no. KO–22.
Fig. 5. *Callista* (*Callista*) *chinensis* (Holten), IGPS coll. cat. no. 95144, Loc. no. KK–03.
Fig. 6. *Gomphina* sp., ×2, IGPS coll. cat. no. 95299, Loc. no. IS–09.
Fig. 7. *Mya* (*Mya*) sp., IGPS coll. cat. no. 95300, Loc. no. UK–04.

Explanation of Plate 13

(All figures in naurtal size, unless otherwise stated)

Figs. 1, 7–8. *Pseudamiantis tauyensis* (Yokoyama), IGPS coll. cat. nos. 95146–1, 95146–2, 95146–3, Loc. no. KO–22.

Figs. 2, 5–6. *Dosinia* (*Phacosoma*) *japonica* (Reeve), figs. 2, 5, IGPS coll. cat. nos. 95151–1, 95151–2, Loc. no. KK–03; fig. 6, IGPS coll. cat. no. 95152, Loc. no. KK–24.

Fig. 3. *Venericardia* (*Megacardita*) *ommaensis* Ogasawara n. sp., IGPS coll. cat. no. 95125, Loc. no. RO–07.

Fig. 4. *Gomphina* sp., ×2, IGPS coll. cat. no. 95301, Loc. no. KO–06.

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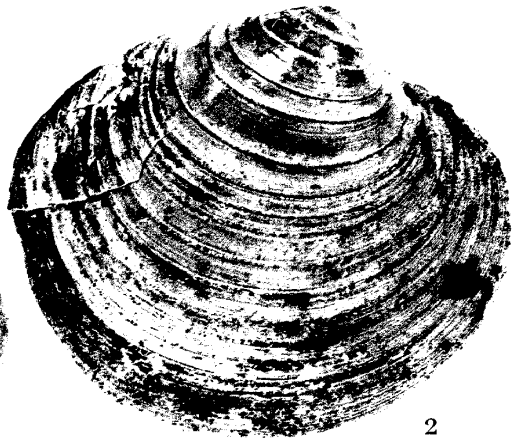

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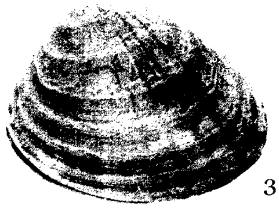

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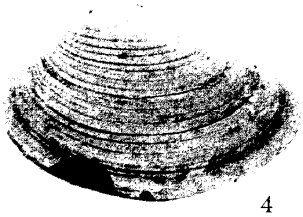

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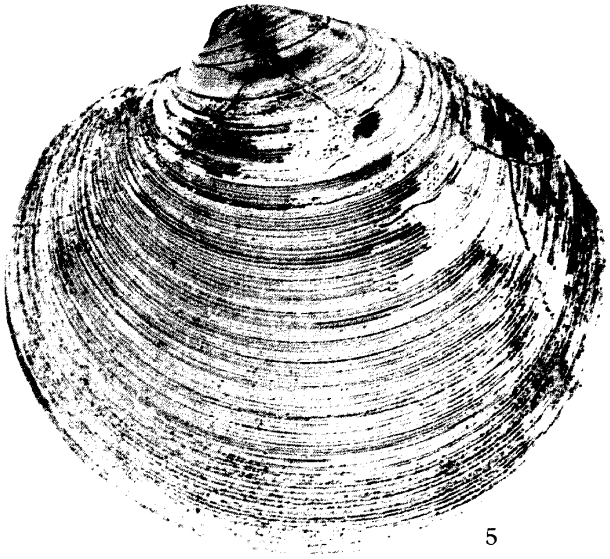

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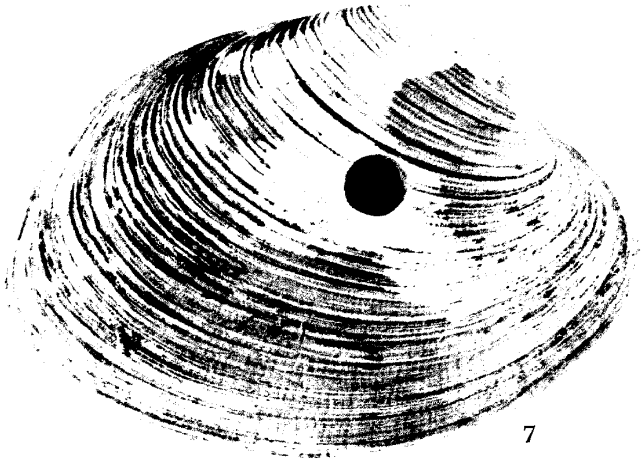

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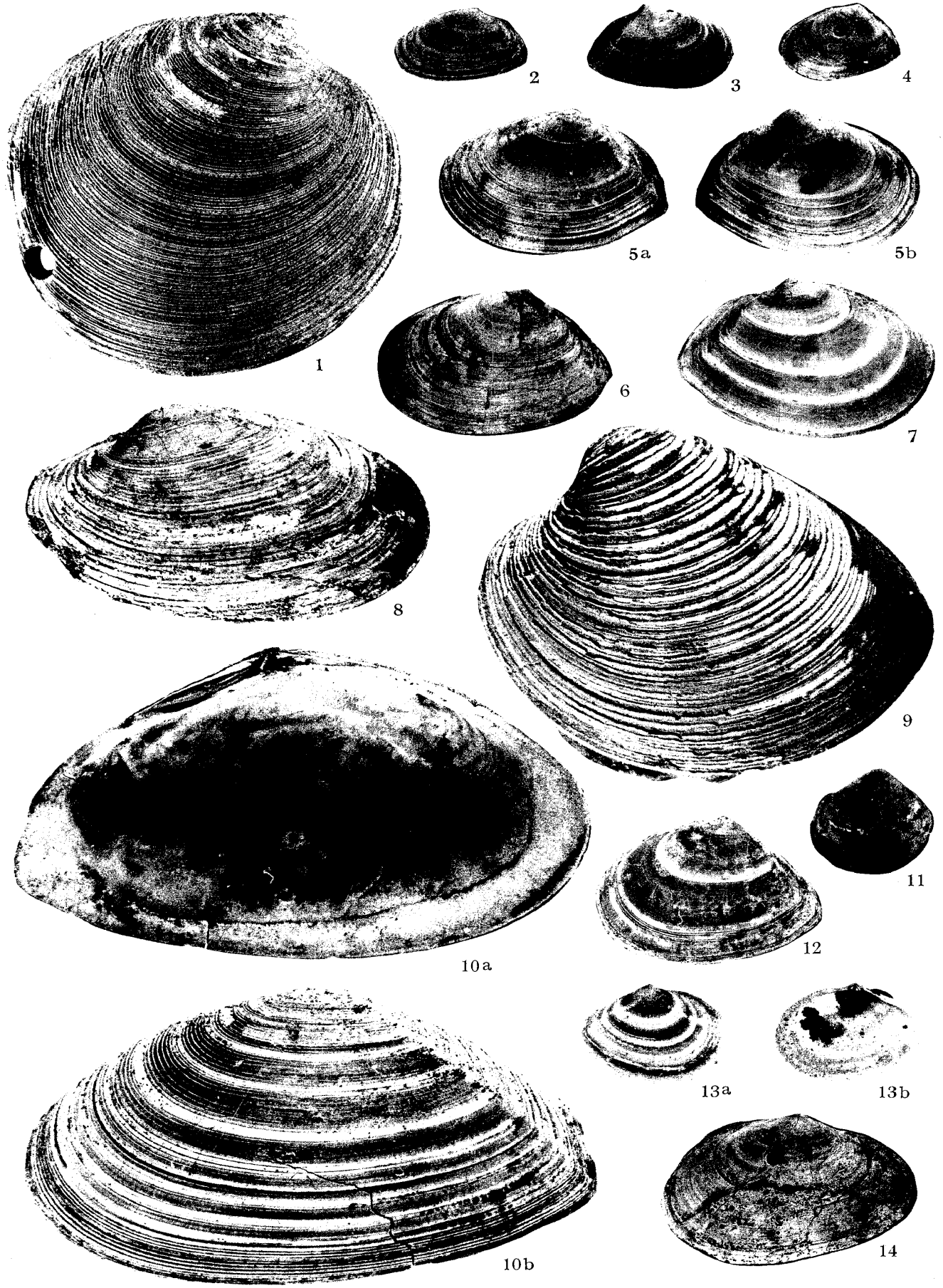
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Explanation of Plate 14

