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TERTIARY MARINE MOLLUSCA FROM THE JOBAN COAL-FIELD JAPAN

By

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Tertiary Marine Mollusca from the Joban Coal-Field, Japan

By

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CONTENTS

Abstract

The molluscan fossils derived from the respective stratigraphical units developed in the Joban coal-field of Fukushima and Ibaraki Prefectures were studied systematically and analysed as to paleoecology and geological significance.

A total of 138 species distributed among 83 genera, of which 86 are Pelecypoda, one Scaphopoda, and 51 Gastropoda are described and illustrated. The species found to be undescribed, that is to say as new to science comprise a total of 21, among which 15 are Pelecypoda and 6 Gastropoda. A new subgenus, *Hataiyoldia*, is established in the genus *Portlandia* (Nuculanidae).

The stratigraphical break separating the Oligocene Uchigo group from the next younger Miocene Yunagaya group corresponds with the faunal

break, because the molluscan species collected from the Uchigo group do not extend up into the Yunagaya. From the respective stratigraphical ranges of the molluscan species in the Yunagaya, Shirado and Taga groups, although each is separated with distinct unconformities, it is inferred that their magnitude in time can be almost neglected, and the molluscs in being intimately related with one another form a rather concrete time unit ranging from early to middle Miocene. The fossils from the Futaba-Tomioka formation indicate the Pliocene in age and show remote relationship with those from the Miocene rocks in the Joban coal-field.

INTRODUCTION

Although there have been published numerous works concerning the geology and paleontology of the Cenozoic deposits in the Joban coal-field distributed in northeast Ibaraki and southeast Fukushima Prefectures since the later part of the nineteenth Century, very little has been published with regard to the systematic classification of the rich molluscan fauna occurring from the different lithological units hitherto recognized in the said coal-field. The first purpose of the present work is to make a systematic classification and monographic study of the large marine molluscan fauna occurring from the respective stratigraphical units in the coal-field.

The previous works on the geology of the mentioned coal-field had been primarily undertaken from the reasons of economical value of the coal deposits developed in the lower horizons, and very little had been accomplished concerning the detail stratigraphy of the respective rock units so far as variations in lithofacies, laterally as well as vertically, structurally as well as paleontologically. This is the second purpose of the present work and it is felt that the relationship between the lithofacies and molluscan fauna, laterally as well as vertically, should be undertaken to clarify the stratigraphic value of those fossils.

The third purpose of the present work is to make a biostratigraphic study of the molluscan fauna distributed chiefly in the classical area of the Joban coal-field. This is necessary because it includes the problems related with paleoecological characters of the molluscan fauna, from which the nature of the sedimentary basin and the relation between the molluscan fauna and lithology may be known.

Since various views have hitherto been expressed concerning the geological ages of the respective Cenozoic stratigraphical units developed in the coal-field and attempts for a correlation of them with other areas in Japan undertaken with different results, it is thought that the time for a reconsideration of the two problems is appropriate. This is the fourth object of the present work.

The present work which incorporates the problems outlined in the above paragraphs is concentrated to the molluscan paleontology, and for this reason, remarks on the stratigraphy and geological structures of the Joban coal-

field will only briefly stated. The historical reviews on the works concerning the stratigraphy and the molluscan paleontology of the Cenozoic formations in the Joban coal-field were recently published by Y. KAMADA (1961), and are omitted from the present article.

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OUTLINE OF THE GEOLOGY OF THE JOBAN COAL-FIELD

The area from which the molluscan fossils treated in the present work were collected extends from Tomioka in Futaba-gun, Fukushima Prefecture in the north southwards to Isohara in Kita-Ibaraki City in Ibaraki Prefecture, covering a distance of about 65 kilometers. This broad area from geological structure and stratigraphic classification is divided into five provinces, which from the north to south are named as, Futaba-, Ishimori-,

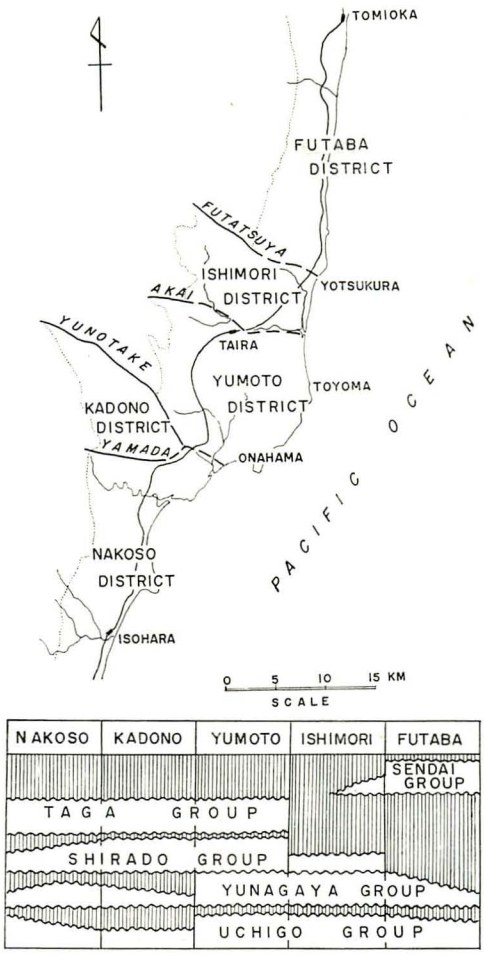


Fig. 1. Index Map showing the Five Districts and Correlation of the Groups.

Yumoto-, Kadono- and Nakoso districts. These five districts are separated from each other by faults of large scale and thereby have different development of the stratigraphic units (Fig. 1).

In the following lines brief descriptions to each of the formations which are distributed in the above-mentioned five districts will be given since this has intimate bearing on the paleontological study upon which the present work is based.

The general sequence of the Tertiary deposits of the Joban coal-field, which commence with Paleogene sediments and terminate with those of the Pliocene which can be classified into several groups and many formations is shown in the Table 1. For the sake of convenience the formations will be described from the older to the younger with only brief remarks on the foundation rocks (Fig. 2).

Foundation Rocks

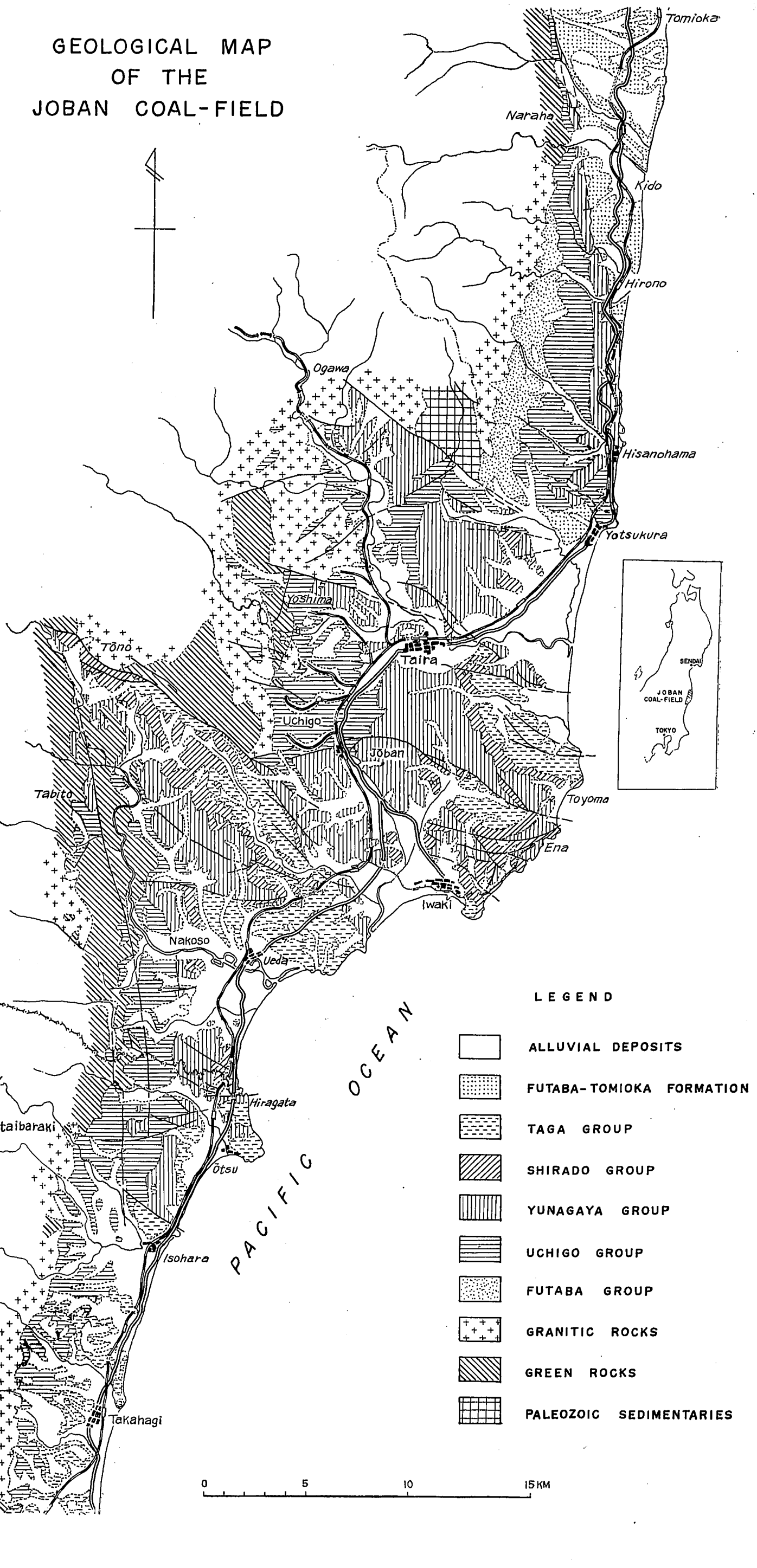
The foundation rocks in the present area which includes five districts comprise granitic rocks, amphibolite and green schists which have been included into the Abukuma metamorphics and also included in part into the Gozaisho series. The degree of metamorphism of these metamorphics increases towards the west. The Paleozoic sediments are distributed in the Takakura-yama Mountain and its environs in a small area in the southern part of the Futaba district. Those sediments are of black slate and schalstein intercalating limestone and sandstone; fossils occur from both the slate and the limestone facies although they are not well preserved. The age is considered to be Permian (I. HAYASAKA, 1957; I. YANAGISAWA, 1958).

The Cretaceous deposits called under the name of the Futaba group are subdivided into the Ashizawa-, Kasamatsu-, and Tamayama formations in upward sequence. These are conformable with one another. Many fossils have been reported by S. TOKUNAGA and S. SHIMIZU (1926) and K. ASANO (1950) and the Cretaceous age seems to be without doubt.

Table 1. Stratigraphic Classification of the Tertiary Deposits of the Joban Coal-Field in Fukushima and Ibaraki Prefectures.

Group	Formation	Thickness in meters
	Futaba-Tomioka	150+
..... Unconformity		
	Shimotakaku	150+
Taga (=Kokozura Formation)	Numanouchi	70
	Kamitakaku	100
..... Unconformity		
Shirado	Nakayama	130
..... Unconformity		
	Misawa	120
	Honya (Ishimori tuff breccia)	150
Yunagaya	Kamenoo	100
	Mizunoya	80
	Goyasu	70
	Kunugidaira	95
..... Unconformity		
	Shirasaka	150
	Asagai	60
Uchigo	Iwaki	250
	Shiramizu	80
..... Unconformity		
Foundation (Futaba Cretaceous sedimentaries, Paleozoic sedimentaries, and metamorphic and igneous rocks)		

Fig. 2. Geological Map of the Joban Coal-Field.



The foundation rocks exposed at the surface are distributed in general in the western marginal part of the Joban coal-field, although their detail distributions are more or less made intricate by the development of both major and minor faults having trends of roughly northwest-southeast to east-west for the major ones and more or less north to south for the minor ones.

Uchigo Group

The Uchigo group is the lowest stratigraphic unit of the Tertiary deposits developed in the Joban coal-field and is important economically because of its production of coal. This group was already defined and designated by K. HATAI and Y. KAMADA (1950) and the details of its many synonyms, stratigraphic nomenclature and subdivision were presented. The group comprises several formations, which in ascending order are, Shiramizu-, Iwaki-, Asagai-, and Shirasaka formations, of which the latter two are typically marine sediments, and the former two brackish, lagoonal and transgressive facies. All of these are conformable with one another and are distributed in all of the five districts, although their grade of development is different. Of these formations only the first two can be distinguished lithologically from each other in the Yumoto district, elsewhere in the other four districts they are combined into a single formation called the Iwaki coal-bearing formation, which is redefined to include the coal measures.

Shiramizu formation.

The type locality of the Shiramizu formation is the valley in Shiramizu in Uchigo City, being exposed along the Shiramizu River flowing through the valley. Here the Shiramizu overlies the foundation rocks of granite and amphibolite with unconformity. The formation begins with basal conglomerate comprising angular fragments of amphibolite measuring up to cobble size with a matrix of coarse grained sandstone and where the foundation consists of granite, there is no basal conglomerate and the formation commences with arkose sandstone derived from the weathering of the granitic rocks. The basal conglomerate when developed is variable in thickness and well developed. This is superposed with arkose sandstone and overlain with the lower coal-bearing member, and this is succeeded upwards with the Miya sandstone member (30 meters thick), and the upper coal-bearing member, which defines the uppermost limit of the Shiramizu formation.

The Shiramizu formation yields plant fossils from the lower coal-bearing member, particularly from the gray shale between the third and fourth coal-seams. These plants have been discriminated by S. ENDO (1950) who found about 20 species, all of which are said to indicate the Oligocene in age and a warm temperature climate.

Molluscan fossils also occur from the Miya sandstone member, these are such as an *Ostrea* reef and *Glycymeris*.

The Shiramizu formation is distributed only in the Yumoto district, and even within this district the formation shows lateral change in its lithofacies according to the foundation rocks with which it is in contact. The chief differences found in the lower coal-bearing member may be that where it directly overlies granitic rocks there is no development of arkose sandstone or basal conglomerate. Although the third coal seam is well devoloped and extensive in distribution the other coal seams may die out or become thin.

Iwaki formation.

The type locality of the Iwaki formation is the Iriyama area of Yumoto-machi in Joban City. The Iwaki commences with greenish colored sandstone on fresh surface, succeeded upwards with massive fine to medium grained sandstone with occasional intercalations of coarse grained sandstone, conglomerate of pebble to cobble size, well rounded rock of the foundation rocks, and concretions.

In the upper part of the formation there is a cross-laminated coarse grained sandstone which is characteristic of the formation and called the Takakura sandstone by S. NAKAMURA (1914). The Iwaki is distinguished from the next younger Asagai formation by the former consisting of dark colored sandstone on weathered surface against the light colored sandstone of the Asagai, and the latter is characteristic in having good development of joints against the massive and homogenous sandstone of the Iwaki. The Iwaki is conformable with the underlying Shiramizu formation and separated from it by the coal seam at the top of the latter and by sandstone in the basal part of the former.

In the vicinity of Yotsukura in the Futaba district the relation between the Iwaki and Asagai is unconformable, there being developed a fossil soil according to J. MAKIYAMA (1934) and this same phenomenon is interpreted as a wash-out by the Geological Survey of Japan (1957). This is the only area in which a probable unconformity has been reported in literature. This may show that uplift had already begun in a local area at the time of continued marine transgression of the Asagai sea.

The Iwaki formation can be distinguished in all of the five districts, but it should be mentioned that in all of them except for the Yumoto district, the Iwaki is treated as to include the coal-members of the Shiramizu formation because the latter cannot be distinguished from the former upon litho-stratigraphical grounds. The Iwaki formation is very variable in its lateral facies being more or less conglomeratic in the northern part and argillaceous in the southern where about ten cyclic developments of coal-seams were recognized by M. EGUCHI and R. SHOJI (1953).

Asagai formation.

The type locality of the Asagai formation which is conformable with both the subjacent Iwaki and superjacent Shirasaka formation is in the Nagashiba

valley in Kami-Asagai in Yumoto-machi, Joban City. In the northern part of this type locality, the relation with the superjacent Shirasaka formation and with the subjacent Iwaki can be observed, and both are conformable, showing gradual change from one to the other. The Asagai consists of bluish-gray very fine grained sandstone on fresh surface and light orange-brown on weathered surface, being jointy and easily crumbling by weathering. The very fine grained sandstone is massive, homogeneous, rarely stratified and frequently with small ellipsoidal concretions. Most characteristic is the profusion of marine molluscs throughout the formation vertically as well as horizontally.

The Asagai formation is conformable with the subjacent and superjacent formations, being distinguished from the Shirasaka formation by the siltstone of the latter covering the very fine grained sandstone of the former, and the lighter color of the Shirasaka against the darker color of the Asagai, and also it may be added that fossils are not abundant in the Shirasaka and their abundant occurrence is confined to the Asagai.

The Asagai formation is distributed in four districts, except in the Kadono district, being characteristic in its lithofacies and fossil content and no differences are noticed in the different districts.

In the Futaba district, K. HIRAYAMA (1955) distinguished within the Asagai formation, 15 sedimentary facies and classified them into three horizons in lateral arrangement, but such a classification cannot be applied to the entire coal-field.

Shirasaka formation.

The type locality of the Shirasaka is the environs of Shirasaka in Yumoto-machi, Joban City. Here, the relation of the Shirasaka with the underlying Asagai can be observed and also with the Goyasu formation which occupies the lower part of the next younger Yunagaya group. The Shirasaka consists of massive siltstone, gray on fresh surface and light gray to white on weathered surface. The basal part of the Shirasaka becomes sandy and some remnants of the Asagai molluscs are found but elsewhere in the formation fossils are very rare and consist of fish scales, ophiuroids and molluscan remains without definite position within the formation.

In the Yumoto district, the tuff layer which is intercalated in the siltstone of the lowest part of the Shirasaka formation measures about 30 centimeters in thickness, and with glauconite grains intercalated (K. HATAI and Y. KAMADA, 1950).

In the Nakoso district, especially in the Isohara area there occurs a nearly two meters thick tuff breccia within the Shirasaka formation. This tuff breccia becomes thin towards the north where it attains only about 30 centimeters in thickness. In the south where it is thickest, it is a massive tuff breccia coarser in the lower and finer above and shows a graded aspect, and the boundary with the siltstones is very sharp above and below. The

breccia consists of fine andesite fragments showing poor sorting, the andesite consisting of hornblende- to augite andesite or basaltic andesite and they are cemented with calcite. Also it may be added that "*Genno-ishi*" concretion has been found in the same area as that of the tuff breccia above mentioned.

The Shirasaka which defines the uppermost part of the Uchigo group is covered by the Yunagaya group with a significant unconformity which is thought to separate the Paleogene deposits from the Neogene sediments. The unconformity separates strata that show differences in the geological structure, a completely renewed marine transgression taking place after the submergence of the eroded land surface of the Uchigo group, a remarkable faunal displacement in the marine molluscan fauna, and different cycle in volcanism. Thus this significant unconformity is considered to separate the Paleogene from the Neogene in the Joban coal-field and in the Japanese Islands.

Yunagaya Group

The next younger Yunagaya group is classified into the following stratigraphic units in upward sequence, namely Kunugidaira-, Goyasu-, Mizunoya-, Kamenoo-, Honya-, and Misawa formations. All of these are marine in origin, characterized by their lithofacies, faunal contents, conformable relationship between one another, and are as a group defined above and below with unconformities. These unconformities separate the Yunagaya group from the subjacent Uchigo and the superjacent Shirado group.

Kunugidaira formation.

The type locality of this formation is the valley of Kunugidaira in Isohara-machi, Kita-Ibaraki City in the Nakoso district. Here the formation lies with unconformity upon the eroded surface of the Shirasaka formation and appears to be valley-filling deposits.

The lower part of the formation consists of a 10 meters thick basal conglomerate comprising cobble to boulder slate, graywacke, hornfels, schist and quartzite with a matrix of coarse grained sandstone, this is superposed with a cross-laminated coarse grained sandstone with rounded pebbles sporadically included. This is overlain with rather well sorted massive medium grained sandstone. Fragments of the Shirasaka siltstone are intercalated sporadically up to about 15 meters from the base of the formation.

The middle part consists of about seven cycles of conglomeratic sandstone, medium grained sandstone and siltstone showing grading, each of the layers being about three to six meters thick. The conglomeratic sandstone sometimes shows cross-laminations, and the siltstone is carbonaceous. The fifth and fourth cycles are characteristic in intercalating massive tuff, the thickness being 80 centimeters in the lower and one meter in the upper.

The upper part comprises mainly massive bluish gray fine to medium

grained sandstone and is separated from the middle part by a two meters thick coarse grained sandstone. The uppermost limit of the upper part consists of a four meters thick coarse grained sandstone bearing numerous sandpipes. In the middle part there are developed two coaly seams measuring about 1.2 meters thick for the lower and two meters thick for the upper. Fossils of *Ostrea*, forming an oyster reef occur in the sandstones above and below the coaly seams; the oyster forms bioherms. This upper part is 18 meters thick.

The eleven meters thick upper part of the formation, has the lower part defined by a three maters thick boulder conglomerate comprising the same kind of rocks as found in the basal conglomerate of the formation. This conglomerate is succeeded upwards with coarse grained sandstone and overlain by a conglomerate layer which is the uppermost part.

The Kunugidaira formation is succeeded upwards with conformity by the Goyasu formation, and its distribution is confined to the Nakoso district and the Yamada area and the Kuroda Basin in the Kadono district, where it represents a valley filling deposit indicating initial marine transgression of the seas which deposited the Yunagaya group.

The uppermost part of the Taki coal-bearing formation (K. SUGAI et al., 1957) in the Yamada area and in the Kuroda Basin both in the Kadono district is the same as the Kunugidaira formation, proved from paleontological evidence. It may be added that the different horizons of the Kunugidaira formation abut against the Shirasaka formation in the Nakoso district, and that the latter overlies unconformably the Iwaki formation in the Kadono district, and is also distributed in the northern part of the Ishimori district.

Goyasu formation.

The type locality of the Goyasu formation is the cliffs surrounding the Benten Pond near Matsukusune in Joban City. Here the formation unconformably overlies the Shirasaka formation with erosion surface and is covered with the Mizunoya formation. The Goyasu consists of micaceous fine to medium grained sandstone intercalating siltstone laminae with abundant plant fragments, and at the lower part there is developed a basal pebble to boulder conglomerate consisting of well rounded, rocks of the foundation except for granitic ones, and the matrix is of coarse grained sandstone. The uppermost part of the Goyasu formation consists of fine grained sandstones which gradually change upwards into siltstone bearing concretions. The siltstone is taken as the basal part of the next younger Mizunoya formation. The gradual change from the lower to the upper shows the conformable relationship of the two formations.

The Goyasu formation is distributed in the all of the districts, being everywhere unconformable with the underlying rocks except for the Kunugidaira formation and conformably superposed with the Mizunoya formation. In the

basal conglomerate of the Goyasu formation there are found intercalated huge boulders of rhyolite, some of which measure about two meters in diameter in the Nakoso district, while in the Futaba district there is a rhyolite flow, and such igneous rock is not found in the other districts.

Mizunoya formation.

The type locality of the Mizunoya formation is the cliffs at Mizunoya in Joban City. Here the Mizunoya conformably overlies the Goyasu formation and is conformably superposed with the next younger Kamenoo formation. The Mizunoya consists of, in the lower half, dark gray siltstone, very micaceous, massive, without bedding and with fossils of molluscs. The lower part near to the boundary between the Goyasu and the Mizunoya was once called the Yotsunami sandy shale by K. WATANABE (1930) and by J. MAKIYAMA (1934). The upper half is separated from the lower half by the first appearance of sandstone layers. The upper half is characterized by an alternation of sandstone and siltstone in its lower part succeeded upwards with massive, loose fine to medium grained sandstone rich in quartz grains and bluish on fresh surface and light orange brown on weathered surface and shows an irregular pattern by the impregnation of limonite. The upper half has yielded no fossils. The Mizunoya of massive sandstone in the upper part is separated from the next younger Kamenoo by the shale, which marks the base of the Kamenoo formation.

The Mizunoya is characterised by such fossils as *Lucinoma, Conchocele* and many buccinids. This formation is distributed in all of the five districts.

Kamenoo formation.

The type locality of the Kamenoo formation is the valley of Kamenoo near to the type locality of the Mizunoya formation in Joban City. The formation begins with massive shale and is superposed with platy shale intercalating thin sandstone layers. The shale is flinty and yields many molluscan remains, fish scales and bones and well preserved plant leaves.

The topmost part of the formation is overlain with a thick sandstone which defines the lowest part of the next younger Honya formation, the relation being conformable.

The Kamenoo formation shows change in its lithofacies being diatomaceous in the Nakoso district, where varved shales are well developed, but flinty shale in the type area. These lithologic features of the formation were described in detail by J. IWAI (1950).

The distribution of the Kamenoo formation is throughout all of the five districts.

Honya formation.

The type locality of the Honya formation is the cliffs in the vicinity of Honya in Iwaki City. Here the basal part of the Honya consists of a 20-30

meters thick massive medium to coarse grained sandstone called the Kamiyada sandstone member and this is succeeded upwards with an alternation of sandstone and siltstone, the sandstone being fine to medium grained and the respective layers of the alternation being about 10-30 centimeters in thickness; massive bluish gray siltstone bearing small pumice patches, and this defines the top of the formation. The basal part of the next younger Misawa formation consists of sandstone, by which it is separated from the Honya.

The massive siltstone of the Honya more or less resembles that of the Mizunoya but can be distinguished therefrom by not being micaceous.

Molluscan fossils are abundant and the characteristic one in the lower part of the siltstone is *Delectopecten peckhami* GABB, while the upper part is characterized by dominant species of molluscs.

The Honya formation is distributed in the Yumoto district, and the Futaba district, and is also in the Ishimori district but with different lithofacies. It is called the Ishimori tuff-breccia in the Ishimori district, and characterized huge boulders of andesite, but its facies when traced laterally interfingers with the typical Honya, which overlies the Kamenoo conformably and is superposed with the Misawa, thus its stratigraphic position corresponds to the Honya. It also yielded some fossils, which were described by S. AOKI (1954) who defined the unit as the Kabeya formation (S. SATO and H. MATSUI, 1951) with which the Honya interfingers; this is also a lateral facies of the Honya. The Ishimori shell beds on the northern side of Ishimori hill consist of sandstone and is also a facies of the Honya.

Misawa formation.

The type locality of the Misawa formation is a small valley at Misawa in Joban City. Here the formation conformably overlies the Honya and is covered unconformably with the Nakayama formation. The Misawa begins with brown colored fine to medium grained sandstone, which defines its basal part. This sandstone characterizes the formation at the type locality but has also many intercalations of micaceous sandy siltstone layers, quartz-rich coarse grained sandstone showing cross-laminations, which sometimes becomes pebbly, and a tuff breccia with pebbles of andesits. The top of the formation is defined by sandstone which is unconformably covered with the Nakayama formation.

From the Misawa formation, plant fossils have been found from the sandy siltstones and some molluscan remains occur from the silty parts, but their preservations are insufficient for specific determination.

The Misawa formation is distributed in the Yumoto, Ishimori and Futaba districts, and is missing in the Kadono and Nakoso districts.

Shirado Group

The name of Shirado group was first proposed by K. WATANABE (1926) to include the Misawa sandstone and the next younger Nakayama tuffite and shale, and was stated to be unconformably situated between the older Yunagaya and overlying Taga group. However, since it has been found that the Misawa is conformable with the Honya and unconformable with the overlying Nakayama, it is removed from the Shirado group and included into the Yunagaya group from stratigraphical reasons. Such procedure leaves only the Nakayama formation in the Shirado group. The Shirado superposes the Yunagaya with unconformity and unconformably underlies the Taga group.

Nakayama formation.

The type locality of the Nakayama formation is the stone quarry at Nakayama in Taira City. Here the formation consists of sandy tuff with laminations and may be called a tuffite. Beginning with a five to six meters thick conglomeratic sandstone superposed upon the eroded surface of the Yunagaya group in which are developed abundant sand-pipes, the said rock is succeeded upwards with tuffite (3.5 meters thick) whose upper part yields a layer of fossil shells, and is overlain with siltstone and (10-15 meters thick), massive fine grained sandstone with mould specimens of molluscs in abundance. The Nakayama is unconformably overlain with the Kamitakaku formation of the next younger Taga group.

The Nakayama is distributed in the Yumoto-, Ishimori-, Kadono-, and Nakoso districts. Within the mentioned areas of distribution, considerable change in its facies is noticed in the Yumoto district, and from the type locality eastwards siltstone is added at the loss of the typical facies of the type locality and in the southern part the formation is represented with massive gray siltstone which was once called the Ona sandy shale by K. WATANABE (1929).

In the Kadono and Nakoso districts the formation begins with basal conglomerate overlain with sediments similar to the type locality in its lower part but consists in its upper part of cyclic sediments of sandy tuff grading into siltstone which contains *Vicarya, Vicaryella, Batillaria* and *Soletellina*. This is overlain with sandstone containing oysters in the form of reefs, then by a non-fossiliferous loose massive sandstone which defines its topmost part in the two areas.

Taga Group

The Taga group as used in the present work comprises the following formations in ascending order, namely, Kamitakaku-, Numanouchi- and Shimotakaku formations in the Yumoto district, the Kokozura formation in the Kadono and Nakoso districts, and the group is not developed in any of the

other districts.

Kamitakaku Formation.

The type locality of the Kamitakaku formation is the environs of Kamitakaku in Taira City. Here the formation which unconformably overlies the Nakayama formation, commences with basal conglomerate about one meter in thickness and consisting of pebbles of the older rocks as slate, amphibolite, gabbro, rarely of granite, and andesite in a matrix of coarse grained sandstone. This is succeeded upwards with brown massive fine to coarse grained sandstone locally with concretions, the whole measuring about 100 meters in thickness at the type locality but decreasing to about 20 meters at the sea coast. The top of the formation is defined by a fine grained sandstone.

The Kamitakaku formation is distributed only in the Yumoto district, and its lithofacies is quite uniform throughout. The Kamitakaku is conformably overlain with the next younger Numanouchi formation, the contact being gradual. No fossils except fragments of *Ostrea* have been found.

Numanouchi Formation.

The type locality of the Numanouchi formation is the sea cliff at Numanouchi in Toyoma-machi, Taira City. This was previously called the Toyoma formation by S. TOKUNAGA (1927). Here the formation consists of massive greenish fine grained sandstone, well sorted with abundant molluscan remains within the intercalated layers or lenticular form. The next younger Shimotakaku formation is conformable with the Numanouchi, the contact being gradual and indistinct, the change being from the sandstone of the Numanouchi to the siltstone facies of the Shimotakaku.

The distribution of the Numanouchi formation is restricted to the eastern half of the Yumoto district.

Shimotakaku Formation.

The type locality of the Shimotakaku formation is the valley of Kamiyasaku, Toyoma-machi, Taira City. Here the formation is divided into three members, they are Kamiyasaku-, Usuiso- and Hamamachi in ascending order.

Kamiyasaku member: The type locality is the valley in the south of the Kamiyasaku village above mentioned. The member comprises massive siltstone which is diatomaceous, dark gray on fresh surface and whitish gray to white on weathered surface.

Usuiso member: The type locality of this member is the eastern hill path side of Usuiso in Toyoma-machi, Taira City. The member conformably overlies the Kamiyasaku member with sharp contact and consists of a nearly ten meters thick massive pumiceous tuff, becoming sandy in its upper part. This member is non-fossiliferous.

Hamamachi member: The type locality is the road side cutting in the south of Hamamachi, Toyoma-machi, Taira City. The boundary with the underlying Usuiso member is rather sharp because of the different lithology. The Hamamachi member consists of well laminated siltstones which are similar to the siltstones of the Kamiyasaku member. However, locally sedimentary structures are well exhibited.

This member is the uppermost division of the Shimotakaku formation and is considered to be unconformable with the next younger Pliocene deposits which are developed in the Futaba district, but not in the present area. No fossils have been found from the member.

Kokozura Formation.

The Kokozura formation which is thought to be an equivalent of the Kamitakaku-, Numanouchi- and Shimotakaku formations developed in the Yumoto district, is distributed in the Nakoso and the Kadono districts, where it is unconformable with older formations.

The type locality of the Kokozura formation is the road side cliffs at Kokozura in Nakoso City. Here the formation overlies the Kamenoo formation with angular contact. The Kokozura consists of massive, sandy siltstone which becomes finer in grain size upwards.

Throughout its distribution, the Kokozura formation shows changes in the facies of its lower part, having basal conglomerate at some places but not in others, this is according to the nature of the rocks upon which it is unconformably superposed. The main part of the formation is almost uniform in its lithology throughout its area of distribution. The occurrence of abundant molluscan fossils and foraminifers is characteristic of the lower part of the formation.

Tempisan Formation.

Overlying the Kokozura formation is the Tempisan formation (S. TOKUNAGA, 1927), and this is the youngest part of the Taga group developed in the Nakoso district. The formation consists of loose, coarse to fine grained micaceous sandstone showing graded bedding and intercalating indurated concretionary layers, and clay laminae at places. *Makiyama* bearing siltstone lenticles are intercalated in the lower part.

The Tempisan formation is distributed only in the Isohara area of the Nakoso district, and the fossils from the formation are not described in the present articles.

Futaba-Tomioka formation.

The youngest Tertiary rocks in the present area consists of the Futaba-Tomioka formation developed in the Futaba district, and its correlative called the Yotsukura formation in the northern part of the Ishimori district. These two formations are Pliocene in age from paleontological evidence and thus

considered to be unconformable with the Miocene rocks so far mentioned.

The type locality of the Futaba-Tomioka formation is the hill surrounding Tomioka-machi, Futaba-gun, Fukushima Prefecture. In this area the formation is in fault or unconformable contact with the next older Yunagaya group or the more older Uchigo group. The formation comprises tuffaceous, massive sandstone to siltstone intercalating thin lignite seams. The basal part consists of subrounded to angular rock fragments of siltstone and shale derived from the older formations.

The formation is distributed on the eastern side of the Futaba tectonic line. The Futaba-Tomioka formation can be correlated with the Pliocene Sendai group developed in Sendai City by its lithologic and faunal similarity (Y. KAMADA and S. HAYASAKA, 1959).

GEOLOGICAL AGE OF THE GROUPS

With regard to the geological ages of the different formations recognized within the Joban coal-field, various opinions have been expressed, but the writer from his studies on the molluscan fauna from the lithological units will, in this section, point out the reasons for determination of the ages. The various opinions hitherto expressed are briefly outlined in the following lines so that the readers may understand the confusion prevailing to the present day.

Concerning the Uchigo group the lowest of the Tertiary divisions in the present coal-field and, which is subdivided into four formations in ascending order, Shiramizu coal-bearing formation, Iwaki sandstone, Asagai sandstone, and Shirasaka shale, the following views have expressed.

M. YOKOYAMA (1924) who studied the molluscan fossils from both the Iwaki and Asagai formations, stated that the geological age of both is Miocene, while J. MAKIYAMA (1934) considered the latter stratigraphic unit to be Upper Oligocene or Aquitanian. K. KANEHARA (1937) although once accepting MAKIYAMA's opinion later expressed the view that the age of both the Asagai and underlying Iwaki is Upper Oligocene or Lower Miocene. K. ASANO (1949) from his studies on the foraminifers derived from the Asagai formation stated that the foraminiferal fauna resembles the Vaqueros formation of California and is Aquitanian in age. However, recently the age of the Vaqueros formation has been subjected to different views, H. G. SCHENCK and T. S. CHILDS (1942) considered a part of it to be late Oligocene or the Aquitanian in age, while A. O. WOODFORD preferred the Miocene, the view of WOODFORD was also agreed upon by L. R. COX, B. L. CLARK and J. W. DURHAM, whereas H. R. RENZ favoured the Oligocene age. On the other hand A. M. KEEN from a statistical analysis of the percentage of living species of molluscs in the formation arrived at the same conclusion as H. G. SCHENCK and T. S. CHILDS. K. HATAI and Y. KAMADA (1950) from their study on the Uchigo group con-

cluded that it represents the Oligocene age.

Therefore, as mentioned in the above, as in the case of the Vaqueros formation of California, the Uchigo group of the Joban coal-field is also subjected to various opinions. Probably the clue to the problem may be in a reconsideration of the typical Aquitanian and its stratigraphical and paleontological relationship with superjacent and subjacent units, the data used for correlation of the type locality with remote areas as California and Japan, and it may be added that the time for such a strict correlation may not be ripe. However, from stratigraphical evidence of the Uchigo group which is unconformably superposed with the Yunagaya group, and that the said unconformity is widespread in Japan, and that the faunal break indicated by the stratigraphical one is an important feature of the early Tertiary rocks of Japan. Therefore, upheld with paleontological evidence of the molluscan remains and fully supported by stratigraphical evidence in various parts of Japan, the writer is in the opinion that the Uchigo group must be considered distinct from the Yunagaya group, the former subjacent to the latter. The Paleogene-Neogene break can be drawn reasonably between the two.

The geological ages of the Yunagaya-, Shirado-, and Taga groups have also been subjected to widely diverging opinions based upon the mollusca-, foraminifera-, mammalia-, plant-, and other kinds of fossils. However, it should be kept in mind that the stratigraphical relationships of the different formations included into those groups, the lateral change in lithofacies, significance of the unconformities separating the groups, the interrelationship of the vertical sequences of the respective molluscan remains of the different formations and other problems must be brought into consideration before statements concerning the geological ages be determined. For this complicate status, the writer in the following lines will express those relationships and remark on the geological ages of the formations.

Among the three groups generally accepted as belonging to the Neogene, M. YOKOYAMA (1925) held that the Shirado and next younger Taga are both Pliocene in age, while the Yunagaya is of Miocene age; his work being based upon the molluscan remains. K. KANEHARA (1937) and K. HATAI and S. NISIYAMA (1949) considered the three to be of Miocene age, although it should be added that the sediments distributed along the sea-coastal area of southern Ibaraki Prefecture are left out of the present consideration. Therefore the problem arises as to what units are to be included into the so-called Taga group, and whether the stratigraphic name can be used for the deposits distributed in the area from Isohara in the south northwards to near Taira City, in the central part of the Joban coal-field. The writer, refrains from including the deposits developed in eastern Ibaraki Prefecture.

As may be noticed from the range chart of the molluscan species occurring from the three groups above mentioned, there exists a very close relationship requentially. Except for the slight displacements of the molluscan

species due to the slight changes in physical conditions and change in the depth of the depositional area of the sedimentary basin the fauna of the formations are similar. Changes have occurred in the shore-line, the amount and kinds of sediments supplied, the oceanographic conditions such as oceanic currents due to local block movement. All such phenomena may have served to bring forth small changes in the fauna. Therefore, if the changes in the physical conditions be neglected, then the relationship of the fauna of the respective groups even though their lithofacies be somewhat different which leads to the difference in part of the fauna contained, it can be said that the fauna of the three different stratigraphic groups are in intimate relationship and may form a single faunal sequence indicating only different parts of the early to middle Miocene age. The late Miocene deposits are considered to be missing because the thermal conditions indicated by the youngest horizons of the Taga group in comparison with the oldest part of the Pliocene deposits show a sharp contrast, though actually if the late Miocene deposits existed, their conditions indicated by the fauna should show a gradual change from the older to the younger and not a sharp and contrasting one. Thus from the physical side considerable evidences can be obtained, and from the paleontological view there can be found a sharp contrast in that none of the typical Taga members extend up into the Pliocene deposits, the species occurring in the Miocene and extending their range up to the present do not occur in the Pliocene which shows that the faunal displacement was abrupt and the physical conditions sharply contrasting. Also the number of species having ranges extending to the present occur in abundance in the Pliocene deposits and less in the Miocene ones, and also the number of extinct species are greater in the Taga and very few in the Pliocene deposits. These are the paleontological reasons for considering that the Taga is not late Miocene in age and should be included into the middle Miocene.

From the distributions of the extinct species of molluscs found from the Taga and older Neogene groups with other areas in Japan it is found that the typical species of the three groups may be represented in a single stratigraphic unit in other areas. Considering those areas in which a single stratigraphic unit yields characteristic species which are distributed throughout the three groups separated by stratigraphic breaks in the Joban coal-field, it is also interesting to notice that those areas of deposition are not the same as recognized in the Joban coal-field. It is natural that stable areas will have relatively thin sediments whereas unstable downsinking areas will develop thick deposits, and should the movements be differential, there would be developed unconformities as in the case of the Joban coal-field. Thus it is considered that the Joban coal-field area subsequent to the deposition of the Uchigo group became an unstable area and that the three groups and the unconformities separating them merely reflect the physical conditions of the sedimentary basin. During a short though the geological age may be only

from early to middle Miocene, as indicated from the distributions of the molluscan remains there was considerable instability of the basin.

The distinction between the early Pliocene and middle Miocene deposits in the present field is rather easy particularly because late Miocene sediments are lacking. However, it is important to notice that prior to the deposition of the early Pliocene sediments in the present field, there occurred rather strong folding, faulting accompanied with uplift of the land followed by extensive denudation by which the land surface was worn down. Subsequent to this movement, there occurred marine transgression which brought into the present area a marine fauna remakably different from that of the middle Miocene and the flowing of the cool marine waters was over the eroded land surface.

The geological structure of the strata below the time plane and those above it are contrasting, the strata of the middle Miocene being folded, faulted, truncated and inclined at various angles against the almost horizontal early Pliocene sediments. The early Pliocene marine fauna of the Futaba-Tomioka formation had already been described, illustrated and discussed in considerable details by S. HAYASAKA (1956), and Y. KAMADA and S. HAYASAKA (1959), and from their works it is noticed that such as *Glycymeris yamaguchii* HAYASAKA, *Chlamys miurensis* (YOKOYAMA), *Mercenaria chitaniana* (YOKOYAMA), and others, which do not appear in the middle Miocene of the present area are dominating. The latter two authors, from their field and laboratory works concluded that the Tateishi fauna is early Pliocene in age and can be taken as a correlative of the early Pliocene Tatsunokuchi formation developed northwards from the Futaba district in the northern part of the present field. The Namie fauna previously described by S. HAYASAKA (1956) is the same as the Tateishi fauna and both are the southern extensions of the Tatsunokuchi fauna, and remarkably different stratigraphically and paleontologically from the molluscan fauna of Taga group of middle Miocene age.

The faunal break from the middle Miocene Taga group to the early Pliocene Futaba-Tomioka-, Ishiguma- and Tatsunokuchi formations as well as the geological structures of them are contrasting. Leaving aside the latter mentioned feature it is evident that none of the characteristic Taga group members extend their range up into the Tateishi and its equivalent molluscan assemblage. This remarkable gap in the faunal sequence of the molluscs of the Joban coal-field and in other regions of Japan clearly shows that such phenomenon may develop when stratigraphic units are missing. It may also be added that except for the final appearance of *Solemya tokunagai* YOKOYAMA, a species which is characteristic in Miocene deposits but rare in the early Pliocene of Japan, all of the recorded molluscan species from the Futaba-Tomioka and Ishiguma formations in the northern part of the Joban coal-field comprise elements which play an important role in the Pliocene and those which extend their range down into the Miocene are not important.

Therefore from the above stated reasons as also can be noticed from the range chart of the molluscan species and remarkable differences in the geological structure between the strata of the Miocene and Pliocene, it is considered that the late Miocene sediments are missing in the present area. This is in good harmony with the geological history of the other regions in Japan where late Miocene deposits are developed such as along the borderland of the Japan Sea, in the southern part of the Boso Peninsula in Chiba Prefecture, and in certain localities along the Pacific borderland of northern Japan.

Analysis of the Molluscan Fauna of the Joban Coal-Field

The number of specifically discriminated molluscs from the Tertiary deposits of the Joban coal-field amounted to 138 species including subspecies. Among these 21 species and subspecies are described as new to science. The respective number of species occurring from each of the stratigraphic units is as follows (Fig. 3).

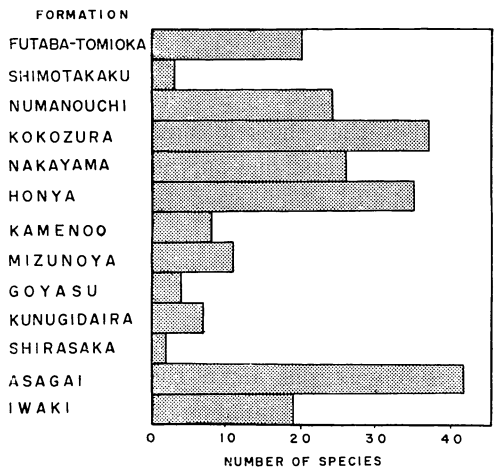


Fig. 3. Frequency of Molluscan Species According to Stratigraphic Units.

Iwaki formation .....19 species
Asagai formation.....42 species
Shirasaka formation ..... 2 species
Kunugidaira formation .... 7 species
Goyasu formation ..... 4 species
Mizunoya formation .....11 species
Kamenoo formation ..... 8 species
Honya formation .....35 species
Nakayama formation .....23 species
Kokozura formation .....37 species
Numanouchi formation ....27 species
Kamiyasaku formation .... 3 species
Futaba-Tomioka form. ....20 species

From the number of species occurring from each of the formations several interesting features can be recognized. For example just before the Paleogene-

Neogene break the number of species shows an abrupt decline, and this same tendency is seen again just before the Miocene-Pliocene boundary. Another feature is that the maximum number of species occur in positions where the sedimentary environment is most stable as in the Asagai-, Honya-, and Kokozura or Numanouchi formations, whereas they are few in unstable environments as the Shirasaka-, Goyasu-, and Shimotakaku formations. This suggests that the stability of the molluscan fauna is related with that of the sedimentary environment. Within the Miocene deposits, there is noticed an abrupt change in number of species from the Kamenoo to the Honya and from the Shimotakaku to the Futaba-Tomioka formation, just as would be expected because those positions correspond to the time boundaries. That the number of species remains rather uniform from the Nakayama to the Numanouchi seems to be a mere reflection of the more or less stable sedimentary environment and also that of the sedimentary basin itself.

From the foregoing remarks it seems evident that, as discussed with regard to the range chart of the molluscan species, the sedimentary environment, sedimentary basin, faunal assemblages and number of species as well as their components are in intimate relationship. However, whether the stability of the physico-chemical side has intimate relation with the biological side as considered from the viewpoint of evolution may be subjected to debate. The writer favors the view that the relationship of the two mentioned phenomena should be separated from one another when attempting explanation or interpretation of the biological changes in the upward sequence of the faunal components or elements.

The list of species distinguished in the Joban molluscan fauna shows that the number of infaunal species is exceedingly large and that epifaunal species is very few. That the number of epifaunal species is few may have some bearing on the rate of sedimentation and of the subsidence of the sedimentary basin, whereas the overwhelming number of infaunal species may suggest that the rate of sedimentation may have been easily adapted to by those shells.

Among the recurrent species such as *Acila divaricata submirabilis* MAKIYAMA and *Dosinia chikuzenensis nomurai* OTUKA are of interest because they occur alternately in the Goyasu, Honya and Numanouchi formations. Many other bivalves also show similar relationships and occur from two to more times either alternately with the stratigraphic units or with more distant spacing in time. The recurrent faunas, as shown in the range chart of the species (Table 2), seem to be good evidence of the alternately changing physical conditions, or that favorable environmental conditions recur according to the nature of the sedimentary basin, the kinds of sediments being deposited and other reasons. Although such features are readily recongnized from the recurrent molluscan species it is also evident that certain species may continue to live continuously throughout the time two or more stratigraphic units are

deposited and thus, whether they should be considered to be persistent species or relic species is problematical. They are not considered to be persistent because of their short chronological distribution, and since they may show change in the sizes of their shells, that is to say, in their grade of development (size, shape, population density) it is suggested that they may be included into the relic faunas in broad sense.

PALEOECOLOGY

As will be recognized from the range chart (Table 2) the different formations established in the present area are characterized with faunal assemblages of the molluscs, and judging from the bathymetrical distributions of the genera represented as well as from the records of the species which extend their range up to the present sea, there exist considerable evidence for discussing the bathymetrical conditions of the sedimentary environment under which the fossil fauna once lived. Here it should be added that since many of the species of molluscs are now extinct in the seas surrounding Japan as well as elsewhere in the world, the paleoecological factors are difficult to interpret from them only. For this reason it is considered that Recent species closely similar to the extinct ones may have had similar peculiarities as may be judged from that the bottom sediments in which the living infauna are now adopted to may be analogous with the sediments in which the fossil fauna was collected. Also from that the sediments yielding the fossil molluscs which are still living in the adjacent seas of Japan is analogous with them, this also affords data for interpreting the paleoecological environment.

Since it is generally accepted that living species of molluscs show change in their shell size, thickness of their external coverings, and in strength of their external sculpture as well as coloration when their bathymetrical environmental zones are different. The development of the shell of the molluscs may also show a change when the prevailing physico-biological conditions are not favorable for their growth. And although other factors for consideration in discussion of the paleoecological conditions under which the fossil fauna once lived should be taken into consideration, for example, the four phases in environment as once discussed by W. H. TWENHOFEL, and the probable incorporation of younger fossil into older deposits or vice versa as described by D. J. JONES (1958), in the present case each of the above mentioned factors, so far as can be determined from both field and laboratory studies, were given consideration.

Before explanations as to the sedimentary environment of the fossil fauna it should be mentioned that, in the field, observations were made as to the mode (whether valves are intact, isolated, brocken, fragmentary, etc.) of occurrence of the fossils, the vertical and lateral change in lithofacies of these sediments as well as their stratigraphical position in the stratigraphic sequence

Table 2. Range Chart of the Molluscan Species based upon their First Appearance in the Tertiary Deposits of the Joban Coal-Field.