(All figures in natural size, unless otherwise stated)

Fig. 1. *Dosinia* (*Phacosoma*) *japonica* (Reeve), IGPS coll. cat. no. 95151–3, Loc. no. KK–03.
Figs. 2–3. *Fabulina nitidula* (Dunker), IGPS coll. cat. nos. 95170–1, 95170–2, Loc. no. KK–03.
Fig. 4. *Macoma nipponica* (Tokunaga), IGPS coll. cat. no. 95162–4, Loc. no. IS–09.
Figs. 5a–b, 7. *Rexithaerus sectior* (Oyama), figs. 5a–b, IGPS coll. cat. no. 95302–1, Loc. no. KK–25; fig. 7, IGPS coll. cat. no. 95165–1, Loc. no. KK–03.
Fig. 6. *Macoma* sp. A, IGPS coll. cat. no. 95303, Loc. no. UK–04.
Fig. 8. *Paphia amabilis* (Philippi), IGPS coll. cat. no. 95158, Loc. no. KK–52.
Fig. 9. *Mercenaria stimpsoni* (Gould), IGPS coll. cat. no. 95155, Loc. no. KK–03.
Figs. 10a–b. *Peronidia zyonoensis* (Hatai and Nisiyama), IGPS coll. cat. no. 95304–1, Loc. no. KK–03.
Fig. 11. *Crenella* sp., × 3/2, IGPS coll. cat. no. 95305, Loc. no. KK–36.
Fig. 12. *Macoma tokyoensis* Makiyama, IGPS coll. cat. no. 95164, Loc. no. KO–29.
Figs. 13a–b. *Macoma praetexta* (v. Martens), × 2, IGPS coll. cat. no. 95199–1, Loc. no. KK–42.
Fig. 14. *Macoma* sp. B, IGPS coll. cat. no. 95306, Loc. no. UK–04.

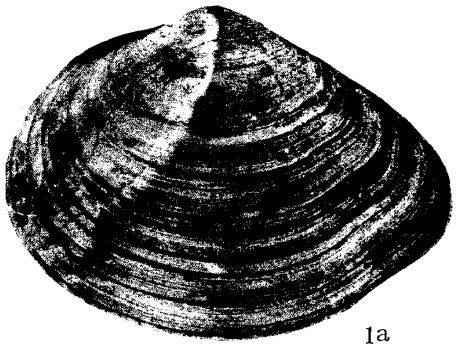
Explanation of Plate 15

(All figures in natural size, unless otherwise stated)

Figs. 1, 3, 5. *Heteromacoma irus* (Hanley), fig. 1, IGPS coll. cat. no. 95410–1, Loc. no. RO–14; figs. 3, 5, IGPS coll. cat. nos. 95169–1, 95169–2, Loc. no. UK–04.

Figs. 2, 7. *Macoma praetexta* (v. Martens), fig. 2, IGPS coll. cat. no. 95307, Loc. no. KK–08; fig. 7, IGPS coll. cat. no. 95199–2, Loc. no. KK–42.

Figs. 4, 6a–b, 8a–b. *Nipponopagia ommaensis* Ogasawara n. gen. et n. sp., fig. 4, IGPS coll. cat. no. 95073–2 (Paratype); figs. 6a–b, IGPS coll. cat. no. 95072 (Holotype); figs. 8a–b, IGPS coll. cat. no. 95073–1 (Paratype), Loc. no. KO–22.



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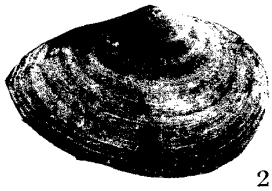

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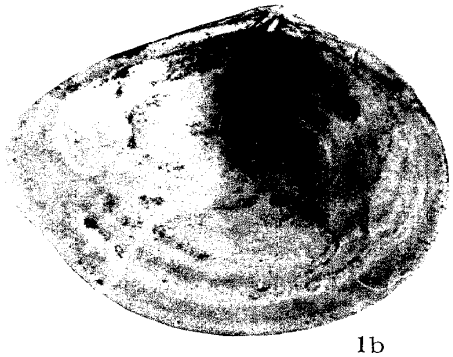

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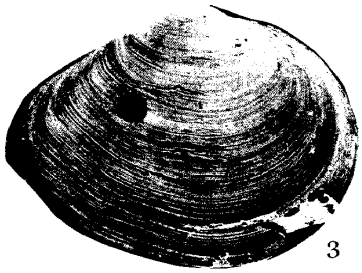

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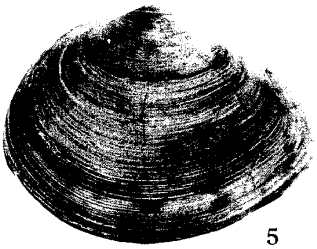

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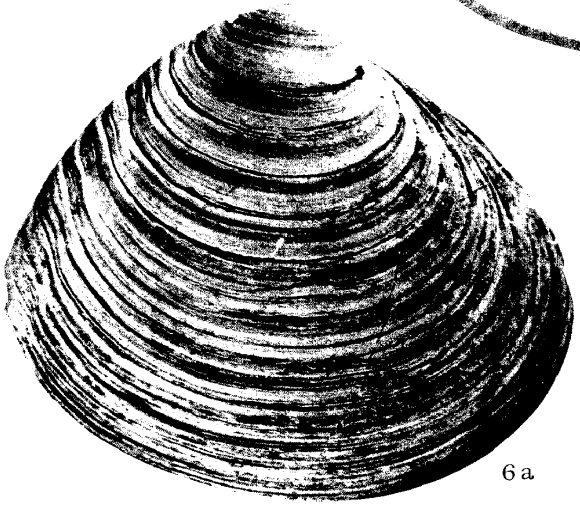

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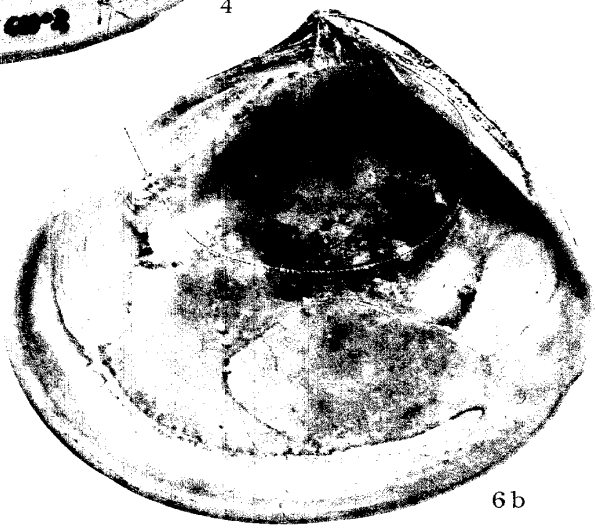

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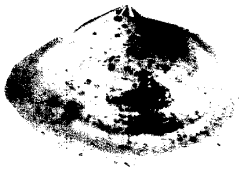

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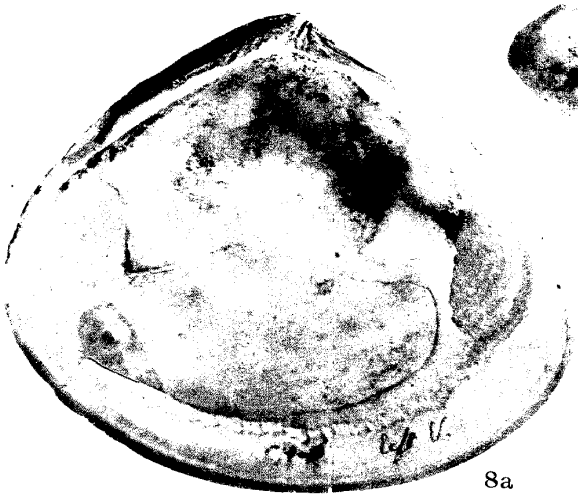

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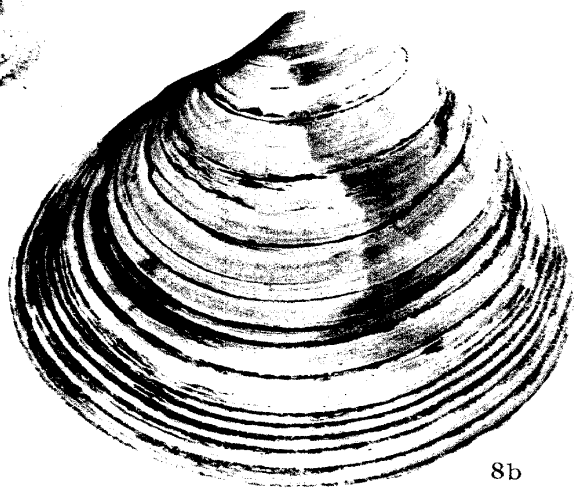

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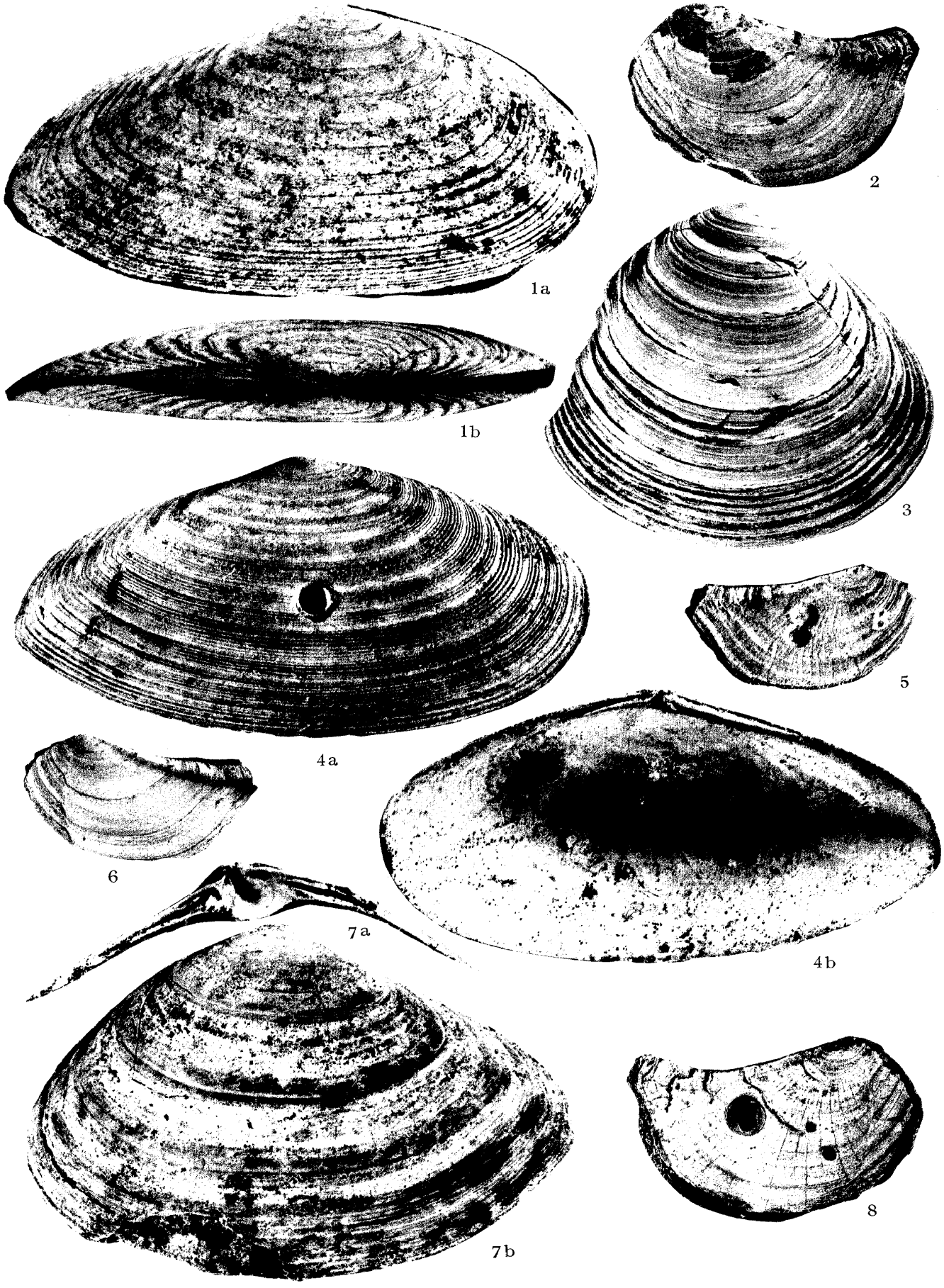
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Explanation of Plate 16

(All figures in natural size, unless otherwise stated)

Figs. 1, 4. *Peronidia zyonoensis* (Hatai and Nisiyama), fig. 1, IGPS coll. cat. no. 95308–1, Loc. no. KK–21; fig. 4, IGPS coll. cat. no. 95309–1, Loc. no. KO–04.

Figs. 2, 5–6, 8. *Pandora* (*Heteroclidus*) *pulchella* Yokoyama, IGPS coll. cat. nos. 95114–1, 95114–2, 95114–3, 95114–4, Loc. no. KK–03.

Fig. 3. *Nipponopagia ommaensis* Ogasawara n. gen. et n. sp., IGPS coll. cat. no. 95310, Loc. no. KO–22.

Figs. 7a–b. *Spisula* (*Mactromeris*) *voyi* (Gabb), IGPS coll. cat. no. 95161–1, Loc. no. KO–04.

Explanation of Plate 17

(All figures in natural size, unless otherwise stated)

Fig. 1. *Umitakea japonica* (Yokoyama), IGPS coll. cat. no. 95108, Loc. Small river side cliff, about 100 m ESE from the Wakamatsu bridge, Wakamatsu-machi, Kanazawa City, Ishikawa Prefecture.

Figs. 2–7. *Myadora japonica* Habe, fig. 2, ×2, IGPS coll. cat. no. 95112–1, Loc. no. KO–22; figs. 3–4, 7, IGPS coll. cat. nos. 95111–1, 95111–2, 95111–3, Loc. no. KK–03; figs. 5–6, ×3/2, IGPS coll. cat. nos. 95112–2, 95112–3, Loc. no. KO–22.

Figs. 8, 13. *Thracia kakumana* (Yokoyama), IGPS coll. cat. nos. 95109–1, 95109–2, Loc. no. KK–25.

Figs. 9a–b. *Mya* (*Mya*) cf. *japonica* Jay, IGPS coll. cat. no. 95160, Loc. no. IS–09.

Fig. 10. *Panope japonica* A. Adams, IGPS coll. cat. no. 95174–1, Loc. no. KK–03.

Figs. 11–12. *Dentalium weinkauffii* Dunker, IGPS coll. cat. nos. 95311–1, 95311–2, Loc. no. KO–22.

Figs. 14a–b. *Solen* (*Solenarius*) *krusensterni* Schrenck, IGPS coll. cat. no. 95173–1, Loc. no. KK–03.