Specific Name \ Stratigraphic Sequence	Uchigo			Yunagaya					Shirado	Taga		
	1	2	3	4	5	6	7	8	9	10	11	12
Ostrea (*Ostrea*) *yokoyamai* KAMADA, n. sp.	1											
Ostrea (*Crassostrea*) *mundana* YOKOYAMA	1											
Brachidontes takiensis KAMADA, n. sp.	1											
Mytilus luciferus YOKOYAMA	1											
Venericardia (*Cyclocardia*) *subnipponica* NAGAO	1											
Trapezium (*Neotrapezium*) *jobanicum* HATAI and NISIYAMA	1											
Ezocallista kurodae KAMADA, n. sp.	1											
Cyclina (*Cyclina*) *jobanica* (YOKOYAMA)	1											
Mactra squalida (YOKOYAMA)	1											
Cultellus rectangulus KANNO	1											
Solen intermedius NAGAO	1											
Cerithidea (*Cerithidea*) *sugaii* MIZUNO and FUJII	1											
Euspira ashiyaensis (NAGAO)	1											
Ocenebra tsuzurensis YOKOYAMA	1											
Neptunea ezana TAKEDA	1											
Glycymeris nakosoensis HATAI and NISIYAMA	1	2										
Spisula (*Mactromeris*) *nagakoensis* HATAI and NISIYAMA	1	2										
Peronidia ochii KAMADA, n. sp.	1	2										
Molopopholus watanabei OTUKA	1	2										
Ennucula yotsukurensis (HIRAYAMA)		2										
Acila (*Truncacila*) *oyamadensis* HIRAYAMA		2										
Portlandia (*Megayoldia*) *yotsukurensis* UOZUMI		2										
Yoldia (*Yoldia*) *laudabilis* YOKOYAMA		2										
Yoldia (*Yoldia*) *yabei* (YOKOYAMA)		2										
Anomia asagaiensis HIRAYAMA		2										
Thracia kidoensis KAMADA		2										
**Cuspidaria makiyamai* KANEHARA		2										
Venericardia (*Cyclocardia*) *tokunagai* YOKOYAMA		2										
Venericardia (*Cyclocardia*) *laxata* YOKOYAMA		2										
Nemocardium (*Keenaea*) *iwakiense* (MAKIYAMA)		2										
Clinocardium asagaiense (MAKIYAMA)		2										
Clinocardium asagaiense makiyamae KAMADA, n. subsp.		2										
Clinocardium asagaiense arakawae KAMADA, n. subsp.		2										
Papyridea harrimani DALL		2										
Papyridea harrimani nipponica YOKOYAMA		2										
Cyclina (*Cyclina*) *asagaiensis* KAMADA		2										
Liocyma terrena (YOKOYAMA)		2										
Nuttallia uchigoensis KAMADA, n. sp.		2										
Macoma sejugata (YOKOYAMA)		2										
Mya (*Arenomya*) *grewingki* MAKIYAMA		2										
Margarites eos HIRAYAMA		2										
"Turritella" tokunagai YOKOYAMA		2										
"Turritella" importuna YOKOYAMA		2										
**Boreoscala oyamadensis* (HIRAYAMA)		2										
Calyptraea tokunagai HATAI and NISIYAMA		2										
Calyptraea aokii HIRAYAMA		2										
Ampullina asagaiensis MAKIYAMA		2										
**Buccinum matchgarense* MAKIYAMA		2										
Colus (*Aulacofusus*) *asagaiensis* MAKIYAMA		2										
Colus (*Aulacofusus*) *fujimotoi* HIRAYAMA		2										
**Molopopholus rara* HIRAYAMA		2										
**Priscofusus ishijimai* HIRAYAMA		2										
**Cylichna stolida* HIRAYAMA		2										
Periploma (*Aelga*) *besshoense* (YOKOYAMA)		2	3									
Liocyma furtiva (YOKOYAMA)		2	3									
Conchocele bisecta (CONRAD)		2				6				10		
Lucinoma acutilineatum (CONRAD)		2	3		5	6		8	9	10	11	
Trapezium (*Neotrapezium*) *isoharense* KAMADA, n. sp.				4								
Nipponomarcia nakamurai (IKEBE)				4								
Vicaryella jobanica KAMADA				4								
Soletellina minoensis YOKOYAMA				4					9			
Vicarya (*Vicarya*) *yokoyamai* TAKEYAMA				4					9			
Dosinia (*Phacosoma*) *chikuzenensis nomurai* OTUKA				4					9		11	
Cultellus izumoensis jobanicus KANNO					5			8	9	10	11	
Acila (*Acila*) *divaricata submirabilis* MAKIYAMA					5			8			11	
**Acirsa watnabei* KANEHARA						6						
**Beringius mitsuc ii* KANEHARA						6						
Japelion yabei KAMADA						6						
Conchocele nipponica (YABE and NOMURA)						6		8				
Ancistrolepis yamanei KANEHARA						6		8				
Buccinum kurodai KANEHARA						6		8		10		
Fulgoraria tokunagai (KANEHARA)						6		8		10		
Turritella (*Hataiella*) *omurai* KANEHARA						6		8	9		11	
Portlandia (*Megayoldia*) *thraciaeformis* (STORER)						6						12
Acila (*Acila*) *eximia* (YOKOYAMA)							7					
Nuculana (*Thestyleda*) *pennula* (YOKOYAMA)							7					
Portlandia (*Hataiyoldia*) *tokunagai* (YOKOYAMA)							7					
Adulomya chitanii KANEHARA							7	8				
Delectopecten peckhami (GABB)							7	8				
Venericardia (*Cyclocardia*) *orbica* YOKOYAMA							7	8				
Lucinoma otukai HATAI and NISIYAMA							7	8				
Solemya (*Acharax*) *tokunagai* YOKOYAMA							7	8	9			12
Ennucula praenipponica KAMADA, n. sp.								8				
Yoldia (*Yoldia*) *omorii* AOKI								8				
Glycymeris cisshuensis MAKIYAMA								8				
Anomia lischkei DAUTZENBERG and FISCHER								8				
Venericardia (*Cyclocardia*) *enaensis* KAMADA, n. sp.								8				
Vesicomya kawadai (AOKI)								8				
Trichotropis enaensis KAMADA, n. sp.								8				
Euspira meisensis (MAKIYAMA)								8				
Ancistrolepis eguchii KAMADA, n. sp.								8				
Nassarius kometubus OTUKA								8				
Cancellaria rara AOKI								8				
Riughudrillia oyamae KAMADA, n. sp.								8				
Patinopecten kobiyamai KAMADA								8	9			
Portlandia (*Portlandella*) *enaensis* KAMADA, n. sp.								8		10		
Periploma pulchellum HATAI and NISIYAMA								8		10		
Macoma izurensis (YOKOYAMA)								8		10		
Patinopecten kimurai (YOKOYAMA)								8	9	10		
Turritella (*Hataiella*) *s-hataii* NOMURA								8	9	10		
Venericardia (*Cyclocardia*) *siogamensis* NOMURA								8	9	10	11	
Macoma optiva (YOKOYAMA)								8	9	10	11	
Dentalium (*Fissidentalium*) *yokoyamai* MAKIYAMA								8	9	10	11	
Thracia hataii KAMADA									9			
Vicaryella ishiiana (YOKOYAMA)									9			
Batillaria (*Tateiwaia*) *tateiwai* MAKIYAMA									9			
Batillaria (*Tateiwaia*) *yamanarii* MAKIYAMA									9			
Megasurcula yokoyamai (OTUKA)									9	10		
Saccella confusa toyomaensis KAMADA, n. subsp.									9	10	11	
Anadara watanabei (KANEHARA)									9	10	11	
Mactra nakayamaensis KAMADA, n. sp.									9	10	11	
Panope nomurae KAMADA, n. sp.									9	10	11	
Mya (*Arenomya*) *cuneiformis* (BÖHM)									9	10	11	
Turritella (*Neohaustator*) *iwakiensis* KOTAKA									9	10	11	
Crepidula nidatoriensis sogabei KAMADA, n. subsp.									9	10	11	
**Nuculopsis kokozurensis* (HATAI and NISIYAMA)										10		
Yoldia (*Cnesterium*) *johanni* DALL										10		
Thracia kamayashikiensis HATAI										10		
Conchocele compacta minor OMORI										10		
Clementia (*Clementia*) *nakosoensis* KAMADA, n. sp.										10		
Panomya simotomensis OTUKA										10		
Calliostoma (*Calotropis*) *simane* NOMURA and HATAI										10		
Doliocassis japonica (YOKOYAMA)										10		
Ancistrolepis yudaensis OTUKA										10		
**Babylonia kozaiensis kokozurana* NOMURA										10		
Chelyconus tokunagai (OTUKA)										10		
Clinocardium shinjiense (YOKOYAMA)										10	11	
Compsomyax iizukai (YOKOYAMA)										10	11	
Neverita coticazae NOMURA										10	11	
Sinum yabei OTUKA										10	11	
Turricula atsukoae KAMADA, n. sp.										10	11	
Modiolus (*Modiolatus*) *yasuhiroi* KAMADA, n. sp.											11	
Dosinia (*Phacosoma*) *chikuzenensis nagaii* OTUKA											11	
Calliostoma (*Tristichotrochus*) *miyokoae* KAMADA, n. sp.											11	
Nassarius simizui OTUKA											11	
**Turritella* (*Hataiella*) *sagai* KOTAKA												12

* See on page 24. 1: Iwaki, 2: Asagai, 3: Shirasaka, 4: Kunugidaira, 5: Goyasu, 6: Mizunoya, 7: Kamenoo, 8: Honya, 9: Nakayama, 10: Kokozura, 11: Numanouchi, 12: Shimotakaku.

of the recognized formations, the density of their remains in each respective fossil locality (crowded, sporadic, abundant, common, few, rare, etc.), assemblage (genus, species) in each of the fossil localities in comparison with geographic position and stratigraphic horizon, nature of the preservation of the shell (excellent, good, fair, poor, fragmentary, waterworn or abraded and their degree), and the stratigraphic position of the fossils from the base of each of the distinguished stratigraphic units. Such kinds of observations were considered to be important to interpreted the above stated problems.

With regard to the bathymetrical ranges of the genera of molluscs represented in the fossil fauna, reference was made to published reports in which the bathymetrical data are given, data obtained from local dredgings (personal dredge operation, verbal and correspondence communications, included), and such data were brought into comparison with the geographical positions for the sake of accuracy. Since the living environments of the epifauna and infauna are different and their respective ranges not the same, these also were given consideration when incorporated into the interpretation of the paleoecological environment of the fossil fauna.

As already stated in earlier sections of the present article, since the respective stratigraphical units in the Joban coal-field were not subjected to the same conditions of sedimentation basin, the paleoecological conditions of the molluscs were also different according to the stratigraphic positions of the formations which yielded them.

In the range chart (Table 2) of the molluscan species distributed vertically from the Iwaki formation to the Futaba-Tomioka formation, the ones indicated with an asterisk comprise those which the author has not been fortunate in collecting, but since they are taxonomically valid and should be mentioned in dealing with the fauna as a whole, they are included.

The respective vertical ranges of the molluscs within the Joban coal-field indicates many outstanding characteristics, and these are treated in the following lines.

First it can be mentioned that there exists a sharp break in the fossil fauna between the Paleogene and Neogene deposits, that is to say between the Iwaki-Asagai-Shirasaka formations and the ones superposed upon them. For example the interrelationships of the molluscan fauna occurring in strata above the said break show intimate relation, while those below the line are similar with one another even though the conditions then prevailing was from transgression to regression. The next significant demarcation in the fauna appears in the Honya formation, because it is in this particular horizon where the important members in the older deposits terminate in their vertical ranges and those characteristic in younger sediments make their first appearance. Also this particular horizon is noteworthy in that it contains many species particular to it.

From the vertical ranges of the molluscan species it is evident that the

two noteworthy horizons making the termination or first appearance of species extending downwards in the former and upwards in the latter should be taken as worthy of separation of the early Miocene from the middle Miocene. Likewise the line of demarcation between the Kunugidaira and Goyasu formations with the Shirasaka and older formations should also be taken as a faunal break and to be considered to represent the Paleogene-Neogene break in the present coal-field.

Even though physical breaks occur between the Shirasaka and the older sediments and the Kunugidaira and Goyasu formations, between the Honya and Nakayama, and between the Nakayama and the Shimotakaku, the faunal breaks are in agreement only between the Shirasaka (including older rocks) and the Kunugidaira (including the Goyasu), and in younger deposits the faunal break occurs in a conformable sequence of sediments. Therefore, since the faunal assemblages above and including the Honya formation are in intimate relationship, and those below the Honya show an analogous phenomenon, it can be said that the physical breaks must have been of very short duration and are related with local block behavior rather than epirogenetic movements.

The present vertical ranges of the molluscan species as correlated with the physical breaks may be the first attempt in Japan as probably as elsewhere. Accordingly, from the above given results of study, it can be understood that unconformities cannot be expected in all cases to have extensive distribution and may not always be taken as a criterion for interbasin correlation. The molluscan fauna, however, are the primary basis for geological age determination as well as interbasin correlation and the physical phenomena indicated in the sediments developed in any area merely reflect the environmental conditions and do not indicate the geological age, as is shown by the above stated.

Another outstanding feature indicated by the vertical ranges of the respective molluscan species is that bottom control of the sedimentary basin closely correlates with the fauna to be developed, and both are in intimate relation with the bathymetrical conditions of the molluscan inhabitants. This is readily recognized when the lithofacies of the respective stratigraphic units are compared with the molluscan fauna yielded from each of them. Conversely, this relationship also reflects the stability of the sedimentary environment and correlates with the geological background of the basin. This just mentioned features has also not been recognized in the Tertiary deposits of Japan and in this article, the writer emphasizes the importance because of its bearing on such problems as determination of geological age, correlation of the stratigraphic units with other areas in Japan, and points to that the value of unconformities may have been overestimated in dealing with such problems as mentioned. It may be added that frequently the unconformities recognized in any area are taken as the chief basis for separation of the geological ages and the fauna merely given second consideration. This has been the case in the Joban coal-field, where the unconformities have been taken to separate the

deposits into late, middle and early Miocene, regardless of the intimate interrelationships of the fossil fauna, the positions of the significant faunal breaks, and the faunal assemblages of each respective lithological unit.

From the faunal components of the respective stratigraphical units in upward sequence, it is quite evident that three or four cycles exist, that is to say from a brackish or very shallow water condition to deeper water and then again to shallow water. These cycles may be more or less complete to incomplete because of subsequent denudation of parts. For example the Uchigo group commences with lagoonal sedimentary environment, then to somewhat deeper conditions with the next shallow parts denudated by the uplift of the sedimentary basin. Such may be expressed in the terms of faunal facies which logically should superpose the Shirasaka are missing because of having been removed by subsequent erosion. Another such cycle although more complete commences with the Kunugidaira and Goyasu formations, culminates in the Kamenoo, declines in the Honya and terminates in the Misawa, another in the Shirado and it is renewed with the Numanouchi and the cycles close with the Shimotakaku. Another cycle begins with the Futaba-Tomioka formation but is largely incomplete owing to the younger deposits having been deposited or having been removed by subsequent erosion. These mentioned faunal cycles are in good agreement with the lithofacies and with their order of superposition. Therefore, transgressive to regressive faunal components constructing a cyclic pattern as well indicated in the range chart are in good agreement with the distinction of the geological ages aforementioned, and serve to show that the duration of the physical breaks is insignificant, contrary to previous opinions.

Indicated in the vertical sequence of the molluscan fauna shown in the range chart, are the changes occurring in thermal conditions of the sea in which the molluscs once lived. From the abundant occurence of *Ennucula, Portlandia, Yoldia, Venericardia, Papyridea,* and the association of *Cultellus, Margarites, Cerithidea, Turritella* and others in the Iwaki and Asagai formations, it can be stated that the thermal conditions were moderate, water conditions previously accepted by other workers. This assemblage can be correlated with the living molluscan fauna from the central part of the western Pacific. Such species of large *Glycymeris, Periploma, Dosinia, Cyclina, Clementia, Soletellina, Cultellus, Calliostoma,* abundant *Turritella, Vicarya, Vicaryella, Batillaria, Sinum, Doliocassis, Babylonia, Fulgoraria, Cancellaria, Riuguhdrillia* and *Chelyconus* in the Miocene rocks are good evidence that the thermal conditions were warm throughout. This is characteristic feature of the early to middle Miocene deposits of the Japanese Islands. However, the molluscan fauna of the Futaba-Tomioka formation is remarkably different from these of the older formations in having a cool water fauna, and one of intermediate character has not been found in the Joban coal-field, which is evidence that late Miccene sediments are missing.

As is known along the borderland of the northeastern to eastern Pacific (DURHAM, 1950) the climatic patterns since the Cretaceous have shown a steady and gradual change from tropical to the present day conditions with a remarkable fluctuation during the Pleistocene. This same or very similar pattern can also be recognized within the Japanese Cenozoic deposits. The evolution of the climatic pattern since the Oligocene in the Tertiary rocks of northeastern Japan shows gradual but steady curve from warm to moderate to the end of the Pliocene, but with the opening of the Pleistocene as noticed from the stratigraphy and fauna of the Boso Peninsula abruptly changed to cold but with fluctuations continued thereafter, until the present day conditions were attained. In the Joban coal-field, since the Oligocene up to the middle Miocene and again in the early Pliocene, correlative cumulative curves can be recognized and these are in good agreement with the general pattern described by DURHAM.

From the stratigraphic units and their molluscan fauna as well as clearly shown in the range chart of the respective species, several lithological units are defined by molluscan assemblages and also with characteristic species. Their lateral distributions are extensive in the sedimentary basins of the Joban coal-field, and so far as the present areas are concerned, the relation between distributions of the respective species seems to point to the existence of local faunizones. The local faunizones cannot be extended outside of the sedimentary basins dealt with in this article, but when those faunizones are brought into more uniformity primarily for the sake of correlation with other areas, it appears that zones may be established. These zones more or less accord with the cycles of the molluscan assemblages already discussed in earlier pages of this article. The most outstanding faunizones would be represented by the Asagai-, Honya- and Kokozura formations, each of them being characterized by a molluscan fauna typical to them although there are species ranging up into those zones or from them to still younger horizons. However, the overlapping-, termination-, first appearances-, and species restricted to them may be taken as the basis for their distinguished features.

DISTRIBUTION OF THE MOLLUSCAN ASSEMBLAGES AND THEIR BEARING ON THE PALEOGEOGRAPHY

As a result of field collections of the molluscan species and specific determinations of them in the laboratory, there have been found several outstanding molluscan assemblages which are thought to have intimate bearing on the paleogeography of the respective stratigraphical units at the time of their deposition in the different parts of the sedimentary basin (including subbasins) of the Joban coal-field. Typical examples of such molluscan assemblages will be outlined in the following lines.

Molluscan fossils derived from the Iwaki formation in its area of distribu-

tion show that the assemblages of the Yumoto are much different from those of the Nakoso and Kadono districts. The Futaba-, Ishimori- and Yumoto districts are characterized by having similar assemblages. The Yumoto district is characterized by having typical marine molluscan assemblages composed of such species as *Glycymeris nakosoensis* HATAI and NISIYAMA, *Venericardia subnipponica* NAGAO, *Peronidia ochii* KAMADA, n. sp., *Spisula nagakoensis* HATAI and NISIYAMA, *Molopopholus watanabei* OTUKA and *Neptunea ezoana* TAKEDA, whereas the Nakoso district yield a brackish water fauna comprising such species as *Ostrea mundana* YOKOYAMA, *Brachidontes takiensis* KAMADA, n. sp., *Mytilus luciferus* YOKOYAMA, *Trapezium jobanicum* HATAI and NISIYAMA, and *Cyclina jobanica* (YOKOYAMA). In the Kadono district the brackish water molluscan assemblage found in the Nakoso district occur in the upper fossil zone, while in its lower fossil zone there is found a characteristic typical marine assemblage.

The lower fossil zone of the Iwaki formation in the Kadono district contains an assemblage comprising such species as, *Glycymeris nakosoensis* HATAI and NISIYAMA, *Venericardia subnipponica* NAGAO and *Ezocallista kurodae* KAMADA, n. sp. This joint association does not occur in any of the other districts.

The assemblages of the Iwaki fauna from their distribution, shows that the physical conditions prevailing during the deposition of the formation were not the same everywhere, being of brackish water in the Nakoso and Kadono districts, but of pure marine elsewhere. Where the brackish water molluscan assemblages occur there are generally found the development coal seams, whereas where the marine molluscan assemblages are found, there is observed no development of such carbonaceous matters. However, it may also be added that the lower fossil zone with pure marine shells as observed in the Kadono district also occurs in other areas, and everywhere they are represented with shallow water near shore molluscan species, and this is considered to be one of the characteristics of a transgressing sea and of its early laid sediments.

The molluscan assemblages of the next younger Asagai formation are contrasting compared with the assemblages of the Iwaki fauna in the Nakoso district which is typically of brackish water whereas those of the Asagai are everywhere typically marine in character. The Asagai formation is developed in all but the Kadono district, and the characteristics of the molluscan fauna in the remaining districts is as follows.

In the Yumoto district the lower half of the Asagai is characterized with *Venericardia laxata* YOKOYAMA, *Papyridea harrimani* DALL and *Mya grewingki* MAKIYAMA while its upper part in the same district is notable in possessing *Clinocardium asagaiense* (MAKIYAMA), *Periploma besshoense* (YOKOYAMA) and *Macoma sejugata* (YOKOYAMA). In the Futaba district the lower half of the Asagai is similar to that of the Yumoto district, except for the additions of gastropods as *Buccinum nakamurai* MAKIYAMA, while its upper half is char-

acterized with *Yoldia laudabilis* YOKOYAMA, *Liocyma furtiva* (YOKOYAMA), *Macoma sejugata* (YOKOYAMA) and "*Turritella*" *tokunagai* YOKOYAMA. Also in the upper half in the Futaba district, *Clinocardium asagaiense* (MAKIYAMA) occurs in profusion. In the Nakoso district the Asagai cannot be divided into two parts as elsewhere, but characteristic in this area are *Glycymeris nakosoensis* HATAI and NISIYAMA, *Venericardia tokunagai* YOKOYAMA, *Lucinoma acutilineatum* (CONRAD), *Spisula nagakoensis* HATAI and NISIYAMA and *Macoma sejugata* (YOKOYAMA). In the Ishimori district the Asagai fauna is similar to that of the Yumoto district.

From the characters of the molluscan assemblages of the different districts just mentioned it is clear that the faunas in the northern and southern parts of the field differ in certain aspects, for example such as *Clinocardium asagaiense* (MAKIYAMA) (s. s.) distributes northwards from the Yumoto district, whereas *Glycymeris* becomes dominant southwards to the Nakoso district. Another characteristic is that gastropods become dominant towards the north from the Yumoto district whereas they are rare in the more southern parts of the field. This shows that the physical conditions from the lower to the upper parts of the Asagai formation were subjected to some differences, even through brackish water conditions are not found. Since in the northern part of the field as evidenced by increasing of gastropods, it may be inferred that the existence of such epifaunal species suggests the presence of rocky coasts nearby the locality of deposition of the major part of the Asagai formation.

The detail local differences during deposition of the Asagai formation may also be interpreted from the local restriction in distribution of many other molluscan genera and species. For example such genera as *Anomia* and *Thracia* occur only in the Futaba district, *Cyclina* and *Nuttallia* only in the Yumoto district; *Papyridea harrimani* DALL in the Yumoto, while *Papyridea harrimani nipponica* YOKOYAMA in the Futaba district and this restriction is also found in the species of gastropods, all of which support the above stated remarks.

The distribution of the Shirasaka formation is in all but the Kadono district, and in the remaining four districts, marine shells occur only at the lower part in the Yumoto and Nakoso districts, whereas elsewhere the fossils are not known to occur. In the Yumoto and Nakoso districts fossils occuring in the lower part of the Shirasaka are relics from the Asagai, the characteristic species being *Periploma besshoense* (YOKOYAMA). Thus there is no molluscan assemblage in the Shirasaka formation.

The Kunugidaira formation which is distributed in the Nakoso and Kadono districts, is characterized by having an assemblage comprising such as *Trapezium isoharense* KAMADA, *Nipponomarcia nakamurai* (IKEBE), *Soletellina minoensis* YOKOYAMA and *Vicarya yokoyamai* TAKEYAMA. From the distribution of the formations and its assemblages in the two areas, it may be noticed that the conditions were more brackish in the Nakoso than in the Kadono district,

even though both are of shallow water conditions.

No molluscan assemblages were found in the Goyasu formation. However, from the next younger Mizunoya formation which is distributed all of the five districts, no assemblage was found, but it may be added that the molluscan fossils from this formation are found in concretions, and the members in found them are generally of only a few species such as *Conchocele bisecta* (CONRAD) and *C. nipponica* (YABE and NOMURA) which are abundant in the Yumoto and Nakoso districts but not elsewhere. *Adulomya chitanii* KANEHARA occurs in abundance in the Nakoso district and is not known from the other districts. No species were found to be distributed in all of the five districts, and this shows the considerable restrictions occurred in their distributions. Probably this may have relation to the physical conditions under which the formation was deposited, and also suggesting the same phenomenon is that all of the fossils occur only from the concretions. The latter phenomenon suggests that peculiar conditions must have prevailed on the sea bottom during the deposition of the formation in the five districts.

The Kamenoo formation which is distributed in all of the five districts and the assemblage is characterized by having no gastropods and only the bivalves, further the individuals are abundant but the number of species are few. The molluscs from this formation are distributed nearly uniformly throughout the five districts, except that in the Nakoso district *Adulomya chitanii* KANEHARA and *Delectopecten peckhami* (GABB) are noteworthy compared with other districts. The fauna of the formation is shown in the range chart, but the formation itself seems to be characterized with such members as *Acila eximia* (YOKOYAMA), *Nuculana pennula* (YOKOYAMA), *Portlandia tokunagai* (YOKOYAMA) and *Lucinoma otukai* HATAI and NISIYAMA, all being more or less deep water forms. Shallow water forms living near the strand line are totally missing, while those living near shore but in moderate depths are also not found.

The next younger Honya formation is distributed in all except the Nakoso district, but fossils brought into consideration are those collected only from the Yumoto and Ishimori districts. In these two districts, two fossil zones are distinguished, the lower is characterized with *Delectopecten peckhami* (GABB), and the upper with *Solemya tokunagai* YOKOYAMA, *Adulomya chitanii* KANEHARA, *Ennucula praenipponica* KAMADA, n. sp., *Acila divaricata submirabilis* MAKIYAMA, *Vesicomya kawadai* (AOKI), *Conchocele nipponica* (YABE and NOMURA), *Macoma izurensis* (YOKOYAMA), *Patinopecten kimurai* (YOKOYAMA), *Turritella omurai* KANEHARA, *Ancistrolepis yamanei* KANEHARA, *Buccinum kurodai* KANEHARA, *Fulgoraria tokunagai* (KANEHARA), *Cancellaria rara* AOKI and *Riughudrillia oyamae* KAMADA, n. sp. Of these mentioned species the only assemblage is that of the *Conchocele-Lucinoma* species, these are found in the upper fossil zone. At one locality there is a shell bed occurring in the uppermost part of the formation in the eastern part of the Yumoto district (Ena in Iwaki City,)

this is characterized with a fauna comprising *Solemya tokunagai* YOKOYAMA, *Periploma pulchellum* HATAI and NISIYAMA, *Venericardia siogamensis* NOMURA, *Macoma optiva* (YOKOYAMA), *Cultellus izumoensis jobanicus* KANNO, *Trichotropis enaensis* KAMADA, n. sp., *Ancistrolepis eguchii* KAMADA, n. sp. and *Nassarius kometubus* OTUKA. In the middle part of the formation in the Ishimori district there is developed a shell bed, called as the "Ishimori shell-bed", having such characteristic species as *Glycymeris cisshuensis* MAKIYAMA, *Patinopecten kobiyamai* KAMADA, *Venericardia orbica* YOKOYAMA, *Anomia lischkei* DAUTZENBERG and FISCHER and *Dentalium yokoyamai* MAKIYAMA. This is a local deposit.

From the characters of the lower and upper parts of the formation it is noticed that the oceanographical conditions were quite different, being of deep water in the former and of more shallower conditions in the latter, yet still considerably deep as may be noticed from such genera as *Buccinum*, *Fulgoraria* and *Ancistrolepis* among the gastropods. The uppermost part of the formation and the middle part in the Ishimori district also suggests fairly shallow water from their molluscan species.

All of the mentioned characteristics of the marine fauna from the respective formations so far enumerated strongly indicate the instability of the sedimentary basin even though the lithological characters have many features in common between them. This feature is again evidenced in the marine fauna of formations younger than the Honya as will mentioned in the following lines.

Although molluscan fossils also occur from the Misawa formation, they are not treated in the present work because of their ill preservation and small collection.

The next fossiliferous stratigraphic unit younger than the Honya formation is the Nakayama formation whose distribution is the Ishimori, Yumoto, Kadono and Nakoso districts. The molluscan remains from this formation at the type locality in the Yumoto district comprise two zones, one in the lower and the upper in the uppermost part, while in the eastern part of the same district, the two zones become combined into one and no distinction can be made between them. The fossils of the two zones become mixed in the eastward portion, but yet the one characterizing the upper part of the type locality are dominant.

In the other three districts the two zones found in the type locality can not be recognized and the fossils in the Nakoso and Kadono districts occur in layers repeated in succession and these have rather extensive distribution. The fossils of the Yumoto district are pure marine in origin, while those of the Nakoso and Kadono districts are brackish water (*Cyclina*, *Vicarya*, *Vicaryella*, *Batillaria*) in origin.

The assemblages of the Nakayama, consists of in its lower part of *Mactra nakayamaensis* KAMADA, n. sp., *Dosinia chikuzenensis nomurai* OTUKA and *Solen* sp., and in the upper part of *Patinopecten kimurai* (YOKOYAMA), *P. kobiyamai*

KAMADA, *Thracia hataii* KAMADA, *Venericardia siogamensis* NOMURA, *Macoma optiva* (YOKOYAMA), *Cultellus izumoensis jobanicus* KANNO and *Turritella iwakiensis* KOTAKA; this latter assemblage occurs in both the type locality and in the eastern part of the Yumoto district. In the Kadono and Nakoso districts the assemblage consists of *Cyclina japonica* KAMADA, *Soletellina minoensis* (YOKOYAMA), *Vicarya yokoyamai* TAKEYAMA, *Vicaryella ishiiana* (YOKOYAMA) and *Batillaria tateiwai* MAKIYAMA.

From the assemblages of the Nakayama formation and the distributions of them in the four districts above mentioned it is readily noticed that brackish water conditions prevailed in the larger parts of the Kadono and Nakoso districts while elsewhere the conditions were purely marine in origin. This shows that the paleogeography at the time of deposition of the Nakayama in the different regions was varied, just as during the time of the Iwaki and Kunugidaira formations mentioned in earlier lines.

The next younger formation yielding abundant marine shells is the Kokozura formation developed in the Nakoso and Kadono districts. In the Nakoso district the typical assemblage at Kokozura comprises such species as *Anadara watanabei* (KANEHARA), *Venericardia siogamensis* NOMURA, *Clementia nakosoensis* KAMADA, n. sp. and *Cultellus izumoensis jobanicus* KANNO, while at Izura the assemblage consists of *Compsomyax iizukai* (YOKOYAMA), *Lucinoma acutilineatum* (CONRAD), *Patinopecten kimurai* (YOKOYAMA) and *Macoma optiva* (YOKOYAMA).

The Numanouchi formation developed in the Yumoto district has an assemblage consisting of *Saccella confusa toyomaensis* KAMADA, n. subsp., *Dosinia chikuzenensis nomurai* OTUKA, *D. c. nagaii* OTUKA, *Acila divaricata submirabilis* MAKIYAMA and *Panope nomurae* KAMADA, n. sp. This same assemblage occurs throughout the distribution of the Numanouchi formation.

The Shimotakaku formation which superposes the Numanouchi is distributed in the Yumoto district only, and so far as examined no characteristic assemblage is contained in the formation. *Turritella sagai* KOTAKA occurs only from this formation in the Joban coal-field.

The Futaba-Tomioka formation is characterized with such fossils as the following, which make two assemblages, each from a different locality, as already described by Y. KAMADA and S. HAYASAKA (1959). One of the assemblages consists of (Locality A of the Tateishi area) *Solemya tokunagai* YOKOYAMA, *S.* cf. *pervernicosa* KURODA, *Portlandia* sp., *Conchocele nipponica* (YABE and NOMURA), *Lucinoma gracilistriata* HIRAYAMA, *Nemocardium samarangae* (MAKIYAMA) and *Macoma* sp. and the other (Locality B) of *Glycymeris yamaguchii* HAYASAKA, *Chlamys miurensis* (YOKOYAMA), *Patinopecten ibaragiensis* MASUDA, *Venericardia ferruginea* CLESSIN, "*Clinocardium*" aff. *nomurai* HAYASAKA, *Cl.* cf. *hataii* HAYASAKA, *Dosinia* cf. *trocheli* LISCHKE, *Mercenaria chitaniana* (YOKOYAMA), *Umbonium* (*Suchium*) sp., *Turritella* aff. *ikebei* KOTAKA, *Neverita didyma* (RÖDING), *Tectonatica janthostomoides* KURODA and HABE and

Fusitriton cf. *oregonensis* (REDFIELD). This formation where it is fossiliferous is found only in the Futaba district.

From the fossils mentioned from the formations older than the Futaba-Tomioka it is evident that their relationship is remote. This is due to the differences in geological age on the one hand and to the prevailing conditions on the other, the former being Miocene and the latter Pliocene.

Thus from the distribution and characteristics of the molluscan assemblages mentioned in the earlier lines of this section, it is clear that considerable differences had taken place in the paleogeographical features, and even when pure marine conditions existed there was also developed brackish and near shore assemblages, and these features closely correlate with the development and distributions of the rocky facies which make up the formation yielding those different kinds of molluscan assemblages.

Thus during the Oligocene there can be recognized conditions changing from brackish, more or less lagoonal or near shore to deeper water by the submergence of the land and finally by a regressive character in which the fossils become almost absent. With the opening of the Miocene there can be observed another marine transgression stage which begun with the deposition of brackish water molluscan species followed with those of shallow water and then gradually to deeper water whose maximum seems to have been attained during the Mizunoya-Kamenoo phase and thereafter by the increasing number of shallower water elements suggesting gradual uplift of the sea bottom and shallowing of the once much more deeper water. This shallow condition continued thereafter through the entire Miocene in the present area as there can be found neither deep water species nor sediments which can be correlated with such conditions at places. After the Miocene another entirely different type of marine molluscan fauna entered the Futaba district and is here called the Futaba-Tomioka formation assemblage to distinguish them from those of the Miocene.

All such evidence from the molluscan assemblages reflected not only the paleogeographical conditions of the sedimentary basin during deposition of the different formations, but also the instability of the basin and the degree of changes taking place during the time from late Oligocene to the middle Miocene, and also early Pliocene age.

CORRELATION

As was mentioned in the earliar pages of this article, the molluscan fauna of the respective stratigraphic units in which they occur have intimate relation with one another. From the respective stratigraphical ranges of the species and genera it was also stated that the unconformities separating the different groups, except for the one between the Uchigo and Yunagaya groups, are crossed by the major species and from faunal analyses, it may be stated

that the time gap represented by those physical breaks is insignificant. From these considerations and from the known distributions of the molluscan species, both geographical and geological, it was stated that the geological age of the Uchigo group is Oligocene and that of the remaining ones older than the Futaba-Tomioka formation is of Miocene age. Also with regard to the position those Miocene groups occupy within that age it was pointed out that the late Miocene is probably lacking because molluscan species characterizing that age have not been found.

Based upon the above stated results obtained from both stratigraphical observations and faunal analyses of the molluscan species, the correlation with areas outside of the Joban coal-field is considered to be as stated in the lines to follow.

As was previously stated by K. HATAI and Y. KAMADA (1950), the Oligocene Uchigo group especially the Asagai and Shirasaka formations from its faunal yield can be correlated with the Poronai and next younger Momijiyama formations of Hokkaido, the Aragai and Nisisakutan formation of South Karafuto (Saghalien), and the Ashiya group of northern Kyushu, further it may be added that probably the Hikokubo group in the Chichibu Basin in Saitama Prefecture may also correspond to the upper part of the Uchigo group developed in the Joban coal-field. These mentioned stratal units are correlated with one another in containing such characteristic fossils as *Yoldia laudabilis* YOKOYAMA, *Periploma besshoense* (YOKOYAMA), *Venericardia subnipponica* NAGAO besides others as given in the Table of the species distinguished from the Uchigo group.

Although paleoecological implications and bathymetrical considerations must be incorporated when dealing with the molluscan fauna of the respective stratigraphical units of the Miocene deposits, it can be broadly stated that the following correlation with other Miocene areas of Japan is justified from the faunal characters.

Compared with the early and middle Miocene deposits developed in Sendai and its environs (HANZAWA, et al., 1953) and the molluscan fossils described by S. NOMURA (1935, '40) as well as in the collection of the Institute of Geology and Paleontology, Tohoku University, the Department of Geology, Faculty of Education of the same university and in the collection of the Saito Ho-on Kai Museum, broad correlation can be made with the whole Natori group. The Natori group used in this work includes the Yumoto tuff previously referred to the Akyu group but later revised by K. HATAI (1960) and proved to stratigraphically belong to the Natori group and to be a sedimentary facies of the Tsunaki formation, the highest unit within the said group. Differences occuring between the Natori group and the Yunagaya to Taga groups in the Joban coal-field are in the development of different lithological facies and therefore a different kind of fauna. However, the major species as *Patinopecten kimurai* (YOKOYAMA), *Dosinia chikuzenensis nomurai* OTUKA, *Veneri-*

cardia siogamensis NOMURA, *Vicarya yokoyamai* TAKEYAMA, *Vicaryella ishiiana* (YOKOYAMA), *Sinum yabei* OTUKA, besides many others are in common. These are extinct species having restricted chronological ranges within the Japanese Miocene, yet rather extensive distributions.

Compared with the Miocene deposits developed in and around Kita-Fukuoka-machi in the Ninohe District, Iwate Prefecture, the present fauna shows intimate relationship with the Kadonosawa group of OTUKA (1934). The mutual species between the Kadonosawa group and the Yunagaya to Taga groups are such as *Clinocardium shinjiense* (YOKOYAMA), *Dosinia chikuzenensis nomurai* OTUKA, *Compsomyax iizukai* (YOKOYAMA), *Patinopecten kimurai* (YOKOYAMA), *Venericardia siogamensis* (NOMURA), *Panomya simotomensis* OTUKA, *Batillaria yamanarii* MAKIYAMA, *Sinum yabei* OTUKA, *Ancistrolepis yudaensis* OTUKA, *Nassarius simizui* OTUKA, *N. kometubus* OTUKA, *Megasurcula yokoyamai* (OTUKA), *Chelyconus tokunagai* (OTUKA), *Desmostylus japonicus* TOKUNAGA and IWASAKI, and many others. The major extinct molluscan species show intimate relationship, and because such have but short chronological ranges and extensive distribution, it is felt that the correlation as just mentioned is fully upheld. Although the differences in thickness of the stratal units, their number, interrelationship and lithological characters may be different, this has no bearing on the geological ages of the deposits brought into discussion.

That the Yunagaya up to and including the Taga groups in the Joban coal-field can be correlated with the molluscan fauna of the formations from the Daishima up to the Funakawa formations of the Oga Peninsula, Akita Prefecture including the correlatives of those formations within the oil-field region of northeast Japan. First it may be added that the sediments distributed in the oil-field region above mentioned comprise geosynclinal facies while those of the Joban coal-field are chiefly epicontinental in origin, from which it may be inferred that the faunal assemblages would be strikingly different. This is the case, but it should be stated that even though the lithological characters and faunal assemblages of the two different sedimentary basins differ from one another, yet there can be found considerable similarity such as both basins yielding *Conchocele bisecta* (GABB), *C. japonica* (YABE and NOMURA), *Vicarya yokoyamai* TAKEYAMA, *Sinum yabei* OTUKA, *Venericardia siogamensis* NOMURA, many common species of the genus *Yoldia*, the sirenian *Desmostylus japonicus* TOKUNAGA and IWASAKI, shark's teeth as *Isurus hastalis* AGASSIZ, besides several other major species of the molluscs. Since detail correlation of the respective stratigraphical units with one another in these two different kinds of sedimentary basins is quite impossible at the present time, it can be added that the mutual species between the two basins, and the physical conditions inferred therefrom, the stratigraphical sequences of the different kinds of lithological units, and other features serve in the attempt for comparing the mentioned deposits.

Correlation of the Joban Miocene deposits with areas in southwest Japan

is more simplified because the major or more important extinct species are more numerous, specifically and generically, and also because peculiar genus as *Nipponomacira* finds it northern most range in distribution in the Joban coal-field. Also the more important extinct species occuring in southwest Japan as *Glycymeris cisshuensis* MAKIYAMA, *Cyclina japonica* KAMADA, *Turritella sagai* KOTAKA, besides others are distributed chiefly southwestwards of the Joban coal-field. Under the mentioned considerations it is evident that the early to middle Miocene deposits in the Mizunami Basin in Gifu Prefecture, the Isshi group in Mie Prefecture, the shallow water deposits in Okayama and Hiroshima Prefectures, and their correlatives are equivalent with the Yunagaya to and including the Taga groups in the Joban coal-field.

A large characteristic of the molluscan fauna of the Yunagaya to and including the Taga groups is that uniform physical conditions are displayed, the thermal gradient seems to have been within the range of warm oceanic waters because no boreal or north temperate zone elements are admixed within the fauna, the extensive distribution but short chronological range of the more important extinct species cross the physical breaks and occur in deposits without such gaps outside of the coal-field, and the cycles represented in the molluscan fauna are in accord with those of the sedimentational one. Further, the minor cycles just mentioned all can be referred to a single major cycle, which belongs according to K. HATAI's (1960) interpretation to the early to middle Miocene in geological age. By the interpretation it can be said that the stratigraphical units developed in the Joban coal-field and classified into the Yunagaya to and including the Taga groups are in good agreement.

LIST OF NEW NAMES

Hataiyoldia, n. subgen. (Nuculanidae). Type species: *Portlandia* (*H.*) *tokunagai* (YOKOYAMA).
Ennucula praenipponica, n. sp.
Saccella confusa toyomaensis, n. subsp.
Portlandia (*Portlandella*) *enaensis*, n. sp.
Ostrea (*Ostrea*) *yokoyamai*, n. sp.
Modiolus (*Modiolatus*) *yasuhiroi*, n. sp.
Brachidontes takiensis, n. sp.
Venericardia (*Cyclocardia*) *enaensis*, n. sp.
Trapezium (*Neotrapezium*) *isoharense*, n. sp.
Clinocardium asagaiense makiyamae, n. subsp.
Clinocardium asagaiense arakawae, n. subsp.
Ezocallista kurodae, n. sp.
Clementia (*Clementia*) *nakosoensis*, n. sp.
Mactra nakayamaensis, n. sp.
Nuttallia uchigoensis, n. sp.
Peronidia ochii, n. sp.
Calliostoma (*Tristichotrochus*) *miyokoae*, n. sp.
Trichotropis enaensis, n. sp.
Crepidula nidatoriensis sogabei, n. subsp.
Ancistrolepis eguchii, n. sp.
Riuguhdrillia oyamae, n. sp.
Turricula atsukoae, n. sp.

All type specimens described and figured in the present article are deposited in the Institute of Geology and Paleontology, Tohoku University, Sendai, while the remainder of the collection will be stored in the Department of Geology, Nagasaki University, Nagasaki.

SYSTEMATIC DESCRIPTIONS

Phylum MOLLUSCA

Class PELECYPODA

Order PALEOBRANCHIA

Family SOLEMYIDAE

Genus *Solemya* LAMARCK, 1818

Solemya, LAMARCK, Anim. s. Vert., Vol. 5, p. 488, 1818.

Type species (by subsequent designation, CHILDREN, 1823), "*Solenomya australis*" LAMARCK=*Solemya mediterranea* LAMARCK=*Solemya togata* (POLI). Recent, Adriatic and Mediterranean Seas, Atlantic Ocean off Spain, Medeira, West Africa, etc.

Subgenus *Acharax* DALL, 1908

Acharax, DALL, Nautilus, Vol. 22, p. 2, 1908.

Type species (by original designation), *Solemya johnsoni* DALL. Recent, from Puget Sound to Panama Bay in 60 to 1740 fathoms.

Ligament opistodetic, wholly external, visible internally only where it crosses the gap between the margins of the valves. Nymphs without props. (DALL, 1908, p. 2.)

Solemya (*Acharax*) *tokunagai* YOKOYAMA, 1925

Pl. 1, Figs. 1-3

1925 *Solemya tokunagai* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 31, pl. 6, figs. 1-3; Ibid., Vol. 45, art. 7, p. 11, pl. 1, figs. 20, 21.

1934 *Solemya tokunagai* YOKOYAMA, OTUKA, Bull. Earthq. Res. Inst., Vol. 12, pt. 3, p. 607, pl. 47, fig. 10.

1937 *Solemya tokunagai* YOKOYAMA, KANEHARA, Jour. Geol. Soc. Japan, Vol. 44, no. 526, p. 704.

1937 *Solemya* (*Acharax*) *tokunagai* YOKOYAMA, KANEHARA, Jap. Jour. Geol. Geogr., Vol. 14, nos. 3-4, p. 156, pl. 15, figs. 10, 11.

1954 *Solemya tokunagai elongata* AOKI, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 3, no. 17, p. 30, pl. 1, fig. 15.

1959 *Solemya* (*Acharax*) *tokunagai* YOKOYAMA, KAMADA and HAYASAKA, Saito Ho-on Kai Mus., Res. Bull., No. 28, p. 20, pl. 2, figs. 3, 4.

Type data:—Lectotype (YOKOYAMA's pl. 6, fig. 2, *fide* HATAI and NISIYAMA, 1952, p. 135) and syntypes are in the Geological Institute, University of Tokyo.

Type locality:—East of the Ide River, at Tateishi, Naraha-machi, (Joban coal-field). Lower Pliocene Futaba-Tomioka formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	AD	H/L(%)	AD/L(%)
83	Both	88.3	32.5	—	64.0	37.6	72.6
84	Both	60.5	22.0	—	44.5	36.1	73.0
85	Both	57.5	ca. 20.0	—	43.5	ca. 33.9	73.7
86	Both	84.0	26.5	16.2(×2)	63.0	31.5	75.0
87	Both	66.0	22.0	—	48.0	34.1	72.7
88	Both	51.0	16.0	—	36.5	31.4	71.5
Average		67.9	23.2	—	49.9	34.1	73.1

AD: Length of anterior dorsal margin.

Remarks:—As already mentioned in the previous paper (KAMADA and HAYASAKA, 1959, p. 20-21), the topotype of *Solemya* (*Acharax*) *tokunagai* from the Tateishi area in the northern end of the Joban coal-field closely resembles the living *S.* (*A.*) *tibai* KURODA (1948, p. 29, figs. 1-3) from off Cape Erimo, south Hokkaido. KURODA (*op. cit.*, p. 30) stated that the radial ribs and grooves of the fossil *tokunagai* are descending with a curve, while those of the living *tibai* are straight and the grooves are narrower than the preceding. The radial ribs, accompany with shallow grooves, are developed in the anterior part of the shell surface and are about six in number, but gradually become obscure towards the posterior half where faint indistinct ribs are radiating.

The new materials of the present species were collected from the Kamenoo,

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The abbreviations given bellow will be used in the present work.

DGS: Department of Geology, Faculty of Education, Tohoku University.
ERI: Earthquake Research Institute, University of Tokyo, Tokyo.
GK: Geological Institute, College of Science, Kyoto University, Kyoto.
GSJ: Geological Survey of Japan, Kawasaki, Kanagawa Prefecture.
GT: Geological Institute, Faculty of Science, University of Tokyo, Tokyo.
IGPS: Institute of Geology and Paleontology, Faculty of Science, Tohoku University, Sendai.
SM: Saito Ho-on Kai Museum, Saito Ho-on Kai Foundation, Sendai.
TKD: Tokyo Kyoiku Daigaku (Tokyo University of Education), Bunkyoku, Tokyo.
UH: Institute of Geology and Mineralogy, Faculty of Science, Hokkaido University, Sapporo, Hokkaido.

The abundance of the molluscan remains from each localities will be indicated by the following terms.

Very abundant ..... More than 25 individuals
Abundant ..... 11 to 25 „
Common ..... 5 to 10 „
Few ..... 2 to 4 „
Rare ..... Only 1 individual

Honya, Nakayama and Shimotakaku formations in the Joban coal-field. The ratio of height to length of the specimens at hand ranges from 31 to 37 per cent (average is 34.1 per cent in six examples). Although, the holotype specimen is somewhat higher than the present ones, a considerable range of variation is recognized in the paratypes and topotypes, as well as in the new materials. *Solemya tokunagai elongata* AOKI from the Kabeya formation in the Joban coal-field also may be included in the range of variation of the species.

Occurrence:—

1) Tateishi, Tatsuta, Naraha-machi (Type locality). Futaba-Tomioka formation. Few. Coll. No. 83.

2) Yagawase cliff, Taira City. Honya formation. Common. Coll. No. 84.

3) Hieda, Shimokajiro, Ena-machi, Iwaki City. Honya formation. Few. Coll. No. 85.

4) Shiroyama, Taira City. Honya formation. Few. Coll. No. 86.

5) North of Nagasaki, Ena-machi, Iwaki City. Nakayama formation. Rare. Coll. No. 87.

6) Southern valley of Suginami, Natsui, Taira City. Shimotakaku formation. Rare. Coll. No. 88.

7) Nametsuzawa, Shimotakaku, Takaku, Taira City. Shimotakaku formation. Rare. Coll. No. 89.

8) 300 m north of Osawa tunnel, Ena-machi, Iwaki City. Shimotakaku formation. Rare. Coll. No. 90.

Genus *Adulomya* KURODA, 1931

Adulomya, KURODA, in F. HOMMA's Geol. Cent. Shinano, Pt. 4, p. 27-28, 1931.

Type species (by monotypy), *Adulomya uchimuraensis* KURODA, 1931. Miocene, Nagano Prefecture, Japan.