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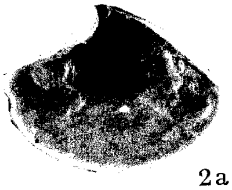
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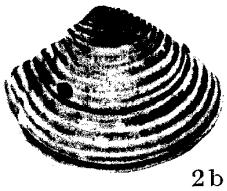
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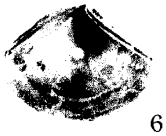
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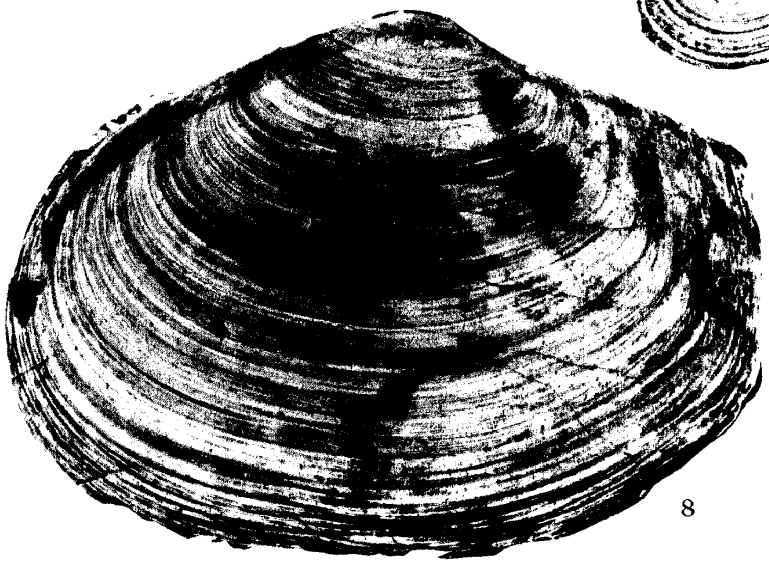
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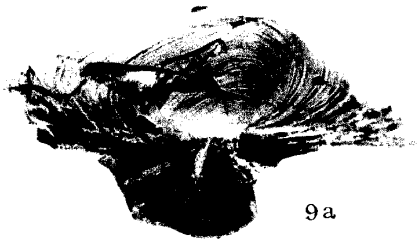
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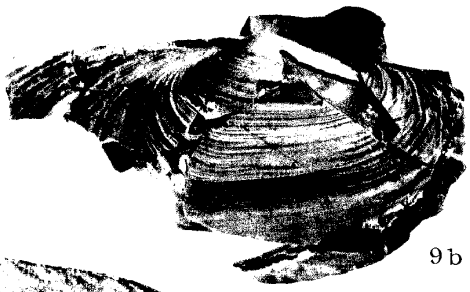
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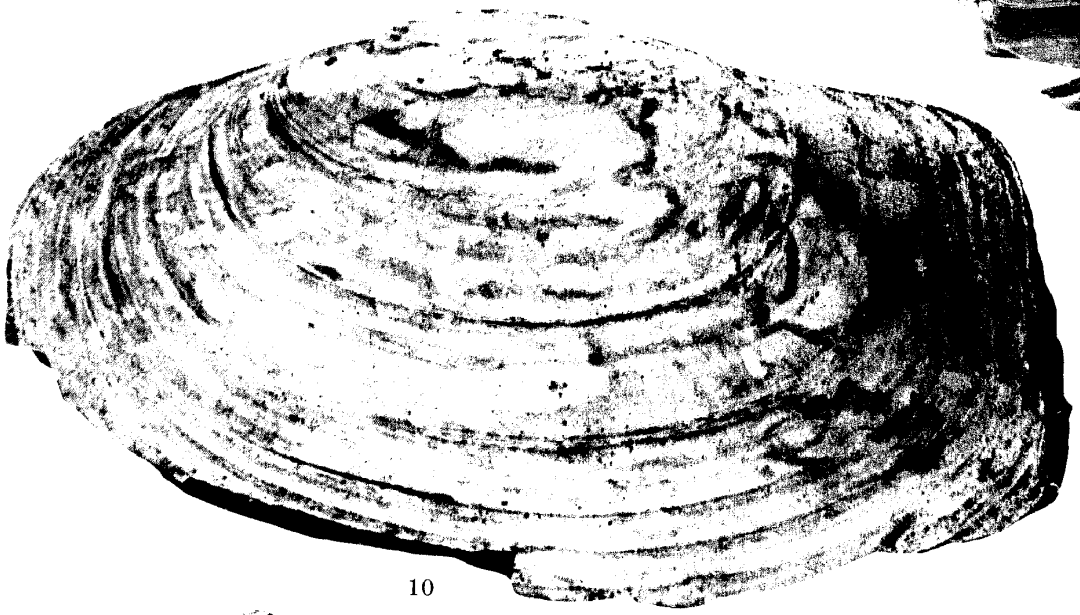
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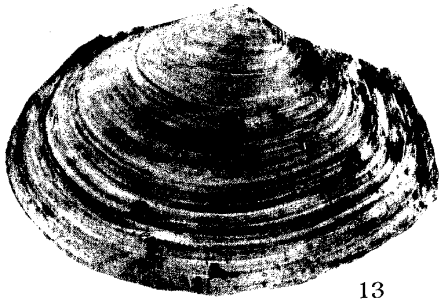
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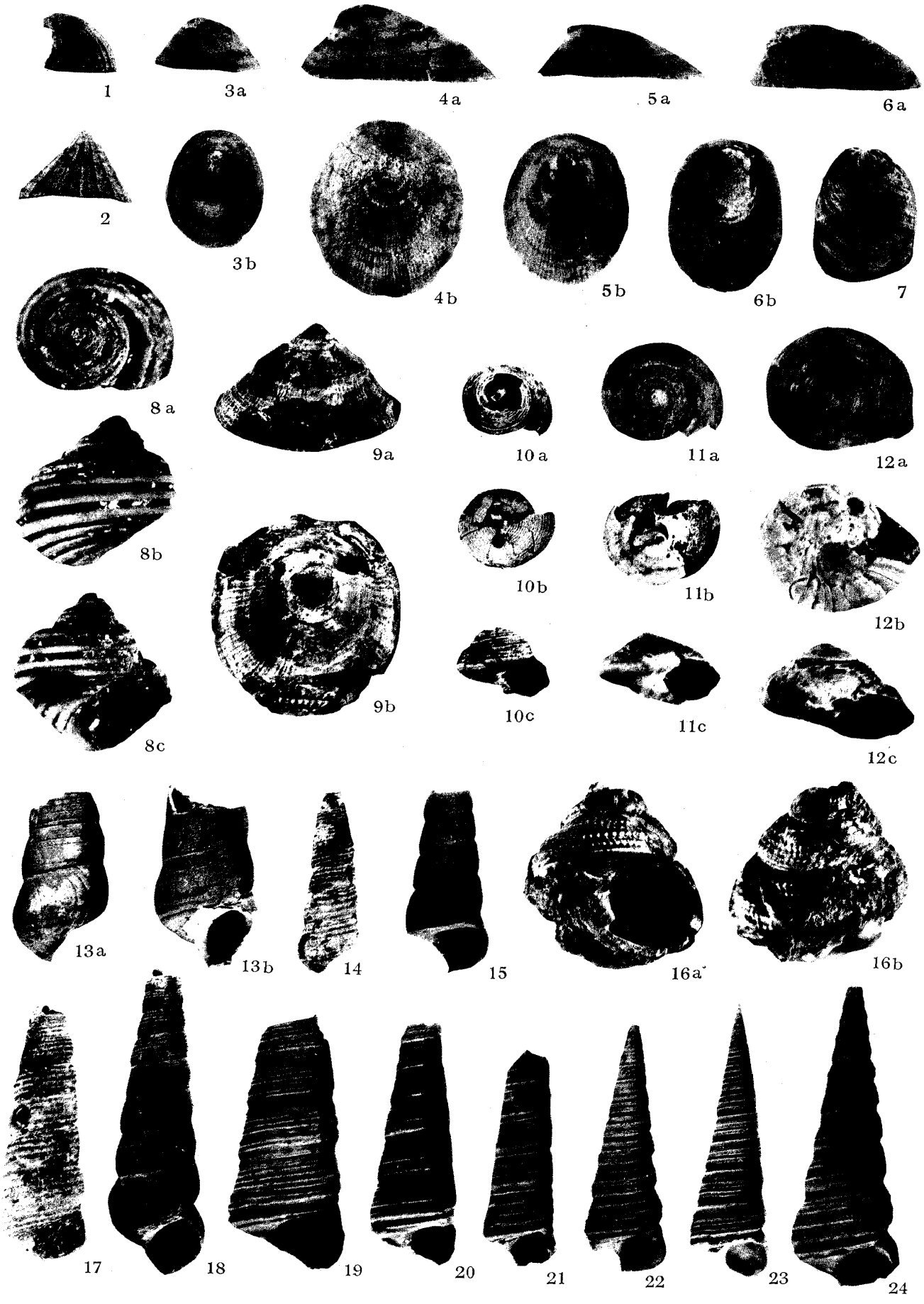
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Explanation of Plate 18

(All figures in natural size, unless otherwise stated)

Figs. 1–2. *Puncturella* (*Puncturella*) *nobilis* A. Adams, fig. 1, × 3/2, IGPS coll. cat. no. 95312–1, Loc. no. UK–04; fig. 2, × 2, IGPS coll. cat. no. 95312–2, Loc. no. UK–04.

Figs. 3, 5. *Notoacmea asperulata* (Yokoyama), IGPS coll. cat. nos. 95313–1, 95313–2, Loc. no. UK–04.

Figs. 4a–b. *Lepeta* cf. *abra* (Dall), IGPS coll. cat. no. 95314, Loc. no. UK–04.

Figs. 6a–b. *Notoacmea* sp., IGPS coll. cat. no. 95315, Loc. no. UK–04.

Fig. 7. *Philine* cf. *argentata* Gould, IGPS coll. cat. no. 95316, Loc. no. KK–03.

Figs. 8a–c. *Littorina brevicula* (Philippi), × 3, IGPS coll. cat. no. 95317, Loc. no. ZU–15. (Zukawa Formation), Road side cutting, about 1800 m N of Morigama bridge, Takaoka City, Toyama Prefecture.

Figs. 9a–b. *Collisella* cf. *pelata shirogai* Habe and Ito, IGPS coll. cat. no. 95318, Loc. no. FM–43.

Figs. 10a–c. *Calliostoma* (*Tristichotrochus*) cf. *multiliratus* (Sowerby), IGPS coll. cat. no. 95409, Loc. no. KO–22.

Figs. 11–12. *Umbonium* (*Suchium*) *akitanum* Suzuki, fig. 11, × 3/2, IGPS coll. cat. no. 95319, Loc. no. ZU–15; fig. 12, IGPS coll. cat. no. 95320, Loc. no. KO–27.

Figs. 13, 18. *Mesalina ommaensis* Ogasawara n. sp., fig. 13, IGPS coll. cat. nos. 75075 (Paratype); fig. 18, IGPS coll. cat. no. 95074 (Holotype), Loc. no. KO–22.

Figs. 14, 17. *Tachyrhynchus venustellus* (Yokoyama), fig. 14, × 3/2, IGPS coll. cat. no. 95321, Loc. no. KO–15; fig. 17, × 6, IGPS coll. cat. no. 95322, Loc. no. KO–10.

Fig. 15. *Turritella* (*Neohaustator*) *saishuensis etigoensis* Ida, IGPS coll. cat. no. 95177, Loc. no. IS–09.

Figs. 16a–b. *Turcica coreensis* Pease, IGPS coll. cat. no. 95175, Loc. no. IS–09.

Figs. 19, 21, 24. *Turritella* (*Neohaustator*) *saishuensis saishuensis* Yokoyama, Fig. 19, IGPS coll. cat. no. 95178–1, Loc. no. KK–52; fig. 21, IGPS coll. cat. no. 95323–1, Loc. no. IS–06; fig. 24, IGPS coll. cat. no. 95324–1, Loc. no. KK–01.

Figs. 20, 23. *Turritella* (*Neohaustator*) *saishuensis etigoensis* Ida, IGPS coll. cat. nos. 95179–1, 95179–2, Loc. no. IS–09.

Fig. 22. *Turritella* (*Neohaustator*) *saishuensis motidukii* Otuka, IGPS coll. cat. no. 95325–1, Loc. no. KK–24.

Explanation of Plate 19

(All figures in natural size, unless otherwise stated)

Figs. 1–3, 10. *Neverita* (*Glossaulax*) *reiniana* (Dunker), fig. 1, IGPS coll. cat. no. 95326, Loc. no. KO–35; figs. 2a–b, IGPS coll. cat. no. 95327, Loc. no. KO–07; fig. 3, IGPS coll. cat. no. 95328, Loc. no. KO–22;, fig. 10, IGPS coll. cat. no. 95329, Loc. no. KO–06.

Fig. 4. An operculum of Naticidae, IGPS coll. cat. no. 95330, Loc. no. KK–03.

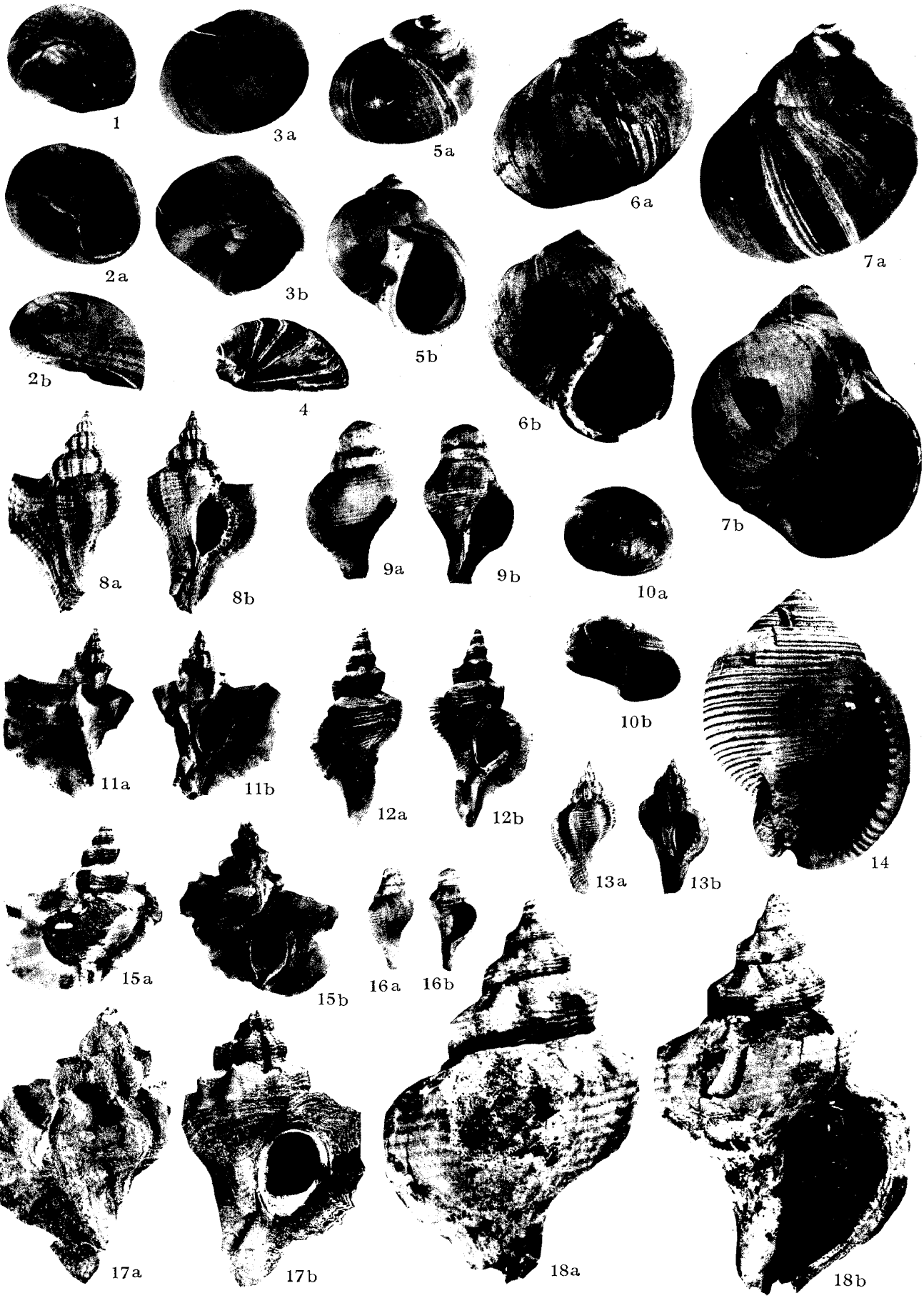
Figs. 5a–b. *Cryptonatica janthostomoides* (Kuroda and Habe), IGPS coll. cat. no. 95331, Loc. no. KK–42.

Figs. 6–7. *Lunatia pila* (Pilsbry), fig. 6, IGPS coll. cat. no. 95332, Loc. no. KK–35; fig. 7, IGPS coll. cat. no. 95333, Loc. no. KO–22.

Figs. 8, 11–13, 15, 17. *Ocenebra aduncum* (Sowerby), fig. 8, × 3/2, IGPS coll. cat. no. 95185, Loc. no. KK–25; fig. 11, IGPS coll. cat. no. 95182, Loc. no. KK–02; fig. 12, IGPS coll. cat. no. 95183, Loc. no. KO–22; fig. 13, IGPS coll. cat. no. 95334, Loc. no. KO–04; fig. 15, IGPS coll. cat. no. 95184, Loc. no. KK–03; fig. 17, IGPS coll. cat. no. 95180, Loc. no. KK–16.