Shell resembles *Adula* (Mytilidae) in outline but has two adductor muscle scars. Shell large, transversely elongate or archform elongate. Both anterior and posterior ends rounded, slightly gaping in front, posterior and ventral margins almost parallel. Beaks situated anterior one sixth or seventh, more or less project, prosogyrate. Surface ornamented with concentric lines of growth, becoming crowded ventrally. Ligament external, opisthodetic, semicylindrical, very long. Cardinal edentulous. A strong inner rib running from beak furrow to anterior ventral corner just behind anterior adductor muscle scar.

Adulomya chitanii KANEHARA, 1937

Pl. 1, Figs. 4-7

1937 *Adulomya chitanii* KANEHARA, Bull. Imp. Geol. Surv. Japan, Vol. 27, no. 1, p. 19, pl. 5, figs. 1, 6-9.

1954 "*Adulomya*" *chitanii* KANEHARA, AOKI, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C. Vol. 3, no. 17, p. 31-32, pl. 1, figs. 9-10.

Type data:—Holotype and paratypes in the Imperial Geological Survey of Japan, Tokyo, were destroyed by fire during the World War II.

Type locality:—Ashikaya-zawa, Sekinami, Kitaibaraki City (Joban coal-field) (here desginated). Miocene Mizunoya formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
76	Both	34.0	13.0	—	38.2	—
„	Both	28.0	10.0	—	35.8	—
77	Left	30.0	12.5	—	41.7	—
„	Right	32.0	11.5	—	36.0	—
78	Right	34.0	15.0	—	44.2	—
79	Left	26.5	10.0	—	37.8	—
80	Both	60.5	17.0	11.0(×2)	28.1	9.1
„	Both	49.3	13.8	9.8(×2)	28.0	9.9
„	Both	46.0	12.5	—	27.2	—
„	Both	39.0	13.5	8.4(×2)	34.6	10.7
81	Both	52.0	14.5	9.5(×2)	27.9	9.1
„	Both	50.0	15.0	10.0(×2)	30.0	10.0
„	Both	50.0	13.0	9.0(×2)	26.0	9.0
„	Both	44.0	15.0	—	34.1	—
„	Both	43.4	14.0	9.2(×2)	32.2	10.6
„	Both	43.0	16.5	10.5(×2)	38.4	12.2
„	Both	38.0	13.0	8.5(×2)	34.2	11.2
„	Both	35.8	11.8	6.1(×2)	33.0	8.5
Average		40.9	13.4	9.2(×2)	33.8	10.0

Remarks:—*Adulomya chitanii* occurred from the Kamenoo, Honya, Misawa and Nakayama formations in the Joban coal-field; especially abundantly occurs from the Mizunoya formation in the Nakoso district and from the Honya formation at Shiroyama and Yagawase in Taira City.

The many specimens of the named species from a cliff near the Taira railroad station and at Tanozawa both in Shiroyama, Taira City were examined. The shell of these new materials possesses an elongate outline and both postero-dorsal and ventral margins are almost straight and parallel with each other and of moderate size, becoming arched and elongated in outline in the full growth stage. The external ligament is cylindrical and exposed nearly half length of the posterior dorsal margin. A strong vertical inner rib situates at just behind the anterior muscle scar, as seen in *Adulomya uchimuraensis* KURODA, the type species of the genus *Adulomya*. A pair of faint grooves extend in the inner surface of the shell from beak just below the posterior

erior adductor muscle scar.

The ratios of height to length of the specimens of the present species from the Kamenoo formation (six individuals), from the Honya formation (12 individuals) and from the Misawa formation (one individual) are 38.9, 31.1 and 32.2 per cent respectively. The average value of the total 22 individuals is calculated as 33.6 per cent. From these results, the specimens from the Kamenoo formation have more or less higher shell than those from higher horizons.

The shell of *Adulomya uchimuraensis* is very elongated and the ratio of height to length in the holotype specimen is 18.9 per cent. Recently, TANAKA (1959, p. 117-118) described this species based on the specimens from the Akanuda limestone of the lowermost of the Bessho formation in Nagano Prefecture, and gave the dimensions of five specimens. The average ratio of height to length of the TANAKA's supplementary collection (five individuals) is 24.7 per cent. Accordingly, *A. chitanii* is distinguishable from *A. uchimuraensis* by having a smaller shell and the higher value of the ratio of height to length. Nevertheless, most of the characteristic features of *chitanii* are closely similar to those of *uchimuraensis*, especially, the arched elongate form of *chitanii* is almost indistinguishable from *uchimuraensis* originally figured by KURODA (1931, pl. 13, fig. 111).

Occurrence:—

1) Shisawa, Nakoso City. Kamenoo formation. Few. Coll. No. 76.

2) Fukuda, Sekinami, Kitaibaraki City. Kamenoo formation. Few. Coll. No. 77.

3) Nagako, Nishiki-machi, Nakoso City. Kamenoo formation. Few. Coll. No. 78.

4) Kanegasawa, Hisanohama-machi. Kamenoo formation. Rare. Coll. No. 79.

5) Tangozawa, Shiroyama, Taira City. Honya formation. Abundant. Coll. No. 80.

6) Northern cliff of Taira railroad station, Shiroyama, Taira City. Honya formation. Very abundant. Coll. No. 81.

7) Yagawase cliff, Taira City. Honya formation. Common.

8) Tsuruga-machi, Iino, Taira City. Misawa formation. Rare. Coll. No. 82.

Order PROTOBRANCHIA

Family NUCULIDAE

Genus *Ennucula* IREDALE, 1931

Ennucula, IREDALE, Rec. Australian Mus., Vol. 18, no. 4, p. 202.

Type species (by subsequent designation, SINGLETON, 1932), *Nucula obliqua* LAMARCK, Recent, Australia.

Inner ventral margin practically smooth. No radial or concentric ribs on surface. Chondrophore notably oblique.

Ennucula praenipponica KAMADA, n. sp.

Pl. 1, Figs. 8-11

1936 *Nucula (Nucula) nipponica* SMITH, OTUKA, Jour. Geol. Soc. Japan, Vol. 43, p. 727, pl. 41, fig. 2 (not figs. 1a, b).

1954 *Ennucula tenuis* (MONTAGU), AOKI, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 3, no. 17, p. 32, pl. 2, fig. 19 (non MONTAGU, 1808).

Shell small in size, obliquely ovate, inequilateral, posterior side much shorter than anterior, well inflated. Anterior dorsal margin long, regularly rounded, subparallel to posterior ventral half; ventral margin convex and its posterior half more or less broadly arched; posterior dorsal margin short, convex but making an angulation just behind beaks; posterior corner forming right angle, so that posterior dorsal margin rapidly turns to arched ventral margin. Surface polished but with numerous concentric growth undulations and lacking radial striation. Umbones tumid, curved inwards and backwards and almost touching each other. Inner surface nacreous, its ventral margin entire. Hinge plate not well observed, however, numerous taxodont teeth on both sides of dorsal margin.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
IGPS 79375*	Both	15.0	11.6	8.2(×2)	77.3	27.3
59	Both	20.3	14.0	9.9(×2)	69.0	24.4
„	Both	16.1	12.3	8.4(×2)	76.5	26.0
60	Both	13.5	9.5	6.5(×2)	70.4	24.0
Average		16.2	11.9	8.3(×2)	73.3	25.4

* Holotype

Remarks:—Compared with *Ennucula obliqua* (LAMARCK), the type species of *Ennucula*, figured by HANLEY (in SOWERBY, 1860, Sp. 23, fig. 150) and SCHENCK (1934, p. 37, pl. 3, figs. 4, 4a, 4b; pl. 4, figs. 3, 3a, 3b), the present new species is easily distinguishable therefrom by having a lower shell, more convex ventral margin and smaller obliquity. There are three living species of *Ennucula* recorded from the seas of North Japan, namely *E. tenuis* (MONTAGU), *E. nipponica* (SMITH) and *E. cyrenoides* (KURODA). *E. tenuis* from Loch Fyne, Scotland, figured by SCHENCK (1939, p. 33, pl. 8, figs. 1-4) is distinguished from the present species by the more rounded outline and less inflation. *E. praenipponica* is closely related to the living *E. nipponica* from Northeast Japan, figured by OTUKA (1936, p. 727, p. 41, figs. 1a, b), but is distinguishable from the living one by the more convex ventral border and smaller shell. OTUKA

also figured a fossil specimen (*Ibid.* pl. 43, fig. 2) from Manganzi in Akita Prefecture under the name of *Nucula* (*Nucula*) *nipponica*. However, the Manganzi specimen is indistinguishable from the present Joban specimen but differs from *nipponica* by the above-mentioned features. *E. cyrenoides* (KURODA) (1929, p. 7, figs. 8, 9) collected by the surveying ship S. S. "Soyo-maru" from Northeast Japan is characterized by its roundly trigonal shell and can be distinguished from *praenipponica*.

Although, AOKI (1954) recorded the occurrence of *Ennucula tenuis* (MONTAGU) from the Kabeya formation in the Joban coal-field, it may be referred to the present new species and not to the living species of *tenuis*.

Occurrence:—

1) Hieda, Shimokajiro, Ena-machi, Iwaki City (Type locality). Honya formation. Few. IGPS Coll. Cat. No. 79375.

2) Yagawase cliff, Taira City. Honya formation. Few. Coll. No. 59.

3) Northern cliff of Taira station, Shiroyama, Taira City. Honya formation. Rare. Coll. No. 60.

Ennucula yotsukurensis (HIRAYAMA, 1955)

Pl. 1, Figs. 12-14

1955 *Nucula ventricosa* HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 77-78, pl. 1, figs. 12-15 (non PCELINCEV, 1927).
1958 *Nucula yotsukurensis* HIRAYAMA (nom. nov.), Venus, Vol. 20, no. 1, p. 96.

Type data:—TKD Reg. No. 10225 (holotype) and TKD Reg. Nos. 10226, 10227 (paratype).

Type locality:—Yotsukura cliff, Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
TKD 10225*	Both	15	11	7 (×2)	73.4	23.3
„ 10226**	Both	13	10	8 (×2)	77.0	30.8
„ 10227**	Both	18	13	8 (×2)	72.3	22.2
61	Both	10.8	8.4	5.1(×2)	77.7	23.6
„	Both	12.2	10.2	6.2(×2)	83.6	25.4
„	Left	10.0	7.5	—	75.0	—
Average		13.2	10.0	6.9(×2)	76.5	25.1

* Holotype, ** Paratype

The measurements of the three first-listed valves are taken from HIRAYAMA (1955, p. 78).

Remarks:—The present species was once named by HIRAYAMA as *ven-*

tricosa, however, this specific name was preoccupied by a Jurassic nuculid fossil. Moreover, the homonyms of *Nucula ventricosa* were used by FLEMING, 1828, HINDS, 1843, HALL and MEEK, 1854 and HALL, 1858, as already pointed out by SCHENCK (1939, p. 22). *Nucula ventricosa* of HIRAYAMA, 1955 was, therefore, renamed as *yotsukurensis* by the original author in 1958.

The supplementary specimens of the present species collected from the Asagai formation at Tsuzura, Uchigo City have no crenulate or denticulate inner ventral margin which is always seen in *Nucula nuculeus* (LINNÉ), the type species of the genus *Nucula*. *Ennucula yotsukurensis* is characterized by its small size and the surface lacks distinct concentric ribs except for the very faint radial striations. This species is restricted to the Asagai formation in its geological occurrence and in the Joban coal-field in its geographical distribution.

Occurrence:—Tsuzura, Uchigo City. Asagai formation. Coll. No. 61.

Genus *Nuculopsis* WOODRING, 1925

Nuculopsis, WOODRING, Carnegie Inst. Wash., Publ. No. 366, p. 14, 1925.

Type species (by monotypy) *Nucula* (*Nuculopsis*) *hilli* WOODRING. Bowden Miocene, Jamaica.

Nuculopsis kokozuraensis (HATAI and NISIYAMA, 1949)

1949 *Nucula kokozuraensis* HATAI and NISIYAMA, Jour. Paleont., Vol. 23, no. 1, p. 87, pl. 23, figs. 1-5.

Type data:—IGPS Coll. Cat. No. 72507.

Type locality:—Kokozura, Nakoso City (Joban coal-field). Miocene Kokozura formation.

Remarks:—The present species is characterized by possessing a smooth inner ventral margin and coarse concentric threads which are occasionaly bifurcated. These features and the outline of the shell of *kokozuraensis* may refer it to the nuculid genus *Nuculopsis*. HATAI and NISIYAMA stated that the present species is distinguished from *Nucula dautzenbergi* PRASHAD (1932, pl. 1, figs. 13-16) by the more outwardly produced dorsal margin, and by the less pronounced posterior margin.

The supplementary specimens could not be collected by the writer. *N. kokozuraensis* is restricted to the type locality in its occurrence, and the named species is, therefore, a peculiar form in the Kokozura formation.

Occurrence:—Kokozura, Nakoso City (Type locality). Kokozura formation. Rare.

Genus *Acila* H. and A. ADAMS, 1858

Acila, H. and A. ADAMS, Gen. Rec. Moll., Vol. 2, p. 545, 1858.

Type species (by subsequent designation by STOLICZKA, 1871), *Nucula divaricata* HINDS. (=*Nucula mirabilis* ADAMS and REEVE). Recent, China Sea from 84 fathoms (type locality of *divaricata*); "Nagasaki Bay (?), Kyushu, Japan" (type locality of *mirabilis*).

Subgenus *Acila* s. s.

Acila (Acila) divaricata submirabilis MAKIYAMA, 1926

Pl. 1, Figs. 15-22

1925 *Nucula mirabilis* ADAMS and REEVE, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 7, p. 21, pl. 3, fig. 6.

1926 *Acila submirabilis* MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 2, no. 3, p. 151-152, pl. 12, fig. 9.

1928 *Nucula (Acila) mirabilis* A. ADAMS and REEVE, var. *ashiyaensis* NAGAO, Sci. Rep., Tohoku Imp. Univ., 2nd Ser., Vol. 12, no. 1, p. 21-22, pl. 7, figs. 6-8, 9(?), 10.

1934 *Acila (Acila) submirabilis* MAKIYAMA, SCHENCK, Mus. Roy. Hist. Nat. Belg., Bull., Tome 10, no. 20, p. 42.

1935 *Acila (Acila) divaricata* (HINDS) var. *submirabilis* MAKIYAMA, SCHENCK, Mus. Roy. Hist. Nat. Belg., Bull., Tome 11, no. 14, p. 4, table.

1936 *Acila (Acila) divaricata* (HINDS) var. *submirabilis* MAKIYAMA, SCHENCK, Geol. Soc. Amer., Spec. Papers No. 4, p. 88-90, pl. 11, figs. 9-11; pl. 14, figs. 1, 5, 8-11; pl. 18, figs. 8, 9, 13-15; text-fig. 8(13).

Type data:—Holotype (left valve) is in the Geological Institute, Kyoto University.

Type locality:—Nanseki, Meisen (Myonchon) district, North Korea. Miocene Heirokudo formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
62	Both	25.0	21.2	13.4(×2)	85	26.8
63	Right	ca. 31	24	ca. 10	77.5	ca. 32.3
64	Right	ca. 30	ca. 25	—	83	—
65	Left	27.5	21.5	—	78	—
66	Right	29	ca. 24	ca. 7	83	24.2
67	Right	24.8	—	—	—	—
„	Both	19.0	—	11.3(×2)	—	29.7
„	Both	10.6	8.5	5.3(×2)	80	25.0
68	Both	17.3	12.0	7.0(×2)	69.5	20.4
„	Right	14.4	10.0	—	69.5	—
„	Left	10.2	10.8	3.5	86.5	34.3
Average		21.7	17.4	5.6	68.0	27.5

Remarks:—The revisions of the present species were given in detail by SCHENCK (1936, p. 88-90) based on the fossil specimens from the Japanese Tertiary and also on the living shells collected from the "Albatoross" stations in the western Pacific. According to him, *submirabilis* is a variety of *Acila* (*Acila*) *divaricata* (HINDS) and distinguishable from the latter by only having the radial ribs crossing the escutcheonal area. These characteristic features of the sculpture on the escutcheonal area are considered as significant value to separate *submirabilis* from *divaricata* specifically, as originally recognised by MAKIYAMA (1926, p. 152).

Several specimens collected from the Honya formation measure from 27 to 31 mm. in length and it seems that most of them are adults. On the other hand, the specimens from the Numanouchi formation are represented by various size ranging from less than 10 mm. to about 25 mm. in length. All of the specimens from the Goyasu, Honya and Numanouchi formations in the Joban coal-field possess radial ribs crossing the escutcheonal area. In some of them, there is a secondary bifurcation behind the rostral sinus so that the trough of the sinus coincides with "V" of the bifurcating lines.

Occurrence:—

1) Shibahara, Shimo-ogawa, Ogawa-machi. Goyasu formation. Few. Coll. No. 62.

2) Hieda, Shimokajiro, Ena-machi, Iwaki City. Honya formation. Few. Coll. No. 63.

3) Kamikajiro, Ena-machi, Iwaki City. Honya formation. Common. Coll. No. 64.

4) Kamikuramochi, Iwaki City. Honya formation. Few. Coll. No. 65.

5) Igamesaku, Nagasaki, Ena-machi, Iwaki City. Honya formation. Few. Coll. No. 66.

6) Shioya-machi, Toyoma-machi, Taira City. Numanouchi formation. Common. Coll. No. 67.

7) Numanouchi harbor, Toyoma-machi, Taira City. Numanouchi formation. Few. Coll. No. 68.

Acila (*Acila*) *eximia* (YOKOYAMA, 1925)

Pl. 1, Figs. 23, 24

1925 *Nucula eximia* YOKOYAMA, Jour. Coll. Sci., Imp. Univ., Tokyo, Vol. 45, art. 7, p. 11, pl. 1, figs. 14-16.

1936 *Acila* (*Truncacila ?*) *eximia* (YOKOYAMA), SCHENCK, Geol. Soc. Amer., Spec. Papers No. 4, p. 88, text-figs. 8(8).

Type data:—Lectotype is in the Geological Institute, University of Tokyo.

Type locality:—Kamenoo-sawa, Mizunoya, Joban City (Joban coal-field), where YOKOYAMA's specimen figured in pl. 1, fig. 14 was collected (here designated). Miocene Kamenoo formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	H/L(%)
71	Right	35	31	88.5
72	Right	32	21	65.7
„	Right	28	20	71.5
218	Right	34.2	24	70.2
Average		32.3	24	74.0

Remarks:—*Acila* (*Acila*) *eximia* (YOKOYAMA) is commonly found from shales and siltstones of the Kamenoo formation in the Joban coal-field. However, owing to its original shell substances having been dissolved and to the subsequent compression after fossilization, only pressed external and internal molds are preserved in the rocks, thus it is difficult to measure the exact width. The original description given by YOKOYAMA seems to be written based on the specimens preserved only as internal molds. Among the supplementary specimens at hand from the Nakoso district, an almost perfect external cast shows that the shell possesses a slightly impressed rostral sinus and the surface is sculptured with radial ribbing without any area of obsolete ribbing. Although, it is not conspicuous, the existence of the rostral sinus indicates that the present species belongs to *Acila, sensu stricto.*

The general features of *A. eximia* are closely related with those of *Acila picturata* (YOKOYAMA, 1890) from the Poronai shale in Hokkaido, as already mentioned by SCHENCK (1936, p. 88). Compared with *A. picturata* (YOKOYAMA) described and figured by NAGAO and HUZIOKA, (1941, p. 127-129, p. 29, figs. 1-4), *A. eximia* possesses a larger and transversely longer shell. The present species is also distinguishable from *Acila* (*Truncacila*) *gottschei* (BÖHM) from the Neogene of various localities in Hokkaido and Saghalien, described and figured by NAGAO and HUZIOKA (1941, p. 121-123, pl. 29, figs. 10-15) and its synonym, *Acila* (*Truncacila*) *kurodai* KANEHARA (KANEHARA, 1937, p. 704-706, pl. 22, figs. 4-10), because *A. eximia* possesses finer radial ribs and more trigonal shell outline.

Occurrence:—

1) Kusanoki, Iino, Taira City. Kamenoo formation. Coll. No. 71.

2) Takai, Otsu-machi, Kitaibaraki City. Kamenoo formation. Coll. No. 72.

3) Hanai, Nishiki-machi, Nakoso City. Kamenoo formation. Coll. No. 218.

Various localities where the Kamenoo formation is distributed.

Subgenus *Truncacila* SCHENCK in GRANT and GALE, 1931

Truncacila SCHENCK, in GRANT and GALE, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 115; 1931; SCHENCK, Bull. Mus. Royal d'Hist. nat. Belg., Tome. 10, no. 20, p. 43, 1934; SCHENCK, Geol. Soc. Amer., Spec. Papers, No. 4, p. 23-24,

1936.

Type species (original designation), *Nucula castrensis* HINDS. Recent, Sitka, Alaska (type locality).

Adult shell seldom exceeds 20 millimeters in length; trigonal; quadrangular or ovate in outline; lacking the well-defined rostral sinus that characterizes *Acila, sensu stricto*; one or more bifurcations (divarications) of the radial ribs. (SCHENCK, 1936, p. 23-24).

Acila (*Truncacila*) *oyamadensis* HIRAYAMA, 1955

Pl. 1, Figs. 25, 26

1924 *Nucula insignis* A. ADAMS, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 21 (not of A. ADAMS or GOULD).

1955 *Acila* (*Truncacila*) *oyamadensis* HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, vol. 4, no. 29, p. 75-77, pl. 1, figs. 1-7.

Type data:—TKD No. 10189 (holotype) and TKD No. 10190 (paratype).

Type locality:—Cliff along the tributary of the Kobisa-gawa, a little west of Oyamada, Hisanohama-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
69	Both	12.5	10.8	6.7(×2)	86.5	26.8
70	Left	13	11.4	—	87.5	—
„	Left	12	10.5	—	87.5	—
„	Left	15	13	—	86.5	—
„	Right	13.5	11.6	—	86.0	—
Average		13.2	11.5	—	86.8	—

Remarks:—The present species is characterized by its medium sized shell, ovate-trigonal outline and fine divaricating ribs. The ratio of the hight to the length is about 87 per cent in the specimens collected from the Yumoto district in the Joban coal-field. The ratio of the specimens from the Futaba district, which is calculated based upon the dimensions of ten shells given by HIRAYAMA, is 86.3 per cent in average. This value is so high among the genus that it seems to be a significant feature for the present species.

Acila (*Truncacila*) *oyamadensis* is restricted to the Asagai formation in its occurrence, therefore, it is an important horizon-marker. *Acila* is usually gregariously mixed together, not including other kinds of molluscan shells, in a single spherical concretion. The mode of occurrence was classed by HIRAYAMA (1955, p. 62) to his B_1-type, which was designated as the "assemblages composed of a single species occurring in patches".

Occurrence:—

1) Tsuzura, Uchigo City. Asagai formation. Rare. Coll. No. 69.

2) Uenohara, Yoshima-mura. Asagai formation. Abundant. Coll. No. 70.
3) Kamiozuta, Hanakawa, Kitaibaraki City. Asagai formation. Common.

Family NUCULANIDAE

Genus *Nuculana* LINK, 1807

Nuculana, LINK, Beschreib. Nat. Samm. Univ. Rostock, Abth. 3, p. 155, 1807.

Type species (by monotypy):—*Arca rostrata* CHEMNITZ. Recent, northern coasts of Europe.

Nuculanidae with the posterior end of the shell generally more produced than the anterior one; pallial line only slightly sinuous; valves closed or but slightly gaping (GRANT and GALE).

Subgenus *Thestyleda* IREDALE, 1929

Thestyleda, IREDALE, Rec. Aust. Mus., Vol. 17, p. 158.

Type species (by original designation), *Leda ramsayi* SMITH. Recent, Off Sydney, New South Wales, in 950 fathoms.

Surface with distinct concentric lines.

Nuculana (*Thestyleda*) *pennula* (YOKOYOMA, 1925)

Pl. 1, Fig. 27

1925 *Leda pennula*, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 7, p. 9, pl. 2, figs. 7-9.

Type data:—Lectotype is in the Geological Institute, University of Tokyo.

Type locality:—Takinosaku, Kami-Arakawa, Iino, Taira City (Joban coal-field), where YOKOYAMA's specimen figured in pl. 2, fig. 8 was collected (*fide* HATAI and NISIYAMA, 1952, p. 70). Miocene Kamenoo formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)
57	Right	12.2	10.0	—	82.0

Remarks:—This species is characterized by its narrowly rostrated posterior part and mostly truncated posterior end. YOKOYAMA compared the present species with the fossil *Leda ramsayi* SMITH from Koshiba, Yokohama City (YOKOYAMA, 1920, p. 176, pl. 19, fig. 3) and stated that this species is longer than the latter. Although *Leda ramsayi* is the subgeneric type species of *Thestyleda*, YOKOYAMA's fossil *ramsayi* was considered as a distinct species by some authors. KURODA (1934, p. 204) proposed the new name, *yokoyamai*, for *Leda ramsayi* of YOKOYAMA from Koshiba. *N.* (*T.*) *yokoyamai* is now living in Sagami Bay, Japan.

The distribution of the present species is restricted to the Kamenoo formation in the Joban coal-field.

Occurrence:—Path-side cutting, north of Nakosonoseki, Nakoso City. Kamenoo formation. Few. Coll. No. 57.

Genus *Saccella* WOODRING, 1925

Saccella, WOODRING, Carnegie Inst. Wash., Publ. No. 266, p. 15-16, 1925.

Type species (by original designation), *Arca fragilis* CHEMNITZ (=*Leda commutata* PHILIPPI). Miocene to Recent, Mediterranean Sea.

Saccella confusa toyomaensis KAMADA, n. subsp.

Pl. 2, Figs. 1-5

Shell small, transversely elongate, posterior part somewhat attenuated. Anterior dorsal margin slightly arched, anterior end regularly rounded without any angulation to dorsal or ventral margins, ventral margin broadly arched, posterior end bluntly pointed and not arcuated upward, posterior dorsal margin almost straight. Escutcheonal area depressed, sharply bordered by an edge extending from beak to posterior corner and sculptured by radial ribs, each of which seems to correspond with posterior extremities of concentric ribs on shell surface; lunule narrowly lanceolated but not so depressed. Surface of shell sculptured with concentric ribs separated by narrower interspaces, and strength of each rib almost uniform in accordance with growth stages. Inner ventral margin entire. Anterior teeth ca. 26 and posterior teeth ca. 20.

Dimensions:—(in mm.)

Coll. No.	Valve	Length	Height	Width	H/L(%)
IGPS 79376*	Left	15.2	7.0	—	46.0
„	Right	16.0	8.6	—	53.7
„	Right	9.2	5.0	—	53.8
„	Left	12.0	5.8	—	48.3
„	Right	10.5	5.5	—	52.4
„	Right	10.8	6.2	—	52.3
74	Right	15.4	8.4	—	54.5
Average		12.7	6.6		51.6

* Holotype

Remarks:—The present subspecies is distinguished from the species by the smaller size in the adult stage and by the posterior end not being arcuated upward. The ratios of height to length of *Saccella confusa* (HANLEY) are 57.0 per cent in the Recent specimens (six valves in number) from the Kamakura coast, Kanagawa Prefecture and 58.4 per cent in the dreged Recent specimens

(45 valves) from off Hachinohe, Aomori Prefecture, while the precent subspecies is 51.1 per cent in six valves from Numanouchi, Toyoma-machi, Taira City in the Joban coal-field. *Saccella confusa kongiensis* (OTUKA) (OTUKA, 1934, p. 608, pl. 47, fig. 14) from the Miocene "Lower Kadonosawa series" at Shiratori, Fukuoka district, Iwate Prefecture, shows almost the same ratio (57 per cent) of height to length as in *confusa*. The feature of the posterior end which is not arcuated upward in both *kongiensis* and *toyomaensis* may suggest that these belong to a single species. However, *toyomaensis* is comparatively lower than *kongiensis* and *confusa*.

Occurrence:—

1) Numanouchi harbor, Toyoma-machi, Taira City (Type locality.) Numanouchi formation. Very abundant. IGPS Coll. Cat. No. 79376.

2) Tsunatori, Ena-machi, Iwaki City. Numanouchi formation. Abundant. Coll. No. 74.

3) Kassozaki Ena-machi, Iwaki City. Nakayama formation. Common. Coll. No. 75.

4) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Common.

5) Tozenji, Yunoami, Sekinami-machi, Kitaibaraki City. Kokozura formation. Common.

6) Minami-mae, Sekinami-machi, Kitaibaragi City. Kokozura formation. Common.

Genus *Portlandia* MÖRCH, 1857

Portlandia MÖRCH, Brod. Faun. Molus. Grönl. in H. J. RINK, Grön. geogr. stratigr. besk., Band 2, pt. 4, p. 21, 1857.

Type species (by subsequent designation by DALL, 1896), *Arca arctica* GRAY.

Subgenus *Portlandella* STEWART, 1930

Portlandella, STEWART, Acad. Nat. Sci. Phila., Spec. Publ., No. 3, p. 61, 1930.

Type species (by original designation), *Leda rosa* HANNA, 1927. Eocene, La Jolla, California.

Portlandia (*Portlandella*) *enaensis* KAMADA, n. sp.

Pl. 1, Figs. 28-30

Shell medium in size, somewhat ventricose, posterior portion compressed, inequilateral, posterior part being rather longer than anterior one, equivalve. Anterior dorsal margin slightly arched, sloping downward to well-rounded anterior end and passing into anterior ventral margin; ventral margin regularly rounded in anterior part, nearly horizontal and broadly arched in middle and steeply curved upwards to posterior end; posterior dorsal margin longer than anterior and nearly straight or slightly concave, posterior end somewhat rost-

rate, rounded and having no demarcation with posterior ventral corner. Depressed posterior area with two obtuse radial lines elevated on it. Surface smooth, polished but with marking of concentric growth lines. Taxodont teeth 22 in anterior row and 17 in posterior row in left valve of holotype.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
79377	Left	19.0	10.0	3.5	52.7	18.4
„	Right	13.5	8.0	—	59.2	—
56	Both	21.0	11.5	8.0(×2)	54.8	19.0
„	Both	16.0	9.5	6.6(×2)	59.4	20.6
„	Both	15.0	8.5	6.0(×2)	56.6	20.0
Average		16.9	9.5	3.5	56.5	19.5

Remarks:—This new species closely resembles the living *Portlandia* (*Portlandella*) *japonica* (ADAMS and REEVE) figured by HANLEY (1866, pl. 1, fig. 14), UOZUMI (1957, pl. 1, figs. 6, 6a-c) and KIRA (1959, pl. 41, fig. 11) from the southwestern seas of Japan, but can be distinguishable from the latter by being more transversly elongated and narrowly rostrated posterior portion. *P.* (*P.*) *hurukutiensis* (NOMURA and ZINBO) (NOMURA and ZINBO, 1935, p. 5, pl. 1, fig. 10) from the Miocene Furukuchi formation in Yamagata Prefecture and *Yoldia intermedia kadonosawaensis* OTUKA (OTUKA, 1934, p. 609, pl. 47, fig. 19) from the "Upper Kadonosawa series" in the Fukuoka district in Iwate Prefecture also resemble the present new one. Compared with the above-mentioned fossil species, the present one is more broadly arched ventrally and more elongated transverselly. *Portlandia* (*Hataiyoldia*) *tokunagai* (YOKOYAMA) (YOKOYAMA, 1925, p. 10, pl. 2 figs. 12-18) from the Kamenoo formation in the Joban coalfield, is easily distinguished from the present new species by its having a larger shell and the peculiar ornamentation on the shell surface.

Occurrence:—

1) Hieda, Shimokajiro, Ena-machi, Iwaki City (Type locality). Honya formation. Common. Coll. No. 79377.

2) West of Mizuoshi, Amakida, Yamada, Nakoso City. Mizunoya formation. Few. Coll. No. 56.

3) Kokozura, Nakoso City. Kokozura formation. Few.

Subgenus *Megayoldia* VERRILL and BUSH, 1897

Megayoldia, VERRILL and BUSH, Amer. Jour. Sci., Ser. 4, Vol. 3, p. 55.

Type species (by original designation), *Nucula thraciaeformis* STORER, Recent. North America.

Portlandia (Megayoldia) thraciaeformis (STORER, 1838)

Pl. 2, Figs. 6a, b

1838 *Nucula thraciaeformis* STORER, Boson Jour. Nat. Hist., Vol. 2, p. 122.
1866 *Leda (Yoldia) thraciaeformis* (STORER), HANLEY in SOWERBY, Thes. Conch., Vol. 3, p. 39, Sp. 66, pl. 1, figs. 4, 13.
1871 *Yoldia thraciaeformis* STORER, Conch. Icon., Yoldia, Sp. 1, Pl. 1, figs. 1a-c.
1926 *Yoldia scapha* YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, Vol. 1, pt. 7, p. 247, pl. 31, figs. 7-11.
1931 *Yoldia thraciaeformis* (STORER), GRANT and GALE, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 128, pl. 1, figs. 12a, b.
1934 *Yoldia thraciaeformis* STORER, OTUKA, Bull. Earthq. Res. Inst., Vol. 12, pt. 3, p. 609, pl. 47, fig. 16.
1935 *Yoldia thraciaeformis* STORER, NOMURA, Sci. Rep., Tohoku Imp. Univ., Ser. 2, Vol. 18, no. 1, p. 53, pl. 4, fig. 10.
1937 *Yoldia thraciaeformis* STORER var. *scapha* YOKOYAMA, KANEHARA, Bull. Imp. Geol. Surv. Jap., Vol. 27, no. 1, p. 20, pl. 5, fig. 4.
1957 *Portlandia (Megayoldia) thraciaeformis* (STORER), UOZUMI, Jour. Fac. Sci., Hokkaido Univ., Ser. 4, Vol. 9, no. 4, p. 574, pl. 1, figs. 5, 5a, 7, 8, 8a; pl. 7, figs. 23, 28.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
49	Both	61.3	35.2	23.0(×2)	57.5	18.8
50	Both	51.5	29.0	19.0(×2)	56.3	28.2

Remarks:—Recently, UOZUMI (1957) discussed about the fossil *Portlandia (Megayoldia) thraciaeformis* (STORER) and *Yoldia scapha* YOKOYAMA from Hokkaido. He concluded that *Yoldia scapha* from the Miocene hard shale beds developed in the Embetsu and Etaibetsu districts in Hokkaido is synonymous with *thraciaeformis*, and referred every fossil recorded as *scapha* to *thraciaeformis*. Therefore, the geological range of this species in Hokkaido was considered by Uozumi as from early Miocene to Recent.

In the Joban coal-field, KANEHARA (1937) once figured a left valve from the Kamenoo Shale under the name of *Yoldia (Megayoldia) thraciaeformis* STORER var. *scapha* YOKOYAMA, but gave no description about it. Two specimens at hand which are from the Mizunoya formation in the Yumoto district were examined. The features of the present specimens closely coincide with those of the Hokkaido ones which were described by UOZUMI. However, the Joban specimens have an elongated trapezoidal shell which is somewhat longer than the Hokkaido specimens figured by UOZUMI and also the Recent specimens from Puget Sound of North America figured by GRANT and GALE (1931). The Joban specimens resemble the Shiratori specimen figured by OTUKA (1934) from his "Lower Kadonosawa Series" in their elongated forms, although the latter one is somewhat lacking in its anterior ventral corner. Because of the variations of the fossil *thraciaeformis* in the Japanese Tertiary, the precise determination

of the present specimens to the named species is still problematical.

Occurrence:—

1) In the tunnel, between Kami-Asagai and Mizunoya, Joban City. Mizunoya formation. Few. Coll. No. 49.

2) Iwasaki colliery, Joban Coal-mine, Joban City. Mizunoya formation. Rare. Coll. No. 50.

Portlandia (*Megayoldia*) *yotsukurensis* UOZUMI, 1957

Pl. 2, Figs. 7, 8

1934 *Yoldia laudabilis* YOKOYAMA, MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 10, no. 2, p. 131, pl. 3, figs. 5, 6 (non YOKOYAMA, 1924).

1955 *Yoldia watasei* KANEHARA, HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 82, pl. 1, fig. 18 (non KANEHARA, 1937).

1957 *Portlandia* (*Megayoldia*) *yotsukurensis* UOZUMI, Jour. Fac. Sci., Hokkaido Univ., Ser. 4, Vol. 9, no. 4, p. 579-580, pl. 1, figs. 3, 4; pl. 7, fig. 13.

Type data:—UH Reg. No. 931 (holotype) and No. 12256 (paratype).

Type locality:—Sea-cliff of Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
34	Left	35.3	21.6	4.5	61.3	12.7
35	Both	39.0	24.5	8.0(×2)	62.9	10.6
36	Right	52.0	ca. 30	—	ca. 58	—

Remarks:—According to MIZUNO's (1954) and UOZUMI's revisons of the so-called *Yoldia laudabilis* YOKOYAMA of several authors, *Yoldia asagaiensis* MAKIYAMA is nothing but *Y. laudabilis*, while *Y. laudabilis* of the same author is a distinct unnamed species. UOZUMI proposed a new name, *yotsukurensis* for MAKIYAMA's *laudabilis*. *Yoldia watasei* of HIRAYAMA (1955) from the Asagai formation is also assigned to the named species.

The present species is characterized by its subquadrate outline, the subtruncate and subvertical posterior margin and the depressed posterior area. The taxonomical position of *yotsukurensis* and its comparisons with allied species were discussed by UOZUMI in his original description.

Occurrence:—

1) Nagasawa, Hisanohama-machi. Asagai formation. Few. Coll. No. 34.

2) Yotsukura sea-cliff, Yotsukura-machi. Asagai formation.

3) Tsuzura, Uchigo City. Asagai formation. Few. Coll. No. 35.

4) Mukaida, Yumoto-machi, Joban City. Asagai formation. Coll. No. 36.

Subgenus *Hataiyoldia* KAMADA, new subgenus

Type species (here designated), *Yoldia tokunagai* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 7, p. 10, pl. 2, figs. 12-13, 1925. Miocene Kamenoo formation in the Joban coal-field, Japan.

Shell medium to large in size, transversely elongate, inequilateral; posterior area rostrated and compressed; posterior dorsal margin long, extending somewhat upwards, slightly concave and its terminal turns into subtruncated posterior end making therewith a nearly perpendicular angle; anterior dorsal margin sloping, slightly convex and turns into regularly rounded anterior end; ventral margin nearly parallel to posterior dorsal margin in middle part and its posterior one third extending upward to posterior corner. Surface sculptured with concentric lines of growth becoming numerous and crowded at ventral margin, peculiar ornamentations developing on most part of surface except on posterior area, equidistant lines seen on umbonal region oblique to incremental lines of growth in anterior half and becoming of zig-zag pattern backwards on main surface in adult stage.

The new subgenus *Hataiyoldia* is represented by *Yoldia tokunagai* YOKOYAMA from the Kamenoo formation in the Joban coal-field and *Portlandia* (*Portlandella*) *tokunagai* var. *hayasakai* UOZUMI (1957, p. 570, pl. 2, figs. 6, 7-9, 15, 15a) from the Miocene formations in Ishikari Province, Hokkaido, Japan.

The characteristic ornamentation on the surface of the shell of *tokunagai* and its variety *hayasakai* cannot be compared with that of the other known species which belong to either yoldias or portlandias in literature. UOZUMI (1957, p. 571) pointed out that the typical form of *Yoldia tokunagai* and var. *hayasakai* should be safely included into *Portlandia* (*Portlandella*) from the outer form of the shell and the nature of the hinge. Therefore, *Hataiyoldia* is distinguished from *Portlandella* STEWART (1930, p. 61), by only the minute complicated ornamentation on the surface except for the lines of growth. These peculiar ornamentations are not simple divarications as stated by YOKOYAMA (1925) in his description of *Yoldia tokunagai*.

Portlandia (*Hataiyoldia*) *tokunagai* (YOKOYAMA, 1925)

Pl. 2, Figs. 9-12

1925 *Yoldia tokunagai* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 7, p. 10, pl. 2, figs. 12-18.

1937 *Yoldia* (*Yoldia*) *tokunagai* YOKOYAMA, KANEHARA, Jour. Geol. Soc. Japan, Vol. 44, no. 527, p. 793, pl. 25, figs. 6, 7.

1957 *Portlandia* (*Portlandella*) *tokunagai* (YOKOYAMA), UOZUMI, Jour. Fac. Sci., Hokkaido Univ., Ser. 4, Vol. 9, no. 4, p. 589, pl. 7, figs. 26, 27 (reproduced from YOKOYAMA, 1925).

Type data:—Lectotype (YOKOYAMA's pl. 2, fig. 15, *fide* HATAI and NISIYAMA, 1952, p. 161) is in the Geological Institure, University of Tokyo.

Type locality:—Saku, Iino, Taira City (Joban coal-field). Miocene Kamenoo formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	H/L(%)
39	Left	41.2	19	46.2
„	Right	33	17	51.5
40	Right	36	18	50.1
41	Left	35	19	54.3
42	Left	29	17	58.7
46	Right	32	18	56.3
„	Left	30	16	53.4
47	Right	40.5	20.5	50.6
Average		34.6	18.1	52.6

Remarks:—This species is the most common element in the Kamenoo formation not only in its geographical distribution but also in its abundant occurrence. Therefore, it is a useful guide fossil of the Kamenoo formation.

Occurrence:—

1) Nakayama, Ono, Yotsukura-machi. Kamenoo formation. Common. Coll. No. 39.

2) Kamiarakawa, Taira City. Kamenoo formation. Common.

3) Kamenoo, Mizunoya, Yumoto-machi, Joban City. Kamenoo formation. Common.

4) Nagako, Nishiki-machi, Nakoso City. Kamenoo formation. Few. Coll. No. 41.

5) Shisawa, Nakoso City. Kamenoo formation. Common. Coll. No. 42.

6) North of Nakosonoseki, Nakoso City. Kamenoo formation. Abundant. Coll. No. 45.

Various localities within the Kamenoo formation in the Joban coal-field.

Genus *Yoldia* MÖLLER, 1842

Yoldia, MÖLLER, Index Moll. Groenland., p. 18, 1842.

Type species (by subsequent designation, GARDNER, 1916), *Nucula arctica* GRAY. Recent, northern seas of Europe.

Subgenus *Yoldia* s. s.

Yoldia (*Yoldia*) *laudabilis* YOKOYAMA, 1924

Pl. 2, Figs. 13, 14

1924 *Yoldia laudabilis* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 22, pl. 4, figs. 11, 12.
1934 *Yoldia asagaiensis* MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 10, no. 2, pt. 6, p. 129, pl. 3, figs. 1, 3, 4.
1954 *Yoldia laudabilis* YOKOYAMA, MIZUNO, Cenozoic Research, No. 20, p. 15, pl. 1, figs. 8-21.
1955 *Yoldia asagaiensis* MAKIYAMA, HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C. Vol. 4, no. 29, p. 80, pl. 1, figs. 16, 17, 21.
1957 *Yoldia* (*Yoldia*) *laudabilis* YOKOYAMA, UOZUMI, Jour. Fac. Sci., Hokkaido Univ., Ser. 4, Vol. 9, no. 4, p. 547, pl. 5, figs. 1, 1a, 4, 5, 9, 9a.
(non *Yoldia laudabilis* YOKOYAMA, MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. C, Vol. 10, no. 2, pt. 6, p. 131, pl. 3, figs. 2, 5, 6, 1934; HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Ser. C, Vol. 4, no. 29, p. 79, pl. 1, figs. 20, 22, 1955.)

Type data:—Lectotype (monotype) is in the Geological Institute, University of Tokyo.

Type locality:—Shinyashiki, Suetsugu, Hisanohama-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	H/L (%)
29	Left	30.0	14.0	46.7
„	Right	44.2	22.0	49.8
„	Right	36.0	20.5	57.0
31	Left	41.0	23.0	56.1
32	Right	25.0	14.0	56.0
Average		35.2	18.7	53.1

Remarks:—This species has been frequently recorded from the Asagai formation under the name of *Yoldia asagaiensis* MAKIYAMA. However, recently, MIZUNO (1954) and UOZUMI (1957) discussed in detail that *laudabilis* is synonymous with *asagaiensis* of MAKIYAMA, and that MAKIYAMA's *laudabilis* is *Portlandia* (*Megayoldia*) *yotsukurensis* UOZUMI. Detailed remark was given by UOZUMI (1957, p. 547-550).

Occurrence:—

1) Yotsukura cliff, Yotsukura-machi. Asagai formation. Common. Coll. No. 29.

2) Oyamada, Ohisa-mura. Asagai formation. Few. Coll. No. 31.

3) Goten, Uchigo City. Asagai formation. Few. Coll. No. 28.

4) Mukaida, Yumoto-machi, Joban City. Asagai formation. Few. Coll. No. 32.

Yoldia (*Yoldia*) *yabei* (YOKOYAMA, 1924)

Pl. 2, Figs. 15, 16

1924 *Leda yabei* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 22,

pl. 4, figs. 9, 10.

1929 *Leda* (?) *yabei* YOKOYAMA, KURODA, Venus, Vol. 1, app. p. 10.

1934 *Yoldia yabei* (YOKOYAMA), MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 10, no. 2, p. 132.

1954 *Yoldia laudabilis h-matsuii* MIZUNO, Cenozoic Research, No. 20, p. 18, pl. 1, figs. 6, 7.

1955 *Yoldia* (*Yoldia*) cf. *yabei* (YOKOYAMA), HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 82, pl. 1, fig. 19.

1957 *Yoldia* (*Cnesterium*) *yabei* (YOKOYAMA), UOZUMI, Jour. Fac. Sci., Hokkaido Univ., Ser. 4, Vol. 9, no. 4, p. 583, pl. 7, figs. 5, 6.

non 1936 *Yoldia yabei* (YOKOYAMA), NOMURA and HATAI, Saito Ho-on Kai, Mus., Res. Bull., No. 10, p. 117, pl. 13, figs. 6, 7.

Type data:—Lectotype is in the Geological Institute, University of Tokyo.

Type locality:—Tengasawa, Oyamada, Ohisa-mura (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
38	Both	21.0	12.0	4.6(×2)	57.2	10.9
53	Right	19.0	10.0	—	52.7	—

Remarks:—This species closely resembles *Yoldia laudabilis* in the outline, but has a shell smaller than the latter. The sculpture of the shell surface consists of concentric coarse undulations.

Although *Y. yabei* was once referred to subgeneric postition in *Cnesterium* by KURODA (1929) and UOZUMI (1957), the concentric sculpture which coincides with the growth lines on the surface of the shell suggests that it does not belong to *Cnesterium* which is characterized by oblique grooves.

NOMURA and HATAI (1936) recorded the occurrence of *Yoldia yabei* from Nishigoto, Tanagura district, Fukushima Prefecture and considered that it may belong to the section *Cnesterium*. However, the Tanagura specimens have distinct oblique grooves, therefore, it cannot be identified with the Joban species. It may belong to either *Y. johanni* DALL or *Y. notabilis* (YOKOYAMA) or its allied species. MIZUNO (1954) described *Yoldia laudabilis h-matsuii* MIZUNO which was collected from a drilling-core sample at Manome, Taira City in the Joban coal-field. Judging from the original description and figures and also their dimensions (said to be 23 mm. in length; 12.5 mm in height; about 2.0 mm in depth of the right valve) of *h-matsuii*, this subspecies is nothing but a synonym of *Yoldia* (*Yoldia*) *yabei* which has coarser concentric lines than *Y. laudabilis*.

Occurrence:—

1) East of Tate, Hirono-machi. Asagai formation. Rare. Coll. No. 38.

2) In the prospecting boring, depth 632 meters, at Takinosawa, Tomioka-machi. Iwaki formation? Rare. Coll. No. 53.

Yoldia (*Yoldia*) *omorii* AOKI, 1954

Pl. 2, Figs. 17, 18

1954 *Yoldia omorii* AOKI, Sci. Rep., Tokyo Kyoiku Daigaku, Vol. 3, no. 17, p. 30, pl. 2, fig. 18.

1957 "*Nuculana omorii*" (AOKI), UOZUMI, Jour. Fac. Sci., Hokkaido Univ., Ser. 4, Vol. 9, no. 4, p. 593, pl. 7, fig. 11 (reproduced from AOKI's figure).

Type data:—TKD Reg. No. 5922.

Type locality:—Small cliff of roadside at Shimokatayose, Kabeya, Taira City (Joban coal-field). Miocene Kabeya (Honya) formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
51	Left	22.0	10.2	—	46.5	—
52	Right	20.0	9.3	—	46.5	—

Remarks:—S. AOKI described *Yoldia omorii* based on specimens from the Miocene Kabeya formation in the Ishimori district in the Joban coal-field. The Kabeya formation (SATO and MATSUI, 1951) is a correlative of the Honya formation typically distributed in the Yumoto district in the central part of the coal-field. Three specimens are at hand from the Honya formation. *Y. omorii* is characterized by its small and narrowly elongated shell and is ornamented with faint concentric lines of growth. A pair of lines running from the beak to the anterior ventral corner is represented in the present specimens, but are very obscure near the umbonal region. MAKIYAMA (1934, p. 128) once emphasized the existence of a pair of radial lines of the anterior portion of the shells of *Yoldia*. He also stated that the living species of *Yoldia kikuchiana* KURODA (KURODA, 1930, p. 10, figs. 10, 11) from Toyama Bay possess a well-marked sinus between these pairs of lines of the anterior portion. Concerning the present species, a slightly shallow depression is developed on the anterior ventral corner between these pair of lines in the left valve of the present specimen from Ena, Iwaki City,

Y. omorii closely resembles the living *Y. similis* KURODA and HABE (a new name for *Y. naganumana* (YOKOYAMA) of KURODA, 1930, fig. 19) from off the east coast of Honshu, but is distinguishable therefrom by the more or less smaller shell (holotype specimen of *similis* is said of 24 mm. in length) and more pointed posterior end.

Occurrence:—

1) Northwestern end of Ena, Iwaki City. Honya formation. Rare. Coll. No. 51.

2) Hieda, Shimokajiro, Ena-machi, Iwaki City. Honya formation. Few. Coll. No. 52.

Subgenus *Cnesterium* DALL, 1898

Cnesterium DALL, Trans. Wagner Inst. Sci., Vol. 3, pt. 4, p. 595.