Figs. 9, 16, 18. *Neptunea* (*Barbitonia*) *arthritica* (Bernardi), fig. 9, × 3/2, IGPS coll. cat. no. 95187, Loc. no. KO–04; fig. 16, IGPS coll. cat. no. 95188, Loc. no. KO–22; fig. 18, IGPS coll. cat. no. 95186, Loc. no. KK–25.

Fig. 14. *Semicassis japonica* (Reeve), IGPS coll. cat. no. 95335, Loc. no. KK–34.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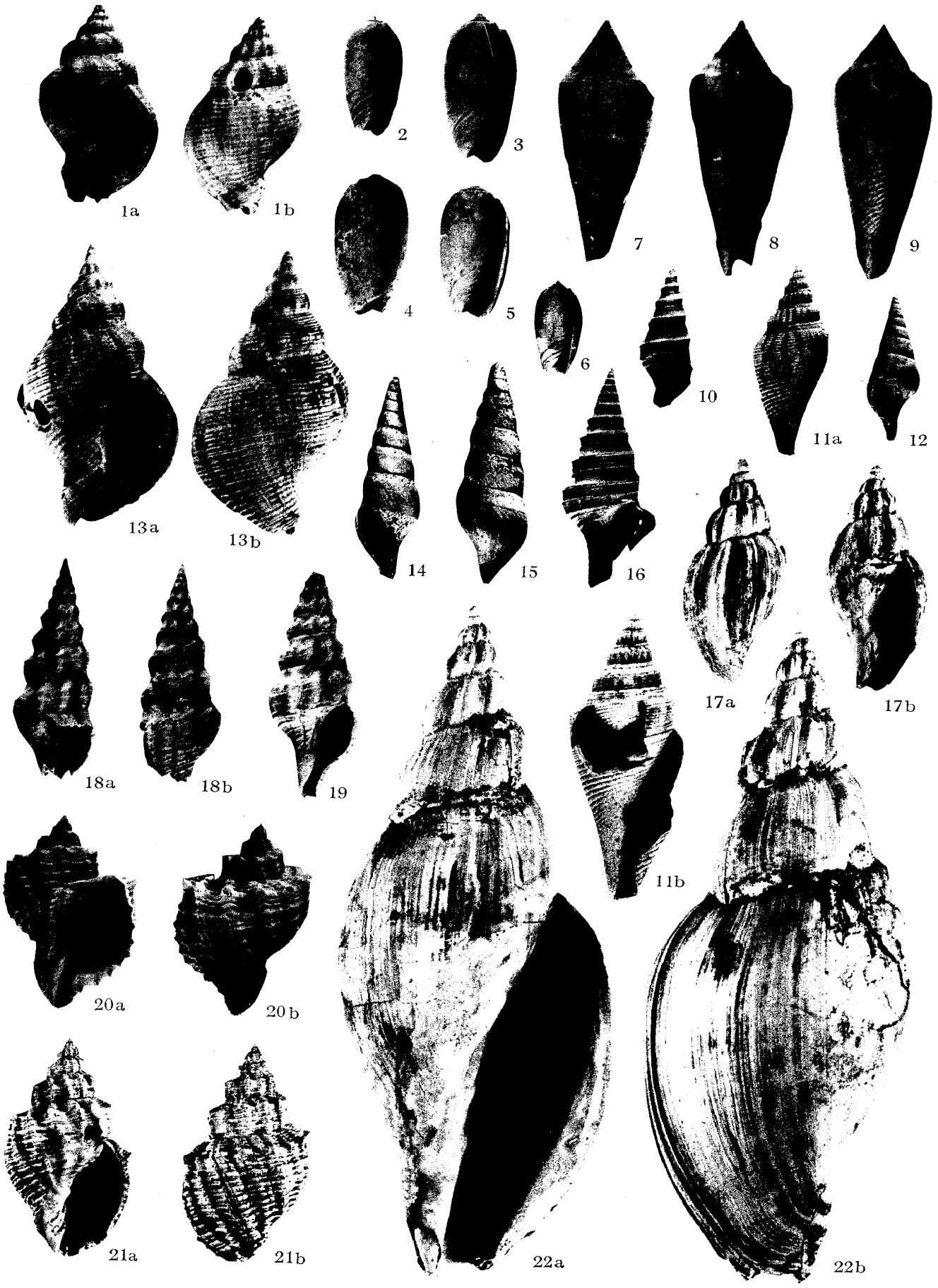
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Explanation of Plate 20

(All figures in natural size, unless otherwise stated)

Figs. 1, 13. *Siphonalia fusoides* (Reeve), fig. 1, IGPS coll. cat. no. 95337, Loc. no. KO–22; fig. 13, IGPS coll. cat. no. 95189, Loc. no. KK–03.

Figs. 2–6. *Oliva mustelina* Lamarck, figs. 2–3, IGPS coll. cat. nos. 95197–1, 95197–2, Loc. no. KO–02; figs. 4–6, IGPS coll. cat. nos. 95196–1, 95196–2, 95196–3, Loc. no. KO–01.

Figs. 7–9. *Endemoconus sieboldi* (Reeve), figs. 7–8, IGPS coll. cat. nos. 95338–1, 95338–2, Loc. no. KO–01; fig. 9, IGPS coll. cat. no. 95339–1, Loc. no. KO–02.

Figs. 10, 16. *Suavodrillia declivis* (v. Martens), fig. 10, IGPS coll. cat. no. 95340, Loc. no. KO–22; fig. 16, × 3/2, IGPS coll. cat. no. 95341, Loc. no. KO–01.

Figs. 11a–b. *Canarium* (*Doxander*) *japonicus* (Reeve), × 3/2, IGPS coll. cat. no. 95200, Loc. no. KO–02.

Figs. 12, 14–15. *Antiplanes contraria* (Yokoyama), figs. 12, 14, IGPS coll. cat. nos. 95342–1, 95342–2, Loc. no. KO–22; fig. 15, IGPS coll. cat. no. 95343, Loc. no. KO–04.

Figs. 17, 22. *Fulgoraria masudae* Hayasaka, fig. 17, IGPS coll. cat. no. 95336, Loc. no. KO–23; fig. 22, IGPS coll. cat. no. 95198, Loc. no. KO–22

Figs. 18–19. *Inquisitor jeffreysii* (Smith), IGPS coll. cat. nos. 95344–1, 95344–2, Loc. no. KO–01.

Figs. 20a–b. *Cancellaria* (*Habesolatia*) *nodulifera* Sowerby, IGPS coll. cat. no. 95345, Loc. no. KO–22.

Figs. 21a–b. *Cancellaria* (*Sydaphera*) *spengleriana* Deshayes, IGPS coll. cat. no. 95346, Loc. no. KO–22.

Explanation of Plate 21

(All figures in natural size, unless otherwise stated)

Figs. 1, 3–4, 7. *Ophiodermella ogurana* (Yokoyama), fig. 1, IGPS coll. cat. no. 95347, Loc. no. KK–03; fig. 3, IGPS coll. cat. no. 95348–1, Loc. no. KO–22; fig. 4, × 3, IGPS coll. cat. no. 95348–2, Loc. no. KO–22; fig. 7, IGPS coll. cat. no. 95348–3, Loc. no. KO–22.

Figs. 2a–b. *Ophiodermella* cf. *maekawaensis* Hatai, Masuda and Suzuki, × 2, IGPS coll. cat. no. 95375, Loc. no. IS–09.

Figs. 5a–b. *Trophon kagaensis* Hatai and Nisiyama, ×2, IGPS coll. cat. no. 95349, Loc. no. KO–22.

Figs. 6, 10. *Cancellaria* (*Merica*) *kobayashii* (Yokoyama), fig. 6, IGPS coll. cat. no. 95350, Loc. no. KO–04; fig. 10, IGPS coll. cat. no. 95351, Loc. no. KO–34.

Fig. 8. *Ophiodermella* cf. *miyatensis* (Yokoyama), × 3/2, IGPS coll. cat. no. 95352, Loc. no. KO–04.