Type species (by original designation), *Nucula arctica* BRODERIP and SOWERBY, 1899 (not GRAY, 1824)=*Yoldia scissurata* DALL, 1897. Recent.

Yoldias with a well-developed dorsal keel on the rostrum and pronounced obliquely in concentric sculpture (GRANT and GALE, 1931).

Yoldia (*Cnesterium*) *johanni* DALL, 1925

Pl. 2, Fig. 19

1925 *Yoldia* (*Cnestrium*) *johanni* DALL, Proc. U. S. Nat. Mus., No. 2554, Vol. 66, art. 17, p. 32, pl. 29, fig. 7.
1929 *Yoldia johanni* DALL, KURODA, Venus, Vol. 1, no. 4, append. p. 12, no. 42, fig. 16.
1932 *Yoldia* cf. *johanni* DALL, YOKOYAMA, Imp. Geol. Surv. Japan, Rep. No. 111, p. 16, pl. 3, fig. 1.
1934 *Yoldia cooperi ochotensis* KHOMENKO, OTUKA, Bull. Earthq. Res. Inst., Tokyo Imp. Univ., Vol. 12, pt. 3, p. 609, pl. 47, figs. 17, 18 (not KHOMENKO, 1930).
1935 *Yoldia johanni* DALL, NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 5, p. 104, pl. 5, fig. 3.

Type locality:—Northern Japan, Recent.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	H/L(%)
54	Right	25.5	13.6	53.5

Remarks:—A single right valve from the Kokozura formation in front of the Tozenji Buddhist temple at Yunoami, Sekinami, Kitaibaraki City is safely referred to *Cnesterium*. The surface of the shell is sculptured with faint striae of concentric growth accompanying with concentric oblique grooves. The oblique grooves which do not coincide with the concentric striae of growth are separated by considerably wide interspaces becoming obscure anteriorly. From these features of the surface ornamentation, the present specimen is closely allied to the living *Yoldia* (*Cnesterium*) *johanni* DALL rather than *Y.* (*C.*) *notabilis* YOKOYAMA. Recently, UOZUMI (1957) discussed about the fossil *notabilis* from Hokkaido and gave a full lists of synonyms of its species.

OTUKA (1934) figured *Yoldia cooperi ochotensis* KHOMENKO from his "Upper Kadonosawa Series" in the Shiratori valley in the Fukuoka district, Iwate Prefecture. However, *Y. cooperi* does not belong to *Cnesterium*, it is a type species of *Kalayoldia* GRANT and GALE, 1931, while KHOMENKO's (1940) *ochotensis* undoubtedly belongs to *Cnesterium*. Although, OTUKA's specimens are not well illustrated and without description, they seem to be close to the present Joban specimen.

Occurrence:—Tozenji, Yunoami, Sekinami, Kitaibaraki City. Kokozura

formation. Rare. Coll. No. 54.

Order FILIBRANCHIA (Taxodonta)

Family ARCIDAE

Genus *Anadara* GRAY, 1847

Anadara GRAY, Proc. Zool. Soc. London for 1847, p. 198.
Type species (by original designation), *Arca obliquata* LINNÉ, 1758.

Anadara watanabei (KANEHARA, 1935)

Pl. 2, Figs. 20-23

1935 *Arca trilineata watanabei* KANEHARA, Venus Vol. 5, no. 5, p. 276-277, pl. 13, figs. 1, 2.

Type data:—Types were destroyed by a fire during the World War II.
Type locality:—Kokozura, Nakoso City (Joban coal-field) (*fide* HATAI and NISIYAMA, 1952, p. 30). Miocene Kokozura formation.
Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
138	Left	44.4	34.0	16.4	76.6	37.0
„	Right	38.6	30.0	13.6	77.7	35.3
„	Right	37.2	29.2	12.5	78.6	33.7
„	Right	38.4	26.2	11.5	68.2	30.0
„	Right	31.5	24.0	9.7	76.3	30.8
140	Left	25.0	19.0	—	76.0	—
„	Right	16.0	10.8	4.4	67.5	27.6
141	Left	52.0	38.0	19.0	73.1	36.6
„	Left	35.0	31.5	10.5	90.0	30.0
„	Left	23.5	19.0	7.5	80.8	31.9
142	Left	33.0	26.0	12.0	78.8	36.4
Average		35.9	26.2	11.7	76.7	32.9

Remarks:—*Anadara watanabei* is characterized by possessing bipartite ribs as seen in *A. trilineata* (CONRAD), *A. amicula* (YOKOYAMA) and *A. ogawai* (MAKIYAMA). The detailed description and comparisons with the allied species were given by KANEHARA in his original paper. The present species is one of the most characteristic in the Kokozura and Numanouchi formations and frequently occurs from the lower part of Nakayama formation in the eastern border of the Yumoto district.

Occurrence:—

1) Hamamachi sea-cliff, Toyoma-machi, Taira City. Numanouchi formation. Common. Coll. No. 140.

2) Numanouchi harbor, Toyoma-machi, Taira City. Numanouchi formation. Common. Coll. No. 141.

3) Tsunatori, near Onahama, Ena-machi, Iwaki City. Numanouchi formation. Few.

4) Kokozura, Nakoso City. Kokozura formation. Abundant. Coll. No. 138.

5) South cliff of Cape Shioya, Toyoma-machi, Taira City. Nakayama formation. Few. Coll. No. 142.

Family GLYCYMERIDAE

Genus *Glycymeris* DA COSTA, 1778

Glycymeris DA COSTA, Hist. Nat. Test. Brit., p. 168, 1778.

Type species (by absolute tautonomy), *Arca glycymeris* LINNÉ, 1758=*Glycymeris orbicularis* DA COSTA. Recent, Atlantic coast of Europe.

Glycymeris cisshuensis MAKIYAMA, 1926

Pl. 3, Figs. 1-3

1926 *Pectunculus* sp. YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 1, pt. 4, p. 136, pl. 16, fig. 5.

1926 *Glycymeris cisshuensis* MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 2, no. 3, p. 155-156, pl. 13, figs. 2, 3.

1928 *Glycymeris cisshuensis* MAKIYAMA, NAGAO, Sci. Rep., Tohoku Imp. Univ., 2nd Ser., Vol. 12, no. 1, p. 29-30, pl. 2, figs. 1-13; pl. 3, figs. 1-3; pl. 4, figs. 22-25.

1936 *Glycymeris cisshuensis* MAKIYAMA, MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 11, no. 4, p. 206.

1937 *Glycymeris cisshuensis* MAKIYAMA, NOMURA and HATAI, Saito Ho-on Kai Mus., Res. Bull., No. 13, p. 125, pl. 17, fig. 7.

1956 *Glycymeris cisshuensis* MAKIYAMA, ITOIGAWA, Mem. Coll. Sci., Univ. Kyoto, Ser. B, Vol. 23, no. 2, art. 2, p. 180, pl. 2, fig. 1.

Type data:—Holotype is in the Geological Survey of Chosen (Korea), Keijo (Soule), South Korea. Reg. No. 70.

Type locality:—Kinsei, Meisen district, North Korea. Lower Banko sandstone, Miocene.

Dimensions (in mm.)—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
259	Left	73	66	24	90.5	32.9
„	Right	64.5	59	17	91.5	26.4
„	Right	63	57.5	19	91.3	30.2
„	Left	62	55	16	88.8	25.9
„	Left	60.5	59	17	97.5	28.5
260	Right	59.0	50.5	15.5	85.6	26.3
„	Right	56.5	50.0	16.5	88.5	29.2
Average		62.6	57.7	17.9	90.5	28.5

Remarks:—This large and heavy glycymerid occurs abundantly from the Ishimori shell-beds in the Ishimori district. The comparison with the other species of *Glycymeris* was done by MAKIYAMA (1926, 1936).

There are few paleontological records of *G. cisshuensis* from the Japanese Tertiary. NAGAO figured many specimens from the Ashiya group in North Kyushu and NOMURA and HATAI recorded its occurrence from the Miocene rocks in the Senpoku district, Miyagi Prefecture. NOMURA and HATAI (1937) stated that the unnamed *Pectunculus* from the Miocene rocks in Shiobara, Tochigi Prefecture figured by YOKOYAMA (1926) is also conferable with the present species.

Occurrence:—

1) West of Mizujina, Kusano, Taira City. Kabeya (Honya) formation. Very abundant. Coll. No. 259.

2) Nakayama, Ono, Yotsukura-machi. Kabeya (Honya) formation. Abundant. Coll. No. 260.

Glycymeris nakosoensis HATAI and NISIYAMA, 1949

Pl. 3, Figs. 4-7

1924 *Pectunculus vestitus* DUNKER, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 21 (non DUNKER).

1937 *Glycymeris* cfr. *cisshuensis* MAKIYAMA, KANEHARA, Bull. Imp. Geol. Surv. Jap., Vol. 27, no. 1, p. 21, pl. 5, figs. 3, 10 (non MAKIYAMA).

1949 *Glycymeris nakosoensis* HATAI and NISIYAMA, Jour. Paleont., Vol. 23, no. 1, p. 88, pl. 23, figs. 15, 16.

Type data:—IGPS Coll. Cat. No. 72502.

Type locality:—A small cliff in front of the dormitory of the Dai-Nippon Coal-Mining Company, Nakoso City (Joban coal-field). Oligocene Iwaki formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
309	Left	29.8	28.6	9.6	96.7	32.2
„	Left	32.5	29.6	9.3	91.0	28.6
„	Left	31.6	31.0	10.7	98.0	33.8
„	Right	30.0	30.2	10.0	100.5	33.4
„	Left	31.0	29.6	10.0	95.5	31.3
„	Right	25.5	23.4	7.5	91.7	29.4
310	Left	38.8	35.0	10.8	90.2	27.8
„	Left	35.5	33.0	11.5	92.8	32.4
„	Left	35.0	35.0	10.9	100.0	31.2
„	Right	29.3	28.2	7.8	96.2	26.6
„	Right	33.8	31.3	9.5	92.7	28.1
„	Left	33.5	31.2	10.4	93.0	31.1
311	Right	39.5	38.0	—	96.2	—
„	Left	34.0	32.5	—	95.5	—
312	Left	32.0	30.0	9.0	93.7	28.2
„	Right	31.5	29.8	8.2	94.5	26.0
Average		32.7	31.0	9.7	94.9	30.0

Remarks:—This species is characteristic by its moderate size, suborbicular or rounded trigonal outline, inflated and high umbonal region and somewhat less number of converging teeth.

Many glycymerid specimens are found from the Iwaki formation at several localities, and all may be referred to the named species, having a larger shell and more produced posterior margin than the holotype. But, except these mentioned points, the new materials are to be indentified with *G. nakosoensis*.

In the Yamada and Kuroda areas in the Kadono district, the present species occurs from a fine-grained sandstone mingled with the granules or pebbles derived from the basement older rocks. In such areas, the glycymerid shells occur associating with *Ostrea, Cyclina, Corbicula* and *Cerithidea* on one hand in the Yamada area and with *Ezocallista, Venericardia* and *Mactra* in the Kuroda area. In the Yumoto district, the present species is usually found from the fine-grained sandstone in the lowermost part of the Iwaki formation associated with *Spisula, Solen* and *Euspira*. In the last mentioned district, the thickness of the test is thinner than that from the two above-mentioned localities.

Occurrence:—

1) Shimoyamada, Nakoso City. Iwaki formation. Abundant. Coll. No. 309.

2) Karasawa, Kuroda, Tabito-mura. Iwaki formation. Common. Coll. No. 310.

3) Yoshima shaft, Yoshima Coal-Mine, Yoshima-mura. Iwaki formation. Common. Coll. No. 311.

4) Yumoto colliery, Joban Coal-Mine, Joban City. Iwaki formation. Common. Coll. No. 312.

5) Kashima colliery, Joban Coal-Mine, Joban City. Iwaki formation. Common.

Order PSEUDOLAMELLIBRANCHIA

Family PECTINIDAE

Genus *Patinopecten* DALL, 1898

Patinopecten DALL, Trans. Wagner Free Inst. Sci., Phila., Vol. 3, p. 695.

Type species (by original designation), *Pecten caurinus* GOULD, 1850. Recent, Puget Sound, California.

Patinopecten kimurai (YOKOYAMA, 1925)

Pl. 5, Figs. 4-6

1925 *Pecten kimurai* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 27, pl. 2, fig. 4; pl. 4, figs. 1-6.

1934 *Patinopecten tokyoensis kimurai* (YOKOYAMA), OTUKA, Bull. Earthq. Res. Inst.,

Tokyo Imp. Univ., Vol. 12, pt. 3, p. 613.

1960 *Patinopecten kimurai kimurai* (YOKOYAMA), MASUDA, Trans. Proc. Palaeont. Soc. Japan, N. S., No. 38, p. 250, pl. 29, fig. 1; pl. 30, fig. 6.

Type data:—Type specimens are probably in the Geological Institute, University of Tokyo.

Type locality:—Izura, Otsu-machi, Kitaibaraki City (Joban coal-field). Kokozura formation, Miocene.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
DGS 3701*	Both	44	45	13.8(×2)	102	15.7
301	Right	63	65	—	103	—
302	Left	55	60	—	109	—

* Topotype collected from Izura and figured by K. MASUDA (1960).

Remarks:—This characteristic scallop is commonly found from the Kokozura formation in the Nakoso district, especially from the sea-cliff of Izura which is the type locality of the named species. In the Yumoto district, the present species occurs from the Honya and Nakayama formations. The Honya specimens possess nine or ten rounded radiating ribs as seen in the YOKOYAMA's original figure 4 of plate 4. The specimens from the type locality at Izura usually possess seven or eight radial ribs and are characterized by the triangular roof-shaped ribs and covered with minute network patterns in the left valve. The detailed discussion concerning the taxonomic position of this species and its affinities was given recently by MASUDA (1960).

Occurrence:—

1) Hieda, Shimokajiro, Ena-machi, Iwaki City. Honya formation. Common. Coll. No. 301.

2) Cliff behind the Onahama Ship-yard, Onahama-machi, Iwaki City. Nakayama formation. Few.

3) Izura, Otsu-machi, Kitaibaraki City (Type locality). Kokozura formation. Abundant.

4) Kokozura, Nakoso City. Kokozura formation. Few.

5) Tozenji in Yunoami, Sekinami, Kitaibaraki City. Kokozura formation. Few.

6) Minamimae, Sekinami, Kitaibaraki City. Kokozura formation.

Patinopecten kobiyamai KAMADA, 1954

Pl. 5, Figs. 1-3

1954 *Patinopecten kobiyamai* KAMADA, Trans. Proc. Palaeont. Soc. Japan, N. S., No. 15, p. 174-177, pl. 23, figs. 1-4.

Type data:—IGPS Coll. Cat. No. 72963 (holotype).

Type locality:—About 500 m east of Nakayama, Ono, Yotsukura-machi (Joban coal-field). Miocene Kabeya (Honya) formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
Holotype	Both	80	85	21(×2)	106	—
303*	Right	70	81	—	115	—
304	Right	72	75	16	104	22.2
305	Left	53	58	6	109	11.3
306	Right	54	56	11	114	20.4
Average		65.8	71	—	109.6	—

* Topotype which is figured in Pl. 5, fig. 1, in this article.

Remarks:—*Patinopecten kobiyamai* is characterized by its few number of well elevated, five or six radial ribs which perhaps seem to be a representative of their minimum extremity within the genus *Patinopecten*. Although, this species was originally described as new to science, based on the specimens from the so-called Ishimori shell-beds in the Ishimori district, the referred specimens commonly occur from the Nakayama formation in the northeastern part of the Yumoto district. The Nakayama specimens were found from the light gray colored massive siltstone and are usually nearly equal in length and height, as seen in the case of *Patinopecten kimurai*. However, the present species differs from *P. kimurai* by the different convexity of the right valve and less number of the radial ribs. Recently, KANNO (1957) described *Patinopecten chichibuensis* from the Iwadonozawa formation in the Chichibu Basin in Saitama Prefecture and stated that *chichibuensis* differs from *kobiyamai* " by lacking the weakly developed and closely spaced intercalary threads on the ventral half of the left valve, and having bifurcated radial ribs, and less convexity of right valve." However, both are closely similar to each other in many respects, the writer considers that both are difficult to separate from one another as distinct species. But, at the present time, the precise comparisons will be retained until more materials are collected from both districts.

Occurrence:—

1) Nakayama, Ono, Yotsukura-machi (Type locality). Kabeya (Honya) formation. Abundant. Coll. No. 303.

2) Kamorisaku, Kamitakaku, Taira City. Nakayama formation. Common. Coll. No. 304.

3) Kamiyamaguchi, Takaku, Taira City. Nakayama formation. Few. Coll. No. 305.

4) Suginami, Natsui, Taira City. Nakayama formation. Rare. Coll. No. 306.

Genus *Delectopecten* STEWART, 1930

Delectopecten STEWART, Acad. Nat. Sci. Phila., Spec. Publ., No. 3, p. 118.

Type species (by original designation), *Pecten* (*Pseudamusium*) *vancouverensis* WHITEAVES, 1893. Recent, Northern Pacific of North America.

Delectopecten peckhami (GABB, 1860)

Pl. 5, Fig. 7

1869 *Pecten peckhami* GABB, Geol. Surv. Calif., Pal., Vol. 2, p. 59, 104, pl. 16, figs. 19, 19a.

1925 *Pecten tairanus* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 7, p. 8, pl. 1, figs. 8, 9.

1929 *Pecten watanabei* YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, Ser. 2, Vol. 2, pt. 9, p. 393, pl. 76, fig. 4.

1930 *Palliolum* (*Delectopecten*) *peckhami* (GABB), STEWART, Acad. Nat. Sci. Phila., Spec. Publ. No. 3, p. 119, pl. 13, fig. 4.

1931 *Pseudamusium* (*Hyalopecten*?) *besshoensis* KURODA, HOMMA's Geol. Cent. Shinano, Pt. 4, p. 39, pl. 12, fig. 99.

1932 *Pecten* (*Pseudamusium*) *peckhami* GABB, YOKOYAMA, Imp. Geol. Surv. Japan, Rep. No. 111, p. 14, pl. 2, figs. 1, 1a.

1934 *Pecten* (*Pseudamusium*) *peckhami* GABB, OHSE, Jour. Geol. Soc. Japan, Vol. 41, no. 486, p. 125, pl. 4, figs. 1-4.

1954 *Palliolum* (*Delectopecten*) *peckhami* (GABB), OMORI and UTASHIRO, Cenozoic Research, No. 19, p. 21, pl. 1, figs. 1-3, 10-13; pl. 2, figs. 1-7; pl. 3, figs. 1, 4-6.

1958 *Palliolum peckhami* (GABB), UTASHIRO, Jub. Publ. Comm. Prof. H. FUJIMOTO, p. 320, pl. 12, figs. 1-6; pl. 13, figs. 1-6; pl. 14, figs. 2-5.

Type data:—Lectotype is in the Museum of Comparative Zoology, Harvard Univ., Reg. No. 15045.

Type locality:—Ojai Ranch, Santa Barbara County, California. Miocene?

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	H/L(%)
282	Left	10.8	10.0	92.7
„	Right	16.0	16.8	105.0
283	Right	22.8	21.0	92.2
284	Left	14.0	13.7	98.0
299	Left	12.5	13.2	105.5
„	Left	13.2	13.5	102.2
300	Right	14.0	15.2	108.5
„	Right	16.3	16.1	98.9
Average		15.0	14.9	100.4

Remarks:—This species is characterized by its small, thin, fragile and semi-circular outline. The first recognition of the present species in the light of the Japanese paleontology was done by YOKOYAMA (1925) who described

Pecten tairanus from the "Kamenoo" formation in the Joban coal-field.

Several authors mentioned in the above-cited works, recognized that YOKOYAMA's *tairanus* may be identical with GABB's *peckhami*. In the Joban coal-field, the present species is a good horizon-marker of the Kamenoo formation in the Nakoso district and of the lower half of the Honya formation in the Yumoto district by its restricted stratigraphical occurrence.

Occurrence:—

1) Shisawa, Nakoso City. Kamenoo formation. Few. Coll. No. 300.

2) Yagawase, Taira City. Honya formation. Few. Coll. No. 282.

3) Kamenoo, Mizunoya, Joban City. Honya formation. Common. Coll. No. 283.

4) Between Kamikajiro and Shimokajiro, Ena-machi, Iwaki City. Honya formation. Common. Coll. No. 284.

5) Harakida, Onahama, Iwaki City. Honya formation. Few. Coll. No. 299.

Family OSTREIDAE

Genus *Ostrea* LINNÉ, 1758

Ostrea LINNÉ, Syst. Nat. Ed. 10, p. 696, 1758.

Type species (by subsequent designation, CHILDREN, 1823), *Ostrea edulis* LINNÉ. Recent, coasts of Europe.

Subgenus *Ostrea* s. str.

Ostrea (*Ostrea*) *yokoyamai* KAMADA, n. sp.

Pl. 4, Fig. 1

1924 *Ostrea* cf. *gigas* THUNBERG, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 20-21, pl. 5, figs. 1, 2 (non THUNBERG, 1793).

Shell moderatly large, thin, ovately elongate in outline and broadest near the base; almost equilateral, inequivalve, left valve being more or less more convex than the right which is nearly flat or somewhat inflated. In the left valve, surface ornamented with irregular concentric ribs; although radial ribbing is not defined, indistinct undulation present on the margin or the ventral half of the valve. In the right valve, surface almost smooth except for lines of growth. Ligamental area broad; medial groove on the left valve distinct but shallow and protuberance of the right valve not projecting. Denticulations present on the inner margin near the ligamental region. Muscle scar concentric and located slightly posterior to the center of the valve.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	H/L(%)
IGPS 79378*	Left	66	90	136
„	Right	58	85	146

* Holotype

Remarks:—When YOKOYAMA described and figured this species from the Iwaki coal-mine, Tsuzura, Uchigo City, he compared it with *Ostrea gigas* THUNBERG (YOKOYAMA, 1920, p. 162, pl. 15, figs. 1, 2) which occurred from the Miura Peninsula in the southern Kwanto region. However, this shorter form of YOKOYAMA's *O. gigas* is now referable to *Ostrea* (s. str.) *denselamellosa* LISCHKE.

Owing to the presence of denticulations on the inner margin near the hinge plate, the present new species is considered to belong to *Ostrea* s. str., as already discussed by OYAMA (1952, p. 338).

Compared with *O. denselamellosa*, the present new species has a more elongated and thinner shell. This species is closely related to *O. lincolnensis* WEAVER (1916, p. 36, pl. 1, figs. 5, 6) from the middle Oligocene Lincoln formation. It is distinguishable from this West American species by the more elongated shell and less convex left valve.

The present species also resembles *O. eorivularis* OYAMA et MIZUNO (1958, p. 10, pl. 4, figs. 1a, b, 2a, b, 3a, b) from the Oligocene Shitakara formation, in eastern Hokkaido. But precise comparisons are reserved until more specimens are obtained from the both coal-fields of Joban and Hokkaido.

Occurrence:—In the Yumoto-Gokô, Joban Coal-mine, Yumoto-machi, Joban City (Type locality). Iwaki formation. Common. IGPS Coll. Cat. No. 79378.

Subgenus *Crassostrea* SACCO, 1897

Crassostrea SACCO, I moll. d. terr. terziar. Piemonte e della Linguria, pt. 23, p. 15, 1897.

Type species (by original designation), *Ostrea virginica* GMELIN, 1791. Recent, east and south coasts of North America from Canada to Mexico.

Ostrea (*Crassostrea*) *mundana* YOKOYAMA, 1924

Pl. 4, Figs. 2, 3

1924 *Ostrea mundana* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 21, pl. 5, figs. 3a, b.
1924 *Ostrea takiana* YOKOYAMA, Ibid., p. 21, pl. 5, figs. 3a, b.

Type data:—Lectotype (monotype) is in the Geological Institute, University of Tokyo.

Type locality:—In front of a building belonging to the Nakoso Coal-Mining Co., Kubota, Nakoso City (Joban coal-field). Oligocene Iwaki formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	H/L(%)
334	Left	46.5	82.3	176
„	Right	50	74	148
335	Left	45	74	164
„	Right	41	75	182
„	Both	65	115	177
337	Right	38	65	171
Average		47.6	80.9	170

Remarks:—YOKOYAMA once described two new species of *Ostrea* from the Iwaki formation in the Joban coal-field, i.e. *O. mundana* and *O. takiana*. *Ostrea mundana* was described based on a single upper (right) valve which was collected from the front of a building of the Nakoso Coal Mining Co., Kubota, Nakoso City. While *Ostrea takiana* was described on a single lower (left) valve obtained from the Taki Coal-mine in Kadono. YOKOYAMA stated that these two new species of *Ostrea* do not belong to the same species, but owing to the localities being different, it is not possible to decide the question. According to KURODA (1931, p. 56) and HATAI and NISIYAMA (1952, p. 102), *takiana* may be synonymous with *mundana*.

From the examination made of the newly obtained specimens from various localities of this coal-field, it is cleared that the YOKOYAMA's *mundana* and *takiana* occur from the same locality and also that these two forms are connected with each other by intermediate individuals. Accordingly, it is obviously that these two species belong to the same one as mentioned by previous authors.

The new materials at hand are elongated in outline and have relatively thin test. Hinge deflected to the left and the pointed beak of the left valve curves to both anterior or posterior sides in each individuals. The beaks of the right valve sometimes point and curve backward. Radial striations are seen on the surface of the right valve, but sometimes almost disappear in some specimens when the prominent concentric imbricated lamellae become more distinct. Although the largest specimen is more than 115 mm. in height, most of them range from 70 to 80 mm. in height which are slightly larger than YOKOYAMA's specimens.

Occurrence:—

1) Umedaira, Yamada, Nakoso City. Iwaki formation. Abundant. Coll. No. 334.

2) Sorida, Taki, Tone-machi. Iwaki formation. Few. Coll. No. 337.

3) Suzunosawa, Shimokawa, Tabito-mura. Iwaki formation. Abundant. Coll. No. 335.

Family ANOMIIDAE

Genus *Anomia* LINNÉ, 1758

Anomia LINNÉ, Syst. Nat., Ed. 10, p. 700, 1758.

Type species (by subsequent designation, CHILDREN, 1823), *Anomia ephippium* LINNÉ, 1758.

Anomia lischkei DAUTZENBERG and FISCHER, 1907

Pl. 3, Figs. 8-11

1907 *Anomia lischkei* DAUTZENBERG and FISCHER, Jour. Conchyl. No. 54, p. 210, pl. 5, figs. 8-11.

1920 *Anomia cytaeum* GRAY var., YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 39, pt. 6, p. 146, pl. 11, fig. 17 (non GRAY, 1849, *fide* TAKI and OYAMA, 1954).

1930 *Anomia lischkei* DAUTZENBERG and FISCHER, MATSUMOTO, Sci. Rep., Tohoku Imp. Univ., Vol. 13, no. 3, p. 107, pl. 40, fig. 4.

1931 *Anomia lischkei* DAUTZENBERG and FISCHER, KURODA, in F. HOMMA's Geol. Central Shinano, Pt. 4, p. 40, pl. 3, figs. 14, 15.

1932 *Anomia lischkei* DAUTZENBERG and FISCHER, KURODA, Venus, Vol. 3, no. 4, Appedix p. 119, fig. 121.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
261	Left	35.5	36	12	101.2	33.9
„	Left	27.5	27	6.5	98.2	23.6
„	Left	23	24	8.4	104.2	36.6
„	Left	20	21.4	9.5	107.0	47.5
„	Left	19.8	21.0	6.0	106.0	30.3
Average		25.2	25.9	8.5	103.3	34.4

Remarks:—The specimens from the Ishimori shell-beds in the Ishimori district may be identified to the well-known living named species. They occur intermingled with glycymerid molluscs and other shell fragments. It is variable in shape, ranging from semicircular, ovate to fan-shaped. The surface of the shell is almost smooth without radial striations or plaits and this appearance may partly be due to the abrasion received during the transportation of the shell. Only the inflated upper valve is found, as similar case as seen in the Pliocene Tatsunokuchi shell-beds exposed at the Goroku cliff in the western border of the Sendai City, which was reported by NOMURA (1938, p. 251).

Occurrence:—West of Mizujina, Kusano, Taira City. Kabeya (Honya) formation. Common. Coll. No. 261.

Anomia asagaiensis HIRAYAMA, 1955

Pl. 3, Fig. 12

1955 *Anomia asagaiensis* HIRAYAMA, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 83, pl. 1, figs. 23-26.

Type data:—TKD Reg. No. 10217 (Holotype).

Type locality:—Road-side cliff of the pass between Yotsukura and Enoami, Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
307	Left	54	57	16	105.5	29.6

Remarks:—The specimen referred to the named species at hand is from Shiraiwa, Yotsukura-machi and possesses a well inflated and ovately rounded shell with thin test. The other specimens from the Yotsukura cliff are imperfect. The present species is not common in the Asagai formation and is restricted in its occurrence to the southern part of the Futaba district.

Occurrence:—

1) Shiraiwa, Yotsukura-machi. Asagai formation. Rare. Coll. No. 307.

2) Yotsukura sea-cliff, Yotsukura-machi. Asagai formation. Few. Coll No. 308.

Family MYTILIDAE

Genus *Modiolus* LAMARCK, 1799

Modiolus LAMARCK, Mém. Soc. Hist. Nat. Paris, p. 87, 1799. (Opinion 325 of the International Commission on Zoological Nomenclature issued January 7th, 1955)

Type species (by subsequent designation, GRAY, 1847), *Mytilus modiolus* LINNÉ, 1758. Recent, European seas.

Subgenus *Modiolatus* LAMY, 1919

Modiolatus LAMY, Bull. Mus. Nat. Hist. Paris, Vol. 25, p. 112, 1919.

Type species (by subsequent designation, HABE, 1951), *Modiolatus sirahensis* JOUSSEAUME. Recent, Sagami Bay, Japan.

Modiolus (*Modiolatus*) *yasuhiroi* KAMADA, n. sp.

Pl. 3, Figs. 13, 14

Shell thin, moderate in size, elongate, expanded posteriorly. Postero-dorsal margin almost straight, about 70 per cent of shell length and forming an

angle of about 145° with obliquely truncated posterior margin; posterior corner regularly rounded; ventral margin long, nearly straight but slightly concave in its midway, ascending to anterior end, forming an obtuse angle; anterior dorsal margin very short, nearly straight and abruptly turns to anterior end with a right angle. Umbonal ridge prominent, well inflated and steeply sloping in front of it. Surface ornamented with incremental lines of growth. Inner surface nacreous, smooth with concentric undulations.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
IGPS 79379*	Right	55.5	28	16	52.2	28.8
„	Right	52	ca. 23	11	ca. 44	21.2

* Holotype

Remarks:—The present new species is closely similar to the living *Modiolus* (*Modiolatus*) *nitida* (REEVE), but differs therefrom by having a more expanded posterior half of the shell and more sharply inflated umbonal ridge. Eight Tertiary species of *Modiolus* (=*Volsella*) were hitherto recorded in Japan and their geological ranges were recently given by KANNO (1958). However, none of these species are referable to the present new one.

The new specific name is given to the name of my son, Yasuhiro KAMADA who was born on March 14th, 1954.

Occurrence:—Numanouchi Harbor, Toyoma-machi, Taira City. Numanouchi formation. Few. IGPS Coll. Cat. No. 79379.

Genus *Brachidontes* SWAINSON, 1840

Brachidontes SWAINSON, Treat. Malacol., p. 384, 1840.

Type species (by monotypy), *Modiola sulcata* LAMARCK, 1819 (not 1805)=*Mytilus citrinus* RÖDING, 1798=*Arca modiolus* LINNÉ, 1767. Recent, Indian Ocean.

Brachidontes takiensis KAMADA, n. sp.

Pl. 3, Figs. 15, 16

Shell small, oblong; anterior short and rounded; postero-dorsal margin nearly straight and extending slightly upwards and then turns downwards to posterior end which shows oblique subtruncation; postero-ventral corner regularly rounded; ventral margin almost straight and subparallel to postero-dorsal margin. Behind obtuse ridge running from umbo to postero-ventral corner is an area depressed and more or less flat. Surface ornamented with numerous fine radiating and concentric lines of growth. Radial riblets rounded on top and rather wider than interspaces on middle part of shell and much narrower than interspaces near both ends. Test thin and very fragile.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
IGPS 79380*	Right	ca. 14	7. 5	2. 5	ca. 54	ca. 18
„	Left	ca. 13	7. 5	3. 5	ca. 58	ca. 27

* Holotype

Remarks:—None of the species of this genus reported from the Japanese Tertiary is identifiable with the present one. *B. takiensis* is distinguishable from *B. setiger* (DUNKER), a Recent species living in south-western Japan by its dorsal margin being subparallel to the ventral margin.

Occurrence:—Sorida, Shimotaki, Tono-machi. Iwaki formation. Few. IGPS Coll. Cat. No. 79380.

Genus *Mytilus* LINNÉ, 1758

Mytilus LINNÉ, Syst. Nat., Ed. 10, p. 704, 1758.

Type species (by subsequent designation, GRAY, 1847), *Mytilus edulis* LINNÉ, 1758. Recent, North Atlantic.

Mytilus luciferus YOKOYAMA, 1924

Pl. 4, Fig. 4

1924 *Mytilus luciferus* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 19, pl. 4, fig. 4.

1952 *Mytilus crassitesta luciferus* YOKOYAMA, HATAI and NISIYAMA, Sci. Rep., Tohoku Univ., 2nd Ser., Spec. Vol. No. 3, p. 94.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
263	Right	44. 0	ca. 85	11. 0	ca. 193	25

Remarks:—A single somewhat broken specimen at hand. As already mentioned by OYAMA and MIZUNO, the present species differs from *M. mabuchii* OYAMA and MIZUNO (1958, p. 9, pl. 3, figs. 8a, b, 9a, b) from the Kushiro coal-field, Hokkaido, by longer form and less developed ventral ridge. From *M. crassitesta* LISCHKE, the present species is distinguishable by having more regularly arched dorsal border.

Occurrence:—Taisho Coal-mine, Kamiyamada, Nakoso City. Iwaki formation. Rare. Coll. No. 263.

Order ANOMALOBRANCHIA

Family PERIPLOMATIDAE

Genus *Periploma* SCHUMACHER, 1817

Periploma SCHUMACHER, Ess. Nouv. Syst. Habit. Vers Test., p. 115, 116, pl. 5, fig. 1, 1817.

Type species (by monotypy), *Periploma inaequivalis* SCHUMACHER, op. cit., p. 116, pl. 5, fig. 1, 1817.

Periploma pulchellum HATAI and NISIYAMA, 1949

Pl. 6, Figs. 5-7

1949 *Periploma pulchellum* HATAI and NISIYAMA, Jour. Paleont., Vol. 23, no. 1, p. 90, pl. 23, figs. 17, 18.

Type data:—IGPS Coll. Cat. No. 72507.

Type locality:—Kokozura, Nakoso City (Joban coal-field). Kokozura formation, Miocene.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
266	Both	36.5	25.6	11.4(×2)	70.2	15.6
,,	Both	33.6	23.0	8.0(×2)	68.5	11.1
,,	Both	28.0	22.5	9.8(×2)	80.5	17.5
Average		32.7	23.7	9.7(×2)	73.1	14.7

Remarks:—A single broken topotype specimen from Kokozura, Nakoso City and several specimens from the Honya formation at Ena, Iwaki City were examined. Although, the referred specimens from the Honya are variable in shape, they exhibit quite the characteristic features of this species by having smaller and more inequilateral shell compared with the well-known species *P. besshoense* (YOKOYAMA) from the Asagai formation.

Occurrence:—

1) Northwestern end of Ena, Ena-machi, Iwaki City. Honya formation. Common. Coll. No. 266.

2) Kokozura, Nakoso City. Kokozura formation. Rare. Coll. No. 267 (Topotype).

Subgenus *Aelga* SLODKEWITSCH, 1935

Aelga SLODKEWITSCH, Ann. Soc. Paleont. Russ., No. 10, 1935.

Type species (by original designation), *Tellina besshoensis* YOKOYAMA, 1924. Oligocene. Japan.

Periploma (*Aelga*) *besshoense* (YOKOYAMA, 1924)

Pl. 6, Figs. 1-4

1924 *Tellina besshoensis* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 14, pl. 2, figs. 1-5.

1934 *Periploma besshoensis* (YOKOYAMA), MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, vol. 10, no. 2, (art. 6), p. 153.
1953 *Periploma besshoensis* (YOKOYAMA), TAKEDA, Studies on Coal Geol., No. 3, pl. 3, fig. 6 (figure only).
1955 *Periploma besshoensis* (YOKOYAMA), HIRAYAMA, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, vol. 4, no. 29, p. 107, pl. 4, fig. 31.

Type data:—Lectotype (YOKOYAMA's pl. 2, figs. 1, 2, 3; here designated) is in the Geological Institute, University of Tokyo.

Type locality:—Bessho, Iwasaki, Joban City (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
1	Both	63.5	44.4	19.0(×2)	69.9	14.9
2	Left	42	32	—	76.2	—
3	Left	35	30.5	—	87.2	—
4	Left	50.5	34.0	—	67.5	—
7	Left	67.0	51.0	—	76.2	—
Average		51.6	38.4	—	75.4	—

Remarks:—This characteristic species from the Asagai formation in the Joban coal-field was described originally by YOKOYAMA (1924) under the generic name of *Tellina*. KURODA (1931, p. 43-44) stated that *besshoensis* is a member of the genus *Periploma* owing to the nacreous shell and the fissured beaks and that the right valve is more swollen than the left. However, the Shinano specimen described by KURODA is a smaller shell and with more conspicuous concentric undulations than the type specimens from the Joban coal-field. Subsequently, MAKIYAMA (1934, p. 153) also suggested that *besshoensis* belongs to *Periploma* other than *Tellina* and *Tellina besshoensis* described by YOKOYAMA (1929, p. 288, pl. 74, fig. 1) from North Sakhalin may be a distinct species of either *Periploma* or *Cochlodesma*. Accordingly, MAKIYAMA named the North Sakhalin specimen *yokoyamai* and included the Shinano specimen into this new one. He mentioned that *yokoyamai* is more equilateral and more broadly rounded at the posterior end than *besshoensis*.

In the specimens at hand from the Asagai and Shirasaka formations in the Joban coal-field, the outline is variable; some individuals are somewhat rostrate posteriorly and depressed posterior area as seen in the YOKOYAMA's figures 1, 2 and 3; the others are more equilateral and broadly rounded posteriorly as seen in the YOKOYAMA's figures 5 and 6. If these different features are only variation in a single species, *P. yokoyamai* from the north Sakhalin may be synonymous with *P. besshoense* which closely resembles the latter in the mentioned features of the Joban specimens. However, except for the aboev-mentioned features in the outline of shell, the strength of the undulations on

the shell surface is somewhat different between *besshoense* and *yokoyamai* as stated by KURODA (1931, p. 43).

This species is a common element of the Asagai molluscan fauna and also frequently occurs from the lower part of the Shirasaka formation in the Joban coal-field. Besides from this coal-field, *P. besshoense* is comparatively abundant in the Poronai shale and its equivalents in the Ishikari coal-field in central Hokkaido and in the Kushiro coal-field in eastern Hokkaido (TAKEDA, 1953).

Occurrence:—

1) Hannukizawa, Yoshima-mura. Asagai formation. Few. Coll. No. 1.

2) Tsuzura, Uchigo City. Asagai formation. Few. Coll. No. 2.

3) Arakawa shaft, Joban Coal-mine, Iino, Taira City. Asagai formation. Coll. No. 3.

4) Goten, Uchigo City. Asagai formation. Few. Coll. No. 4.

5) Isohara-shinko, Dai-Nippon Coal-mine, Usuba, Kitaibaraki City. Shirasaka formation. Few. Coll. No. 7.

Family THRACIIDAE

Genus *Thracia* BLAINVILLE, 1824

Thracia BLAINVILLE, Dict. Sci. Nat., Vol. 32, p. 347, 1824.

Type species (by subsequent designation, GRAY, 1847), *Thracia corbuloides* BLAINVILLE. Recent, Mediterranean Sea.

Thracia kidoensis KAMADA, 1955

Pl. 6, Fig. 8

1955 *Thracia kidoensis* KAMADA, Sci. Rep. Nagasaki Univ., No. 4, p. 11, pl. 1, figs. 1, 2a, b.

Type data:—IGPS Coll. Cat. No. 72958 (Holotype) and No. 72959 (Paratype).

Type locality:—In a tunnel, west of the Iriumi mineral spring, Kobanasaku, Naraha-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
IGPS 72958	Both	45.0	33.5	16.0(×2)	74.5	17.8
72959	Left	52.8	38.6	9.3	73.2	17.6

Remarks:—According to the result of the writer's previous work (KAMADA, 1955), eight Tertiary species of *Thracia* were recognized as valid. Besides, KANNO (1958) described *T. chigayensis* KANNO from the upper Oligocene Nenokami sandstone in the Chichibu Basin, Saitama Prefecture. In the Japanese

Tertiary species, *kidoensis* and *chigayensis* are restricted to the Oligocene, while the remaining seven species are from the Miocene and Pliocene deposits of various places.

Comparisons with the present species to the other species from the Japanese Tertiary were already given in the above-cited article. *T. kidoensis* is closely related to *T. condoni* DALL figured by WEAVER (1942, p. 119, pl. 25, fig. 10; pl. 29, fig. 15) from the middle Oligocene of Oregon and Washington, but differs from the American species by the less distinct posterior ridge and the lower umbonal region.

Thracia kidoensis is restricted stratigraphically in the Asagai formation and geographically in the Futaba district in the Joban coal-field.

Occurrence:—

1) In a tunnel, west of the Iriumi mineral spring, Kobanasaku, Naraha-machi (Type locality). Asagai formation. Rare.

2) Tadonosaku, Shimokitaba, Hirono-machi. Asagai formation. Rare.

Thracia kamayashikiensis HATAI, 1940

Pl. 6, Fig. 10

1925 *Thracia pubescens* PULTENEY, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 1, fig. 11 (non PULTENEY, 1799).

1940 *Thracia kamayashikiensis* HATAI, Bull. Biogeogr. Soc. Japan, Vol. 10, no. 9, p. 123, pl. 1, fig. 2.

1940 *Thracia beringi* DALL, NOMURA and HATAI, Jap. Jour. Geol. Geogr., Vol. 17, nos. 3-4, p. 187, pl. 19, fig. 11 (non DALL, 1915).

1955 *Thracia kamayashikiensis* HATAI, KAMADA, Sci. Rep. Nagasaki Univ., No. 4. p. 9, pl. 1, figs. 7, 8.

Type data:—Lectotype (monotype) is in the Institure of Geology and Paleontology, Tohoku University, Sendai. IGPS Coll. Cat. No. 61349.

Type locality:—Kamayashiki, Tomai-mura, Ninohe-gun, Iwate Prefecture. Pliocene Suenomatsuyama formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
179	Both	27	21	11.5(×2)	77.8	19.4
Holotype	Both	44	32	18 (×2)	72.8	20.4

Remarks:—*Thracia kamayashikiensis* HATAI was originally described based on a single intact valve from the Suenomatsuyama formation in Iwate Prefecture and its referred specimens were recorded from the Miocene Murata (=Hatatate) formation in the Sendai area (KAMADA, 1955). Although it is small in size, a specimen indistinguishable from the holotype was derived from the sea-cliff at Izura in the Nakoso district. YOKOYAMA (1925, p. 25, pl. 1, fig. 11) figured his *Thracia pubescens* from Gomazawa in Taira City and

subsequently HATAI and NISIYAMA (1952, p. 144) gave it a new name as *yokoyamai*. Although the writer (1955, p. 2) once asigned it to *Periploma pulchellum* HATAI and NISIYAMA from the Kokozura formation, it is not correct. The specimen figured by YOKOYAMA is now considered to be identifible with *Thracia kamayashikiensis* HATAI.

Occurrence:—Sea-cliff at Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Rare. Coll. No. 179.

Thracia hataii KAMADA, 1955

Pl. 6, Fig. 9

1955 *Thracia hataii*, KAMADA, Sci. Rep. Nagasaki Univ., No. 4, p. 10, pl. 1, figs. 5, 6.

Type data:—IGPS Coll. Cat. No. 72960 (holotype) and No. 72961 (paratype).

Type locality:—About 600 meters north of the Ena water-reservoir. Igamesaku, Nagasaki, Ena-machi, Iwaki City (Joban coal-field). Miocene Nakayama formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
IGPS 72960	Both	36.7	25.3	8.7(×2)	69.0	11.9
72961	Right	28.5	17.8	4.5	62.4	15.7
„	Left	25.3	14.3	4.8	56.5	19.0
„	Left	24.1	12.8	ca. 3.0	53.0	12.4
„	Right	19.0	13.4	3.0	70.5	15.8
„	Left	18.4	9.8	ca. 3.0	52.7	16.3
Average		25.3	15.6	3.8	60.7	15.2

Remarks:—The present species is characteristic by its transversely elongated shell and the narrowly rostrated posterior compressed area. Comparisons of *hataii* with the other species of *Thracia* were given in the previous article entitled "On the Tertiary Species of *Thracia* from Japan" (KAMADA, 1955). *T. hataii* is restricted in its occurrence to the upper part of the Nakayama formation in the Yumoto district of the Joban coal-field, up to the present time.

Occurrence:—

1) About 600 meters north of the Ena water-reservoir, Igamesaku, Nagasaki, Iwai City (Type locality). Nakayama formation. Rare.

2) Kamorisaku, Kamitakaku, Taira City. Nakayama formation. Common.

Subclass TELEODESMACEA

Order HETERODONTA

Family CARDITIDAE

Genus *Venericardia*, LAMARCK, 1801

Venericardia, LAMARCK, Syst. Anim. sans Ver., ed. 1, Paris, p. 123, 1801.

Type species (by subsequent designation, SCHMIDT, 1818), "*Venus imbricata*" LAMARCK=*Venus imbricata* GMELIN, 1791. Middle Eocene; Grignon, west of Paris, France.

Subgenus *Cyclocardia* CONRAD, 1832

Cyclocardia, CONRAD, Amer. Jour. Conch., Vol. 3, p. 191, 1832.

Type species (by monotypy), *Cardita borealis* CONRAD. Recent, Northern Pacific.

Venericardia (*Cyclocardia*) *tokunagai* YOKOYAMA, 1924

Pl. 7, Figs. 1, 2

1924 *Venericardia tokunagai* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 18, pl. 3, figs. 10, 11.
1924 *Vennericardia pacifera* YOKOYAMA, *Ibid.*, p. 18, pl. 4, figs. 1, 2.
1925 *Venericardia tokunagai* YOKOYAMA, YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 1, pt. 7, p. 223, pl. 28, figs. 17, 18.
1929 *Venericardia tokunagai* YOKOYAMA, YOKOYAMA, *Ibid.*, Vol. 2, pt. 9, p. 392, pl. 75, fig. 2.
1936 *Venericardia tokunagai* YOKOYAMA, NOMURA and HATAI, Saito Ho-on Kai Mus., Res. Bull., No. 10, p. 123, pl. 15, fig. 15.
1955 *Venericardia* (*Cyclocardia*) *tokunagai* YOKOYAMA, HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 89, pl. 2, figs. 17, 19, 20.
1955 *Venericardia* (*Cyclocardia*) *pacifera* YOKOYAMA, HIRAYAMA, *Ibid.*, p. 90, pl. 2, fig. 11.
1955 *Venericardia* sp., HIRAYAMA, *Ibid.*, p. 92, pl. 2, figs. 14, 18.

Type data:—Lectotype and syntype are in the Geological Institute, University of Tokyo.

Type locality:—Ohisa, Ohisa-mura (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
152	Both	26.0	24.8	—	95.5	—
„	Right	28.0	27.0	—	96.5	—
153	Right	21.0	21.5	—	102.2	—
„	Left	21.0	21.5	—	102.2	—
154	Both	29.0	29.0	14.0(×2)	100.0	24.1
„	Both	26.5	24.0	12.5(×2)	90.5	23.6
155	Left	31.0	29.0	—	93.7	—
„	Both	33.5	28.0	ca. 15.0(×2)	83.6	22.4
156	Both	40	38	—	95.0	—
157	Left	26	24.5	—	94.4	—
158	Both	30.5	30.0	—	98.5	—
Average		28.4	27.0	—	95.6	—

to west- and south-wards to the two above-mentioned localities where *C. compacta minor* occurred. The present subspecies may have been described based on the inner mold. The surface of the shell was ornamented with conspicuous radial ribs, 27-30 in number. The specimen at hand is also ornamented with similar radial ribs, but possess two radiating weak ridges extending from the beak to the ventral border as seen in YABE and NOMURA's specimen. Accordingly, if more well-preserved specimens with shell substances are collected, the present subspecies may be indistinguishable from *C. subexcavata*. At the present time, the writer retains the name of *minor*, until better specimens are collected.

Occurrence:—Minamimae, Sekinami, Kitaibaraki City. Kokozura formation. Rare. Coll. No. 321.

Family LUCINIDAE

Genus *Lucinoma*, DALL, 1901

Lucinoma, DALL, Proc. U. S. Nat. Mus., Vol. 23, no. 1237, p. 806.

Type species (by original designation), *Lucina filosa* STIMPSON, 1833. Recent. Casco Bay, Maine, south to Cape Florida, in 16 to 528 fathoms (DALL, 1901, p. 809).

Lucinoma acutilineatum (CONRAD, 1849)

Pl. 9, Figs. 10-16; Pl. 10, Figs. 1-3

1849 *Lucina acutilineata* CONRAD, U. S. Explor. Exped. Geol., Vol. 10, p. 725, pl. 18, figs. 2, 2a, 2b.

1909 *Phacoides acutilineatus* CONRAD, DALL, U. S. Geol. Surv., Prof. Pap. No. 59, p. 116-117, pl. 12, fig. 6.

1925 *Lucina* (*Phacoides*) *borealis* LINNÉ, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 7, p. 24, pl. 5, fig. 5-8.