Figs. 9a–b. *Cancellaria japonica* Lischke, × 5/2, IGPS coll. cat. no. 95408, Loc. no. IS–09.

Figs. 11a–b. *Suavodrillia declivis* (v. Martens), IGPS coll. cat. no. 95353, Loc. no. KK–01.

Figs. 12–14, 16–18. *Searlesia japonica* Yokoyama, fig. 12, IGPS coll. cat. no. 95193–1, Loc. no. KK–03; fig. 13, IGPS coll. cat. no. 95194–1, Loc. no. KO–04; fig. 14, × 2, IGPS coll. cat. no. 95194–2, Loc. no. KO–04; figs. 16–18, IGPS coll. cat. nos. 95193–2, 95193–3, 95193–4, Loc. no. KK–03.

Figs. 15a–b, 21a–b. *Nassarius* (*Zeuxis*) *caelatus* (A. Adams), figs. 15a–b, × 2, IGPS coll. cat. no. 95415, Loc. no. IS–09; figs. 21a–b, IGPS coll. cat. no. 95355, Loc. no. KO–03.

Figs. 19–20. *Reticunassa spura* (Gould), × 2, IGPS coll. cat. nos. 95354–1, 95354–2, Loc. no. KO–22.

Figs. 22, 26, *Propebela kagana* (Yokoyama), fig. 22, × 2, IGPS coll. cat. no. 95356–1, Loc. no. KO–22; fig. 26, × 3/2, IGPS coll. cat. no. 95356–2, Loc. no. KO–22.

Fig. 23. *Inquisitor* sp., × 3, IGPS coll. cat. no. 95357, Loc. no. IS–09.

Fig. 24. *Crassispira pseudoprincipalis* (Yokoyama), IGPS coll. cat. no. 95358, Loc. no. KO–02.

Figs. 25a–b. *Volutharpa perryi* (Jay), IGPS coll. cat. no. 95359, Loc. no. KK–03.

Figs. 27a–b. *Ringicula doliaris* Gould, × 3, IGPS coll. cat. no. 95360, Loc. no. KK–03.

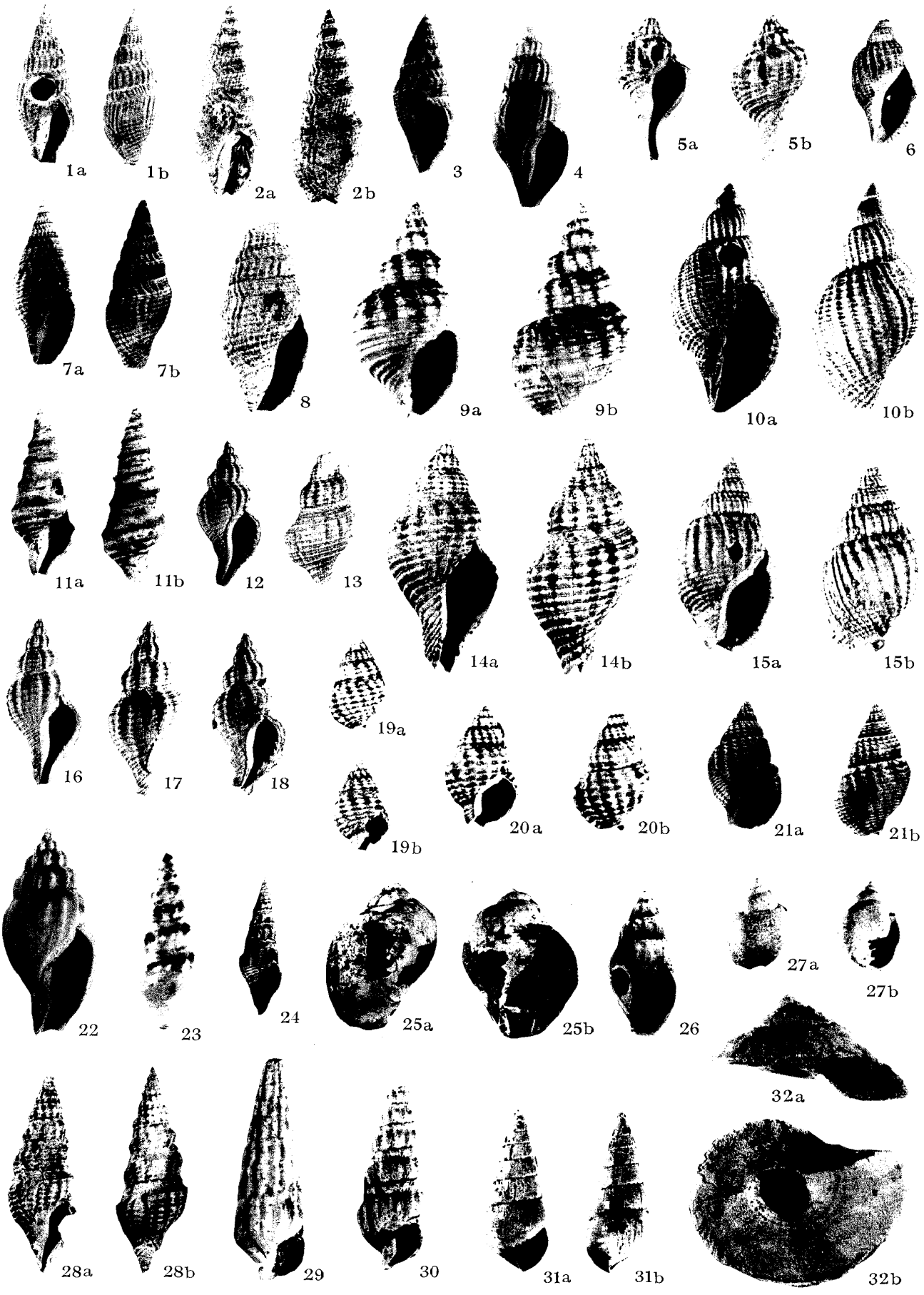
Figs. 28a–b. *Paradrillia inconstans* (Sowerby), × 3/2, IGPS coll. cat. no. 95361, Loc. no. KO–22.

Fig. 29. *Punctoterebra* (*Brevimyurella*) *lischkeana* (Dunker), × 2, IGPS coll. cat. no. 95362, Loc. no. IS–09.

Fig. 30. *Noditerebra* (*Noditerebra*) *recticostata* (Yokoyama), IGPS coll. cat. no. 95363, Loc. no. KO–22.

Figs. 31a–b. *Odostomia* (*Margnodostomia*) *subangulata* A. Adams, × 3, IGPS coll. cat. no. 95364, Loc. no. KO–04.