1931 *Phacoides* (*Lucinoma*) *acutilineatus* (CONRAD), ETHERINGTON, Univ. Calif. Publ., Bull. Dept. Geol. Sci., Vol. 20, p. 76-77, pl. 4, fig. 5.

1931 *Lucina* (*Myrtea*) *acutilineata* CONRAD, GRANT IV and GALE, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 286-287, pl. 14, figs. 22a, b (with synonymy).

1935 *Lucina* (*Myrtea*) *acutilineata* CONRAD, NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 5, p. 76-79 (with full references up to 1935).

1940 *Lucina acutilineata* CONRAD, NOMURA and ONISI, Jap. Jour. Geol. Geogr., Vol. 17, nos. 3-4, p. 182, pl. 17, figs. 9-12.

1942 *Lucina acutilineata* CONRAD, WEAVER, Univ. Washington Publ., Geol., Vol. 5, p. 143-144, pl. 34, figs. 8, 11, 16.

1945 *Lucinoma acutilineata* (CONRAD), HIRAYAMA, Sci. Rep. Tokyo Kyoiku Daigaku, Vol. 3, no. 18, p. 60-62, pl. 5, figs. 2-7.

1957 *Lucinoma acutilineata* (CONRAD), ITOIGAWA, Trans. Proc., Palaeont. Soc. Japan, N. S., No. 25, p. 4-5, pl. 1, figs. 9-12.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
124	Both	48.0	45.0	24.5(×2)	93.8	25.6
„	Both	33.0	30.0	16.0(×2)	91.0	24.3
„	Both	29.0	26.0	15.5(×2)	89.7	26.8
„	Both	25.5	25.0	15.0(×2)	98.1	29.5
„	Both	30.0	27.5	17.6(×2)	91.8	29.4
121	Both	44.4	41.3	221.2(×)	93.2	23.9
122	Both	52.5	50.8	26.3(×2)	96.8	25.1
„	Both	58.5	56.0	31.0(×2)	96.0	26.5
„	Both	45.5	45.0	25.0(×2)	99.0	27.5
„	Both	52.2	50.0	29.5(×2)	95.7	28.3
„	Both	51.0	48.0	30.0(×2)	94.2	29.4
„	Both	47.2	43.3	25.0(×2)	91.8	26.5
„	Both	38.5	35.5	22.5(×2)	92.3	29.3
„	Both	29.5	26.4	14.0(×2)	89.5	23.8
123	Both	37.2	35.6	18.5(×2)	95.8	24.9
„	Both	30.5	28.5	13.0(×2)	93.5	21.3
„	Both	30.0	27.5	11.5(×2)	91.8	19.2
„	Both	34.0	31.0	11.2(×2)	91.2	16.5
„	Both	26.0	25.0	8.0(×2)	96.2	15.4
127	Both	26.0	25.0	10.5(×2)	96.2	20.2
Average		38.6	36.1	19.8(×2)	93.9	24.7

Remarks:—This species was originally described by CONRAD from the Astoria Miocene at Astoria, Oregon and subsequently figured by ETHERINGTON (1931) from the Astoria formation in Washington, GRANT and GALE (1931) from the Pleistocene of San Pedro, Los Angeles Co., California and others. Although the Japanese Tertiary lucinid mollusks have been often called as *Phacoides borealis* or *Lucina borealis* by YOKOYAMA, most of them are now referable to the present species. Recently, however, HIRAYAMA (1954, 1958) discussed on the so-called Japanese *Lucinoma acutilineata* and recognized several distinct species among them. The specimens abundantly occuring from the Honya formation in the Yumoto district and the Kokozura formation in the Nakoso district are indistinguishable from the typical form from the Astoria Miocene in Oregon and Washington and are referable to the named species without question.

In the Kokozura formation, the specimens from the Izura sea-coast seem to represent fully grown individuals and attain nearly 60 mm. in length, while all of the referred specimens from Yunami, near Tozenji are smaller (31.5 mm. in average length) and less inflated than those from Izura.

Besides these occurrences from the Honya and Kokozura formations, the present species frequently occurs from the Asagai formation in the Nakoso

	Valve	Length	Height	Width	H/L(%)	W/L(%)
V. tokunagai						
Holotype	Both	40	36	20(×2)	90.0	25.0
Paratype	Both	34	33	16(×2)	94.3	23.5
V. pacifera						
largest perfect specimen	Both	40	36	20(×2)	90.0	25.0

Remarks:—According to the original description given by YOKOYAMA, *Venericardia tokunagai* is characterized by the obliquely trigonal shell outline with a little over 25 radial ribs, while *V. pacifera* is an ovately trigonal shell with about 20 radial ribs and both were originally described from a single and the same formation. Many specimens from the Asagai formation at hand show that these two forms usually occur together and are indistinguishable from each other not only in outline but also in size. There are many intermediate forms between the typical *tokunagai* and *pacifera*. The number of radial ribs ranges from 20 to 25. Therefore, *V. tokunagai* may be conspecific with *pacifera* and the specific name must be retained as *tokunagai*, because, it was written by YOKOYAMA in the preceding paragraph. The present species is characterized by its rather low umbones and comparatively straightened radial ribs.

Occurrence:—

1) Doggameki, Hirono-machi. Asagai formation. Common. Coll. Nos. 152 and 153.

2) Tate, Hirono-machi. Asagai formation. Few. Coll. No. 154.

3) Nagasawa, Hirono-machi, Asagai formation. Few. Coll. No. 155.

4) Arakawa shaft, Joban Coal-mine, Iino, Taira City. Asagai formation. Rare. Coll. No. 156.

5) Chuoko, Nakoso Coal-mine, Nagako, Nakoso City. Asagai formation. Common. Coll. No. 158.

6) Usuba, Hanakawa, Kitaibaraki City. Asagai formation. Common. Coll. No. 157.

Venericardia (*Cyclocardia*) *laxata* YOKOYAMA, 1924

Pl. 7, Figs. 3-4

1924 *Venericardia laxata* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 19, pl. 3, figs. 16-18.

1934 *Venericardia* (*Cyclocardia*) *laxata* YOKOYAMA, MAKIYAMA, Mem. Coll. Sic., Kyoto Imp. Univ., Ser. B, Vol. 10, no. 2, art. 6, p. 145, pl. 6, figs. 36-40, 49.

1955 *Venericardia* (*Cyclocardia*) *laxata* YOKOYAMA, HIRAYAMA, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 90, pl. 2, figs. 12, 13, 15, 16.

Type data:—Lectotype is in the Geological Institute, University of Tokyo.

Type locality:—Yotsukura coast, Yotsukura-machi where YOKOYAMA's figured specimen was collected (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll No.	Valve	Length	Height	H/L(%)
149	Both	39.0	27.0	69.2
„	Both	30.0	25.5	85.0
150	Both	34.0	27.0	79.5
151	Both	27.5	22.0	80.2
„	Left	26	19.5	75.0
Average		31.3	24.2	77.8

Remarks:—The characteristic features of *Venericardia* (*Cyclocardia*) *laxata* are its low and transversely elliptical outline, the obliquely subtruncated posterior margin, the little incurved beaks, and more or less straightened radial ribs of about 20 to 25 in number. These features separate it readily from *V. tokunagai* from the Asagai formation. An exceptional specimen possessing about 30 radial ribs separated by narrower interspaces was collected from Doggameki, Hirono-machi in the Futaba district.

MAKIYAMA (1934, p. 146) stated that *V. laxata* appears to be closely connected with *V. hamiltonensis* CLARK (1932, p. 810, pl. 14, figs. 9, 10) of the Alaskan Oligocene.

Occurrence:—

1) Doggameki, Hirono-machi. Asagai formation. Abundant. Coll. No. 151.
2) Kamiogawa, Ogawa-machi. Asagai formation. Common. Coll. No. 150.
3) Chuoko, Nakoso Coal-mine, Nagako, Nakaso City. Common. Coll. No. 149.

Venericardia (*Cyclocardia*) *orbica* YOKOYAMA, 1925

Pl. 7, Figs. 5, 6

1925 *Venericardia orbica* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 7, p. 8, pl. 1, fig. 10.

Type data:—Lectotype is in the Geological Institute, University of Tokyo.

Type locality:—Ishibatake, Nishiki, Nakaso City (Joban coal-field). Miocene Kamenoo formation.

Dimensions (in mm.):

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
159	Left	39.5	38.0	—	96.1	—
„	Left	40.0	41.0	—	102.3	—
„	Right	44.0	43.0	—	97.8	—
Average		41.2	40.7	—	98.7	—

Remarks:—*Venericardia orbica* was established by YOKOYAMA based on an ill-preserved specimen from the Kamenoo formation in the Joban coal-field, and is characterized by its nearly circular outline. Unfortunately, the subsequent paleontologic record of this species is noty et known from the Kamenoo formation. However, probably referable specimens were collected from the Ishimori shell-beds in the Ishimori district. The general features of the new materials are as follows:

"Shell rather large for *Cyclocardia*, semi-circular, almost as high as long, subequilateral, equivalve. Anterior and posterior margins rounded but the latter more convex than the former; anterior dorsal margin short, nearly straight, sloping downward. Umbones low and not elevated; beaks small, incurved forward. Surface sculptured by radial triangular ribs of 20 to 22 in number, separated by wider, shallow interspaces."

The Ishimori specimens differ from the type described by YOKOYAMA only in the number of radial ribs. Inasmuch as the size and shape, the outline of both coincides with each other, and it is reasonable to identify the Ishimori specimens with *V. orbica* YOKOYAMA, until additional well preserved specimens are obtained from the Kamenoo formation. YOKOYAMA described the radial ribs of *orbica* as flattish. However, as already mentioned by MAKIYAMA (1934, p. 145), the uppermost shell layer of venericardias are sometimes eroded away to expose the second layer with flattish radial ribs. Some specimens from the Ishimori show that the low, triangular and narrow ribs are characteristic in the upper layer of the shell and the flat topped radial ribs are seen in the next subjacent one.

Occurrence:—South of Nakayama, north-west slope of Ishimoriyama, Ono, Yotsukura-machi. Ishimori shell-beds (Honya formation). Common. Coll. No. 159.

Venericardia (Cyclocardia) subnipponica NAGAO, 1928

Pl. 6, Figs. 11-17

1924 *Venericardia* sp. YOKOYAMA, Jour. Coll. Sci. Tokyo Imp. Univ., Vol. 45, art. 3, p. 19, pl. 3, figs. 8, 9.

1928 *Venericardia subnipponica* NAGAO, Sci. Rep., Tohoku Imp. Univ., 2nd Ser., Vol. 12, no. 1, p. 55, pl. 13, figs. 9, 14; pl. 14, figs. 1-29.

1952 *Cyclocardia dodairensis* HATAI and NISIYAMA, Sci. Rep., Tohoku Univ., 2nd Ser. Spec. Vol. No. 3, p. 154.

Type data:—IGPS Coll. Cat. No. 36405 (holotype).

Type locality:—Taya, Ashiya-machi, Onga-gun, Fukuoka Prefecture. Oligocene Yamaga formation of the Ashiya group.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
343	Left	40.2	35.2	7.5	87.6	18.7
„	Right	31.0	27.0	6.7	87.2	21.6
„	Right	28.6	30.0	8.1	104.8	28.3
344	Both	22.5	23.6	12.0(×2)	104.9	26.6
345	Right	22.3	20.8	7.8	93.3	35.1
„	Left	21.9	20.9	7.4	95.5	33.7
„	Right	23.3	21.0	7.5	91.4	32.2
„	Both	20.0	19.5	15.8(×2)	97.6	39.5
„	Both	22.0	20.0	13.8(×2)	91.0	31.4
Average		25.8	24.2	7.3	94.8	29.7

Remarks:—The revision of the Tertiary species of the genus *Venericardia* was already given by HIRAYAMA (1955, p. 84-89) who enumerated more than 30 species from various localities and geologic horizons of Japan. The Paleogene species of the genus recorded in the Joban coal-field are *tokunagai*, *pacifera* and *laxata* from the Asagai formation and *Venericardia* sp. from the Iwaki formation. All of these species were first described by YOKOYAMA (1924) and lately discussed by MAKIYAMA (1934) and HIRAYAMA (1955). The last mentioned unnamed species was subsequently named by HATAI and NISIYAMA (1952) as *dodairensis*.

In northeast Kyushu, MIZUNO (1956) mentioned that *V. subnipponica* from his *Venericardia yoshidai* Zone is characterized by having a weak ridge running from the beak to the postero-ventral corner, slightly angulated postero-dorsal margin and 27-28 radial ribs. While *subnipponica* from his *Venericardia vestitoides* Zone, has 22-24 ribs, and the posterior ridge and the postero-dorsal angulation are obscure, like the case of *V. dodairensis*. However, he also stated that *subnipponica* and *dodairensis* are transitional eacho ther in the *V. vestitoides* Zone.

When *subnipponica* was first described, NAGAO (1928, p. 56) mentioned that this new species is closely akin to an unnamed species obtained from the Iwai Beds of the Joban Coal-field, which was figured and referred to the large form of *V. ferruginea* ADAMS by YOKOYAMA.

Eight specimens collected from the Kuroda basin in the Kadodo district, from a hard granule-bearing coarse-grained sandstone, are rather small in size, measuring 20-23 mm. in length and 18-20 mm. in height. Surface ornamented with radial ribs numbering 24-25 and with minute granulations on the top of the ribs near the umbo and downwards (ventrally) becoming roof-shaped triangular ribs wider than the interspaces. This characteristic features of the radial ribs are very closely related to the type specimens of this species, especially in the case of from 15 or 20 mm. below the umbo.

From a stream of Doggameki, Hirono-machi, Futaba district, about 20

specimens of *Venericardia* were collected. The majority of these specimens are with both valves intact, and some are somewhat flattened by subsequent deformation. Shell obliquely trigonal, umbo slightly projected and posterior margin subtruncated. Ribs usually 20 in number and more or less rounded on top. Compared with the Kuroda specimens, the Doggameki ones have smaller number and more flattened radial ribs. However, from the observations of the outline of the shell, both forms may be included into the named species.

The specimens collected from the pit of the Yumoto colliery of the Joban Coal Mining Co. in the Yumoto district, have 23-25 radial ribs and are indistinguishable from the holotype of *subnipponica* from the Yamaga formation of the Ashiya group in the outline of shells.

These Joban specimens are undoubtedly identified to not only NAGAO's *subnipponica* from North Kyushu but also HATAI and NISIYAMA's *dodairensis*. Therefore, the writer is inclined to believe that these two species are synonymous and the form of *dodairensis* may be included in the range of variation of *subnipponica*.

Occurrence:—

1) Yoshima Coal-mine, Yoshima-mura. Iwaki formation. Few. Coll. No. 342.

2) Yumoto colliery, Joban Coal-mine, Yumoto-machi, Joban City. Iwaki formation. Common. Coll. No. 343.

3) Suzunosawa, Shimokawa, Tabito-mura. Iwaki formation. Few. Coll. No. 344.

4) Karasawa, Kuroda, Tabito-mura. Iwaki formation. Common. Coll. No. 345.

Venericardia (*Cyclocardia*) *siogamensis* NOMURA, 1935

Pl. 7, Figs. 9-23; Pl. 8, Figs. 1a, b

1935 *Venericardia siogamensis* NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 212, pl. 17, figs. 8-11.

1941 *Venericardia* (*Cyclocardia*) *siogamensis* NOMURA, OTUKA, Jap. Jour. Geol. Geogr., Vol. 18, nos. 1-2, p. 23, figs. 2, 3.

1958 *Venericardia siogamensis* NOMURA, CHINZEI, Venus, Vol. 20, no. 1, p. 124, pl. 7, fig. 3.

Type data:—SM Reg. No. 2553 (Holotype) and No. 6309 (Paratype).

Type locality:—Ajiri, Shiogama City, Miyagi Prefecture. Miocene Ajiri formation. (NOMURA's Loc. 3, Upper Shell-Beds=*Cultellus izumoensis* zone.)

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
171	Both	30.0	27.2	20.5(×2)	90.7	34.2
„	Left	25.0	25.4	8.0	101.5	32.0
160	Both	24.2	25.0	16.0(×2)	103.2	33.0
„	Left	23.5	22.8	—	97.0	—
„	Right	21.5	20.2	—	94.1	—
162	Left	24.0	24.0	—	100.0	—
„	Left	23.0	23.5	—	104.0	—
163	Left	24.0	24.6	ca. 7.0	102.3	29.2
164	Right	30.5	29.5	ca. 9.0	96.8	29.4
165	Right	23.2	21.0	7.5	90.6	32.4
„	Left	18.0	16.5	6.2	91.7	34.4
„	Right	23.5	ca. 21	—	89.5	—
167	Both	25.0	24.0	16.0(×2)	97.6	32.0
„	Both	23.5	24.0	16.0(×2)	102.1	34.0
„	Both	23.5	22.5	14.3(×2)	95.8	30.4
„	Both	23.0	23.2	15.2(×2)	100.8	33.0
„	Left	29.5	29.2	9.3	98.9	31.6
168	Both	34.0	32.0	—	94.3	—
169	Both	35.2	34.6	16.5(×2)	98.5	23.4
„	Right	21.5	19.2	—	89.3	—
170	Left	26.5	24.6	—	94.0	—
„	Right	20.0	19.5	—	97.7	—
Average		25.1	24.3	8.0	96.8	31.5

Remarks:—Venericardia (*Cyclocardia*) *siogamensis* NOMURA was originally described based on the specimens from the Shiogama Miocene. The referred specimens are quite dominant in the Joban coal-field, and they commonly occur from the Honya-, Nakayama-, Numanouchi- and Kokozura formations. The characteristic features of the shell outline and the sculpture of radial ribs are closely identical with those of the type specimens from Shiogama, Miyagi Prefecture. The internal characters exhibited by the excellent samples from the Kokozura formation are as follows:

"Hinge of right valve consists of three teeth: anterior tooth is quite small, median cardinal tooth heavy, elevated and long, posterior one also long but thin, curved and fused into posterior nymph. Hinge of left valve consists of two cardinal teeth: a short narrow triangular anterior cardinal tooth separated by deep obliquely trigonal socket from a long, slender curved posterior one, anterior pit situated at posterior end of small lunule. Adductor muscle scars sharply defined; anterior one elongate elliptical and posterior one ovate. Inner margin moderately crenate in harmony with interspaces of radial ribs."

The number of the radial ribs of the present species from the Joban coal-field range from 21 to 26 and the average number is 23.5 in 30 valves. These

numbers are very similar to those of the living *V.* (*C.*) *ferruginea* (CLESSIN), but *siogamensis* differs from the living species by the more inflated shell and the narrower radial ribs. Recently, CHINZEI (1958) described *V.* (*C.*) *ochiaiensis* from the middle Pliocene deposits in the Ninohe district, Iwate Prefecture, and compared it with *siogamensis*. The former is distinguished from the latter by the smaller shell and the fewer number (18-19) of radial ribs.

Occurrence:—

1) Kamikuramochi, Kashima, Iwaki City. Honya formatian. Few. Coll. No. 160.

2) Kamikajiro, Ena-machi, Iwaki City. Honya formation. Common. Coll. No. 161.

3) Igame-saku, Ena-machi, Iwaki City. Honya formation. Few. Coll. No. 162.

4) Western end of Ena, Ena-machi, Iwaki City. Honya formation. Common. Coll. No. 171.

5) Miyo, Kashima, Iwaki City. Honya formation. Few. Coll. No. 172.

6) Kamorisaku, Kamitakaku, Taira City. Nakayama formation. Common. Coll. No. 163.

7) Kamiyamaguchi, Takaku, Taira City. Nakayama formation. Few. Coll. No. 164.

8) South cliff of Cape Shioya, Toyoma-machi, Taira City. Nakayama formation. Few. Coll. No. 341.

9) Onahama ship-yard, Onahama, Iwaki City. Nakayama formation. Common. Coll. No. 165.

10) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Abundant. Coll. No. 166.

11) Shioya-machi, Toyoma, Taira City. Numanouchi formation. Common. Coll. No. 168.

12) Numanouchi harbor, Toyama, Taira City. Numanouchi formation. Common. Coll. No. 169.

13) Hamamachi, Toyoma, Taira City. Numanouchi formation. Few. Coll. No. 170.

Venericardia (*Cyclocardia*) *enaensis* KAMADA, n. sp.

Pl. 7, Figs. 7-8

Shell small, almost as high as long, roundly trigonal, subequilateral, equivalve. Dorsal margins sloping downwards; anterior one very short, posterior one broadly arched passing into posterior margin without demarcation. Anterior end vertically subtruncated: ventral margin broadly arched. Umbones low, inflated but not pointed; beaks small, slightly incurved forward. Surface sculptured with about 20 radial ribs with interspaces much narrower than ribs, and crossed with numerous concentric striae of growth. Cardinal area

not observed.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
IGPS 79381	Left	15.0	14.5	4.2	96.7	28.0
„	Left	15.2	14.2	4.5	93.5	29.6
„	Left	15.0	14.8	4.0	98.7	26.6
„	Both	14.7	14.5	11.0(×2)	98.7	37.4
Average		15.0	14.5	4.6	96.9	30.4

Remarks:—The characteristic features of the present new species are its small and nearly equilateral shell and not prominent umbonal region. *V.* (*C.*) *enaensis* occurred from the Honya formation in the Yumoto district associated with *V.* (*C.*) *siogamensis* NOMURA. It closely resembles the young form of *siogamensis*, but differs therefrom by less obliquity in outline, lower umbones and narrower interspaces between the radial ribs. *V.* (*C.*) *orbicularis* YOKOYAMA (1923, p. 5, pl. 1, fig. 6) and *V.* (*C.*) *ochiaiensis* CHINZEI (1958) are species similar to the present new one, but the present one is easily distinguishable therefrom by the lower shell and not granulated radial ribs.

Occurrence:—Igamesaku, Nagasaki, Ena-machi (Type locality). Honya formation. Common. IGPS Coll. Cat. No. 79381.

Family VESICOMYACIDAE

Genus *Vesicomya* DALL, 1886

Vesicomya DALL, Bull. Mus. Comp. Zoll., No. 12, p. 272, 1886.

Type species (by original designation), *Callocardia* (?) *atlantica* SMITH.

Vesicomya kawadai (AOKI, 1955)

Pl. 8, Figs. 2a, b

1954 *Lamelliconcha kawadai* AOKI, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, Vol. 13, no. 17, p. 36-37, pl. 2, figs. 1-10, 12-15, 22.

Type data:—TKD Reg. No. 5909 (Holotype) and No. 5910 (Paratype).

Type locality:—Cliff of valley side, Donosaku, Kamikatayose, Kabeya, Taira City (Joban coal-field). Loc. 7 in the original paper. Miocene Kabeya (=Honya) formation.

Supplementary description:—Shell of medium size, thin, chalky, roundly trigonal, inequilateral, somewhat ventricose. Lunule faintly defined, shallow, heart-shaped; escutcheon long, defined by blunt ridge extending from beaks to posterior ventral corner. Surface rather smooth except for irregular concentric lines of growth which are crowded near ventral margins. Ventral

margin entire. Pallial sinus triangular, small, shallow, bluntly pointed. Only a part of cardinals of right valve exposed. A deep socket placed in front of bifid posterior cardinals, middle one nearly horizontal, projected. Nymphs long, elevated, smooth.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
136	Both	38.0	28.5	20.0(×2)	75.0	26.4
„	Left	39.0	29.8	11.0	76.3	28.2
„	Both	33.5	25.2	16.5(×2)	75.0	24.6
„	Both	40.0	27.5	18.6(×2)	68.8	23.1
„	Both	28.5	21.0	14.0(×2)	73.8	24.6
„	Left	26.0	20.5	—	78.9	—
237	Both	20.0	15.0	10.0(×2)	75.1	25.0
„	Both	23.0	19.0	14.0(×2)	82.7	30.4
„	Both	25.0	18.0	12.0(×2)	72.0	24.0
Average		30.2	22.7	7.9	75.3	25.8

Remarks:—The sculpture of the present species clearly differs from those of *Pitar* (*Lamelliconcha*) which is characterized by the lamellated surface as well represented in *P.* (*L.*) *eocenica* WEAVER and PALMER figured by TEGLAND (1929, p. 279, pl. 22, fig. 6). The general outline of the shell, sharply recurved beaks, entire ventral margin, shallow pallial sinus and characteristic cardinals seem to refer the present species to the genus *Vesicomya*. The present species differs from the living *V. katsuae* KURODA (1952, p. 2, figs. 5-9) from off Tosa in the Bungo Channel by having a larger and more rounded shell. Compared with *V. stearnsii* DALL from deep water off La Jolla, California (DALL, 1921, p. 40, pl. 1, figs. 6, 7), *V. kawadai* is distinguishable by having more rounded posterior end and less produced anterior end.

Vesicomya kawadai is restricted in its occurrence in the upper part of the Honya formation in the northernmost Yumoto district and its correlative the Kabeya formation in the Ishimori district.

Occurrence:—

1) Tangozawa, Kyujoseki, Taira City. Honya formation. Abundant. Coll. No. 136.

2) North cliff of the Taira railroad station, Taira City. Honya formation. Common. Coll. No. 137.

3) Yagawase cliff, Taira City. Honya formation. Common.

Family TRAPEZIIDAE

Genus *Trapezium* MEGERLE, 1811

Trapezium, MEGERLE, Gesel. Naturf. Fre. Berlin, Vol. 5, 1811, p. 68.

Type species (by subsequent designation, STEWART, 1930), *Trapezium perfectum* MEGERLE.

Subgenus *Neotrapezium* HABE, 1951

Neotrapezium, HABE, Gen. Jap. Shells, No. 2, p. 119, figs. 241, 242.

Type species (by original designation), *Cardita sublaevigata* LAMARCK, 1818-1822.

Trapezium (*Neotrapezium*) *jobanicum* HATAI and NISIYAMA, 1949

Pl. 8, Fig. 3

1949 *Trapezium jobanicum*, HATAI and NISIYAMA, Jour. Paleont., Vol. 23, no. 1, p. 90, pl. 24, figs. 8, 9.

Type data:—IGPS Coll. No. 72506 (Holotype).

Type locality:—A small cliff in front of the domitory of the Dai-Nippon Coal-Mining Co., Idekura, Nakoso City (Joban coal-field). Oligocene Iwaki formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
Holotype	Right	23.5	17.0	6.0	72.5	25.6
180	Right	23.6	17.0	6.5	72.2	27.6
181-1	Right	22.2	17.0	7.8	76.5	35.8
„ -2	Right	22.1	15.1	6.5	68.2	29.4
„ -3	Left	22.0	15.8	4.0	71.8	18.4
„ -4	Left	20.2	13.6	5.0	67.5	24.8
„ -5	Right	20.0	14.4	4.0	72.0	20.0
„ -6	Left	19.6	13.3	6.0	67.3	33.6
„ -7	Right	14.8	11.4	3.5	77.0	23.6
„ -8	Left	14.4	10.8	2.7	75.0	18.7
„ -9	Left	13.0	9.6	3.3	73.8	25.4
„-10	Right	12.0	8.3	3.5	69.1	29.2
Average		18.5	13.3	4.8	71.9	26.0

Remarks:—*Trapezium* (*Neotrapezium*) *jobanicum* resembles *T. japonicum* PILSBRY, but has a more quadrate outline and does not develop a distinct median depression.

The new materials of this species are derived from the medium- to coarse-grained sandstone at Mizugami and Shimokawa, where the brackish water molluscs, such as *Cyclina*, *Corbicula* and *Ostrea*, are preserved abundantly. In the type locality, the present species is also found in the sandstone just below the oyster banks.

There are five species of *Trapezium* in the Japanese Tertiary. Of these *japonicum* PILSBRY and *nipponicum* YOKOYAMA are also living in the adjacent seas of Japan. *T. isoharense* n. sp. from the Kunugidaira formation of this coal-field, which will described in the present article, and *modiolaeforme* OYAMA and SAKA (1944, p. 141, pl. 15, figs. 12a, b, 13a, b) from the Tsukiyoshi formation in Gifu Prefecture are Miocene species. In addition, the writer found indeterminable species of this genus from the basal parts of the Eocene Futagojima formation in the Takashima coal-field, western Kyushu.

Occurrence:—

1) Mizugami, Sekimoto, Kitaibaraki City. Iwaki formation. Rare. Coll. No. 180.

2) Shimokawa, Tabito-mura. Iwaki formation. Common. Coll. No. 181.

Trapezium (*Neotrapezium*) *isoharense* KAMADA, n. sp.

Pl. 8, Figs. 4-6

Shell moderate in size, roundly trapezoidal, rather inequilateral, equivalve. Beaks situated almost anterior to terminal, small, weakly pointed. Anterior dorsal margin subvertical and passing into ventral margin making rounded corner with nearly right angle. Posterior dorsal margin long, convex, projected upward in its middle part and making obtuse angle with subtruncated posterior margin. Ventral margin long, nearly horizontal, slightly concave in middle part. A curved blunt ridge extends from umbo to postero-ventral corner. Surface sculptured only with concentric lines of growth.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
IGPS 79382*	Right	25.2	15.5	5.0	61.5	19.8
„	Left	29.0	18.5	5.5	63.8	19.0
183	Right	45.0	26.0	7.0	57.8	15.5
184	Both	ca. 30.0	19.0	11.0(×2)	63.4	18.3
„	Both	31.5	18.0	10.0(×2)	57.2	15.9
Average		32.1	19.4	5.6	60.7	17.7

Remarks:—The characteristic features of the present new species are its projected convex postero-dorsal margin and the position of the beaks which is situated at nearly the anterior teminal part of the shell. These features separate it from *T. modiolaeforme* OYAMA and SAKA (1944) from the Tsukiyoshi formation in Gifu Prefecture, which is closely related to *T. isoharene*. The beak of the *modiolaeforme* is situated at the anterior one eighth of the shell length.

Occurrence:—

1) 100 meters upstream from the Futatsujima mineral-spring, Isohara-machi,

Kitaibaraki City (Type locality). Kunugidaira formation. Common. IGPS Coll. Cat. No. 79382.

2) In a valley west of Minamimae, Sekinami, Kitaibaraki City. Kunugidaira formation. Few. Coll. Nos. 183 and 184.

Family THYASIRIDAE

Genus *Conchocele* GABB, 1866

Conchocele GABB, Pal. Calif., Vol. 2, sec. 1, pt. 1, p. 27, 1866.

Type species (by monotypy), *Conchocele disjuncta* GABB, 1866. Pleistocene, Dead Man's Island, San Pedro Bay, California.

Conchocele bisecta (CONRAD, 1849)

Pl. 8, Figs. 7-9; Pl. 9, Fig. 1

1849 *Venus bisecta* CONRAD, U. S. Exped. (Wilkes), Vol. 10, Geol., p. 724.
1925 *Thyasira bisecta* (CONRAD), YABE and NOMURA, Sci. Rep. Tohoku Imp. Univ., 2nd Ser., Vol. 7, no. 4. p. 84, pl. 23, figs. 2, 7-10.
1931 *Thyasira bisecta* (CONRAD), GRANT and GALE, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 281, 282 (with full references).
1934 *Thyasira bisecta* (CONRAD), MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 10, no. 2, art. 6, p. 147 (with Japanese literatures).

Type data:—U. S. N. M. No. 3518 (CONRAD's type).
Type locality:—City of Astoria, Oregon. Middle Miocene.
Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
315	Both	75	78	38.5(×2)	104.0	25.7
„	Both	62	67	34 (×2)	108.0	27.4
„	Both	60	62	32 (×2)	103.2	26.7
„	Both	51.5	56	27 (×2)	108.5	26.2
316	Both	57	68	40 (×2)	119.2	35.1
317	Both	42.5	57.5	24 (×2)	135.2	28.3
319	Both	21.5	22	10 (×2)	102.4	23.3
Average		52.8	58.6	14.7	111.5	27.5

Remarks:—The so-called "*Thyasira*" *bisecta* is widely distributed in the Japanese Neogene (YABE and NOMURA, 1925) and also in the Oligocene Asagai formation in the Joban coal-field (YOKOYAMA, 1925; MAKIYAMA, 1934) and the Poronai shale in Hokkaido (TAKEDA, 1953). YABE and NOMURA discriminated two types among them; one was assigned to CONRAD's and the other was named *nipponica* as a variety of *bisecta*. Since then, KURODA (1931) mentioned that the Japanese living and fossil species are not referable to those from West

America and recognized two Japanese species, namely *nipponica* YABE and NOMURA and *bisectoides* KURODA. However, MAKIYAMA (1934) subsequently discussed on the Japanese species of "*Thyasira*" and concluded that *disjuncta*, *nipponica* and *bisectoides* are all synonymous with *bisecta*. From the Joban coal-field, "*Thyasira*" *bisecta* and its allied species occur from the Asagai, Mizunoya, Honya, Kokozura and Futaba-Tomioka formations and include two forms. One is characterized by the large and oblique shell and the other has a medium-sized quadrate shell. The former is referable to YABE and NOMURA's first type and referable with *bisecta* and the latter is indistinguishable from YABE and NOMURA's second type or *nipponica*. Compared with plaster specimens of the topotype specimen of *Conchocele disjuncta* GABB, recently received from A. Myra KEEN of Stanford University, the specimens from the Joban coal-field which are referred to *bisecta* are distinguishable therefrom by the less development of the curvature of the posterior furrow and more equilateral shell.

Occurrence:—

1) Kamikitaba, Hirono-machi. Asagai formation. Rare. Coll. No. 319.

2) Asakawa shaft, Joban Coal-mine, Joban City. Asagai formation. Rare. Coll. No. 320.

3) Kami-Asagai, Joban City. Asagai formation. Rare.

4) Ozawa, Sekinami, Kitaibaraki City. Mizunoya formation. Few. Coll. No. 315.

5) Tabasaka, Iwasaki, Joban City. Mizunoya formation. Few. Coll. No. 316.

6) In the tunnel, between Kami-Asagai and Mizunoya, Joban City. Mizunoya formation. Rare. Coll. No. 317.

7) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Few. Coll. No. 318.

Conchocele nipponica (YABE and NOMURA, 1925)

Pl. 9, Figs. 2-6

1925 *Thyasira bisecta* (CONRAD), YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 24, pl. 6, fig. 5.

1925 *Thyasira bisecta* CONRAD var. *nipponica* YABE and NOMURA, Sci. Rep., Tohoku Imp. Univ., 2nd Ser., Vol. 7, no. 4, p. 84-85, pl. 23, fig. 3; pl. 24, figs. 2-4.

1931 *Thyasira* (*Conchocele*) *bisectoides* KURODA, HOMMA's Geol. Cent. Shinano, Pt. 4, p. 50-52, pl. 12, figs. 95, 96.

1954 *Conchocele bisecta* (CONRAD), AOKI, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 3, no. 17, p. 33-34, pl. 1, figs. 1, 3, 5-7.

Type data:—IGPS Call. Cat. No. 7485 (*fide* HATAI and NISIYAMA, 1952, p. 145).

Type locality:—Sea cliff, south of Morai, Atsuta-mura, Ishikari Province, Hokkaido. Miocene Kawabata formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
332	Both	43.2	42.5	24 (×2)	97.8	27.8
322	Both	55.0	55.3	31 (×2)	100.5	28.2
„	Both	31.5	31.0	16 (×2)	98.5	25.4
„	Both	29.0	29.0	15 (×2)	100.0	25.9
„	Both	24.2	24.0	12.5(×2)	100.5	25.8
„	Both	19.3	18.5	10.5(×2)	96.0	27.2
„	Both	12.0	11.5	7 (×2)	95.9	29.2
Average		30.7	30.3	8.3	98.5	27.1

Remarks:—This is a common species of *Conchocele* in the Japanese Neogene and commonly occurs from the Honya formation in the Joban coal-field. Although KURODA (1931) stated that YOKOYAMA's figured specimen from Taira Park in the Joban coal-field may be referable to his *bisectoides*, it is assigned to the present named species.

Occurrence:—

1) Otaka, Yunami, Sekinami, Kitaibaraki City. Mizunoya formation. Few. Coll. No. 332.

2) Yagawase cliff, Taira City. Honya formation. Abundant. Coll. No. 322.

Conchocele compacta minor OMORI, 1954

Pl. 8, Fig. 10

1954 *Conchocele compacta minor* OMORI, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C. Vol. 3, no. 20, p. 90-96, pl. 7, figs. 1a, b, 2.

Type data:—TKD Reg. No. 7678 (Holotype).

Type locality:—Nanatsu-ishi, Shimo-go, Oyamada-mura, Nasu-gun, Tochigi Prefecture. Miocene Kobana formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
321	Right	23	23	9	100.0	39.1

Remarks:—A single inner mold of the right valve from the Kokozura formation is at hand. The locality of the present collection is not far from Tozenji, Yanami, which is OMORI's locality of his paratype specimens and they are from the same horizon. As already mentioned by the original author of this subspecies, the present one is closely related to *Thyasira subexcavata* (YABE and ENDO, MS) YABE and NOMURA (1925) which is now probably assigned to the genus *Conchocele*. *C. subexcavata* was described based on single left valve from Takai, Sekimoto, Kitaibaraki City in the Joban coal-field. This fossil locality probably belongs to the Kokozura formation which extends

to west- and south-wards to the two above-mentioned localities where *C. compacta minor* occurred. The present subspecies may have been described based on the inner mold. The surface of the shell was ornamented with conspicuous radial ribs, 27-30 in number. The specimen at hand is also ornamented with similar radial ribs, but possess two radiating weak ridges extending from the beak to the ventral border as seen in YABE and NOMURA's specimen. Accordingly, if more well-preserved specimens with shell substances are collected, the present subspecies may be indistinguishable from *C. subexcavata*. At the present time, the writer retains the name of *minor*, until better specimens are collected.

Occurrence:—Minamimae, Sekinami, Kitaibaraki City. Kokozura formation. Rare. Coll. No. 321.

Family LUCINIDAE

Genus *Lucinoma*, DALL, 1901

Lucinoma, DALL, Proc. U.S. Nat. Mus., Vol. 23, no. 1237, p. 806.

Type species (by original designation), *Lucina filosa* STIMPSON, 1833. Recent. Casco Bay, Maine, south to Cape Florida, in 16 to 528 fathoms (DALL, 1901, p. 809).

Lucinoma acutilineatum (CONRAD, 1849)

Pl. 9, Figs. 10-16; Pl. 10, Figs. 1-3

1849 *Lucina acutilineata* CONRAD, U.S. Explor. Exped. Geol., Vol. 10, p. 725, pl. 18, figs. 2, 2a, 2b.

1909 *Phacoides acutilineatus* CONRAD, DALL, U.S. Geol. Surv., Prof. Pap. No. 59, p. 116-117, pl. 12, fig. 6.

1925 *Lucina* (*Phacoides*) *borealis* LINNÉ, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 7, p. 24, pl. 5, fig. 5-8.

1931 *Phacoides* (*Lucinoma*) *acutilineatus* (CONRAD), ETHERINGTON, Univ. Calif. Publ., Bull. Dept. Geol. Sci., Vol. 20, p. 76-77, pl. 4, fig. 5.

1931 *Lucina* (*Myrtea*) *acutilineata* CONRAD, GRANT IV and GALE, Mem. San Diego Soc. Nat. Hist., Vol. 1, p. 286-287, pl. 14, figs. 22a, b (with synonymy).

1935 *Lucina* (*Myrtea*) *acutilineata* CONRAD, NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 5, p. 76-79 (with full references up to 1935).

1940 *Lucina acutilineata* CONRAD, NOMURA and ONISI, Jap. Jour. Geol. Geogr., Vol. 17, nos. 3-4, p. 182, pl. 17, figs. 9-12.

1942 *Lucina acutilineata* CONRAD, WEAVER, Univ. Washington Publ., Geol., Vol. 5, p. 143-144, pl. 34, figs. 8, 11, 16.

1945 *Lucinoma acutilineata* (CONRAD), HIRAYAMA, Sci. Rep. Tokyo Kyoiku Daigaku, Vol. 3, no. 18, p. 60-62, pl. 5, figs. 2-7.

1957 *Lucinoma acutilineata* (CONRAD), ITOIGAWA, Trans. Proc., Palaeont. Soc. Japan, N.S., No. 25, p. 4-5, pl. 1, figs. 9-12.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
124	Both	48.0	45.0	24.5(×2)	93.8	25.6
„	Both	33.0	30.0	16.0(×2)	91.0	24.3
„	Both	29.0	26.0	15.5(×2)	89.7	26.8
„	Both	25.5	25.0	15.0(×2)	98.1	29.5
„	Both	30.0	27.5	17.6(×2)	91.8	29.4
121	Both	44.4	41.3	221.2(×)	93.2	23.9
122	Both	52.5	50.8	26.3(×2)	96.8	25.1
„	Both	58.5	56.0	31.0(×2)	96.0	26.5
„	Both	45.5	45.0	25.0(×2)	99.0	27.5
„	Both	52.2	50.0	29.5(×2)	95.7	28.3
„	Both	51.0	48.0	30.0(×2)	94.2	29.4
„	Both	47.2	43.3	25.0(×2)	91.8	26.5
„	Both	38.5	35.5	22.5(×2)	92.3	29.3
„	Both	29.5	26.4	14.0(×2)	89.5	23.8
123	Both	37.2	35.6	18.5(×2)	95.8	24.9
„	Both	30.5	28.5	13.0(×2)	93.5	21.3
„	Both	30.0	27.5	11.5(×2)	91.8	19.2
„	Both	34.0	31.0	11.2(×2)	91.2	16.5
„	Both	26.0	25.0	8.0(×2)	96.2	15.4
127	Both	26.0	25.0	10.5(×2)	96.2	20.2
Average		38.6	36.1	19.8(×2)	93.9	24.7

Remarks:—This species was originally described by CONRAD from the Astoria Miocene at Astoria, Oregon and subsequently figured by ETHERINGTON (1931) from the Astoria formation in Washington, GRANT and GALE (1931) from the Pleistocene of San Pedro, Los Angeles Co., California and others. Although the Japanese Tertiary lucinid mollusks have been often called as *Phacoides borealis* or *Lucina borealis* by YOKOYAMA, most of them are now referable to the present species. Recently, however, HIRAYAMA (1954, 1958) discussed on the so-called Japanese *Lucinoma acutilineata* and recognized several distinct species among them. The specimens abundantly occuring from the Honya formation in the Yumoto district and the Kokozura formation in the Nakoso district are indistinguishable from the typical form from the Astoria Miocene in Oregon and Washington and are referable to the named species without question.

In the Kokozura formation, the specimens from the Izura sea-coast seem to represent fully grown individuals and attain nearly 60 mm. in length, while all of the referred specimens from Yunami, near Tozenji are smaller (31.5 mm. in average length) and less inflated than those from Izura.

Besides these occurrences from the Honya and Kokozura formations, the present species frequently occurs from the Asagai formation in the Nakoso

district. One well-preserved specimen with intact valves from the Asagai formation at Kamiozuta, Hanakawa, Kitaibaraki City measured 26 mm. in length, 24 mm. in height and 12.5 mm. in width of both valves. Although, the size of the specimens from the Asagai formation is more or less smaller than those from the overlying Miocene rocks, the shell outline and the ornamentation of shell surface closely resemble each other. Several indeterminable specimens which are asigned to *Lucinoma* are also frequently found from the Shirasaka formation in the Yumoto district in the collections from the drilling cores or shaft of the Joban Coal-mine.

Occurrence:—

1) Nagako, Nishiki, Nakoso City. Asagai formation. Common.

2) Kamiozuta, Hanakawa, Kitaibaraki City. Asagai formation. Few.

3) Tangozawa, Shiroyama, Taira City. Honya formation. Common. Coll. No. 127.

4) Yagawase cliff, Taira City. Honya formation. Abundant.

5) Kamimae, south of Teramae, Toyoma-machi, Taira City. Honya formation. Abundant.

6) Hieda, Nagasaki, Ena-machi, Iwaki City. Honya formation. Abundant. Coll. No. 124.

7) Kokozura, Nakoso City. Kokozura formation. Rare. Coll. No. 121.

8) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Very abundant. Coll. No. 122.

9) Near Tozenji, Yunami, Sekinami-machi, Kitaibaraki City. Kokozura formation. Common. Coll. No. 123.

10) Numanouchi harbor, Toyoma-machi, Taira City. Numanouchi formation. Rare. Coll. No. 224.

Lucinoma otukai HATAI and NISIYAMA, 1949

Pl. 9, Figs. 7-9

1925 *Lucina* (*Phacoides*) sp. YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 7, p. 7, pl. 1, figs. 3-5, 18.

1939 *Lucina kamenooensis* OTUKA, Jubil. Publ. Commem., Prof. H. YABE, 60th Birthday, Vol. 1, p. 495 (nom. nud.).

1949 *Lucinoma otukai* HATAI and NISIYAMA, Jour. Paleont., Vol. 23, no. 1, p. 91, pl. 24, fig. 10.

1954 *Lucinoma katayosensis* AOKI, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 3, no. 17, p. 34-35, pl. 1, figs. 13, 14.

1954 *Lucinoma katayosensis* AOKI, HIRAYAMA, Jap. Jour. Geol. Geogr., Vol. 25, nos. 1-2, p. 107-109, pl. 11, figs. 9a-b, 10a-c, 11, 12a-b.

Type data:—IGPS Coll. Cat. No. 72501 (Holotype).

Type locality:—Fukusa, Sekimoto, Kitaibaraki City (Joban coal-field). Miocene Kamenoo formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
222	Both	35.0	31.0	16.0(×2)	88.6	22.8
218	Right	34.2	24.0	—	70.2	—
„	Right	30.5	26.5	—	86.8	—
219	Left	50.5	45.5	—	88.2	—
„	Both	55.5	43.5	—	78.5	—
220	Right	25.0	19.0	—	76.1	—
221	Left	26.0	20.0	—	77.0	—
126	Both	33.0	28.0	15.0(×2)	84.8	22.8
„	Both	32.0	25.6	13.0(×2)	80.0	20.3
Average		35.7	29.1	—	81.1	22.0

Remarks:—This species is characterized by the low and transversely expanded shell, the nearly straight, long postero-dorsal margin, the reversely sloping well truncated posterior margin and the very small and short lunule. Owing to the pressure caused by the subsequent compaction of rock, the specimens from the Kamenoo formation were always very compressed and less inflated. However, the new material from the Honya formation at hand possess considerable thickness.

AOKI once described *Lucinoma katayosensis* (AOKI, 1954, p. 34, pl. 1, figs. 13, 14) from the Kabeya formation in the Ishimori district in the Joban coal-field based on the inner mold of the lucinid molluscan remains and subsequently HIRAYAMA (1954, p. 107-108, pl. 11, figs. 9-12) recorded its occurrence from the Miocene Kobana formation in Tochigi Prefecture and from the Miocene Akahira formation in Saitama Prefecture. However, according to the observation on the Joban specimens in several states of the preservation, the characteristic features of *L. otukai* closely agree with those of *L. katayosensis*. Thus, *L. katayosensis* is considered to be nothing but the inner mold of *L. otukai*.

As already mentioned by HATAI and NISIYAMA (1949, p. 91), *L. otukai* is a good horizon marker of the Kamenoo formation in the Joban coal-field. Although, it is not common in units other than the Kamenoo formation, *L. otukai* ranges vertically from the Mizunoya formation to up to the Honya formation.

Occurrence:—

1) Tabasaka, Iwasaki, Joban City. Mizunoya formation. Rare. Coll. No. 222.

2) Hanai, Nishiki-machi, Nakoso City. Kamenoo formation. Common. Coll. No. 218.

3) Kamiyamada, Yamada-machi, Nakoso City. Kamenoo formation. Few. Coll. No. 219.

4) Shimokawa, Izumi-machi, Iwaki City. Kamenoo formation. Few. Coll. No. 220.

5) Nagako, Nishiki-machi, Nakoso City. Kamenoo formation. Common. Coll. No. 221.

6) Shiroyama, north of Taira station, Taira City. Honya formation. Few.

Coll. No. 126.

Lucinoma gracilistriata HIRAYAMA, 1954

Pl. 10, Fig. 4

1954 *Lucinoma gracilistriata* HIRAYAMA, Jap. Jour. Geol. Geogr., Vol. 25, nos. 1-2, p. 104, pl. 10, figs. 1a-c, 2.

1959 *Lucinoma gracilistriata* HIRAYAMA, KAMADA and HAYASAKA, Saito Ho-on Kai Mus., Res. Bull., No. 28, p. 22-23, pl. 2, fig. 7.

Type data:—TKD Reg. No. 10150 (Holotype) and TKD Reg. No. 10161 (Paratype).

Type locality:—Along the river cliff of Ide-gawa, a little north of Tateishi, Tatsuta, Naraha-machi (Joban coal-field). Lower Pliocene Futaba-Tomioka formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
223	Both	54.0	49.0	24.0(×2)	90.7	22.2
„	Both	47.0	45.0	26.0(×2)	95.8	27.7

Remarks:—The occurrence of *Lucinoma gracilistriata* is restricted to the type locality and its environs at the present time. The detailed remarks and full discussion about the species and its affinities are given by HIRAYAMA (1954) in his original article. The characteristic features of this species are the orbicular shell and the numerous fine concentric striae with ill-developed conspicuous lamellar threads. The supplementary record of the occurrence of this species from Tateishi in the Futaba district was given recently by KAMADA and HAYASAKA (1959).

Occurrence:—A cliff on the east side of the Ide River, north of Tateishi, Tatsuta, Naraha-machi (Type locality). Futaba-Tomioka formation. Abundant. Call. No. 223.

Familiy CARDIIDAE

Genus *Nemocardium* MEEK, 1876

Nemocardium MEEK, U.S. Geol. Surv. Territories, Vol. 9, p. 167, 1876.

Type species (by subsequent designation, SACCO, 1899), *Cardium semi-asperum* DESHAYES, 1858. Eocene, Paris Basin, France.

Subgenus *Keenaea* HABE, 1951

Keenaea HABE, Gen. Jap. Shells, No. 2, p. 152, 1951; KEEN, Bull. Amer. Paleont., Vol. 35, no. 153, p. 11, 1954.

Type species (by original designation), *Cardium samarangae* MAKIYAMA, 1934=

Cardium modestum A. ADAMS et REEVE, 1850, non PHILIPPI, 1849; *Cardium adamsi* TRYON, 1872, non A. ADAMS et REEVE, 1850. Neogene to Recent, North Circum-Pacific.

Shell moderate in size, slightly thin; surface sculptured with fine radiating lines, those over posterior portion being cancellate by crossing with concentric striations; epidermis smooth; inner ventral margin crenulated. (HABE, 1951)

The present subgenus corresponds with the section of *Nemocardium samarangae* of MAKIYAMA (1934) and the unnamed subgenus of KEEN (1950). This is represented by fossil and living species of the North Circum-Pacific regions which are characterized by the cancellated posterior portion of the surface.

In the Joban coal-field, two forms are recognized, one is *N.* (*K.*) *iwakiense* (MAKIYAMA) from the Asagai formation and the other is *N.* (*K.*) *samarangae* (MAKIYAMA) from the Tateishi area in the Futaba district (KAMADA and HAYASAKA, 1959, p. 23).

Nemocardium (*Keenaea*) *iwakiense* (MAKIYAMA, 1934)

Pl. 10, Figs. 5-7

1934 *Cardium* (*Nemocardium*) *iwakiense* MAKIYAMA, Mem. Coll. Sc., Kyoto Imp. Univ., Ser. B, Vol. 10, no. 2, art. 6, p. 144, pl. 5, figs. 25-29.

1955 *Nemocardium iwakiense* (MAKIYAMA), HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 99, pl. 4, fig. 16.

Type data:—Holotype and paratypes are in the Geological Institute, Kyoto University.

Type locality:—Yotsukura cliff, Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
25	Right	30.5	28.5	17.0	93.4	55.7
„	Right	37	38	—	102.8	—
26	Right	43	40	—	93.2	—
27	Left	41	40	—	97.7	—
Average		37.9	36.6	—	96.8	—

Remarks:—Although the cancellated posterior portion was well recognized in figure 28 in plate 5 of MAKIYAMA, which is a paratype from Matchgar, North Sakhalin, those of the other specimens, as well as holotype, were obscure in the original figures. The several specimens at hand from the Asagai formation are easily identified to the named species in the outline of shell, but the cancellation on the posterior area is also ill defined. It is probably due to the state of preservation, because the substances of most molluscan

shells from the Asagai formation have been changed to soft chalky matter and are easy eroded out by fossil hunting. In the examined specimens, the blunt ridge running from the beak to the posterior ventral corner is developed and the posterior area is separated by this ridge from the main surface of the shell. Radial lines on the main surface are said to be more than 40 in number while the rest on the posterior area sculptured by narrower radial ribs of 18 to 20 in number. Therefore, number attains about 60 or more. These characteristic features, the posterior blunt ridge, the number of radial ribs and ill-defined cancellated posterior area, seem to well correspond with those of *Cardium* (*Laevicardium*) *tristiculum* YOKOYAMA, 1924 from the Asagai formation at Yamadaoka and Numanosaku, both in the Futaba district in the Joban coal-field.

The generic position of YOKOYAMA's *tristiculum* was referred to *Nemocardium* by HATAI and NISIYAMA (1957, p. 42) and to *Keenaea* by MAKIYAMA (1957) with a question mark. Accordingly, *tristiculum* may be considered to belong to *Nemocardium* or its allied positions. Notwithstanding their detailed reexamination by MAKIYAMA (1934) and HIRAYAMA (1955) who studied the Asagai fauna, this species has not been subsequently recorded.

The discussion whether *iwakiense* is conspecific with *tristiculum* or both are distinct species will be reserved until better preserved and more specimens are obtained.

TAKEDA (1953) described two forms of *Nemocardium* from the Poronai formation in eastern Hokkaido and its equivalents in South Sakhalin, the one is *N. ezoana* TAKEDA, and the other is *N. yokoyamai* TAKEDA. The latter is a new name for *Cardium tristiculum* of YOKOYAMA (1930, non 1924) from South Sakhalin. The specific relation of *tristiculum, iwakiense, ezoana* and *yokoyamai* is another problem for future studies.

Occurrence:—

1) West of Tate, Hirono-machi. Asagai formation. Few. Coll. No. 27.
2) Mukaida, Yumoto-machi, Joban City. Asagai formation. Few. Coll. No. 25.
3) Arakawa shaft, Joban Coal-mine, Iino, Taira City. Rare. Coll. No. 26.

Genus *Clinocardium* KEEN, 1936

Clinocardium, KEEN, Trans. San Diego Soc. Nat. Hist., Vol. 8, no. 17, p. 119, 1936; Bull. Amer. Paleont., Vol. 35, no. 153, p. 14, 1954.

Type species (by original designation), *Cardium nuttallii* CONRAD, 1837 (= "*Cardium corbis* (MARTYN)" of auct.). Recent, a few miles off the estuary of the Columbia River, North America.

Clinocardium asagaiense (MAKIYAMA, 1934)

Pl. 10, Figs. 8-14

1924 *Cardium shinjiense* YOKOYAMA, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 16, pl. 3, figs. 13-15 (non YOKOYAMA, 1923).
1934 *Cardium* (*Cerastoderma*) *asagaiense* MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 10, no. 2, p. 139-140, pl. 5, figs. 20, 22, 23.
1937 *Cardium* (*Cerastoderma*) *shinjiense* YOKOYAMA, KANEHARA, Venus, Vol. 7, no. 4, p. 173, figs. 3, 5, 9 (in part).
1955 *Clinocardium shinjiense* (YOKOYAMA), HIRAYAMA, Sci. Rep. Tokyo Kyoiku, Daigaku, Sec. C, Vol. 4, no. 29, p. 96, pl. 2, figs. 4, 10.
1955 *Clinocardium asagaiense* (MAKIYAMA), HIRAYAMA, *Ibid.*, p. 97, pl. 2, figs. 2, 3, 5-9, 23.

Type data:—Holotype and paratypes are in the Geological Institute, Kyoto University.

Type locality:—The Yotsukura cliff, Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
Holotype	Left	28	25	—	89.3	—
Paratype 1		27	26	16	96.3	29.6
„ 2		24	21	—	87.5	—
„ 3		21.6	19.4	11.4	89.7	26.4
„ 4		25.4	23	11.5	90.5	22.6
96	Right	29.0	27.0	—	93.0	—
97	Both	27.2	27.0	13.0(×2)	99.0	23.9
„	Both	26.0	25.0	14.8(×2)	96.3	28.4
98	Both	25.3	23.5	13.4(×2)	93.0	26.4
„	Both	26.7	25.8	13.4(×2)	96.3	25.1
„	Both	22.2	21.5	11.8(×2)	97.0	26.6
99	Both	20.6	18.0	11.2(×2)	87.3	27.2
„	Both	18.5	16.7	10.3(×2)	90.2	27.8
100	Left	27.5	26.0	—	94.5	—
101	Both	27.6	25.3	15.0(×2)	91.8	27.2
„	Both	22.8	23.0	14.6(×2)	101.0	32.0
„	Both	24.0	23.1	14.0(×2)	96.5	29.2
„	Both	26.0	23.5	13.0(×2)	90.4	25.0
„	Both	23.2	24.2	13.0(×2)	104.0	28.0
Average		24.8	23.5	13.1(×2)	95.0	27.2

Remarks:—The shell remains of "*Cardium*" occurs abundantly from the Asagai formation, therefore, NAKAMURA (1918) once named his Asagai sandstone as "*Cardium* Beds." YOKOYAMA (1924) referred the Asagai specimens to his *Cardium shinjiense* which was originally described based on a specimen from the Miocene Fujina formation of Izumo (Shimane Prefecture), and stated that the Asagai specimens are generally somewhat flatter than, being about 3/5 of the length, of those from Izumo and these differences may be due to

the subsequent deformation in the Joban specimens.

MAKIYAMA (1934) classified the subgenus *Cerastoderma* into three species groups, namely, *Cardium* (*Cerastoderma*) *decoratum* GREWINGK, *C.* (*C.*) *ciliatum* FABRICIUS and *C.* (*C.*) *californiense* DESHAYES groups. He described *Cardium* (*Cerastoderma*) *asagaiense* based on the specimens from the Asagai formation at the Yotsukura cliff in the Futaba district and assigned it to the *C. californiense* group. According to MAKIYAMA, *C. asagaiense* is distinguishable from *C. shinjiense* YOKOYAMA, because the latter species is very closely related to *C. ciliatum* FABRICIUS. The above-mentioned YOKOYAMA's *shinjiense* from the Asagai formation was also referred to *asagaiense* by him. All species of *Cardium* (*Cerastoderma*) treated by MAKIYAMA (1934) may be asigned to the genus *Clinocardium* KEEN, 1936.

Subsequently, KANEHARA (1937) stated in his revision on the so-called "*Cardium shinjiense* YOKOYAMA", that the species from Tsuzura, Uchigo City is indistinguishable from the typical *shinjiense* and should be separated from *C. asagaiense* (MAKIYAMA). According to him it is characterized by the triangular radial ribs and truncated posterior margin as seen in the type of *shinjiense* from Izumo. Recently, HIRAYAMA (1955) pointed out that *C. asagaiense* can be subdivided into three varieties represented by the features of radial ribs and interspaces, but no further detailed discussion was given. Although, he also identified some of the specimens with *C. shinjiense* from the Futaba district, the relation between his *shinjiense* and the variational forms of *asagaiense* is obscure, because no detailed remarks were given about the specimens referred to *C. shinjiense* from the Asagai formation.

The majority of the referred specimens of the named species at hand are medium-sized shells which are characterized by being slightly longer than high and the obliquely sub-truncated posterior margin. The radial ribs are usually about 26 in number on the main surface except on the posterior depressed area bounded by an obtuse ridge extending from beaks to posterior ventral corner where the distinct radials are ill-defined. The type of sculpture of *asagaiense* was said to belong to *C. californiense*, however, the present species seems to more intimate to *C. decoratum* (GREWINGK) figured by GRANT and GALE (1931, pl. 19, fig. 12) and *C. matchgarense* (MAKIYAMA) (1934, pl. 5, figs. 30, 31). A well preserved specimen (Pl. 10, fig. 8) from Yumoto, Joban City is sculptured with somewhat triangular radial ribs but not sharp roof-shaped triangular as seen in *C. ciliatum*. Such form probably corresponds with the above mentioned *C. shinjiense* of KANEHARA from Tsuzura, Uchigo City. However, the present species differs from *C. ciliatum* and also from *C. shinjiense* by the less depth of the shell and the less forward curve of the beaks.

There are some large specimens ranging from 35 to 50 mm. in length. This form is different from the typical *asagaiense* by possessing an obliquely trigonal shell outline, as in *C. nuttallii* (CONRAD). So that, a new name of

makiyamae is proposed here for this large type, as a subspecies of *asagaiense*.

Although, the examples which possess 35 to 40 radial ribs as described in the original description is exceptional, a few specimens of this group occurred from both the Iwaki and Asagai formation. It may be recognized as a subspecies of *asagaiense* and a new name *arakawae* is proposed here and will be described in the next paragraph.

Occurrence:—

1) Nabezuka, Hirono-machi. Asagai formation. Abundant. Coll. No. 101.

2) Takakura, Hirono-machi. Asagai formation. Abundant. Coll. No. 98.

3) Futaba distirct. Coll. No. 99 (IGPS Coll. Cat. No. 23260).

4) Mukaida, Yumoto-machi, Joban City. Asagai formation. Abundant. Coll. Nos. 96 and 97.

5) Arakawa shaft, Joban Coal-mine, Iino, Taira City. Asagai formation. Abundant.

6) Tsuzura, Uchigo City. Asagai formation. Very abundant.

Clinocardium asagaiense makiyamae KAMADA, n. subsp.

Pl. 10, Figs. 18-21

Shell larger than *C. asagaiense*, obliquely trigonal, anteriorly about two thirds of posterior. Anterior margin rounded and passing into ventral margin without any demarcation; posterior margin broadly arched. Surface sculpture consisting of about 28 radial ribs, rounded on tops and separated by interspaces of nearly equal breadth. Beaks small, pointed and not curved forward.

Dimensions (in mm):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
IGPS 15800*	Both	36.2	36.4	18.8(×2)	99.5	26.0
104	Both	44.0	43.8	27.6(×2)	99.6	31.4
105	Right	34.0	32.5	—	95.5	—
„	Right	43.0	44.0	—	104.3	—
106	Right	38.0	35.5	—	93.4	—
107	Right	37.5	37.0	—	98.7	—
108	Left	42.0	39.5	—	94.0	—
Average		39.2	38.4	—	97.0	—

* Holotype

Remarks:—As already mentioned in the preceding, the present new subspecies is a remarkable large type of *C. asagaiense*. It is characterized by the more obliquely trigonal outline of the shell.

Occurrence:—

1) Nabezuka, Hirono-machi (Type locality). Asagai formation. Rare.

IGPS Coll. Cat. No. 15800 (Holotype).

2) In a tunnel, west of the Iriumi mineral bath, Kido, Naraha-machi. Asagai formation. Few. Coll. No. 104.

3) Mukaeda, Yumoto-machi, Joban City. Asagai formation. Few. Coll. No. 105.

4) Takasaka, Uchigo City. Asagai formation. Few. Coll. No. 106.

5) Omachi shaft, Joban Coal-mine, Uchigo City. Asagai formation. Rare. Coll. No. 107.

6) Tebaizaka, east of Bessho, Iwasaki-machi, Joban City. Asagai formation. Rare. Coll. No. 108.

Clinocardium asagaiense arakawae KAMADA, n. subsp.

Pl. 10, Figs. 15-17

Shell medium sized, ovate or suborbicular in outline, rather compressed in width. Surface sculptured by about 40 radial ribs rounded on tops separated by narrow interspaces. The other features similar to *asagaiense*.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	H/L(%)
109	Left	24.5	22.5	91.8
„	Left	25.0	—	—
110	Right	23.0	20.0	87.0
IGPS 79383*	Right	25.0	22.0	88.0
Average		24.4	21.5	88.9

* Holotype

Remarks:—The present subspecies is distinguishable from the species by the larger number of radial ribs which are separated by very narrow interspaces. Among the subspecies of *asagaiense* of the Asagai formation, only *arakawae* ranges down to the basal part of the Iwaki formation. The new subspecific name is dedicated to Mr. Toru ARAKAWA, a geologist of the Joban Coal-mining Company, for his continued friendship.

Occurrence:—

1) Iwasaki-Honko, Nagakura, Iwasaki, Joban City. Iwaki formation. Rare. Coll. No. 109.

2) Mukaida, Yumoto-machi, Joban City. Asagai formation. Rare. IGPS Coll. Cat. No. 79383.

3) Kubota, Nakoso City. Asagai formation. Few. Coll. No. 110.

Clinocardium shinjiense (YOKOYAMA, 1923)

Pl. 11, Figs. 1, 2

1923 *Cardium shinjiense* YOKOYAMA, Jap. Jour. Geol. Geogr., Vol. 2, no. 1, p. 7, pl. 2, fig. 6.
1925 *Cardium shinjiense* YOKOYAMA, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 7, p. 18, pl. 3, figs. 10, 11.
1934 *Cardium* (*Cerastoderma*) *shinjiense* YOKOYAMA, OTUKA, Bull. Earthq. Res. Inst., Tokyo Imp. Univ., Vol. 12, pt. 3, p. 616, pl. 47, fig. 36.
1935 *Cardium* (*Cerastoderma*) *shinjiense* YOKOYAMA, NOMURA, Saito Ho-on Kai Mus. Res. Bull. No. 5, p. 110-111, pl. 6, fig. 3.
1937 *Cardium* (*Cerastoderma*) *shinjiense* YOKOYAMA, KANEHARA, Venus Vol. 7, no. 4, p. 173-174, text-figs. 2, 4.
1935 *Cardium* (*Cerastoderma*) *ciliatum* FABRICIUS, NOMURA, Saito Ho-on Kai Mus. Res. Bull., No. 6, p. 213-214, pl. 16, figs. 6, 7 (non FABRICIUS, 1780).

Type data:—The lectotype specimen measures 33 mm. in length, 32 mm. in height and 23.5 mm. in thickness is in the Geological Institute, University of Tokyo.

Type locality:—Fujina, Tamayu-mura, Yatsuka-gun, Shimane Prefecture. Miocene Fujina formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
IGPS 15793	Both	40.5	39.0	27.2(×2)	96.3	33.6
113	Right	35	33	11	94.3	31.5
114	Right	30	27	10.8	90.0	36.1
„	Right	29.5	25.8	8.0	87.5	27.2
115	Left	37	35.5	11.0	96.0	29.8
„	Right	39	35	12.9	89.8	33.2
116	Both	24.6	24.2	18.0(×2)	98.5	36.6
„	Right	25.6	25.0	9.5	97.7	37.1
Average		32.7	30.6	10.7	93.8	33.1

Remarks:—The specific position of "*Cardium shinjiense* YOKOYAMA" has been discussed by many authors and conclusive remarks have been given by KANEHARA (1937). However, the specimens from the Asagai and Iwaki formations in the Joban coal-field, which was referred to *C. shinjiense* by KANEHARA is probably *C. asagaiense* or its variety, as above stated. The described and figured specimens from Shibahara, Ogawa-machi in the Joban coal-field by YOKOYAMA (1925) and from the Tsukiyoshi formation in Gifu Prefecture by KANEHARA (1937) under the name of *Cardium shinjiense* YOKOYAMA and from the Shiogama district in Miyagi Prefecture by NOMURA (1935) under the name of *Cardium ciliatum* FABICIUS are undoubtedly referable to the type from the Miocene Fujina formation in Izumo (Shimane Prefecture). An excellent specimen described and figured by YOKOYAMA (1926) from the Pliocene Sawane formation in the Sado Island, Niigata Prefecture is indistinguishable from the living *C. ciliatum* as suggested by NOMURA (1935).

A well preserved specimen at hand from Kokozura, Nakoso City is hardly distinguished from the type specimen from Izumo. It is characterized by

possessing a well inflated shell, more or less triangular radial ribs which are 38 in number and the obliquely subtruncated posterior margin. The present species is distinguished from the living *C. ciliatum* from the Bering Sea, figured by GRANT and GALE (1931, pl. 19, fig. 11) by its less sharped triangular ribs and more wider interspaces.

Occurrence:—

1) Kokozura, Nakoso City. Kokozura formation. Few. IGPS Coll. Cat. No. 15793.

2) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Few. Coll. No. 113.

3) Tozenji, Yunoami, Sekinami, Kitaibaraki City. Kokozura formation. Few. Coll. No. 114.

4) Minamimae, Sekinami, Kitaibaraki City. Kokozura formation. Few. Coll. No. 115.

5) Numanouchi habor, Toyama-machi, Taira City. Numanouchi formation. Few. Coll. No. 116.

Genus *Papyridea* SWAINSON, 1840

Papyridea SWAINSON, Treat. Malac., p. 374, 1840.

Type species (by subsequent designation, GRAY, 1847), *Cardium soleniforme* BRUGUIÈRE, 1789=*C. spinosum* MEUSCHEN, 1787.

Valves elongate-oval, gaping, moderatly ventricose or flattenend, posterior portion of shell longer than anterior; ribs numerous, narrow, often spiny. (GRANT and GALE, 1931, p. 311.)

Papyridea harrimani DALL, 1904

Pl. 11, Figs. 3-5

1904 *Papyridea harrimani* DALL, Harriman Alaskan Expedition, Geology (vol. 4), p. 114, pl. 10, fig. 5.

1934 *Cardium* (*Papyridea*) *harrimani* (DALL), MAKIYAMA, Mem. Coll. Sci., Kyoto Univ., Ser. B, vol. 10, no. 2 (art. 6), pl. 6, fig. 34 (in part).

1950 *Papyridea yokoyamai* HATAI and NISIYAMA (MS), HATAI and KAMADA, Short Papers IGPS, No. 2, p. 66.

Type locality:—Propof Island, 3372, Alaska. "Miocene".

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
8	Right	70	55.5	17	79.3	24.3
9	Left	78	64	24	82.1	30.8
10	Right	59	53	14	76.9	23.8
11	Left	56	51	12	91.2	21.4
13	Both	52	45	25(×2)	86.7	24.1
Average		63	54	16	83.2	24.9

Remarks:—YOKOYAMA (1924) once described *Papyridea* (*Fulvia*) *nipponica* n. sp. from the Asagai formation in the Joban coal-field and compared it with *Papyridea harrimani* DALL from Alaska. According to him, *harrimani* is shorter and possesses a less number of ribs (said to be 35) than *nipponica*. Subsequently, MAKIYAMA (1934, p. 141) stated that the specimens found from the Yotsukura cliff coincide with DALL's description and figure, so that *nipponica* is conspecific with *harrimani*. However, the several specimens collected from the Asagai formation at hand exhibit somewhat variation in number of radial ribs: some specimens from the Yumoto district have ribs ranging 30 to 35 in number (33 in average) and the other from the Futaba district range 45 to 56 (48 in average) in number. These differences on the number of ribs may be caused by some sort of the paleo-geographical or chronological separation of species or subspecies. Accordingly, the specimens from the Yumoto district which have less number of the ribs are referred to *harrimani*, while the specimens from the Futaba district which have more number of the ribs are referred to *nipponica* as subspecies of *harrimani*. A figured specimen from Matchgar in north Sakhalin, recorded by MAKIYAMA (1934, pl. 6, fig. 34) from one of his horizons 1, 2 and 5, is probably referred to *harrimani*.

Occurrence:—

1) Tsuzura, Uchigo City. Asagai formation. Few. Coll. No. 8 and 10.

2) Fujiwara shaft, Joban Coal-mine, Iwasaki, Joban City. Asagai formation. Rare. Coll. No. 9.

3) Omachi shaft, Joban Coal-mine, Uchigo City. Asagai formation. Rare. Coll. No. 11.

4) Sumiyoshi colliery, Joban Coal-mine, Uchigo City. Asagai formation. Few. Coll. No. 12.

5) Hannukizawa, Yoshima-mura, Asagai formation. Rare. Coll. No. 13.

Papyridea harrimani nipponica YOKOYAMA, 1924

Pl. 11, Figs. 6-8

1924 *Papyridea* (*Fulvia*) *nipponica* YOKOYAMA, Jour. Coll. Sci. Imp. Univ. Tokyo, Vol. 45, art. 3, p. 17, figs. 3, 4.

1934 *Cardium* (*Papyridea*) *harrimani* (DALL), MAKIYAMA, Mem. Coll. Sci., Kyoto Univ., Ser. B, vol. 10, no. 2 (art. 6), p. 141, figs. 32, 33 (in part).

1955 *Papyridea harrimani* DALL, HIRAYAMA, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, vol. 14, no. 29, p. 100, pl. 2, fig. 24.

Type data:—Lectotype (YOKOYAMA's pl. 3, fig. 3; here designated) is in the Geological Institute, University of Tokyo.

Type locality:—Tatsuta Coal-mine, Naraha-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
14	Left	71	57	16	80.4	22.6
15	Right	72	55	—	76.5	—
16	Left	64	56	14	87.5	21.9
17	Both	65	51	—	78.5	—
Average		68	55	15	80.7	22.3

Remarks:—Although, MAKIYAMA (1934) referred the named species to *Papyridea harrimani* DALL, as already mentioned in the preceding, the specimens from the Futaba district in the Joban coal-field are identifiable with YOKOYAMA's *nipponica*. This subspecies closely resembles *harrimani* in outline, but has a more number of radial ribs as already stated by YOKOYAMA.

YOKOYAMA (1925, p. 14) recorded the occurrence of a single specimen referred to *nipponica* from Shiragami in Nagano Prefecture, but did not figure it. Additional records of the named species in the same province were made by KURODA (1931, p. 54, pl. 6, figs. 35, 36) with some question. However, KURODA mentioned that the named species distinctly belongs to the typical section of *Payridea* but not *Fulvia*. YOKOYAMA (1926) also described and figured a fine perfect left valve occurred from the Pliocene Sawane formation in Sado Island of Niigata Prefecture, under the specific name of *nipponica*. As pointed out by YOKOYAMA (1926, p. 294, pl. 34, fig. 16), the Sado specimen with about 50 radiating ribs is closely similar to *nipponica* from the Joban coal-field, however, the shape and strength of the radial ribs are somewhat different from one another. Thus, HATAI and NISIYAMA (1952, p. 105) proposed a new name for YOKOYAMA's *nipponica* from the Sado Island as *kurodai*. The full description about this Sado specimens was given by YOKOYAMA, so that the new name of HATAI and NISIYAMA's *kurodai* is of course valid.

Papyridea kurodai HATAI and NISIYAMA (Pl. 11, fig. 9 in the present article) is distinguishable from *P. harrimani* DALL and *P. h. nipponica* YOKOYAMA by having a more horizontally extended posterior dorsal margin, the roof-shaped triangular radial ribs on the most part of the shell surface and about five distinct and the coarsest round-topped ribs separated with the considerable width of the interspaces in the posterior area just behind the line running from the beak to the posterior ventral corner.

P. kurodai seems to be confined to the Pliocene in age as indicated by the geologic age of the fossil-bearing Sawane formation in the Sado Island, while *P. harrimani* and *P. h. nipponica* may be restricted to the upper Oligonene in age.

Occurrence:—

1) Yotsukura cliff, Yotsukura-machi. Asagai formation. Few. Coll. No. 14.
2) Doggamekizawa, Hirono-machi. Asagai formation. Common. Coll. No. 16.
3) Enoami, Hisanohama-machi. Asagai formation. Few. Coll. No. 17.

Family VENERIDAE

Genus *Ezocallista* KURODA in KIRA, 1959

Type species (here designated), *Saxidomus brevisiphonata* CARPENTER, 1865= *Macrocallista chishimana* PILSBRY, 1905; figured by KIRA, Colour. Illust. Shells Japan, pl. 56, fig. 4, 1959. Recent, northern Pacific.

The lateral tooth is situated basally on the hinge plate; anterior cardinal large and high, central small and low, the posterior laminately elongated; pallial sinus rounded at the end (KURODA, MS).

Ezocallista kurodae KAMADA, n. sp.

Pl. 12, Figs. 1-3

Shell moderate in size, ovate or rounded quadrate in outline, rather heavy, very inequilateral, anterior side being about one-fourth of whole length of shell; beaks progyrous and pointed; equivalve. Antero-dorsal margin short, faintly convex in front of umbo and passing into rounded anteriorly. Postero-dorsal margin longer and more gently sloping than anterior one and broadly arched. Posterior end obliquely subtruncated and passing into ventral margin with obtuse angle. Ventral margin broadly arched, curved upward to anterior end, and anterior half somewhat subparallel to posterior-dorsal margin. Surface smooth except for periodic concentric lines of growth. Concentric lines much more crowded ventrally than on younger part of shell. Inner margin smooth. Pallial sinus moderately deep, rounded, slightly ascending and not reaching to center of shell. Anterior adductor muscle scar ovate and posterior one pyriform and larger than preceeding.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
IGPS 79384*	Left	55.0	45.2	17.3	82.2	31.4
„	Right	53	45	13	85	24.6
„	Right	35	27	11	77	31.4
„	Right	40	33	—	82.5	—
258	Left	69.0	52.5	18.0	76.1	26.1
„	Left	76.5	58.0	19.5	75.8	25.5
„	Both	81	60	—	74.1	—
Average		59.6	45.5	15.8	79.0	27.8

* Holotype

Remarks:—By the characteristic features of the outline, inflation and ornamentation of the shell and the shape of the pallial sinus, the present new species is closely related with the living *Ezocallista brevisiphonata* (CARPENTER). But, *E. kurodae* differs from the living species by having shorter and more

inequilateral shell and the shallower and more rounded pallial sinus.

YOKOYAMA (1924) once figured *Meretrix* (*Callista*) *chinensis* HOLTEN from the Iwaki formation at Dodaira, Misawa, Nakoso City. However, the fossil specimens figured by YOKOYAMA do not correspond with the named living species. Subsequently, HATAI and NISIYAMA (1952, p. 88) proposed a new name, *Callista misawaensis* for the fossil specimens, but they gave no descriptions or remarks. Therefore, this new specific name may be invalid. Although YOKOYAMA's figured specimens are probably identified with *E. kurodae*, the anterior portion of the former is somewhat more produced and longer than the latter.

Callista pseudobrevisiphonata HIRAYAMA (1954, p. 68, pl. 4, figs. 4, 5, 6) from the Miocene Arakawa group in Tochigi Prefecture is not exactly asignable to the genus *Ezocallista*, owing to the description about the hinge described simply as "Teeth as in *Callista*." HIRAYAMA's species is easily distinguishable from *E. kurodae* by its more equilateral shell.

The present species is also distinguishable from *Callista hanzawai* (NAGAO) (1928, p. 69, pl. 13, fig. 7, etc.) from the Ashiya group of North Kyushu by having shorter shell and subtruncated posterior margin.

Occurrence:—

1) Karasawa, Kuroda, Tabito-mura. Iwaki formation. Few. IGPS Coll. Cat. No. 79384.

2) In the pit of the Kaminoyama colliery, Joban Coal-mine, Hattan, Sekimoto, Kitaibaraki City. Iwaki formation. Common. Coll. No. 258.

Genus *Dosinia* SCOPOLI, 1777

Dosinia SCOPOLI, Intr. Hist. Nat., p. 399, 1777.

Type species (by monotypy), *Chama dosin* ADANSON, 1757=*Dosinia africana* HANLEY. Recent, west coast of Africa.

Subgenus *Phacosoma* JUKES-BROWNE, 1912

Phacosoma, JUKES-BROWNE, Proc. Malac. Soc. London, Vol. 10, p. 100, 1912.

Type species (by original designation), *Artemis japonica* REEVE, 1850. Recent, Japan.

Dosinia (*Phacosoma*) *chikuzenensis* NAGAO, 1928

1928 *Dosinia chikuzenensis* NAGAO, Sci. Rep., Tohoku Imp. Univ., Ser. 2, Vol. 12, no. 1, p. 64-65, pl. 10, figs. 4-7, 9.

1938 *Dosinia chikuzenensis* NAGAO, HATAI, Jap. Jour. Geol. Geogr., Vol. 15, nos. 1-2, p. 61-65.

1955 *Dosinia* cf. *chikuzenensis* NAGAO, KANNO, Trans. Proc. Palaeont. Soc. Japan, N. S., No. 18, p. 34, pl. 6, fig. 13.

1956 *Dosinia chikuzenensis* NAGAO, HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 5. no. 45, p. 109-112, pl. 7, figs. 1-15.

Type data:—IGPS Coll. Cat. No. 36277 (Holotype) and IGPS Coll. Cat. No. 36277 and 36285 (Paratypes).

Type locality:—Sea coast of Sakamizu, Wakamatsu City, Fukuoka Prefecture. Oligocene Sakamizu formation.

Dosinia chikuzenensis was originally described by NAGAO based on the specimens from the Sakamizu formation of the Ashiya group in the northern part of the Chikuho coal-field, Kyushu. HATAI (1938, p. 62), in his revision on some species of the fossil *Dosinia* from Japan, pointed out that the shell outline of *D. chikuzenensis* is quite identical with *D. nomurai* OTUKA from the Miocene of the Ninohe district, Iwate Prefecture and considered that *chikuzenensis* must be synonymous with *nomurai* when the full consideration about the NAGAO's original description and figures other than the figure of the holotype of *chikuzenensis* are taken. HIRAYAMA (1956, p. 111-112) agreed with HATAI's consideration and further mentioned that *D. nomurai* OTUKA and *D. nagaii* OTUKA, both from the Miocene from the above-mentioned Ninohe district, are closely related with each other and both should be included into *chikuzenensis* as synonyms. However, he still recognized the three groups within the specimens of *chikuzensis* from Hikoshima and divided them into *nomurai*, *nagaii* and *chikuzenensis* (s. s.) types.

As already stated by OTUKA (1937, p. 29), *Dosinia anguloides* NOMURA from the Miocene of Shiogama, Miyagi Prefecture is indistinguishable from OTUKA's *nagaii*. Therefore, if the relation between *chikuzenensis* with *nomurai* and *nagaii* is reasonable in consideration as synonym, *anguloides* should be also included in the range of species of *chikuzenensis*.

At the present time, the writer wishes to retain the specific name of *nomurai* and *nagaii* (inclusive of *anguloides*) as subspecies of *chikuzenensis*, based on their morphological characteristics. Compared with *D. japonica* (REEVE), a subgenotypic species of *Phacosoma*, *chikuzenensis* and its subspecies are easily distinguishable therefrom by possessing more rounded posterior dorsal margin and the less acute antero-dorsal corner or the more sloping antero-dorsal margin.

It is interesting to say, that the associated occurrence of *nomurai* and *nagaii* is seen in the Miocene of the several districts in Japan, namely, in the Ninohe district in Iwate Prefecture (NOMURA, 1935), Hamada district (OTUKA, 1937) and Shinji district (NOMURA and HATAI, 1938) both in Shimane Prefecture and also in the Joban coal-field as will be stated later, as similar as in the case of variation in the Hikoshima specimens treated by HIRAYAMA (1956).

Dosinia (*Phacosoma*) *chikuzenensis nomurai* OTUKA, 1934

Pl. 12, Figs. 4-5, 7-10

1934 *Dosinia japonica nomurai* OTUKA, Bull. Earthq. Res. Inst., Tokyo Imp. Univ., Vol. 12, pt. 3, p. 618, pl. 48, figs. 5a, b.

1935 *Dosinia akaisiana* NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 60, pl. 8, figs. 1 and 4 (not the other figures).

1935 *Dosinia nomurai* OTUKA, NOMURA, *Ibid.*, No. 6, p. 217, pl. 17, fig. 7.
1937 *Dosinia japonica nomurai* OTUKA, OTUKA, Jap. Jour. Geol. Geogr., Vol. 14, nos. 1-2, p. 29-30, pl. 3, figs. 3, 4.

Type data:—ERI Reg. No. 1465.

Type locality:—Nisatai, Fukuoka-machi, Ninohe-gun, Iwate Prefecture (Loc. 3 in fig. 2 of the original paper). Lower Kadonosawa series, Miocene.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
148	Left	43.0	39.0	11.4	90.7	26.6
„	Left	40.0	38.5	10.0	96.3	25.0
„	Right	37.5	34.5	9.4	92.0	25.0
143	Both	43.0	40.5	19.6(×2)	94.2	22.8
„	Right	47.0	—	—	—	—
144	Left	30.1	29.3	7.4	97.4	24.6
„	Right	42.0	38.6	9.5	92.0	22.6
„	Left	47.0	46.5	12.8	98.8	25.1
Average		41.2	38.1	9.9	94.5	24.5

Remarks:—As already stated in the foregoing page, *D. nomurai* OTUKA is asignable to the subspecies of *D. chikuzenensis* NAGAO. It differs from the typical form by possessing a considerably lower shell. The pallial sinus of the Joban specimen from the Numanouchi formation is quite identical to those from Hikoshima figured by HIRAYAMA in his figures 4 and 5 in plate 7.

Occurrence:—

1) Hironosaku, Kamiyamada, Yamada-machi, Nakoso City. Kunugidaira formation. Adundant. Coll. No. 148.

2) Hamamachi, Toyoma-machi, Taira City. Numanouchi formation. Common. Coll. No. 143.

3) Numanouchi habor, Toyoma-machi, Taira City. Numanouchi formation. Abundant. Coll. No. 144.

Dosinia (*Phacosoma*) *chikuzenensis nagaii* OTUKA, 1934

Pl. 12, Fig. 6

1934 *Dosinia nagaii* OTUKA, Bull. Earthq. Res. Inst., Tokyo Imp. Univ., Vol. 12, pt. 3, p. 618, p. 48, fig. 55.
1935 *Dosinia anguloides* NOMURA, Saito Ho-on Kai Mus., Res. Bull. No. 6, pl. 17, fig. 2.

Type data:—ERI Reg. No. 1461.

Type locality:—Nisatai, Fukuoka-machi, Ninohe-gun, Iwate Prefecture. (Loc. 3 in fig. 2 of the original paper.) Lower Kadonosawa series, Miocene.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
147	Left	52.0	52.5	13.8	100.8	26.6

Remarks:—A single left valve at hand from the Numanouchi formation has nearly equal length and height. It is closely similar to the type specimen of *D. nagaii* OTUKA from the Ninohe district as well as those of *D. anguloides* NOMURA from the Shiogama district.

Occurrence:—Numanouchi habor, Toyoma-machi, Taira City. Numanouchi formation. Rare. Coll. No. 147.

Genus *Cyclina* DESHAYES, 1849

Cyclina, DESHAYES, Trait. Element. Conchy., Vol. 1, fasc. 2, p. 623-626.

Type species (by subsequent designation, DALL, 1902), *Venus sinensis* GMELIN, 1790. Recent, China Sea.

Subgenus *Cyclina* s. s.

Cyclina (*Cyclina*) *jobanica* (YOKOYAMA, 1924)

Pl. 13, Figs. 2, 3

1924 *Cardium* (*Laevicardium*) *jobanicum* YOKOYAMA, Jour. Sci. Coll., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 15, pl. 2, figs. 12-18.

1952 *Cyclina* (s. s.) *japonica* KAMADA, Trans. Proc. Palaeont. Soc. Japan, N. S., No. 6, p. 168, pl. 15, fig. 4 (in part).

1952 *Protothaca jobanica* HATAI and NISIYAMA, Sci. Rep., Tohoku Univ., 2nd Ser. Spec. Vol., No. 3, p. 37.

Type data:—Syntypes are in the Geological Institute, University of Tokyo.

Type locality:—Tenjinmae, Kamidaki, Tono-machi (Joban coal-field). Oligocene Iwaki formation.

Remarks:—The writer once described the cyclinid shell from the 1st pit of the Taisho colliery, Kamiyamada, Yamada-machi, Nakoso City, under the mame of *Cyclina japonica*. However, according to the additional collections and more detail study, he inclines to distinguish the Kamiyamada specimen from the typical *japonica* from the Miocene strata of various localities of Japan. The Kamiyamada specimen is now considered to belong to YOKOYAMA's *Cardium jobanicum*. And also additional specimens collected from Mizugami and Shimokawa are identified to the same named species. However, the new materials show that this species belongs to *Cyclina* s. str. and not to *Cardium* or *Protothaca*.

The hinge-teeth are characteristic of the genus. Of the three cardinals of the right valve, the anterior one is shortest and thin, the middle one is also thin but longer than the preceding and the posterior one is largest and

bifid as is seen in the Recent *C. orientalis* (SOWERBY). The left valve also has three cardinals and the posterior one is thinner than the middle and anterior ones.

Cyclina jobanica closely resembles *C. japonica* KAMADA (1952), but differs from the latter in having a smaller shell and less promient umbonal regions. The present species is probably an ancestral race of the Miocene *C. japonica* which is common in the Miocene Kunugidaira and Nakayama formations in this coal-field. The trend of *jobanica-japonica-orientalis* may be an evolutional series.

Occurrence:—

1) Sorida, Shimotaki, Tono-machi. Iwaki formation. Common. Coll. No. 360.

2) Taisho Coal-mine, Kamiyamada, Nakoso City. Iwaki formation. Few. IGPS Coll. Cat. No. 72954.

3) Mizugami, Sekimoto, Kitaibaraki City. Iwaki formation. Common. Coll. No. 361.

Cyclina (*Cyclina*) *japonica* KAMADA, 1952

Pl. 13, Fig. 4

1926 *Cyclina chinensis* (CHEMNITZ), YOKOYAMA, Jour. Fac. Sci. Imp. Univ. Tokyo, Ser. 2, Vol. 1, pt. 7, p. 222, pl. 28, fig. 7 (non GMELIN, 1791).

1952 *Cyclina* (*Cyclina*) *japonica* KAMADA, Trans. Proc. Palaeont. Soc. Japan, N. S., No. 6, p. 168, pl. 15, figs. 1a, b, 2 (non fig. 4).

Type data:—IGPS Coll. Cat. No. 72952 (Holotype); 7110, 52776 (Paratypes).

Type locality:—200 m west of Tokunari, Machino-machi, Fugeshi-gun, Ishikawa Prefecture. Miocene Higashi-Innai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
Holotype	Both	47.7	50.2	30.9(×2)	105.0	32.4
176	Both	46	50	28.0(×2)	108.5	32.2
„	Both	47	51	—	108.4	—
178	Right	43	43	—	100.0	—
Average		45.9	48.6	29.5(×2)	105.5	32.3

Remarks:—*Cyclina japonica* is characteristic by its regularly and broadly rounded posterior margin from beaks to the base and the steeply inclined anterior dorsal margin. In the Joban coal-field, the present species commonly occurs from the Kunugidaira formation, associated with the brackish-dweller genera, such as *Vicarya*, *Vicaryella* and *Soletellina*.

Occurrence:—

1) Hirosaku, Kamiyamada, Yamada-machi, Nakoso City. Kunugidaira for-

mation. Common. Coll. No. 176.

2) Shimokawa, Tabito-mura. Kunugidaira formation. Common. Coll. No. 178.

Cyclina (Cyclina) asagaiensis KAMADA, 1952

Pl. 13, Fig. 1

1952 *Cyclina (Cyclina) asagaiensis* KAMADA, Trans. Proc. Placont. Soc. Japan, N. S., No. 6, p. 169, pl. 15, figs. 3a-c.

Type data:—IGPS Coll. Cat. No. 72955 (Holotype).

Type locality:—In the Omachi abandoned shaft of the Joban Coal Mining Co., north of Takasaka, Uchigo City (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

	Valve	Length	Height	Width	H/L(%)	W/L(%)
Holotype	Both	37.0	40.8	26.6(×2)	110.2	35.9

Remarks:—The radial ribs of the present species are stronger than the impressed radial striae of *C. jobanica* (YOKOYAMA), *C. japonica* KAMADA and *C. orientalis* (SOWERBY). It is also characterized by possessing a rounded pallial sinus and therefore differs from those three species which have a pointed triangular pallial sinus. *C. asagaiensis* is restricted in its occurrence to the Asagai formation and in the Yumoto district.

Occurrence:—

1) In the Omachi abandoned shaft of the Joban Coal-Mining Co., north of Takasaka, Uchigo City (type locality). Asagai formation. Few. IGPS Coll. Cat. No. 72955.

2) Mukaida, Yumoto-machi, Joban City. Asagai formation. Few. Coll. No. 357.

Genus *Liocyma* DALL, 1870

Liocyma DALL, Proc. Boston Soc. Nat. Hist., Vol. 13, p. 256, 1870.

Type species (by original designation), *Venus fluctuosa* GOULD, 1840. Recent, North Atlantic and Arctic oceans.

Liocyma furtiva (YOKOYAMA, 1924)

Pl. 13, Figs. 5-7

1924 *Venus furtiva* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 15, pl. 2, fig. 6.

1934 *Liocyma furtiva* (YOKOYAMA), MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 10, no. 2, art. 6, p. 152, pl. 6, figs. 41-43, 45-48.

1955 *Liocyma furtiva* (YOKOYAMA), HIRAYAMA, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 102, pl. 3, figs. 18, 19, 20.

Type data:—Syntypes are in the Institute of Geology, University of Tokyo.

Type locality:—Kobisa, Ohisa-mura (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
210	Both	21.0	15.5	6.0(×2)	74.0	14.3
„	Both	16.8	12.2	5.6(×2)	72.6	16.7
„	Right	20.0	15.0	—	75.2	—
211	Both	14.5	12.3	7.4(×2)	85.0	25.6
212	Both	ca. 18.0	15.0	ca. 5.5(×2)	ca. 83.4	ca. 18.8
„	Both	ca. 18.0	13.5	—	ca. 75.0	—
213	Left	16.0	11.0	—	68.7	—
214	Both	15.8	11.8	6.3(×2)	74.7	19.9
„	Both	16.0	11.6	7.6(×2)	72.7	21.0
„	Left	18.0	12.0	—	66.8	—
215	Left	ca. 29.0	22.0	—	ca. 76.0	—
217	Both	28.0	19.8	10.0(×2)	70.8	17.8
„	Right	30.0	23.0	5.0	76.8	16.7
Average		20.1	15.0	3.7	74.7	18.9

Remarks:—MAKIYAMA (1934, p. 152) first assigned *Venus furtiva* YOKOYAMA to the genus *Liocyma* which now inhabits cold northern waters. A detailed remark and discussion about the species and its affinities are given by MAKIYAMA (op. cit.). *Liocyma furtiva* is one of the most abundant species in the Asagai formation in the Futaba district.

Occurrence:—

1) Osaka, Kido, Naraha-machi. Common. Coll. No. 210.
2) Tadanosaku, Shimokitaba, Hirono-machi. Rare. Coll. No. 211.
3) Doggameki, Hirono-machi. Abundant. Coll. No. 212.
4) West of Tate, Hirono-machi. Rare. Coll. No. 213.
5) Oyamada, Ohisa-mura. Abundant. Coll. No. 214.
6) Tsuzura, Uchigo City. Rare. Coll. No. 215.
7) In the pit of Chuo-ko, north of Kubota, Nakoso City. Few. Coll. No. 217.

(All localities are in the Asagai formation.)

Liocyma terrena (YOKOYAMA, 1924)

Pl. 13, Figs. 8, 9

1924 *Venus terrena* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 15, pl. 2, fig. 19.

1934 *Liocyma terrera* (YOKOYAMA), MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 10, no. 2, art. 6, p. 153, pl. 6, fig. 44.

1955 *Liocyma terrera* (YOKOYAMA), HIRAYAMA, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 103, pl. 3, figs. 15, 16, 17.

Type data:—Syntypes are in the Geological Institute, University of Tokyo.

Type locality:—Tengasawa, Oyamada, Ohisa-mura (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
216	Both	23.0	15.0	6.5(×2)	65.2	14.1
„	Right	23.0	14.0	—	61.0	—
Average		23.0	14.5	6.5(×2)	63.1	14.1

Remarks:—As already pointed out by YOKOYAMA and MAKIYAMA, *L. terrena* is closely related to *L. furtiva* from the same formation. Compared with the latter species, the present one is characterized by its longer and more inequilateral shell possessing an obliquely posterior truncation. While *L. furtiva* is dominant in the Asagai formation in the Joban coal-field, *L. terrena* scarcely occurs from this formation.

Occurrence:—Doggameki, Hirono-machi. Asagai formation. Few. Coll. No. 216.

Genus *Nipponomarcia* IKEBE, 1941

Nipponomarcia IKEBE, Venus, Vol. 11, nos. 2-3, p. 50, 1941.

Type species (by monotypy), *Katelysia* (*Nipponomarcia*) *nakamurai* IKEBE, 1941. Sendani, Ayugawa, Shiga Prefecture, Japan, Miocene.

Shell small, thick, like *Eumarcia*; hinge as *Katelysia* (s.s.); while in general outline, in characters of surface and pallial sinus nearer akin to *Eumarcia*. (IKEBE)

Nipponomarcia nakamurai (IKEBE, 1941)

Pl. 13, Figs. 10-12

1931 *Pitar*(?) sp. KURODA, in HOMMA's Geol. Central Shinano, Pt. 4, p. 57, text-fig. 5 (*fide* IKEBE, 1941).

1941 *Katelysia* (*Nipponomarcia*) *nakamurai* IKEBE, Venus, Vol. 11, nos. 2-3, p. 50, pl. 2, figs. 1-8.

1956 *Nipponomarcia nakamurai* IKEBE, ITOIGAWA, Mem. Coll. Sci., Univ. Kyoto, Ser. B, Vol. 23, no. 2, p. 182, pl. 1, figs. 4, 5.

Type data:—Holotype and paratypes are in the Geological and Mineralogical Institute, Kyoto University.

Type locality:—Sendani, Ayugawa, Tsuchiyama-machi, Koga-gun, Shiga Prefecture. Miocene Ayugawa formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
262	Both	14.0	10.5	6.0(×2)	75.0	21.4
„	Right	13.6	10.0	3.6	73.6	26.4
„	Left	13.5	9.5	3.4	70.5	25.2
„	Both	13.0	9.2	5.8(×2)	70.7	22.3
„	Left	13.0	8.5	3.5	65.4	27.0
„	Left	11.5	8.2	3.4	71.3	29.0
„	Right	11.0	7.8	3.2	71.0	29.1
Average		12.8	9.1	3.3	71.1	25.9

Remarks:—*Nipponomarcia nakamurai* is characterized by the small-sized shell with the truncated posterior end and the quadrate short pallial sinus. The specimens from the Joban coal-field are safely referable to the named species by the possessing of the above-mentioned features.

This species is recorded from the Ayugawa, Tsuzuki, Awa and Togari formations and said to be restricted in the Setouchi province of the Miocene age (IKEBE, 1941, 1957), except from the Tertiary of Shinano reported by KURODA (1931) under the unnamed species of *Pitar* (?). The occurrence from the Joban coal-field is exceptional, being far from the Setouchi province, however, the associated molluscan fauna of this species from both areas are closely similar with one another.

Occurrence:—Hirosaku, Kamiyamada, Nakoso City. Kunugidaira formation. Very abundant. Coll. No. 262.

Genus *Clementia* GRAY, 1842

Clementia GRAY, Synop. Cont. Brit. Mus., Ed. 44, p. 75, 1842 (genus without species), *fide* WOODRING, 1926; Proc. Zool. Soc. London, pt. 15, p. 184, 1847.

Type species (by original designation), *Venus papyracea* GRAY, 1825, Recent, Australia.

Subgenus *Clementia* s. str.

Clementia (*Clementia*) *nakosoensis* KAMADA, n. sp.

Pl. 13, Figs. 15a, b

1925 *Clementia speciosa* YOKOYAMA, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 21, pl. 1, fig. 6 (non YOKOYAMA, 1923=*Clementia vatheleti* MABILLE, 1901).

1944 *Clementia papyracea* (GRAY), OYAMA and SAKA, Bull. Sigenkagaku Kenkyusyo, Vol. 1, no. 2, p. 141, pl. 15, figs. 15a, b, 16.

1952 *Clementia nakosoensis* HATAI and NISIYAMA, Sci. Rep., Tohoku Univ. 2nd Ser Spec. Vol., No. 3, p. 46 (nom. nud.).