Figs. 32a–b. *Tugarium* (*Onustus*) *exutus* (Reeve), IGPS coll. cat. no. 95365, Loc. no. KK–32.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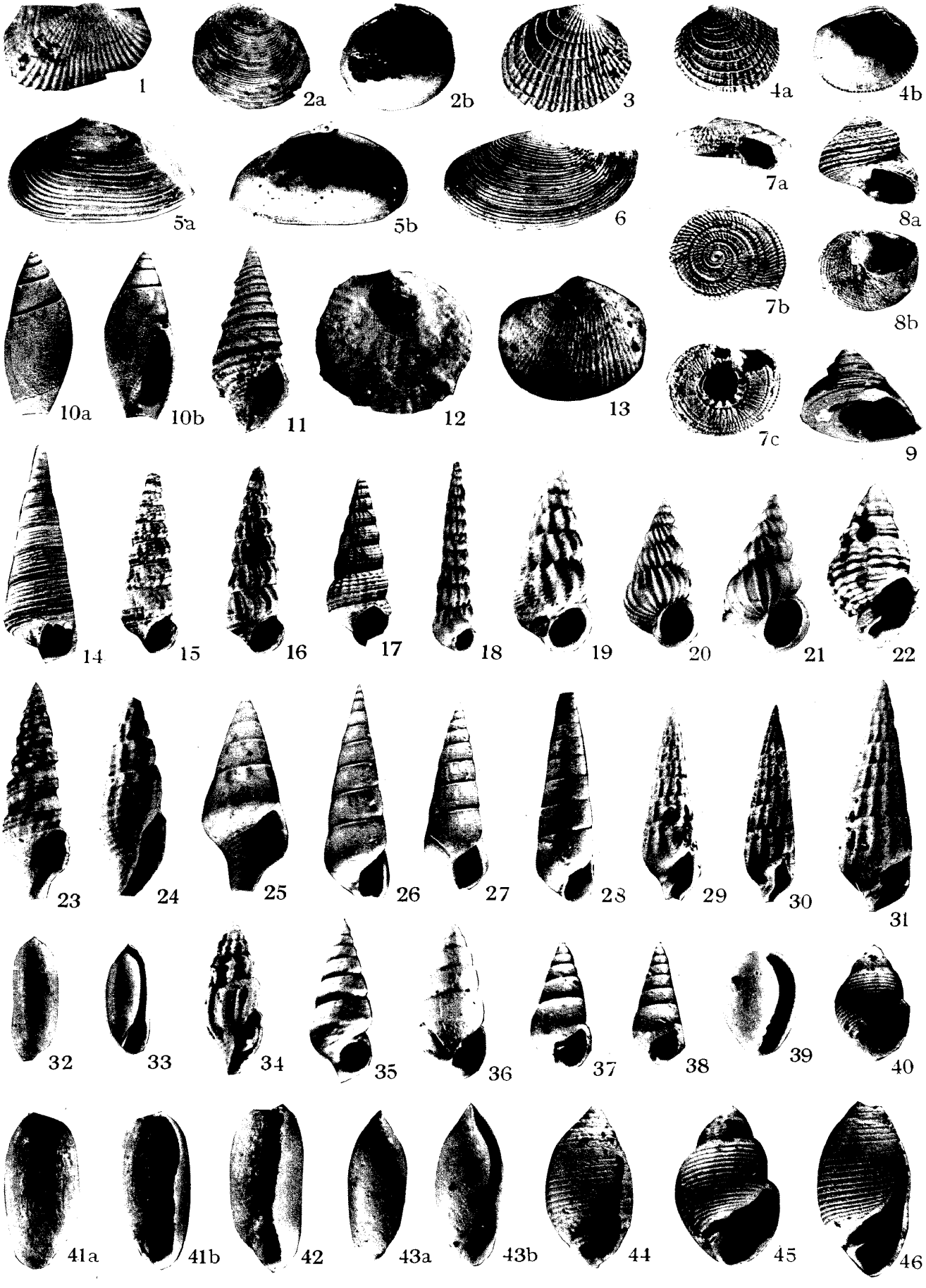
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Explanation of Plate 22

(All figures in natural size, unless otherwise stated)

Fig. 1. *Anadara* (*Scapharca*) sp., × 5, IGPS coll. cat. no. 95366, Loc. no. KO–22.
Figs. 2a–b. *Pillucina* (*Wallucina*) sp., × 3, IGPS coll. cat. no. 95367, Loc. no. KK–03.
Figs. 3–4. *Anomalocardia* (*Veremolpa*) *minuta* (Yokoyama), fig. 3, × 4, IGPS coll. cat. no. 95368, Loc. no. KO–02; fig. 4, × 3, IGPS coll. cat. no. 95369, Loc. no. KO–23.
Figs. 5a–b. *Anisocorbula* sp., × 3, IGPS coll. cat. no. 95370, Loc. no. IS–09.
Fig. 6. *Saccella confusa* (Hanley), × 2, IGPS coll. cat. no. 95078–3, Loc. no. KO–01.
Figs. 7a–c. *Architectonica* sp., × 4, IGPS coll. cat. no. 95371, Loc. no. IS–09.
Figs. 8a–b. *Homalopoma amussitatum* (Gould), × 3, IGPS coll. cat. no. 95372, Loc. no. KO–24.
Fig. 9. *Calliostoma* sp., × 3, IGPS coll. cat. no. 95373, Loc. no. KO–01.
Figs. 10a–b. *Olivella* cf. *japonica* (Stearns), × 3, IGPS coll. cat. no. 95374, Loc. no. KO–01.
Fig. 11. *Suavodrillia declivis* (v. Martens), × 3, IGPS coll. cat. no. 95376, Loc. no. KO–01.
Fig. 12. *Monia umbonata* (Gould), × 3, IGPS coll. cat. no. 95104, Loc. no. IS–09.
Fig. 13. *Pillucina* (*Pillucina*) *psidium* (Dunker), × 5, IGPS coll. cat. no. 95377, Loc. no. KO–01.
Fig. 14. *Tachyrhynchus venustellus* (Yokoyama), × 3, IGPS coll. cat. no. 95378, Loc. no. IS–09.
Figs. 15–16. *Bittium* cf. *yokoyamai* Otuka, × 4, IGPS coll. cat. nos. 95379–1, 95379–2, Loc. no. KO–22.
Fig. 17. *Clathorofenella* sp., × 4, IGPS coll. cat. no. 95380, Loc. no. KK–03.
Fig. 18. *Turbonilla* (*Paramormula*) *tokunagai* Yokoyama, × 4, IGPS coll. cat. no. 95381, Loc. no. KO–01.
Fig. 19. "*Epitonium*" sp., × 4, IGPS coll. cat. no. 95382, Loc. no. KO–01.
Figs. 20–21. *Spiniscala japonica* (Dunker), fig. 20, × 4, IGPS coll. cat. no. 95383–1, Loc. no. KO–01; fig. 21, × 5, IGPS coll. cat. no. 95383–2, Loc. no. KO–01.
Fig. 22. *Reticunassa* sp., × 4, IGPS coll. cat. no. 95384, Loc. no. KO–01.
Fig. 23. *Inquisitor* sp., × 4, IGPS coll. cat. no. 95385, Loc. no. KO–02.
Fig. 24. *Kuroshiodaphne* ? sp., × 4, IGPS coll. cat. no. 95386, Loc. no. KO–02.
Fig. 25. *Mitrella lischkei* (Smith), × 4, IGPS coll. cat. no. 95387, Loc. no. KO–02.
Figs. 26–27. *Odostomia* sp. A, fig. 26, × 4, IGPS coll. cat. no. 95388, Loc. no. KO–01; fig. 27, × 4, IGPS coll. cat. no. 95389, Loc. no. IS–09.
Fig. 28. *Syrnola* (*Syrnola* ?) *cinnamomea* A. Adams, × 4, IGPS coll. cat. no. 95390, Loc. no. KO–01.
Figs. 29–30. *Punctoterebra* (*Brevimyurella*) *lischkeana* (Dunker), × 4, IGPS coll. cat. nos. 95391–1, 95391–2, Loc. no. KO–01.
Fig. 31. *Noditerebra* (*Noditerebra*) *recticostata* (Yokoyama), × 4, IGPS coll. cat. no. 95392, Loc. no. KO–01.
Figs. 32–33. *Rhizorus cylindrellus* (A. Adams), × 4, IGPS coll. cat. nos. 95393–1, 95393–2, Loc. no. KO–22.
Fig. 34. *Mangelia* sp., × 4, IGPS coll. cat. no. 95394, Loc. no. KO–01.
Fig. 35. *Tachyrhynchus* ? sp., × 4, IGPS coll. cat. no. 95395, Loc. no. KO–01.
Figs. 36–37. *Odostomia* sp. B, × 4, IGPS coll. cat. nos. 95396–1, 95396–2, Loc. no. KO–01.
Fig. 38. *Odostomia* (*Odostomia*) *hilgendorfi* Clessin, × 4, IGPS coll. cat. no. 95418, Loc. no. KO–01.
Fig. 39. *Crithe* (*Microvulina*) *comatago* (Yokoyama), × 4, IGPS coll. cat. no. 95397, Loc. no. KO–04.
Figs. 40, 45. *Leucotina dianae* A. Adams, × 4, IGPS coll. cat. nos. 95398–1, 95398–2, Loc. no. KO–01.
Figs. 41–42. *Adamnestia japonica* A. Adams, × 3, IGPS coll. cat. nos. 95399–1, 95399–2, Loc. no. IS–09.
Figs. 43a–b. *Rhizorus* cf. *radiola* (A. Adams), × 3, IGPS coll. cat. no. 95400, Loc. no. KO–01.
Figs. 44, 46. *Solidula* (*Stigopupa*) *strigosa* (Gould), × 4, IGPS coll. cat. nos. 95401–1, 95401–2, Loc. no. KO–01.