Shell moderate sized for genus, oval and well inflated; test thin and fragile. Anterior dorsal margin almost straight or slightly concave, short and decending into rounded anterior margin; ventral margin regularly arcuated; posterior dorsal margin nearly straight or slightly arched, long and subparallel with anterior ventral margin. Lunule ill-defined; escutcheon elongately lanceolate, its length almost coincide with posterior dorsal margin and forming V-shaped valley. Beaks pointed and incurved forward. Surface sculptured by concentric feeble threads associated with irregular concentric wavy undulations becoming conspicuous on umbonal region. Inner margin entire. Pallial sinus triangular, ascending but not reaching to center of shell. Hinge teeth cannot be observed.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
IGPS 79385	Both	35.0	30.0	21.0(×2)	85.8	30.0
„	Both	32.0	27.0	18.0(×2)	84.4	28.2
„	Both	29.0	26.5	17.8(×2)	91.5	30.7
„	Right	34.0	29.0	9.0	85.3	26.4
Average		32.5	28.1	9.3	86.5	28.8

Remarks:—YOKOYAMA (1925) once referred the Joban specimens of *Clementia* to his *C. speciosa* YOKOYAMA (1923) which was originally described from the Pliocene Dainichi sand of the Kakegawa group in Shizuoka Prefecture. Subsequently, MAKIYAMA (1927, p. 45) stated that *C. speciosa* is synonymous with *C. vatheleti* MABILLE. Because of the differences between from the Dainichi and from the Joban coal-field, HATAI and NISIYAMA (1952, p. 46) proposed a new name, *nakosoensis*, for YOKOYAMA's *speciosa* from the Joban coal-field, but gave no description or remarks at that time.

The present new species closely resembles the living *Clementia vatheleti* MABILLE in many respects, but the present fossil species is smaller in size and more rounded in outline than the living one. It is easily distinguishable from *Clementia dariena* (CONRAD) from the middle Miocene Gatun formation and its equivalents in tropical America, which was described and figured by WOODRING (1926), by the smaller shell and weaker concentric waves on the shell surface.

The fossil *Clementia papyracea* (GRAY) was described and figured by OYAMA and SAKA (1944, p. 141, pl. 15, fig. 15a, b, 16) from the Miocene Tsukiyoshi formation in Gifu Prefecture. The Tsukiyoshi *Clemetia* seems to be closely related to *C. nakosoensis* rather than to the typical living *C. papyracea* from the Philippine Islands and East Indies.

Occurrence:—

1) Kokozura, Nakoso City (Type locality). Kokozura formation. Common. IGPS Coll. Cat. No. 79385.

2) Between Niida and Shimoyamada, Ueda-machi, Nakoso City (YOKOYAMA).

Genus *Compsomyax* STEWART, 1930

Compsomyax STEWART, Acad. Nat. Sci. Phila., Spec. Publ. No. 3, p. 224.

Type species (by original designation), *Saxidomus gibbosus* GABB, 1869= *Clementia subdiaphana* CARPENTER, 1864. Recent, Puget Sound.

Compsomyax iizukai (YOKOYAMA, 1925)

Pl. 13, Figs. 13, 14, 16

1925 *Meretrix iizukai* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 7, p. 20-21, pl. 3, figs. 2, 3.

1934 *Clementia* (*Compsomyax*) aff. *subdiaphana* CARPENTER, OTUKA, Bull. Earthq. Res. Inst., Vol. 12, pt. 3, p. 617, p. 48, fig. 42.

?1934 *Clementia* (*Compsomyax*) *subdiaphana yazawaensis* OTUKA, *Ibid.*, p. 617, pl. 49, figs. 64a, b.

1940 *Clementia* (*Compsomyax*) *iizukai* (YOKOYAMA), NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 19, p. 13-16, pl. 1, figs. 1-7.

Type data:—Syntypes are in the Geological Institute, University of Tokyo.

Type locality:—Sea cliff at Izura, Otsu-machi, Kitaibaraki City (Joban coal-field). Miocene Kokozura formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
117	Both	72.0	60.0	38.5(×2)	83.2	26.8
„	Left	63.0	55.0	16.0	87.3	25.4
„	Left	59.0	48.0	—	81.3	—
„	Both	56.0	50.0	31.0(×2)	89.3	27.7
„	Both	56.0	46.5	30.0(×2)	83.0	26.6
119	Both	35.0	31.0	17.8(×2)	88.6	25.4
Average		56.8	48.4	14.9	85.5	26.3

Remarks:—The present species is characteristic in the Kokozura formation, especially occurring abundantly at the type locality of Izura. YOKOYAMA (1925) originally assigned this species to the genus *Meretrix*, but NOMURA (1940) subsequently referred it to the genus *Clementia* and its subgenus *Compsomyax*. As already mentioned by STEWART (1930, p. 226), *C.* (*C.*) *iizukai* is closely related to the living as well as fossil *C.* (*C.*) *subdiaphana* CARPENTER, the subgenotypic species of *Compsomyax*, from western North America. Nomura gave the supplementary description in detail about the hinge plate of this species based on the specimens from the sea-cliff at Izura, and stated that *iizukai* appears to be scarcely distinct from *subdiaphana*, although it has a larger size, with more or less narrower and a trifle less ascending pallial sinus.

OTUKA (1934) recorded the occurrence of *C.* (*C.*) aff. *subdiaphana* and described *C.* (*C.*) *subdiaphana yazawaensis* OTUKA from the Miocene Kadonosawa group in the Fukuoka district of Iwate Prefecture. According to the reexamination of OTUKA's figure (Pl. 48, fig. 42) and the subsequently collected specimens from the Shiratori formation at Yuda and Tate in the same district, *C.* (*C.*) aff. *subdiaphana* of OTUKA seems to be conspecific with *C. iizukai*, although the Fukuoka specimens possess more or less thinner test than the Joban ones from the sea-cliff at Izura. Both forms from the Joban and the Fukuoka districts have more convex and more regular rounded ventral margin than the American *subdiaphana*. Because of the ill-state of preservation of *C.* (*C.*) *subdiaphana yazawaensis* OTUKA, its precise determination as to whether it is a distinct taxonomic unit is not clear, however, it seems to be closely related to *iizukai*.

The stratigraphical and geographical distribution of the present species in the Joban coal-field, as already hbeen discussed by NOMURA (1940) and also by YABE (1949). As far as known at present, *C.* (*C.*) *iizukai* (YOKOYAMA) is restricted in its occurrence to the Kokozura and Numanouchi formations stratigraphically and in the Nakoso and Yumoto districts geographically.

Occurrence:—

1) Sea-cliff at Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Abundant. Coll. No. 117.

2) Kokozura, Nakoso City. Kokozura formation. Rare. Coll. No. 118.

3) Sea-cliff at Hamamachi, Toyoma-machi, Taira City. Numanouchi formation. Rare. Coll. No. 119.

Family MACTRIDAE

Genus *Mactra* LINNÉ, 1767

Mactra LINNÉ, Syst. Nat., Ed. 12, p. 1125, 1767.

Type species (by subsequent designation, GRAY, 1847), *Mactra stultorum* (LINNÉ)=*Cardium stultorum* LINNÉ, 1758. Recent, European seas.

Mactra squalida (YOKOYAMA, 1924)

Pl. 14, Fig. 3

1924 *Cardium* (*Laevicardium*) *squalidum* YOKOYAMA, Jour. Coll., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 16, pl. 3, fig. 1.

1952 *Serripes squalidum* (YOKOYAMA), HATAI and NISIYAMA, Sci. Rep., Tohoku Univ., 2nd Ser., Spec. Vol., No. 3, p. 42.

Type data:—Lectotype is in the Geological Institute, University of Tokyo.

Type locality:—Dodaira, Misawa, Nakoso City (Joban coal-field). Oligocene Iwaki formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
269	Right	38	35	11.5	92	32.9

Remarks:—The present species was originally described by YOKOYAMA under the generic name of *Cardium* (*Laevicardium*) and compared with *Cardium pauperculum* YOKOYAMA (1923, p. 6, pl. 1, fig. 2) from the Miocene of Izumo Province, Shimane Prefecture. Recently, HATAI and NISIYAMA considered the latter species to belong to the genus *Serripes* and *squalidum* was referred to the same genus. However, by the observations of the new materials from the Iwaki formation and YOKOYAMA's original description and figure, the writer considers that the present species may by belong to *Mactra* and can be comparable with the living *Mactra veneriformis* REEVE.

A right valve collected from the Kuroda basin is examined. Surface smooth except for periodical concentric rude lines of growth without radial striations. A blunt ridge extends from the beak to the postero-ventral corner. Pallial sinus shallow as characteristic as seen in *M. veneriformis*.

The present species is distinguishable from *veneriformis* by having more orbicular in outline and less angulated postero-ventral corner.

Occurrence:—Karasawa in the Kuroda basin, Tabito-mura. Iwaki formation. Rare. Coll. No. 269.

Mactra nakayamaensis KAMADA, n. sp.

Pl. 14, Figs. 1, 2

1925 *Mactra spectabilis* LISCHKE, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 17, pl. 1, figs. 7, 8 (non LISCHKE, 1871).

Shell moderate sized, thin, somewhat inflated, trigonal, nearly equilateral. Anterior dorsal margin almost straight and passing into obliquely truncated anterior end, forming a broadly obtuse angle; posterior dorsal margin broadly arched and turns to steeply inclined truncated posterior end; ventral margin regularly rounded. Umbo somewhat projected; beak pointed and incurved. Surface smooth but ornamented with periodic concentric striations of growth. Pallial sinus rather deep and rounded in its extremity.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
IGPS 79386*	Right	62	47	13.5	76.0	21.8
„	Right	64	52	13	81.3	20.3
277	Left	70	58	17	83.0	24.3
„	Left	61	49	13	80.4	21.3
„	Left	42	36	11	85.7	25.2
278	Left	56	41	14	73.2	25.5
279	Left	46	36	13	78.4	28.3
Average		57.3	45.5	13.5	79.7	24.4

*Holotype

Remarks:—The present new species is closely related to *Mactra sulcataria* REEVE, a common living species in the temperate waters of Japan, but differs therefrom by the less development of concentric undulations on the surface and by having deeper pallial sinus. Compared with *Mactra haboroensis* YOKOYAMA (1927, p. 198-199, pl. 52, figs. 3, 4) from the Haboro coal-field in Hokkaido, *M. nakayamaensis* is easily distinguishable by having a transversely longer shell.

Occurrence:—

1) West of Tatsuzawa, Iino, Taira City (Type locality). Nakayama formation. Common. IGPS Coll. Cat. No. 79386.

2) Nakayama, Iino, Taira City. Nakayama formation. Abundant.

3) Southern sea-cliff of Cape Shioya-misaki, Toyoma-machi, Taira City. Nakayama formation. Common. Coll. No. 277.

4) Numanouchi habor, Toyoma-machi, Taira City. Numanouchi formation. Few. Coll. No. 278.

5) Kogaya-no-tsutsumi, Takaku, Taira City. Numanouchi formation. Common. Coll. No. 279.

6) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. (YOKOYAMA, 1925)

Genus *Spisula* GRAY, 1837

Spisula GRAY, London's Mag. Nat. Hist., New Series, Vol. 1, p. 372, 1837.

Type species (by subsequent designation, GRAY, 1847), *Cardium solida* LINNÉ, 1758.

Subgenus *Mactromeris* CONRAD, 1868

Mactromeris CONRAD, "Cat. Mactridae," Amer. Jour. Conch., Vol. 3, Appendix, p. 45, 1868.

Type species (by subsequent designation, DALL, 1898), *Mactra polynyma* STIMPSON, 1860. Recent, Hudson's Bay south to Massachusetts and (?) Long Island, New York.

Spisula (*Mactromeris*) *nagakoensis* HATAI and NISIYAMA, 1949

Pl. 14, Figs. 5, 6

1949 *Spisula ploynyma nagakoensis* HATAI and NISIYAMA, Jour. Paleont., Vol. 23, no. 1, p. 92, pl. 24, fig. 18.

Type data:—IGPS Coll. Cat. No. 72506 (Holotype).

Type locality:—Small exposure in drainage west of Nagako, Nishiki-machi, Nakoso City (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
270	Left	69	52	14	75.5	21.5
„	Left	58	47	12	81.2	20.7
271	Left	59.5	47	12	79.0	20.2
272	Left	71.0	53.5	10.2	75.4	14.4
„	Right	69.0	57.0	11.8	82.6	15.7
„	Right	76.0	55.5	12.5	73.0	16.5
„	Left	56.0	43.5	8.5	77.6	15.2
„	Right	43.6	33.3	6.0	76.4	13.7
273	Left	68	58	8.5	85.4	12.5
„	Right	69	52	9.0	75.4	13.0
„	Right	63	49	—	77.8	—
274	Left	63	54	10	85.8	15.9
275	Right	60	48	10.5	80.2	17.5
„	Right	55.5	ca. 45	8	ca. 18	14.4
Average		62.9	49.6	10.2	79.0	16.2

Remarks:—HATAI and NISIYAMA described the present species as a subspecies of *Spisula polynyma* STIMPSON and compared it with *S. voyi* (GABB). NOMURA (1933, 1937) and TAKI and OYAMA (1954) considered that *S. voyi* is a distinct species and is not a subspecies of *polynyma*. *S. polynyma* is an Atlantic species while *S. voyi* is distributed along the west coast of North America, from the Arctic Ocean at Cape Lisburne south-eastward to Puget Sound, north Japan, the Kurile Islands and the Okhotsk Sea in the northern Pacific region. In Japan *S. voyi* is one element of the cold Oyashio current fauna, ranging from Onahama, Iwaki City (NOMURA and SUMITA, 1933) and Soma City (KOTAKA, KAMADA and HAYASAKA, 1955) both in Fukushima Prefecture to further north along the Pacific coast of North Japan.

S. voyi was first described by GABB (1866) based on a fossil specimens from the Pliocene middle Wildcat formation in Humboldt County (near Humboldt Bay below Bear River) under the generic name as *Callista*.

The Japanese living *S. voyi* of authors seems to be somewhat different from GABB's type specimen figured by STEWART (1930, pl. 15, fig. 6), especially the posterior portion of the former is much shorter than the type. HATAI and NISIYAMA (1949) mentioned that the present species differs from *S. voyi* from the adjacent seas of Hokkaido which was figured by KINOSHITA and ISAHAYA (1934, pl. 14, fig. 102) by the shorter antero-dorsal border and more incurved umbonal region. In spite of the different forms of *S. voyi* from both sides of the Pacific Ocean, the fossil *S. nakosoensis* is a distinct species and differs from the type of *S. voyi* by the more triangular shell outline. For such reason it is considered to be of specific rank.

Spisula (*Mactromeris*) *nagakoensis* was originally reported from the Asagai formation in the Nakoso district and the writer also collected it from the en-

virons of the type locality and the same horizon. In the Agagai formation, the present species is distributed from the type locality in the north to Hanakawa-machi, Kitaibaraki City in the south. While in the Yumoto district, the present species could not be discovered from the Asagai formation, but is commonly found from the underlying Iwaki formation and is especially restricted to its basal part.

Occurrence:—

1) In the Chuoko colliery, south of Nagako, Nishiki-machi, Nakoso City. Asagai formation. Few. Coll. No. 270.

2) Kamiozuta, Hanakawa, Kitaibaraki City. Asagai formation. Few. Coll. No. 271.

3) Yoshima Coal-mine, Yoshima-mura. Iwaki formation. Abundant. Coll. No. 272.

4) Sumiyoshi colliery, Joban Coal-mine, Uchigo City. Iwaki formation. Common. Coll. No. 273.

5) Yumoto colliery, Joban Coal-mine, Yumoto-machi, Joban City. Iwaki formation. Common. Coll. No. 274.

6) Kashima colliery, Joban Coal-mine, Mizunoya, Joban City. Iwaki formation. Few. Coll. No. 275.

Family SANGUINOLARIIDAE

Genus *Soletellina* BLAINVILLE, 1824

Soletellina BLAINVILLE, Dict. Sci. Nat., No. 32, p. 350, 1824.

Type species (Subsequent designation by GRAY, 1847), *Solen diphos* GMELIN. Recent.

Soletellina minoensis YOKOYAMA, 1926

Pl. 14, Fig. 7

1926 *Soletellina minoensis* YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 1, pt. 7, p. 221, pl. 28, figs. 13–16.

1934 *Sanguinolaria* (*Soletellina*) *minoensis* (YOKOYAMA), OTUKA, Bull. Earthq. Res. Inst., Vol. 12, pt. 3, p. 619, pl. 49, figs. 65a, b.

1944 *Sanguinolaria* (*Soletellina*) *minoensis* (YOKOYAMA), OYAMA and SAKA, Bull. Sigenkagaku Kenkyusyo, Vol. 1, no. 2, p. 141, pl. 15, figs. 17–18.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
130	Right	62.5	34.0	—	54.4	—
131	Right	50.0	31	—	62.0	—
132	Right	65	33	—	50.8	—
„	Left	54	31	—	57.5	—
133	Both	54	31	15.3	57.5	28.1
Average		57.1	32	—	56.4	—

Remarks.—*Soletellina minoensis* was originally described by YOKOYAMA based on the specimens from the Miocene deposits at Tsukiyoshi, Mizunami City, Gifu Prefecture. The Joban specimens referred to the named species is hardly distinguishable from the Tsukiyoshi ones. The largest specimens at hand attains about 65 mm. in length being similar to YOKOYAMA's description.

Occurrence:—

1) Minamimae, Sekinami, Kitaibaraki City. Kunugidaira formation. Few. Coll. No. 130 and 177.

2) Hirosaku, Kamiyamada, Nakoso City. Kunugidaira formation. Common. Coll. No. 132.

3) Izumisaki, Kusano, Taira City. Nakayama formation. Few. Coll. No. 131.

4) Kano, Miyamada, Tono-machi. Nakayama formation. Few. Coll. No. 133.

Genus *Nuttallia* DALL, 1898

Nuttallia DALL, Proc. Acad. Nat. Sci. Phila., p. 58, 1898.

Type species (by monotypy), *Sanguinolaria nuttallii* CONRAD, 1837. Recent, San Diego, California.

Nuttallia uchigoensis KAMADA, n, sp.

Pl. 14, Figs. 4a, b

Shell large, very thin, elongate ovate or sub-elliptical, much compressed, subequilateral, inequivalve, left valve more swollen than right. Anterior dorsal margin slightly convex and gently sloping downwards to rounded anterior end without any angulation; ventral margin broadly arcuated; posterior dorsal margin nearly straight, sloping downward making with obtuse angle about 150° to anterior dorsal margin; posterior end somewhat narrowed and subtruncated almost vertically. Beaks subcentral and small. Surface nearly smooth but with indistinct concentric undulations of growth. Adductor muscle scars large, subequal; pallial sinus shallow, and not reaching center of shell.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
IGPS 79387	Both	81.0	53.6	21.5	66.2	26.5
136	Both	75.0	50.0	18.5	66.7	24.7
Average		78.0	51.8	20.0	66.5	25.6

Remarks:—The present new species is characterized by its inequivalve and transversely elliptical form. It is easily distinguishable from the living species from the Japanese seas, such as *N. olivacea* (JAY), *N. japonica* (REEVE) and *N. solida* KIRA which were treated and figured by KIRA (1953), by the mentioned characteristic features. *Psammobia commoda* YOKOYAMA (1925d, p. 12, pl. 3, fig. 2) from the Pliocene Shigarami formation in Nagano Prefecture, which was subsequently refigured by KURODA (1931, p. 61, pl. 7, fig. 47) under the generic name of *Sanguinolaria* (*Nuttallia*) is one of the most allied species to the present new one. MAKIYAMA (1958, pl. 27, fig. 2) assigned *commoda* to the subspecies of *S.* (*N.*) *petri* BARTSCH (1929, p. 133, pl. 3, three views) from the Gulf of Peter the Great, off Vladiovostok. *N. uchigoensis* differs from *commoda* and also from *petri* by the central position of the beaks. It is considered that *uchigoensis* may be an ancestoral species of both the Pliocene *commoda* and the living *petri*. *N. nuttallii* (CONRAD) from the California coast, figured by OLDROYD (1924, p. 185, pl. 55, figs. 1, 4) possess a more roundly ovate and higher shell than ours.

Occurrence:—

1) Goten, Uchigo City (Type locality). Asagai formation. Rare. IGPS Coll. Cat. No. 79387.

2) Hannukizawa, Yoshima-mura Asagai formation. Rare. Coll. No. 136.

Family TELLINIDAE

Genus *Macoma* LEACH, 1819

Macoma LEACH, in ROSS's Voy. Discovery in H. M. S. Isabella & Alexander, Appendix 2, p. lxii, 1819; Jour. de Physique, Vol. 88, p. 465, 1819.

Type species (by monotypy), *Macoma tenera* LEACH, 1819=*Tellina calcarea* GMELIN, 1791. Recent, northern seas of Europe and North America.

Macoma optiva (YOKOYAMA, 1923)

Pl. 15, Figs. 1-6

1923 *Tellina optiva* YOKOYAMA, Jap. Jour. Geol. Geogr., Vol. 2, no. 1, p. 6, pl. 2, figs. 3, 4.

1925 *Tellina optiva* YOKOYAMA, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 19.

1925 *Macoma dissimililis* (MARTENS), YOKOYAMA, *Ibid.*, p. 20, pl. 5, fig. 9 (non DESHAYES nor *Macoma tokyoensis* MAKIYAMA, 1927).

1925 *Tellina optiva* YOKOYAMA, YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, Vol. 1, pt. 3, p. 118, pl. 15, figs. 4, 5.
1926 *Tellina optiva* YOKOYAMA, YOKOYAMA, *Ibid.*, Vol. 1, pt. 7, p. 242, pl. 30, fig. 2.
1929 *Macoma dissimilis* (MARTENS), YOKOYAMA, *Ibid.*, Vol. 2, pt. 9, p. 388, pl. 74, fig. 2 (*fide* OTUKA, 1934, p. 619; non *Macoma tokyoensis* MAKIYAMA, 1927).
1934 *Macoma optiva* (YOKOYAMA), OTUKA, Bull. Earthq. Res. Inst., Vol. 12, pt. 3, p. 619, pl. 48, fig. 51.
1935 *Macoma optiva* (YOKOYAMA), NOMURA, Sci. Rep. Tohoku Imp. Univ., 2nd Ser., Vol. 18, no. 1, p. 36, pl. 4, figs. 4, 12.
1940 *Macoma optiva* (YOKOYAMA), OTUKA, Jap. Jour. Geol. Geogr., Vol. 17, nos. 1-2, p. 97, text-figs. c.

Type data:—Lectotype (YOKOYAMA, 1923, pl. 2, fig. 3) is in the Geological Institute, University of Tokyo.

Type locality:—Fujina, Tamayu-mura, Yatsuka-gun, Shimane Prefecture. Miocene Fujina formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
185	Both	71	54	25 (×2)	76.0	17.6
186	Both	45.0	36.3	15.8(×2)	80.6	17.9
„	Both	44.0	35.0	14.0(×2)	79.6	15.9
„	Both	46.2	39.5	ca. 18.0(×2)	85.6	ca. 19.5
„	Both	46.5	36.0	ca. 13 (×2)	77.6	ca. 14.0
„	Both	35.0	31.0	11.5(×2)	88.7	16.4
187	Both	35.0	26.0	9.6(×2)	74.4	13.7
188	Both (Cast)	53	41	18.2(×2)	77.5	17.2
„	Both (Cast)	51	43	19.0(×2)	84.3	18.6
191	Both	26.0	22.0	9.0(×2)	84.6	17.3
Average		45.3	36.4	15.3(×2)	80.9	16.8

Supplementary description:—The following description is based on a well-preserved specimen from the Numanouchi formation at Numanouchi, Taira City in the Yumoto district.

Shell of large size, compressed, somewhat ventricose, roundly trigonal in outline, beaks nearly central and touching each other. More or less inequivalve; the left valve more swollen than the right and posterior extremity flexed to the right but not strong. Anterior margin regularly rounded, ventral margin broadly arched or nearly straight and gently ascending to behind, posterior dorsal margin almost straight and sloping downward and passing into obliquely subtruncated posterior end. Surface sculptured with inconspicuous incremental lines of growth. Inner rib-like ridge narrow, low, flat-topped and running just behind anterior muscle scar in each valve. Apex of pallial sinus of left valve reaching to this ridge.

Remarks:—The above-mentioned specimen from the Numanouchi formation completely coincides with the types from Izumo, Shimane Prefecture, not

only in outline but also the shapes of the pallial sinus. The average size of the other referred specimens in the present collection from various localities in the Joban coal-field is quite variable. The largest specimen is more than 70 mm. in length and occurred from the Numanouchi formation. From Kokozura, the largest one in the Kokozura formation is about 46 mm. in length and the average of ten individuals is calculated to be only 35.8 mm. In the example in the Honya formation at Ena, Iwaki City, the largest specimen in 36 mm. in length and the average of five specimens is 33.4 mm. OTUKA (1934) already stated the similar phenomena that the specimens of *M. optiva* from the Upper Kadonosawa series are generally small in size, but those from the Lower Kadonosawa series are large. A specimen from Kokozura figured by YOKOYAMA (1925, pl. 5, fig. 9) under the name of *Tellina dissimilis* MARTENS also can be identified to the named species by the comparison with the specimens at hand from the same locality. It is not *Macoma tokyoensis* MAKIYAMA as referred to by HATAI and NISIYAMA (1952, p. 81) and also by MAKIYAMA (1957, pl. 20, fig. 9). *M. optiva* is distinguished from *M. tokyoensis* by possessing a more rounded shell and the less flexvosity of the posterior extremity.

Occurrence:—

1) Numanouchi, Toyoma-machi, Taira City. Numanouchi formation. Rare. Coll. No. 185.

2) Kokozura, Nakoso City. Kokozura formation. Abundant. Coll. No. 186.

3) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Coll. No. 187.

4) Tozenji, Yunami, Kitaibaraki City. Kokozura formation. Few. Coll. No. 196.

5) Minamimae, Sekinami, Kitaibaraki City. Kokozura formation. Coll. No. 188.

6) Kamimae, Toyoma-machi, Taira City. Honya formation. Rare. Coll. No. 189.

7) Ena, Ena-machi, Iwaki City. Honya formation. Common. Coll. No. 191.

8) Shioyamisaki, Toyoma-machi, Taira City. Nakayama formation. Few. Coll. No. 190.

9) Yagawase, Taira City. Honya formation. Rare. Coll. No. 192.

Macoma sejugata (YOKOYAMA, 1924)

Pl. 16, Figs. 1-5

1924 *Tellina sejugata* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 14, pl. 2, figs. 9, 10, 11.

1934 *Macoma sejugata* (YOKOYAMA), MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 10, no. 2, art. 6, p. 155, pl. 4, fig. 18.

1934 *Macoma asagaiensis* MAKIYAMA, *Ibid.* p. 155, pl. 4, figs. 15, 16, 19.

1955 *Macoma asagaiensis* MAKIYAMA, HIRAYAMA, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 104, pl. 3, figs. 4-11.

1955 *Macoma* cf. *sejugata* (YOKOYAMA), HIRAYAMA, *Ibid.* p. 105.

Type data:—A single specimen with both valves perfect (lectotype) is in the Geological Institute, University of Tokyo.

Type locality:—Bessho, Iwasaki, Joban City (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
202	Both	32.0	24.0	10.0(×2)	75.0	15.6
„	Both	27.3	19.0	8.0(×2)	69.6	14.6
„	Both	27.0	20.0	7.2(×2)	74.1	13.4
„	Both	21.3	15.4	6.6(×2)	72.3	15.4
203	Both	22.0	17.0	5.6(×2)	77.3	12.7
204	Both	26.0	20.0	6.8(×2)	77.0	13.1
205	Both	31.0	23.0	—	74.2	—
„	Both	32.0	25.0	7.0(×2)	78.2	11.9
„	Left	26.0	19.5	—	75.0	—
„	Right	23.0	17.5	—	76.2	—
„	Both	20.0	15.8	5.0(×2)	79.0	12.5
206	Both	29.0	18.0	7.0(×2)	61.1	12.1
„	Both	30.0	22.0	—	73.5	—
207	Left	35.0	27.0	—	77.2	—
„	Right	34.0	24.0	—	70.6	—
208	Right	28.0	20.0	—	71.5	—
Average		27.7	20.5	7.0(×2)	73.9	13.5

Remarks:—Although YOKOYAMA described the present species under the generic name of *Tellina*, MAKIYAMA subsequently pointed out that it is a *Macoma* and not a *Tellina*, because of no lateral tooth. The lectotype from Bessho in Joban City is roundly rectangular in outline and its height is 68.6 per cent of the shell length, while the referred specimen from Matchgar in North Sakhalin figured by MAKIYAMA (1934, pl. 4, fig. 18) is a low shell and somewhat seems to be transversely elongated and trigonal in outline, although the ratio of the height to length is 65.6 per cent and its valve is nearly those of the lectotype. Besides, MAKIYAMA also described *Macoma asagaiensis* from the Asagai formation, which is characterized by the more rounded anterior margin and the narrower posterior end than *sejugata*. The result of the examination on the several specimens at hand shows that there is a considerable variation of the shell form of *Macoma* from the Asagai formation in the Yumoto and Futaba districts. The intermediate forms between the typical form of *sejugata* figured by YOKOYAMA and *asagaiensis* by MAKIYAMA are in the collection at hand. Therefore, *M. asagaiensis* is considered as a synonym of *sejugata*. However, the shell outline figured by MAKIYAMA and

also by HIRAYAMA under the name of *asagaiensis* is the most predominant type in the Asagai formation.

Occurrence:—All localities are in the Asagai formation.

1) Shimokitaba, Hirono-machi. Common. Coll. No. 202.
2) Doggameki, Hirono-machi. Common. Coll. No. 203.
3) Takasaka, Uchigo City. Few. Coll. No. 204.
4) Omachi shaft, Joban Coal-mine, Uchigo City. Common. Coll. No. 205.
5) Arakawa shaft, Joban Coal-mine, Taira City. Common. Coll. No. 206.
6) Mukida, Yumoto-machi, Joban City. Common. Coll. No. 207.
7) Bessho, Iwasaki, Joban City. Few. Coll. No. 208.

Macoma izurensis (YOKOYAMA, 1925)

Pl. 15, Figs. 7-9

1925 *Tellina izurensis* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 19, pl. 2, fig. 12.

Non 1927 *Tellina izurensis* YOKOYAMA, YOKOYAMA, Jour. Fac. Sci., Univ. Tokyo, Sec. 2, pt. 4, p. 200, pl. 52, figs. 1, 2 (=*Macoma optiva* (YOKOYAMA), 1923 *fide* HATAI and NISIYAMA, 1952, p. 140).

Type data:—Lectotype (left valve) is in the Geological Institute, University of Tokyo.

Type locality:—Izura, Otsu-machi, Kitaibaraki City (Joban coal-field). Miocene Kokozura formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
193	Left	51.0	35.5	—	69.7	—
„	Both	49	35	13.5(×2)	71.5	13.8
„	Both	40	29.5	11.3(×2)	73.7	14.2
„	Both	40	30	12 (×2)	75.0	15.0
„	Both	38.5	28	8 (×2)	72.8	10.4
„	Both	36	28.5	8.2(×2)	74.0	11.4
194	Both	41.5	32	13 (×2)	77.2	15.7
„	Both	41	28	10.5(×2)	68.4	12.8
„	Both	39	28	12.3(×2)	71.8	15.8
195	Both	53	ca. 36	14 (×2)	ca. 68.0	13.2
Average		42.9	31.1	10.3(×2)	72.2	13.5

Remarks:—*Macoma izurensis* is closely related to the living *M. tokyoensis* MAKIYAMA figured by YOKOYAMA (1920, pl. 7, figs. 19, 20), but differs therefrom by the more transversely elongate outline, less flexuosity of the posterior extremity and more convex posterior dorsal margin. Compared with *M. optiva* (YOKOYAMA), the present species is characteristic by the lower and more com-

pressed shell.

Although the external shell of the lectotype of *M. izurensis* was not preserved, the new materials at hand have a thin and fragile shell on which the sculpture is of faint incremental lines of growth.

Occurrence:—

1) Kamikuramochi, Kashima, Iwaki City. Honya formation. Common. Coll. No. 193.

2) Igamesaku, Nagasaki, Ena-machi, Iwaki City. Honya formation. Common. Coll. No. 194.

3) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Few. Coll. No. 195.

4) Tozenji, Yunoami, Sekinami, Kitaibaraki City. Kokozura formation. Few. Coll. No. 197.

Genus *Peronidia* DALL, 1900

Peronidia Dall, Proc. U.S. Nat. Mus., Vol. 23, p. 291, 1900.

Type species (by original designation), *Tellina albicans* GMELIN.

Peronidia ochii KAMADA, n. sp.

Pl. 16, Figs. 6-8

1924 *Tellina alternata* var. *chibana* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3. p. 13, pl. 2, fig. 20.

1952 *Peronidia lutea* HATAI and NISIYAMA, Sci. Rep., Tohoku Univ. 2nd Ser., Spec. Vol., No. 3, p. 139.

Shell similar to *P. venulosa* (SCHRENCK) in outline, but with smaller, thinner and more compressed test. Beaks situated nearly central of the shell length. Anterior margin rounded, posterior margin somewhat rostrated and obliquely subtruncated posterior end. Posterior keel running from umbo to postero-ventral corner and area behind keel narrow and depressed. Surface nearly smooth and ornamented by faint concentric lines or periodic lines of growth but not elevated.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)
IGPS 79388*	Right	27	15.5	—	57.5
„	Left	—	22.4	—	—
336	Left	27.2	14.5	—	53.3
„	Left	26.0	12.5	—	48.2
339	Left	35	18	—	51.5
Average		28.8	16.6	—	52.6

* Holotype

Remarks:—YOKOYAMA (1924) stated that the present species is to be identified with his *Tellina alternata* var. *chibana* which was originally described based on the specimens from the Pleistocene deposits in the south Kwanto region. However, this variety is now assigned to *Peronidia lutea* (WOOD) by HABE (1952, p. 226) or to *Angulus* (*Peronidia*) *venulosa* (SCHRENCK) by TAKI and OYAMA (1954, pl. 30, figs. 5, 6). HATAI and NISIYAMA also considered YOKOYAMA's specimen from the Joban coal-field to be *P. lutea*. The writer inclined to consider that the Joban specimens belong to a distinct species which is just now described as new to science.

This new form is closely related to *P. venulosa* in many respects, but differs from this living species by having smaller and thinner shell and more faint concentric ornamentation in the adult specimens. The present species is also distinguishable from *Tellina umedairensis* SHIKAMA (1951) from the Oligocene Wada fromation in the south of Nagano Prefecture by having smaller shell and prominent anterior angulation.

YOKOYAMA's figured specimen is said to occur from Wariyama, Akai and from the Asagai Beds. However, the Asagai formation is not distributed in the Akai district which is formerly in Akai-mura and now of Taira City. According to S. TOKUNAGA (1927, p. 150) *Tellina alternata* SAY var. *chibana* YOKOYAMA was collected from the railroad cutting of Tamachi, Akai. Beside this variety *Natica, Turritella, Nassa, Solen, Pectunculus, Nucula* associated with the now considered specimens occured from the compact sandstone and shaly sandstone belonging to TOKUNAGA's "Ishiki Beds" that is the Iwaki formation. Inasmuch as all of YOKOYAMA's described specimens were collected by Dr. TOKUNAGA, the present specimens under consideration said to be from Akai are probably of the Iwaki formation. Therefore, the distribution of the present species is restricted to the Iwaki formation in the Yumoto district. However, this species also occurred from the Asagai formation in Nakoso district as stated in elsewhere of this article.

The new specific name is dedicated to Mr. Hideo ÔCHI, a mine-inspector of the Iwaki colliery of the Joban Coal-mining Company, for his kind aid to my investigation in the Joban coal-field.

Occurrence:—

1) Yumoto colliery, Joban Coal-mine, Yumoto-machi, Joban City (Type locality). Iwaki formation. Few. IGPS Coll. Cat. No. 79388.

2) Nagako, Nishiki-machi, Nakoso City. Asagai formation. Common. Coll. No. 336.

3) Chuoko, south of Nagako, Nishiki-machi, Nakoso City. Asagai formation. Rare. Coll. No. 339.

4) Wariyama, Akai, Taira City. Iwaki formation. Rare. (YOKOYAMA)

Order ADAPEDONTA

Family HIATELLIDAE (SAXICAVIDAE)

Genus *Panope* MENARD, 1807

Panope MENARD, Mémoire sur un Nouveau Genre de Coquille bivalve équival de la Famille des Solenoides, pp. 16, 30, 1807.

Type species (virtually by monotypy, designated by CHILDREN, 1823), *Panope aldrovandi* MÉNARD. Recent, Mediterranean Sea.

Panope nomurae KAMADA, n. sp.

Pl. 16, Figs. 9-12

1925 *Panope generosa* (GOULD), YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 16, pl. 6, fig. 6.

1934 *Panope japonica* A. ADAMS, OTUKA, Bull. Earthq. Res. Inst., Vol. 12, pt. 3, p. 620-621.

1935 *Panope japonica* (A. ADAMS), NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 222-223.

Shell resembles *Panope japonica* (A. ADAMS), but smaller and more transversely elongated in outline. Beaks orthogyrated and situated anterior at nearly two fifths of shell length. Surface ornamented with concentaic irregular rugose undulations. Nymphs not so heavy as in *Panope japonica*.

Dimensions:—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
225	Left	64.5	42.0	11.5	65.2	17.8
IGPS 79395*	Left	80.0	45.0	14.5	56.2	18.1
227	Right	77.0	49.0	ca. 11.0	63.7	ca. 41.3
228	Both	67.0	39.0	27.0(×2)	58.1	20.2
Average		72.1	43.8	12.6	60.8	17.6

* Holotype

Remarks:—In his investigation about the Tatsunokuchi molluscan fauna from the Pliocene Tatsunokuchi formation in Sendai, NOMURA (1938, p. 268) stated that "The Miocene specimens referred to *P. japonica* are invariably smaller and proportionally somewhat longer compared to those from the Pliocene and Pleistocene, as well as to the Recent forms from Japan.", but gave no specific or subspecific name for the Miocene forms. The conspicuous variations of the shape in *Panope japonica* (A. ADAMS) or *Panope generosa* GOULD were recognized by YOKOYAMA (1922, p. 121) and GRANT and GALE (1931, p. 424) respectively, however, the present new species is separate from the Recent species by the above-mentioned features. The well known species of *Panope japonica* is widely distributed in central to northern Japan (as *P. japonica*)

and along the west coast of North America from Puget Sound to San Diego (as *P. generosa*). The specific name of *generosa* seems to be preoccupied by *japonica* as frequently stated by Japanese authors. The full references and synonyms about *Panope japonica* up to 1935 was given by NOMURA (1935, p. 94-96).

Of the so-called *P. japonica*, the specimens from the Shiogama Miocene recorded by NOMURA (1935, p. 222) are probably referred to the present new species. The dimensions of the Shiogama specimens measured by NOMURA show that the maximum length is less than 100 millimeter and the average ratio of height to length of the shell is 59.4 per cent in six individuals, as similar in the case of the Joban specimens. The living *P. japonica*, as well as from the Pliocene Tatsunokuchi formation in Sendai, is commonly over 100 millimeter in the length of the shell.

Occurrence:—

1) Shimokajiro, Ena, Iwaki City. Nakayama formation. Rare. Coll. No. 225.

2) Numanouchi harbor, Toyoma-machi, Taira City (Type locality). Numanouchi formation. Rare. IGPS Coll. Cat. No. 79395.

3) Sea-cliff at Hamamachi, Toyoma-machi, Taira City. Numanouchi formation. Rare. Coll. No. 227.

4) Kokozura, Nakoso City. Kokozura formation. Rare. Coll. No. 228.

Genus *Panomya* GRAY, 1857

Panomya GRAY, Fig. Moll. Anim., Vol. 5, p. 29, pl. 346, fig. 1, 1857.

Type species (by monotypy), *Mya norvegica* SPENGLER, 1793. (non *M. norvegica* GMELIN, 1790). Recent, Northern Seas.

Panomya simotomensis OTUKA, 1934

Pl. 16, Fig. 13

1934 "*Panomya*" *simotomensis* OTUKA, Bull. Earthq. Res. Inst., Vol. 12, pt. 3, p. 621, pl. 49, figs. 66a, b.

1935 *Panomya simotomensis* OTUKA, NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 223, pl. 16, fig. 12.

1941 *Panomya simotomensis* OTUKA, OTUKA, Jour. Jap. Assoc. Petrol. Tech., Vol. 9, no. 2, p. 153, fig. 1 on p. 148.

Type data:—Holotype is in the Geological Institute, University of Tokyo.

Type locality:—Shimotome, Fukuoka-machi, Ninohe-gun, Iwate Prefecture. Suenomatsuyama Series.

Dimensions (in mm.):—

No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
174	Right	49.0	28.5	8.0	58.2	16.6
„	Both	40	31.0	15.0(×2)	77.5	18.7
175	Right	ca. 29.0	ca. 19.0	—	ca. 65.5	—
Average		39.3	26.2	7.8	67.1	17.7

Supplementary description:—The following descriptions are based on the specimens from Yunami, Sekinami, Kitabaraki City in the Kokozura formation.

Shell of moderate in size, thin, subquadrate, left valve somewhat larger than right, left umbonal region overlapped on right. Anterior margin rounded, posterior dorsal margin nearly horizontal, long, slightly arched, posterior end obliquely truncated, ventral margin nearly straight, subparallel with posterior dorsal one, slightly concave in somewhat front from midway corresponding with medial depression bounded by two radiating ridges. Beaks situated at anterior one third of shell length. Surface with concentric undulation.

Remarks:—The Joban specimens are safely identified with the type from the Ninohe district in Iwate Prefecture. Since OTUKA described the present species, NOMURA (1935) figured its left valve from the Shiogama district in Miyagi Prefecture from his Upper Shell-Beds (*Cultellus izumoensis* zone) and OTUKA (1941) also figured its left valve from the Kurosawa formation in the Yokote Basin, Akita Prefecture.

Occurrence:—

1) Tozenji, Yunami, Sekinami, Kitaibaraki City. Kokozura formation. Few. Coll. No. 174.

2) Kamori, Kamitakaku, Iino, Taira City. Nakayama formation. Few. Coll. No. 175.

Family SOLENIDAE

Genus *Cultellus* SCHUMACHER, 1817

Cultellus SCHUMACHER, Ess d'un Nouv. Sysc., 1817.

Type species, Cultellus lacteus (SPENGLER). Recent, Malacca.

Cultellus izumoensis jobanicus KANNO, 1956

Pl. 17, Figs. 2-5

1925 *Cultellus izumoensis* YOKOYAMA, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 18, pl. 5, figs. 2, 3 (non YOKOYAMA, 1923).

1935 *Cultellus izumoensis* YOKOYAMA, NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 220, pl. 15, figs. 16, 17.

1956 *Cultellus izumoensis jobanicus* KANNO, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 34, p. 214-215, pl. 5, figs. 1, 2.

Type data:—TKD Reg. No. 5527 (Holotype) and No. 5528 (Paratype).

Type locality:—Shimotakaku, Taira City (Joban coal-field). Miocene "Takaku group."

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
91	Left	87	26.5	—	32	—
92	Both	98	31	15.6(×2)	31.6	8.0
93	Both	94	33	14.0(×2)	35.1	7.5
94	Right	140	40	—	28.5	—
95	Both	97	26	14.0(×2)	26.8	7.2
Average		103	31.3	14.5(×2)	30.8	7.6

Remarks:—Recently, KANNO (1956) discussed in detail the Japanese fossil and living species of *Cultellus*. According to his result, the Joban specimen which was called as *C. izumoensis* by YOKOYAMA (1925) is assigned to his new subspecies of *izumoensis* as *jobanicus*. KANNO (op. cit., p. 215) stated that the present subspecies can be distinguished from *izumoensis* "by the more narrowly rounded ends, especially, the anterior is the more predominant of the two, concave ventral margin, and the more rounded anterior adductor muscle scar." The characteristic feature of the concave ventral margin is well marked in the specimens at hand collected from various horizons and localities in the Joban coal-field, as well as in the Shiogama specimens from the Shiogama district in Miyagi Prefecture where Miocene molluscan fauna was described by NOMURA (1935).

C. izumoensis jobanicus KANNO occurred from the basal part of the Goyasu formation near the Futatsujima mineral-spring in Isohara-machi, Kitaibaraki City. This is a unique example of the occurrence of this subspecies from the Goyasu formation and the lowest appearance in the Joban coal-field. The next appearance of *jobanicus* is from the upper part of the Honya formation and its remarkable abundance is represented in the Nakayama formation in the Iwaki district and the Kokozura formation in the Nakoso district.

Occurrence:—

1) Ena-machi, Iwaki City. Honya formation. Few. Coll. No. 91.

2) Aikojima, Iwaki City. Nakayama formation. Few. Coll. No. 92.

3) South cliff of Cape Shioya, Toyoma-machi, Taira City. Few. Nakayama formation. Coll. No. 95.

4) Numanouchi habor, Toyoma-machi, Taira City. Numanouchi formation. Rare. Coll. No. 94.

5) Kokozura, Nakoso City. Kokozura formation. Abundant. Coll. No. 93.

6) Near Futatsujima mineral-bath, Isohara-machi, Kitaibaraki City. Goyasu formation. Rare.

Cultellus rectangulus KANNO, 1956

1956 *Cultellus rectangulus* KANNO, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 34, p. 215-216, pl. 5, figs. 3-7.

Type data:—TKD Reg. No. 5529 (Holotype) and Nos. 5530, 5531 and 5532 (Paratypes).

Type locality:—Nenokami, Yoshida-machi, Chichibu basin, Saitama Prefecture. Oligocene Akahira group.

Remarks.—Two specimens are at hand; they occurred from the 1st pit of the Taisho colliery, Yamada, Nakoso City. Both specimens are small in size and more or less broken at posterior ends. But the position of the beaks are seemingly situated at the anterior one-third of the shell-length. The characteristic features of the sloping to the antero-dorsal margin and the position of the beaks are comparable with the young stage of the named species.

Occurrence:—1st pit of the Taisho Coal-mine, Yamada, Nakoso City. Iwaki formation. Few. Coll. No. 346.

Genus *Solen* LINNÉ, 1758

Solen LINNÉ, Syst. Nat., Ed. 10, p. 672, 1758.

Type species (by subsequent designation, CHILDREN, 1822), *Solen vagina* LINNÉ. Recent, Great Britain.

Solen intermedius NAGAO, 1928

Pl. 17, Fig. 6

1928 *Solen intermedius* NAGAO, Sci. Rep., Tohoku Imp. Univ., 2nd Ser., Vol. 12, no. 1, p. 83, pl. 4, figs. 5, 6.

1956 *Solen intermedius* NAGAO, HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 5, no. 45, p. 117, pl. 8, figs. 14-16.

Type data:—IGPS Coll. Cat. No. 36435.

Type locality:—Yamaga, Ashiya-machi, Onga-gun, Fukuoka Prefecture. Oligocene Yamaga formation.

Remarks:—A single right valve collected from Shimokawa, Tabito-mura, measures 89 mm. + in length and 19.6 mm. in height. Anterior end broken and posterior end truncate with slightly convex. The dorsal margin straight and subparallel to ventral margin which is nearly straight and gently curved upward near the posterior end.

S. intermedius was described by NAGAO based on a specimen from the Yamaga formation of the Ashiya group in the northern end of the Chikuho coal-field, north Kyushu and also figured by HIRAYAMA. NAGAO also reported an indeterminable *Solen* from the *Athleta japonica* Zone in the Kiuragi formation of the Karatsu coal-field and it is very similar to *intermedius* in many

features. However, owing to the ill preservation of the Kiuragi specimen, Nagao did not refer it to *intermedius*. Although the present Joban specimen is in bad state of preservation, it is comparable to not only *intermedius* from the Yamaga formation but also *Solen* sp. from the Kiuragi formation. The characteristic outline of the shell serve to distinguish this form from the recorded Neogene or living species of the genus of Japan.

Occurrence:—Suzunosawa, Shimokawa, Tabito-mura. Iwaki formation. Rare. Coll. No. 347.

Family MYACIDAE

Genus *Mya* LINNÉ, 1758

Mya LINNÉ, Syst. Nat., Ed. 10, p. 670, 1758.

Type species (by subsequent designation, CHILDREN, 1822), *Mya truncata* LINNÉ.

Subgenus *Arenomya* WINKWORTH, 1930

Arenomya WINKWORTH, Proc. Malac. Soc. London, Vol. 19, p. 15, 1930.

Type species (by original designation), *Mya arenaria* LINNÉ, 1758. Recent, British coasts.

Mya (*Arenomya*) *grewingki* MAKIYAMA, 1934

Pl. 17, Figs. 1a, b

1921 *Mya crassa* GREWINGK, MAKIYAMA, Jour. Geol. Soc. Tokyo, Vol. 28, no. 334, p. 301. (non GREWINGK, 1850).

1924 *Mya crassa* GREWINGK, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 12, pl. 1, figs. 11-16 (non GREWINGK, 1850).

1932 *Mya crassa* GREWINGK, YOKOYAMA, Rep. Imp. Geol. Surv., Japan, No. 111, p. 12, pl. 12, figs. 1, 3.

1934 *Mya grewingki* MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ. Ser. B, Vol. 10, no. 2, p. 156, pl. 7, figs. 50-52.

1941 *Mya grewingki* MAKIYAMA, NAGAO and INOUE, Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4, Vol. 6, no. 2, p. 147, pl. 32 (1), figs. 1, 7-10; pl. 33 (2), figs. 7, 8.

1955 *Mya* (*Arenomya*) *grewingki* MAKIYAMA, HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 109, pl. 3, figs. 21-24.

Type data:—Holotype is in the Geological Institute, University of Tokyo, figured by YOKOYAMA, 1924, pl. 1, figs. 14-16 (*fide* MAKIYAMA, 1934, p. 156).

Type locality:—Yotsukura cliff, Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
18	Both	58	40.6	25.5(×2)	70.0	22.0
19	Both	63	46	31.8(×2)	73.0	25.2
20	Both	57	46.5	29.4(×2)	81.5	25.8
21	Both	55.5	43	27 (×2)	77.5	24.4
22	Both	56	43	21.5(×2)	71.8	19.2
Average		57.9	43.8	27.0(×2)	74.8	23.3

Remarks:—This species is widely distributed in the Asagai formation in the Joban coal-field and also is recorded from the Paleogene strata in Hokkaido, Sakhalin and the Chichibu basin in Saitama Prefecture. Concerning the specimens from the type locality in the Joban coal-field and from Matchgar in north Sakhalin, MAKIYAMA (1934) gave a description in detail and also discussed about the synonyms of *Mya crassa* GREWINGK. Lately, NAGAO and INOUE (1941) described the myarian fossils from Hokkaido and Sakhalin and found that most of the specimens belonging to *grewingki* have been derived from the equivalent of the Poronai formation in Hokkaido and the Nishisakutan formation in south Sakhalin, so that this species seems to have a rather restricted geological range as already demonstrated by MAKIYAMA. In the Chichibu basin in Saitama Prefecture, *M. grewingki* occurred from the upper Oligocene Akahira formation in association with the other Asagai molluscan fauna (WATANABE, ARAI and HAYASHI, 1950).

In the Joban coal-field, this species occurred at the Yotsukura cliff and other localities in the Asagai formation. At the Yotsukura cliff this myarian fossil is preserved in the very fine grained sandstone with the posterior part of shells in upward position which indicates that they were buried in their original living position.

Occurrence:—All localities are in the Asagai formation.

1) In the tunnel, west of the Iriumi mineral-bath, Kido, Naraha-machi. Common. Coll. No. 19.

2) Yotsukura cliff, Yotsukura-machi (Type locality). Very Abundant. Coll. No. 18.

3) Sumiyoshi colliery, Joban Coal-mine, Uchigo City. Few. Coll. No. 20.

4) Tsuzura, Uchigo City. Few. Coll. No. 348.

5) Arakawa shaft, Joban Coal-mine, Taira City. Common. Coll. No. 21.

6) Bessho, Iwasaki, Joban City. Few. Coll. No. 22.

Mya (*Arenomya*) *cuneiformis* (BÖHM, 1915)

Pl. 16, Figs. 14-16

1915 *Pleuromya cuneiformis* BÖHM, Jahrb. d. königl. preussisch. geol. Landesanst., Vol. 26, p. 577, pl. 29, figs. 1a-c, text-figs. 1, 2.

1925 *Mya arenaria* L. var. *japonica* JAY, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 16, pl. 6, fig. 4.
1926 *Mya arenaria* LINNÉ, YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 1, pt. 7, p. 241, pl. 30, fig. 1.
1927 *Mya arenaria* LINNÉ, YOKOYAMA, *Ibid.*, Vol. 2, pt. 4, p. 198, pl. 51, fig. 2.
1929 *Mya arenaria* LINNÉ, YOKOYAMA, *Ibid.*, Vol. 2, pt. 9, p. 385, pl. 74, fig. 3.
1931 *Mya donaciformis* KURODA, HOMMA's Geol. Central Shinano, pt. 4, p. 63, text-fig. 7.
1941 *Mya cuneiformis* (BÖHM), NAGAO and INOUE, Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4, Vol. 6, no. 2, p. 151–155, pl. 34, figs. 1–6.

Dimensions (in mm.):—

Coll. No.	Valve	Length	Height	Width	H/L(%)	W/L(%)
280	Right	44	26	8	59.2	18.2
281	Left	35	24	6.5	68.7	27.0
„	Right	30	20.5	7.5	68.5	25.0
Average		36.3	23.5	7.3	65.5	23.4

Remarks:—Concerning the present species from the Neogene of Hokkaido and Sakhalin, NAGAO and INOUE (1941, p. 152) published detailed accounts and gave figures. Although the specimens from the Joban coal-field at hand are few in individuals and small in size, their morphological features are closely identical with those of the specimens treated by NAGAO and INOUE.

Occurrence:—

1) Northeast of Tatsuzawa, Iino, Taira City. Nakayama formation. Rare. Coll. No. 280.

2) Numanouchi habor, Toyoma-machi, Taira City. Numanouchi formation. Few. Coll. No. 281.

3) Tozenji in Yunami, Sekinami, Kitaibaraki City. Kokozura formation. Few.

4) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Few.

5) Minamimae, Sekinami, Kitaibaraki City. Kokozura formation. Few.

Class SCAPHOPODA

Order SOLENOCONCHA

Family DENTALIIDAE

Genus *Dentalium* LINNÉ, 1758

Dentalium LINNÉ, Syst. Nat., Ed. 10, p. 785, 1758.

Type species (by subsequent designation, MONTFORT, 1810), *Dentalium elephantinum* LINNÉ. Recent, Philippine Islands.

Subgenus *Fissidentalium* FISCHER, 1885

Fissidentalium FISCHER, Man. de Conchyl., p. 894, 1885.
Type species (by monotypy), *Dentalium ergastricum* FISCHER.

Dentalium (*Fissidentalium*) *yokoyamai* MAKIYAMA, 1931

Pl. 18, Figs. 1, 2

1920 *Dentalium complexum* DALL, YOKOYAMA, Jour. Coll. Sci., Tokyo Imp. Univ., Vol. 39, art. 6, p. 101-102, pl. 6, fig. 27.
1927 *Dentalium* (*Fissidentalium*) sp., MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Vol. 3, no. 1, art. 1, p. 58.
1931 *Dentalium yokoyamai* MAKIYAMA, *Ibid.*, Vol. 7, no. 1, art. 1, p. 44, pl. 1, fig. 1.
1936 *Dentalium yokoyamai* MAKIYAMA, NOMURA and HATAI, Saito Ho-on Kai Mus., Res. Bull., No. 10, p. 135, pl. 15, fig. 1.

Type data:—Holotype is in the Geological Institute, Kyoto University and paratype is in the Geological Institute, University of Tokyo.

Type locality:—Nojima near Yokosuka, Kanagawa Prefecture. Pliocene Nojima formation.

Dimensions (in mm.):—

Coll. No.	Length	Maximum diameter
324	50	5.6
325	41+	7
„	40+	8
„	32+	6
338	50	8.2

Remarks:—The several specimens referable to the named species were collected from the Honya and Kokozura formations. Although the curvature of the shell at hand is slightly stronger than the holotype, the ornamentation on the shell surface is quite identical to the type specimens figured by YOKOYAMA and MAKIYAMA. The present species ranges from Miocene to the Pliocene in the Japanese Islands.

Occurrence:—

1) Hieda, Ena-machi, Iwaki City. Honya formation. Common. Coll. No. 324.
2) Eastern end of Onahama, Iwaki City. Nakayama formation. Rare. Coll. No. 338.
3) Kokozura, Nakoso City. Kokozura formation. Common. Coll. No. 325.
4) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Few. Coll. No. 326.

Class GASTROPODA

Order ARCHAEOGRASTROPODA

Family TROCHIDAE

Genus *Margarites* LEACH in GRAY, 1847

Margarites LEACH MS., GRAY, Ann. Mag. Nat. Hist., Vol. 20, p. 271, 1847.

Type species (by monotypy), *Trochus helicinus* FABRICIUS, 1780=*Helix margarita* MONTAGU, 1808. Recent, northern Atlantic, Arctic, and Pacific coast south to Catalina Island, California.

Margarites eos HIRAYAMA, 1955

Pl. 18, Fig. 8

1955 *Margarites eos* HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 111-112, pl. 5, figs. 23-32.

Type data:—TKD Reg. No. 10204 (Holotype).

Type locality:—Road-side cliff at about 1 km. north of the Yotsukura Fishing Port, Yotsukura-machi (Joban coal-field). (Loc. A-15 in text-figure 1 of the original paper.) Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Height	Diameter
238	8.5	11.2×9.0

Remarks:—A single specimen referred to the named species is at hand. This species is characterized by its depressed aspect, small height, surface ornamentation, deep and large umbilicus, as stated by the original author. *M. eos* is restricted in its occurrence to the Asagai formation in the Futaba district at the present time.

Occurrence:—Oyamada, Hisanohama-machi. Asagai formation. Rare. Coll. No. 238.

Subfamily Calliostomatinae

Genus *Calliostoma* SWAINSON, 1840

Calliostoma SWAINSON, Treat. Malac., p. 218, 351, 1840.

Type species (by subsequent designation, HERRMANNSEN, 1846), *Trochus conulus* LINNÉ (="*Calliostoma conula* MART." of SWAINSON). Recent, Mediterranean Sea.

Subgenus *Calotropis* THIELE, 1929

Calotropis THIELE, Handb. Weichtkde., Bd. 1, p. 49, 1929.

Type species (by original designation), *Trochus selectus* CHEMNITZ=*T. cunnighamii* GRAY.

Calliostoma (*Calotropis*) *simane* NOMURA and HATAI, 1938

Pl. 18, Figs. 3, 4

1938 *Calliostoma simane* NOMURA and HATAI, Jap. Jour. Geol. Geogr., Vol. 16, nos. 1-2, p. 8, pl. 1, figs. 5a-c.

1942 *Calliostoma* (*Calotropis*) *simane* NOMURA and HATAI, IKEBE, Jap. Jour. Geol. Geogr., Vol. 18, no. 4, p. 256, pl. 26, figs. 3a-c.

Type data:—Four specimens from the type locality were examined by NOMURA and HATAI. IGPS Coll. Cat. No. 60005 (Holotype).

Type locality:—Shinji-machi, Yatsuka-gun, Shimane Prefecture. Miocene Kimachi formation.

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
231	20.5+	24.5×23.0	75°
„	13.5	16.2×15.0	74°

Remarks:—*Calliostoma simane* is characterized by its flat-sided shell with the acutely angulated periphery and eight or nine subequal spiral ribs without visible granulations. The two specimens from the Numanouchi formation at hand are quite identical with the original description. The size of the smaller shell of the Joban specimen at hand almost corresponds with those of the holotype.

IKEBE assigned *C. simane* to the subgenus *Calotropis* and figured a referred specimen stored in the Geological Institute, Kyoto University, probably derived from the Miocene of the Chichibu basin as its variety. Accordingly, the occurrence of the present species from the Joban coal-field is the third occasion in the Japanese paleontology. *C.* (*C.*) *simane* NOMURA and HATAI is now restricted in its distribution to Honshu Island geographically and to the Miocene in geologic range.

Calliostoma (*Calotropis*) *hataii* KANNO (1958) from the upper Oligocene Nenokami formation in Chichibu is indistinguishable from the present species. However, KANNO stated that the former differs from the latter by having less number of spiral ribs.

Occurrence:—Kokozura, Nakoso City. Kokozura formation. Few. Coll. No. 231.

Subgenus *Tristichotrochus* IKEBE, 1942

Tristichotrochus IKEBE, Jap. Jour. Geol. Geogr., Vol. 18, no. 4, p. 258.

Type species (by original designation), *Calliostoma aculeatum* SOWERBY, 1912,

Recent

Shell conical, small, sculptured by 3 primary, 3 secondary and some tertiary spirals; spirals granulated all over or partly on younger whorls; whorls shouldered, suture distinct, but not marginate; aperture roundly quadrate; columella without tubercle; not umbilicate. (IKEBE)

Calliostoma (*Tristichotrochus*) *miyokoae* KAMADA, n. sp.

Pl. 18, Figs. 5-7

Shell more or less small, conical, seven whorls preserved in holotype. Whorls scupltured by primary (P), secondary (S), tertiary and quaternary spirals; first four post-nuclear whorls ornamented with only three beaded primary spirals (P_1, P_2 and P_3); three secondary (S_1, S_2 and S_3) appear and one tertiary spiral starting at between P_1 and S_1 in next whorl; spirals on penultimate whorl consisting three primary, three secondary and six tertiary ones and a suprasutural row become stronger; of these 12 spirals, P_1 and S_1 well beaded, P_2 and P_3 crenulated and projected. On the body whorl, quaternary fine spirals added each interspaces between above-mentioned ones. Base slightly convex and ornamented by eight beaded spirals and smooth interstal fine cords.

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
IGPS 79389*	17.8	17.0×15.6	70°
„	11.3	10.6×10.0	69°

* Holotype

Remarks:—The present new species is closely similar to the living *Calliostoma aculeatum*, the type species of *Tristichotrochus*, in its shape of shell outline and aperture, but the detailed sculpture of whorls somewhat differs from each other. *C.* (*T.*) *miyokoae* possesses distinct quaternary spirals in the body whorl and the interstitial fine cords on the base.

According to the result of study on the Japanese *Calliostoma* treated by IKEBE (1942), the species group of *C. aculeatum* SOWERBY ranges from the early Pliocene to Recent. Thus, *C.* (*T.*) *miyokoae* is probably the oldest representative of this stock in Japan.

The new species is named in memory of my mother, Miyoko KAMADA, who died on January 11, 1955.

Occurrence:—Numanouchi harbor, Toyoma-machi, Taira City (Type local ity). Numanouchi formation. Few. IGPS Coll. Cat. No. 79389.

Order MESOGASTOROPODA

Family TURRITELLIDAE

Genus *Turritella* LAMARCK, 1799

Turritella LAMARCK, Mem. Soc. d'Hist. Nat. Paris, Ser. 1, Tome 1, p. 74, 1799.

Type species (by monotypy), *Turritella terebra* (LINNÉ)=*Turbo terebra* LINNÉ. Recent, Indo-Pacific.

Subgenus *Neohaustator* IDA, 1952

Neohaustator IDA, Geol. Surv. Japan. Rep. No. 150, p. 47, 1952.

Type species (by original designation), *Turritella nipponica* YOKOYAMA, 1920. Koshiba coast, Yokohama City, Japan. Pliocene Koshiba formation.

Turritella (*Neohaustator*) *iwakiensis* KOTAKA, 1951

1925 *Turritella nipponica* YOKOYAMA, YOKOYAMA, Jour. Coll. Sci., Imp. Univ., Tokyo, Vol. 45, art. 5, p. 13, pl. 2, fig. 8 (non YOKOYAMA, 1920).
1951 *Turritella iwakiensis* KOTAKA, Saito Ho-on Kai Mus., Res. Bull., No. 21, p. 11, pl. 1, figs. 19–21.
1952 *Turritella iwakiensis* KOTAKA, IDA, Geol. Surv. Japan, Rep. No. 150, p. 16.
1959 *Turritella* (*Neohaustator*) *iwakiensis* KOTAKA, KOTAKA, Sci. Rep., Tohoku Univ., 2nd Ser., Vol. 31, no. 2, p. 75–76, pl. 3, figs. 17–20.

Type data:—IGPS Coll. Cat. No. 72997 (Holotype).

Type locality:—Near Onahama Ship-Yard, Onahama-machi, Iwaki City (Joban coal-field). Miocene Nakayama formation.

Occurrence:—

1) Near Onahama Ship-Yard, Onahama-machi, Iwaki City (Type locality). Nakayama formation. Common.
2) Kamori, Kamitakaku, Iino, Taira City. Nakayama formation.
3) Between Kamikajiro and Shimokajiro, Ena-machi, Iwaki City. Nakayama formation.
4) North of Nagasaki, Ena-machi, Iwaki City. Nakayama formation.
5) Kokozura, Nakoso City. Kokozura formation. Common.
6) Numanouchi habor, Toyoma-machi, Taira City. Numanouchi formation.
7) Tsunatori, Ena-machi, Iwaki City. Numanouchi formation.

Subgenus *Hataiella* KOTAKA, 1959

Hataiella KOTAKA, Sci. Rep., Tohoku Univ., 2nd Ser., Vol. 31, no. 2 p. 88, 1959.

Type species (by original designation), *Turritella s-hataii* NOMURA, 1935. Higashi-Shiogama, Shiogama City, Miyagi Prefecture. Miocene Ajiri formation.

Turritella (*Hataiella*) *s-hataii* NOMURA, 1935

1935 *Turritalla s-hataii* NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 231, pl. 17, figs. 19-21.
1938 *Turritella* (*Haustator*) *s-hataii* NOMURA, OTUKA, Jap. Jour. Mal., Vol. 8, no. 1, p. 41, text-fig. 28.
1940 *Turritella* (*Haustator*) *s-hataii* NOMURA, NOMURA and ONISI, Jap. Jour. Geol. Geogr., Vol. 17, nos. 3-4, p. 185, pl. 17, 18.
1952 *Turritella s-hataii* NOMURA, IDA (part), Geol. Surv. Japan Rep. No. 150, p. 59.
1959 *Turritella* (*Hataiella*) *s-hataii* NOMURA, KOTAKA, Sci. Rep., Tohoku Univ., 2nd Ser., Vol. 31, no. 2, p. 88-89, pl. 9, figs. 1-5.

Type data:—SM Reg. No. 2551 (Holotype).

Type locality:—Higashi-Shiogama, Shiogama City, Miyagi Prefecture (Loc. 4 in the original paper, 1935). Miocene Ajiri formation.

Occurrence:—

1) Shimokajiro, Ena-machi, Iwaki City. Honya formation.
2) Hieda, Nagasaki, Ena-machi, Iwaki City. Honya formation.
3) Southwest of Tatsuzawa, Iino, Taira City. Nakayama formation.
4) Kokozura, Nakoso City. Kokozura formation.

Turritella (*Hataiella*) *omurai* KANEHARA, 1937

1937 *Turritella omurai* KANEHARA, Bull. Imp. Geol. Surv., Japan, Vol. 27, no. 1, p. 9-10, pl. 4, figs, 5-7.
1938 *Turritella omurai* KANEHARA, OTUKA, Jap. Jour. Mal., Vol. 8, no. 1, p. 41, text-fig. 12.
1952 *Turritella omurai* KANEHARA, IDA, Geol. Surv. Japan, Rep., No. 150, p. 61.
1959 *Turritella* (*Hataiella*) *omurai* KANEHARA, KOTAKA, Sci. Rep., Tohoku Univ., 2nd Ser., Vol. 31, no. 2, p. 91-92, pl. 7, figs. 7-9.

Type data:—Types were destroyed by a fire during the World War II.

Type locality:—Nagako, Nishiki-machi, Nakoso City (Joban coal-field). Miocene Mizunoya formation.

Occurrence:—

1) Kamimae, south of Teramae, Toyoma-machi, Taira City. Honya formation.
2) Shimokajiro, Ena-machi, Iwaki City. Honya formation.
3) Hieda, Nagasaki, Ena-machi, Iwaki City. Honya formation. Abundant.
4) South of Kamiyamaguchi, Takaku, Taira City. Nakayama formation.
5) Kogayano-tsutsumi, northeast of Shimoyamaguchi, Takaku, Taira City. Numanouchi formation.
6) Tsunatori, Ena-machi, Iwaki City. Numanouchi formation.

Generic or Subgeneric position uncertain

"*Turritella*" *tokunagai* YOKOYAMA, 1924

1924 *Turritella tokunagai* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 10, pl. 1, figs. 8-10.
1934 *Turritella tokunagai* YOKOYAMA, MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 10, no. 2, art. 6, p. 160.
1950 *Turritella tokunagai* YOKOYAMA, KOTAKA, Short Papers IGPS, No. 1, p. 34, pl. 5, figs. 7, 8.
1952 *Turritella tokunagai* YOKOYAMA, IDA, Geol. Surv. Japan, Rep. No. 150, p. 56.
1955 *Turritella* (*Haustator*) *tokunagai* YOKOYAMA, HIRAYAMA, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 114-115, pl. 5, figs. 37-40.
1959 "*Turritella*" *tokunagai* YOKOYAMA, KOTAKA, Sci. Rep. Tohoku Univ., 2nd Ser., Vol. 31, no. 2, p. 106, pl. 11, figs. 7, 8, 11, 12, 15.

Type data:—Holotype is in the Geological Institute, University of Tokyo.

Type locality:—Tanoami, Hisanohama-machi (Joban coal-field). Oligocene Asagai formation.

Occurrence:—The records from many localities were given by YOKOYAMA, MAKIYAMA and HIRAYAMA in their above cited works. Asagai formation.

"*Turritella*" *importuna* YOKOYAMA, 1924

1924 *Turritella importuna* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 10-11, pl. 1, figs. 6, 7.
1934 *Turritella importuna* YOKOYAMA, MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 10, no. 2, art. 6, p. 161, pl. 7, figs. 54, 55, 60.
1950 *Turritella importuna* YOKOYAMA, KOTAKA, Short Papers IGPS, No. 1, p. 34, pl. 5, figs. 9, 10.
1952 "*Turritella*" *importuna* YOKOYAMA, IDA, Geol. Surv. Japan, Rep. No. 150, p. 61, pl. 5, figs. 2, 3.
1955 *Turritella* (*Haustator*) *importuna* YOKOYAMA, HIRAYAMA, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 113-114, pl. 5, figs. 33-36.
1959 "*Turritella*" *importuna* YOKOYAMA, KOTAKA, Sci. Rep. Tohoku Univ., 2nd Ser., Vol. 31, no. 2, p. 106-107, pl. 11, figs. 11-14.

Type data:—Lectotype is in the Geological Institute, University of Tokyo.

Type locality:—Yotsukura sea-cliff, Yotsukura-machi (Joban coal-field). Oligocene Asagai formation.

Occurrence:—The records from many localities were given by YOKOYAMA, MAKIYAMA and HIRAYAMA. Asagai formation.

Family POTAMIDIDAE

Genus *Cerithidea* SWAINSON, 1840

Cerithidea SWAINSON, Treatise Malac., 1840.

Type species (by subequent designation, MAKIYAMA, 1936), *Melania lineolata* GRIFFITH and PIDGEON, 1843.

Subgenus *Cerithidea* s. str.

Cerithidea (*Cerithidea*) *sugaii* MIZUNO and FUJII, 1957

Pl. 18, Figs. 9-10

1957 *Cerithidea* (*Cerithidea*) *sugaii* MIZUNO and FUJII, Venus, Vol. 19, nos. 3-4, p. 258, textfigs. 3-5.

Type data:—GSJ Reg. No. 5015.

Type locality:—East of Taki, Tono-machi (Joban coal-field). (Loc. 6 in text-fig. 1 of the original paper, 1957.)

Dimensions (in mm.):—Most of the specimens at hand are broken and more or less deformed.

Coll. No.	Height	Diameter
288	37+	17
"	30+	14.5
"	26+	13

Remarks:—Several specimens which were collected from Shimokawa, Kuroda basin are examined. Although not well preserved, they are safely identified to the type specimens which occurred Taki in the Kadono district.

Occurrence:—Suzunosawa, Shimokawa, Tabito-mura in the Kuroda basin. Iwaki formation. Common. Coll. No. 288.

Genus *Vicarya* D'ARCHIAC and HAIME, 1854

Vicarya D'ARCHIAC and HAIME, Descript. Anim. Foss. Group. Nummulit. l'Inde., 2 Liv. p. 298, 1854.

Type species (by original designation), *Nerinea? verneuili* D'ARCHIAC, 1850. Gaj series in Sind, Western India, Miocene.

Recently, KAMADA (1960) discriminated two subgenera in the genus *Vicarya*, one is *Vicarya sensu stricto* and the other is *Shoshiroia* which was established based on *Vicarya callosa* JENKINS, 1847 from the Miocene of Java.

Vicarya s. str. has the lower whorls with eight subsutural tubercles, which change into a larger number of small beads of its younger whorls, while *Shoshiroia* has the subsutural tubercles invariably nine or ten on all whorls.

Vicarya s. str. includes *V. verneuili* (D'ARCHIAC), 1850, *V. eocenica* COX, 1931, *V. yokoyamai* TAKEYAMA, 1933 and *V. yatuoensis* YABE and HATAI, 1938, while *Shoshiroia* includes such species or subspecies of *V. callosa* JENKINS, 1864, *V. callosa japonica* YABE and HATAI, 1938 and *V. yabei* KAMADA, 1960.

Subgenus *Vicarya* s. str.

Vicarya (*Vicarya*) *yokoyamai* TAKEYAMA, 1933

Pl. 18, Figs. 13, 14

1925 *Cerithium* sp. YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 12, pl. 2, fig. 5.
1926 *Vicarya baculum* (YOKOYAMA), YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 1, pt. 7, p. 219, pl. 28, figs. 4-6 (not *Cerithium baculum*, 1924, 1925).
1933 *Vicarya verneuili yokoyamai* TAKEYAMA, Jap. Jour. Geol. Geogr., Vol. 10, nos. 3-4, p. 134-137, pl. 13, fig. 4.
1938 *Vicarya callosa yokoyamai* (TAKEYAMA), YABE and HATAI, Sci. Rep., Tohoku Imp. Univ., 2nd Ser., Vol. 19, no. 2, p. 157-159, pl. 21, figs. 25, 27, 32, 37.
1938 *Vicarya callosa martini* SAGA (MS), YABE and HATAI, *Ibid.*, p. 159, pl. 21, fig. 29 (=*Vicarya verneuili yokoyamai*, *fide* IKEBE, 1939, p. 544).
1939 *Vicarya verneuili yokoyamai* TAKEYAMA, IKEBE, Jour. Geol. Soc. Japan, Vol. 64, no. 553, p. 542-545, text-figs. 3-7.
1944 *Vicarya yokoyamai* TAKEYAMA, OYAMA and SAKA, Bull. Sigenkagaku Kenkyusyo, Vol. 1, no. 2, p. 138-139, pl. 14, figs. 2a-c, 3a-c.
1960 *Vicarya yokoyamai* TAKEYAMA, KAMADA, Sci. Rep., Tohoku Univ., 2nd Ser., Spec. Vol., No. 4, p. 283, pl. 30, figs. 3a, b; pl. 31, figs. 6, 7, 10.

Type data:—Holotype (mould) is in the Geological Insitute, College of Science, Kyoto University.

Type locality:—Matsubora, Shimizu, Mizunami City. Gifu Prefecture. Miocene Tsukiyoshi formation.

Remarks:—Concerning the present species which is often called as "Tsukiyoshi-type *Vicarya*", several authors discussed its taxonomic and ecological problems. At the present time, the well-figured YOKOYAMA's *Vicarya baculum* from the Tsukiyoshi Miocene in Gifu Prefecture is assigned to TAKEYAMA's species and YOKOYAMA's *Cerithium baculum* from the Kadono district in the Joban coal-field can be assigned to *V. yokoyamai*. Recently, KAMADA (1960) reconsidered the taxonomic position of the present species and mentioned about the associated occurrence with *Vicaryella ishiiana* (YOKOYAMA) in several Miocene deposits in the Japanese Islands.

Occurrence:—

1) Shimokawa, in the Kuroda basin, Tabito-mura. Kunugidaira formation. Common. Coll. No. 327.

2) Hironosaku, Kamiyamada, Nakoso City. Kunugidaira formation. Common. Coll. No. 328.

3) Near Futatsujima mineral bath, Isohara-machi, Kitaibaraki City. Kunugidaira formation. Rare. Coll. No. 329.

4) Kano, Miyamada, Tono-machi. Nakayama formation. Very abundant. Coll. No. 330.

5) Matsukawaiso sea-coast, between Sekida and Kokozura, Nakoso City. Nakayama formation. Few.

Genus *Vicaryella* YABE and HATAI, 1938

Vicaryella TAKEYAMA (MS), YABE and HATAI, Sci. Rep., Tohoku Imp. Univ., 2nd Ser., Vol. 19, no. 2, p. 165, 1938.

Type species (by original designation), *Vicaryella tyosenica* YABE and HATAI, 1938. Nanseki, Meisen district, North Korea, Miocene.

Vicaryella ishiiana (YOKOYAMA, 1926)

Pl. 18, Figs. 15, 16

1925 *Ceithium baculum* YOKOYAMA, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 12, pl. 2, fig. 6 (not *Cerithium baculum*, 1924).

1926 *Cerithium ishiianum* YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 1, pt. 7, p. 218, pl. 28, figs. 11, 12.

1935 *Cerithium* (*Proclava*) *otukai* NOMURA, Saito Ho-on Kai Mus., No. 6, p. 227, pl. 17, fig. 17 (new name for "*Proclava*" aff. *ishiiana* of OTUKA, 1934, but not *otukai*= *Vicaryella tyosenica otukai* NOMURA, *fide* KAMADA, 1960).

1938 "*Vicaryella*" *ishiiana* (YOKOYAMA), YABE and HATAI, Sci. Rep., Tohoku Imp. Univ., 2nd Ser., Vol. 19, no. 2, p. 169.

1944 *Vicaryella ishiiana* (YOKOYAMA), OYAMA and SAKA, Bull. Sigenkagaku Kendyusho, Vol. 1, no. 2, p. 139, pl. 14, figs. 5, 6a, b, 7a, b, 8a, b.

1960 *Vicaryella ishiiana* (YOKOYAMA), KAMADA, Sci. Rep., Tohoku Univ., 2nd Ser., Spec. Vol., No. 4, p. 284, pl. 31, figs. 4a, b, 8, 9.

Type data:—Lectotype is in the Geological Institute, University of Tokyo.

Type locality:—Matsubora, Shimizu, Mizunami City, Gifu Prefecture. Miocene Tsukiyoshi formation.

Remarks:—Although, YABE and HATAI (1938) referred the present species to the genus *Vicaryella* with quotation marks to denote doubt, OYAMA and SAKA (1944) stated that *Cerithium ishiianum* belongs to the named genus based on the specimens from the Tsukiyoshi area which possess the characteristic features of *Vicaryella tyosenica*. *Cerithium baculum* of YOKOYAMA from Yamoto, Kadono in the Joban coal-field is referred to the named species. It is interesting from the viewpoint of the paleoecology that the associated occurrence of *Vicarya yokoyamai* and *Vicaryella ishiiana* from the Joban coal-field is closely similar to those from Tsukiyoshi in Gifu Prefecture, as already stated by KAMADA (1960) in his recent paper.

The full descriptions of *Vicarya yokoyamai* and *Vicaryella ishiiana* were given by YOKOYAMA, TAKEYAMA, YABE and HATAI, and OYAMA and SAKA, so that no more descriptions are needed in the present article.

Occurrence:—Kano, Miyamada, Tono-machi. Nakayama formation. Abundant. Coll. No. 331.

Genus *Batillaria* BENSON, 1842

Batillaria BENSON, Ann. Mag. Nat. Hist., 1842.

Type species (by monotypy), *Batillaria zonalis* (LAMARCK)=*Cerithium zonalis* BRUGUIÈRE, 1792.

Subgenus *Tateiwaia* MAKIYAMA, 1936

Tateiwaia MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 11, No. 4, Art. 6, p. 219.

Type species (by original designation), *Batillaria tateiwai* MAKIYAMA, 1926. Miocene Heiroku conglomerate.

Shell like *Batillaria* s. s., but the spire is scalariform with shouldered whorls which are given a little tight feeling at the suture. Ornaments: catagenetic axial forming high sharp pointed tubercles on the angle of the later whorls and a small number of anagenetic spirals which extend over the axials. Base curved in, without a varix. Columella upright. (MAKIYAMA, 1936)

Batillaria (*Tateiwaia*) *tateiwai* MAKIYAMA, 1926

1926 *Batillaria tateiwai* MAKIYAMA, Mem. Coll Sci., Kyoto Imp. Univ., Ser. B, Vol. 2, no. 3, p. 147, pl. 12, figs. 5, 6.

1929 *Cerithium sakamotoi* YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 2, pt. 7, p. 367, pl. 70, fig. 4.

1934 *Batillaria tateiwai* MAKIYAMA, OTUKA, Bull. Earthq. Res. Inst., Tokyo Imp. Univ., Vol. 12, pt. 3, p. 624, pl. 49, fig. 71.

1935 *Batillaria tateiwai* MAKIYAMA, NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 228, pl. 17, figs. 30-33.

1936 *Batillaria* (*Tateiwaia*) *tateiwai* MAKIYAMA, MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 11, no. 4, art. 6, p. 219.

Type data:—Cotype are in the Geological Survey of Chosen (Korea) and in the Geological Institute, Kyoto University.

Type locality:—Nanseki, Meisen district, North Korea. Miocene Heiroku conglomerate.

Remarks:—The specimens referred to the named species frequently occur from the Nakayama formation in the Kadono district. *B.* (*T.*) *tateiwai* usually occurs in association with *B.* (*T.*) *yamanarii* in the present district, as similar in the Meisen district, North Korea (MAKIYAMA, 1926, 1936), the Ninohe district, Iwate Prefecture (OTUKA, 1934), the Shiogama district, Miyagi Prefecture (NOMURA, 1935) and the Mimasaka and Bitchu districts in Okayama Prefecture (YOKOYAMA, 1929).

Occurrence:—Kamanomae, Tono-machi and so forth in the Kadono district. Nakayama formation. Common.

Batillaria (*Tateiwaia*) *yamanarii* MAKIYAMA, 1926

1926 *Batillaria yamanarii* MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 2, no. 3, p. 148, pl. 12, fig. 4.

1929 *Ceritihium proavitum* YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 2, pt. 7, p. 366, pl. 70, fig. 3.
1934 *Batillaria yamanarii* MAKIYAMA, OTUKA, Bull. Earthq. Res. Inst., Tokyo Imp. Univ., Vol. 12, pt. 3, p. 624, pl. 49, figs. 80, 81.
1935 *Batillaria yamanarii* MAKIYAMA, NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 228-229, pl. 17, figs. 27, 28.
1936 *Batillaria* (*Tateiwaia*) *yamanarii* MAKIYAMA, MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 11, no. 4, art. 6, p. 219-220.

Type data:—Holotype is in the Geological Survey of Chosen (Korea).

Type locality:—Nanseki, Meisen district, North Korea. Miocene Heiroku conglomerate.

Remarks:—The specimen referred to the named species is usually found from the Nakayama formation in the Kadono district associated with *Batillaria* (*Tateiwaia*) *tateiwai*. An indeterminable specimen of *Batillaria* from the uppermost part of the Honya formation at the northwestern end of of Ena, Enamachi in the Yumoto district may be assigned to the named species.

From the viewpoint of paleoecology, it may be a significant fact that the occurrence of *B.* (*T.*) *tateiwai* and *B.* (*T.*) *yamanarii* are restricted to the Nakayama formation in the Kadono district and are associated with some characteristic brackish water dwellers, as *Vicarya yokoyamai* and *Vicaryella ishiiana*.

Occurrence:—Kamanomae, Tono-machi and so forth in the Kadono district. Nakayama formation. Common.

Family TRICHOTROPIDAE

Genus *Trichotropis* SOWERBY, 1829

Trichotropis SOWERBY, Zool. Jour., Vol. 4, p. 373, 1829.
Type species, Trichotropis bicarinata SOWERBY.

Trichotropis enaensis KAMADA, n. sp.

Pl. 18, Figs. 11, 12

Shell small, tabulated with a high angular shoulder, whorls rapidly increasing and about five in number. Carinated shoulder appears on post-nuculear whorl and becomes a more strongly raised rope-like keel on penultimate and body whorls. Area above shoulder gently sloping and slightly concave; below it nearly flat, subvertical and sculptured with indistinct equeidistant axial sculpture on body whorl. Base angulated by two spiral threads. Aperture equal to nearly half of shell length pyriform, acute towards anterior canal. Both inner and outer lips thin and entire. Umbilicus deep and sharply bordered by curved elevated ridge.

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
IGPS 79390	ca. 17	9. 0	55°

Remarks:—One specimen (holotype) with the penultimate and body whorls and one lacking the body whorls were examined. The present new species is closely similar to *Trichotropis unicarinata* (BRODERIP and SOWERBY) figured by YOKOYAMA (1922, pl. 13, fig. 2), but differs from the latter by possessing a narrower body whorl, aperture and umbilicus and seemingly a more angulated base.

Occurrence:—Northwestern end of Ena, Ena-machi, Iwaki City (Type locality). Honya formation. Few. IGPS Coll. Cat. No. 79390.

Family CALYPTRAEIDAE

Genus *Calyptraea* LAMARCK, 1799

Calyptraea LAMARCK, Mem. Soc. Hist. Nat. Paris, Vol. 1, p. 78, 1799.
Type species (by monotypy), *Patella chinensis* LINNÉ. Recent, seas of Europe.

Calyptraea tokunagai HATAI and NISIYAMA, 1952

Pl. 18, Fig. 17

1924 *Calpytraea mammilaris* (BRODERIP), YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 11-12, pl. 1, fig. 17. (non BRODERIP, 1843; non *C. yokoyamai* KURODA, 1929)
1952 *Calyptraea tokunagai* HATAI and NISIYAMA, (n. n.), Sci. Rep., Tohoku Univ., 2nd Ser. Spec. Vol., No. 3, p. 181.
1954 *Calyptraea tokunagai* HATAI and NISIYAMA, HIRAYAMA, Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, Vol. 3, no. 18, p. 72, pl. 5, fig. 14.
1955 *Calpptraea tokunagai* HATAI and NISIYAMA, HIRAYAMA, *Ibid.* Vol. 4, no. 29, p. 116, pl. 4, figs. 3-5.

Type data:—Holotype (YOKOYAMA's pl. 1, fig. 7) is in the Geological Institute, University of Tokyo.

Type locality:—Akiyama, Uchigo City (Joban coal-field). Oligocene Asagai formation.

Dimensions (in mm.):—

Coll. No.	Height	Diameter
240	7	15
241	10	16. 6×16
„	8. 5	17 ×14. 5
„	5	9 × 7

Remarks:—The present species is not common in the Asagai formation, but is a characteristic element of this formation. *Calyptraea aokii* HIRAYAMA

(1955, p. 117, pl. 4, figs. 1, 2) from the same formation is closely related to the present species. However, HIRAYAMA stated that *C. aokii* is distinguished from *C. tokunagai* by "the large size, convex shell, elliptical outline and surface ornamentation."

Occurrence:—

1) Oyamada, Hisanohama-machi. Asagai formation. Few. Coll. No. 240.

2) Nagasawa, between Hisanohama- and Hirono-machi. Asagai formation. Few. Coll. No. 241.

Family CREPIDULIDAE

Genus *Crepidula* LAMARCK, 1799

Crepidula LAMARCK, Mem. Soc. Hist. Nat. Paris, Ser. 1, Vol. 1, p. 78, 1799.

Type species (by monotypy), *Patella fornicata* LINNÉ. Recent, Atlantic and Gulf coasts of North America.

Crepidula nidatoriensis sogabei KAMADA. n. subsp.

Pl. 18, Figs. 18-20

Shell like *Crepidula nidatoriensis* OTUKA, moderate in size, thick, gibbous, somewhat ventricose with axial plane of greatest curvature inclined to right; sculptured with incremental lines of growth. Aperture ovate in outline. Beak sharply twisted to side, obliquely upwards and appressed to body whorl.

Dimensions (in mm.):—

Coll. No.	Height	Length	Width
IGPS 79391*	22	34	24
„	16.5	30	18
251	18	34	22
252	20	33	22
Average	19.1	32.5	21.5

* Holotype

Remarks:—*Crepidula nidatoriensis* OTUKA (1934, p. 626, pl. 48, figs. 63a, b) was described based on the specimens from the upper Kadonosawa series in the Ninohe district, Iwate Prefecture. The present new subspecies may be distinguished from *nidatoriensis* by only the higher shell. The other characters almost correspond with each other. The well known Miocene *Crepidula jimboana* YOKOYAMA (1931, p. 194, pl. 11, figs. 1a, b) from various localities in Japan, compared with the present one, has a smaller and higher shell with ovate aperture.

The new subspecific name is dedicated to Mr. Masatoshi SOGABE, a geologist of the Geological Survey of Japan, for his encouragements.

Occurrence:—

1) South cliff of Cape Shioya, Toyoma-machi, Taira City. Nakayama formation. Few. Coll. No. 298.

2) Numanouchi habor, Toyoma-machi, Taira City (Type locality). Numanouchi formation. Few. IGPS Coll. Cat. No. 79391.

3) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Rare. Coll. No. 251.

4) Minamimae, Sekinami, Kitaibaraki City. Kokozura formation. Rare. Coll. No. 252.

Family NATICIDAE

Genus *Neverita* RISSO, 1826

Neverita RISSO, Hist. Nat. Eur. Merid., Vol. 4, p. 149, 1826.

Type species (by monotypy), *Neverita josephina* RISSO.

Neverita coticazae (MAKIYAMA, 1926)

Pl. 18, Figs. 21, 22

1926 *Polinices* (*Neverita*) *coticazae* MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 2, no. 3, p. 150, pl. 12, fig. 8.

1931 *Natica kiritaniana* YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo, Ser. 2, Vol. 3, pt. 4, p. 201, pl. 12, fig. 2.

1935 *Polinices* (*Neverita*) *kiritaniana* (YOKOYAMA), NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 5, p. 99-100.

1935 *Polinices* (*Neverita*) *kiritaniana* (YOKOYAMA), NOMURA, and ZINBO, *Ibid.*, No. 6, p. 190, pl. 15, fig. 31.

1936 *Polinices* (*Neverita*) *kiritaniana* (YOKOYAMA), NOMURA and HATAI, *Ibid.*, No. 10, p. 147.

1936 *Natica* (*Neverita*) *coticazae* (MAKIYAMA), MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 11, no. 4, p. 223.

1939 *Polinices* (*Neverita*) *coticazae* MAKIYAMA, NOMURA, Jour. Geol. Soc. Japan, Vol. 46, no. 529, p. 255, pl. 13, figs. 13a, b, 14a, b.

1940 *Polinices kiritanianus* YOKOYAMA, NOMURA and ONISI, Jap. Jour. Geol. Geogr., Vol. 17, nos. 3-4, p. 185, pl. 18, figs. 3a, b.

Type data:—Holotype is in the Geological Survey of Chosen (Korea), Reg. No. 75.

Type locality:—Kinshodo, Meisen district, North Korea. Miocene Mankodo formation.

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
256	31	29.5×26	86°
,,	28.5	28.6×23	92°
,,	31.5	24.5×22	91°
,,	25.6	22 ×17	78°
,,	25	21.8×17.2	85°
293	28	28 ×21.5	85°
Average	28.3	25.7×21.1	86°

Remarks:—There is a large number of well-preserved individuals belonging to the named species in the collection from the Kokozura formation at Kokozura in the Nakoso district. The characteristic feature of the heavy callous deposit with distinct groove proves the Joban specimens to be easily identified with the named species. There is variation of the shape of whorls in the collection at hand and some of them are closely similar to *Natica kiritaniana* YOKOYAMA originally described on a specimen from the Tanagura Miocene in Fukushima Prefecture. NOMURA and HATAI (1936) already stated that the degree of variation in regard to the outline of the *kiritaniana* from the type locality in Tanagura appears to grade into *Neverita coticazae*. Accordingly, YOKOYAMA's *kiritaniana* may be synonymous with the present named species.

Occurrence:—

1) Numanouchi habor, Toyoma-machi, Taira City. Numanouchi formation. Few. Coll. No. 289.

2) Kokozura, Nakoso City. Kokozura formation. Abundant. Coll. No. 256.

3) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Common. Coll. No. 293.

Genus *Euspira* AGASSIZ in SOWERBY, 1838

Euspira AGASSIZ, in SOWERBY, Min. Conch. Gt., German Ed., p. 14, 320, 1838.

Type species (by subsequent designation, DALL, 1908, 1909), *Natica laucinoides* SOWERBY, not DESHAYES (=? *Natica labellata* LAMARCK). Eocene, England.

Euspira meisensis (MAKIYAMA, 1926)

Pl. 18, Fig. 23

1926 *Polinices* (*Euspira*) *meisensis* MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 2, no. 3, p. 150-151, pl. 12, fig. 7.

1934 *Polinices* (*Euspira*) *meisensis* MAKIYAMA, OTUKA, Bull. Earthq. Res. Inst., Tokyo Imp. Univ., Vol. 12, pt. 3, p. 627, pl. 49, figs. 76, 77.

1938 *Natica* (*Euspira*) aff. *meisensis* (MAKIYAMA), OTUKA, Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 5, pt. 2, p. 37, pl. 3, figs. 25, 28.

Typedata:—Holotype is in the Geological Survey of Chosen (Korea). Rəg.

No. 45.

Type locality:—Daitokudo, Meisen district, North Korea. Miocene Heiroku-do formation.

Dimensions (in mm.):—

Coll. No.	Height	Diameter
291	15.5	14 ×13
„	14	12.8×11
292	18	16.5×14

Remarks:—The Joban specimens are more or less small in size, but the characteristic features of the shell outline, depressed area below the suture and aperture are closely similar to those of the type specimen from the Meisen Miocene. Some of the so-called *Natica janthostoma* DESHAYES recorded from the Tertiary formations in Japan may be referable to the named species.

Occurrence:—

1) Yagawase cliff, Taira City. Honya formation. Common. Coll. No. 291.

2) Northwestern end of Ena, Ena-machi, Iwaki City. Honya formation. Few. Coll. N. 290.

3) Hieda, Nagasaki, Ena-machi, Iwaki City. Honya formation. Few. Coll. No. 292.

Euspira ashiyaensis (NAGAO, 1928)

Pl. 19, Figs. 1-4

1928 *Polinices* (*Euspira*) *ashiyaensis* NAGAO, Sci. Rep., Tohoku Imp. Univ., 2nd Ser., Vol. 12, no. 1, p. 95-96, pl. 15, figs. 19-21.

1956 *Euspira ashiyaensis* (NAGAO), HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 5, no. 45, p. 119, pl. 8, figs. 17, 18, 20-22.

Type data:—IGPS Coll. Cat. No. 36135 (Holotype).

Type locality:—Taya, Ashiya-machi, Onga-gun, Fukuoka Prefecture. Oligocene Yamaga formation.

Dimensions (in mm.):—

Coll. No.	Height	Diameter
349	36.0	31.0
„	35.6	31.0
„	36.0	34.5
„	36.7	33.0
„	29.5	27.5
350	35.0	30.0
351	29.5	27.5
Average	32.7	30.6

Remarks:—This species commonly occurs from the pits in the Yumoto, Uchigo and Yoshima colliery in the Yumoto district, and also from the Kuroda Basin. Especially in the Yoshima colliery more than 40 individuals of this species were collected from the lowermost part of the Iwaki formation. Although these Joban specimens are somewhat deformed, they are indistinguishable from the Ashiya specimens which were originally described and figured by NAGAO and subsequently figured by HIRAYAMA in many respects.

Occurrence:—

1) Yoshima Coal-mine, Yoshima-mura, Iwaki formation. Very abundant. Coll. No. 349.

2) Yumoto colliery, Joban Coal-mine. Iwaki formation. Common. Coll. No. 350.

3) Suzunosawa, Shimokawa, Tabito-mura. Iwaki formation. Few. Coll. No. 351.

Genus *Ampullina* BOWDICH, 1822

Ampullina BOWDICH, Elements Conch., p. 31, 1822.

Type species (by subsequent designation, DALL, 1909), *Ampullina depressa* LAMARCK, 1804.

Ampullina asagaiensis MAKIYAMA, 1934

Pl. 19, Figs. 5a, b

1924 *Natica janthostoma* DESHAYES, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 12, pl. 1, fig. 20.

1934 *Ampullina* ? *asagaiensis* MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 10, no. 2, art. 6, p. 162-163, pl. 7, figs. 58, 59, 66, 67.

1955 *Ampullina asagaiensis* MAKIYAMA, HIRAYAMA Sci. Rep. Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 118, pl. 4, figs. 10, 11, 13, 15.

Type data:—Holotype is in the Geological Insitute, College of Science, Kyoto University.

Type locality:—Matchgar (horizon 4 of Makiyama), North Sakhalin.

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
297	45	35.2×30.0	94°

Remarks:—MAKIYAMA (1934) gave a brief note concerning the genus and also detailed comparisons between *A. asagaiensis* and its known allied species, therefore, no further accounts are necessary in the present article. A well preserved specimen from the Yumoto district is figured.

Occurrence:—

1) Mukaida, Yumoto-machi, Joban City. Asagai formation. Few. Coll.

No. 297.

2) Nagasawa, Hisanohama-machi, Asagai formation. Common.

Genus *Sinum* ("BOLTEN") RÖDING, 1798

Sinum RÖDING, Mus. Boltenianum, Pt. 2, p. 14, 1798.

Type species (by subsequent designation, DALL, 1915), *Helix haliotoides* LINNÉ. Recent, western Pacific ?.

Sinum yabei OTUKA, 1934

Pl. 19, Figs. 6-8

1929 *Sigaretus pala* GMELIN, YOKOYAMA, Jour. Fac. Sci., Imp. Univ. Tokyo., Sec. 2, Vol. 2, pt. 8, p. 364 (non GMELIN, *fide* OTUKA, 1937).
1934 *Sinum yabei* OTUKA, Bull., Earthq. Res. Inst., Tokyo Imp. Univ., Vol. 12, pt. 3, p. 627-628, pl. 49, figs. 74, 75.
1935 *Sinum yabei* OTUKA, NOMURA, Saito Ho-on Kai. Mus., Res. Bull. No. 6, p. 232.
1936 *Sinum yabei* OTUKA, NOMURA and HATAI, *Ibid.*, No. 10, p. 145-146, pl. 17, figs. 9, 10.
1936 *Sinum yabei* OTUKA, NOMURA and ZINBO, *Ibid.*, No. 10, p. 344.

Type data:—ERI Reg. No. 1561 (Holotype) and ERI Reg. No. 1564 (Paratype).

Type locality:—Shiratori, Fukuoka-machi, Ninohe-gun, Iwate Prefecture (Loc. 7 in fig. 2 of the original paper, 1934). Miocene Shiratori formation.

Dimensions (in mm.):—

Coll. No.	Height	Diameter
229	17.0	18.0×14.0
„	15.6	15.2×12.5
230	16.4	17.5×13.0
„	15.2	17.0×13.0
Average	16.1	16.9×13.1

Remarks:—The characteristic features of the specimens referred to *Sinum yabei* OTUKA from the Numanouchi and Kokozura formations in the Joban coal-field quite correspond to those of the original description based on the specimens from the Ninohe district.

Since OTUKA described and figured this species, there are several records of its occurrence from the Miocene rocks in Japan as well as from the Myonchon (Meisen) district in North Korea. This species may be restricted in its geologic range only to Miocene, especially to the medial part in a three fold division.

Occurrence:—

1) Numanouchi harbor, Toyoma-machi, Taira City. Numanouchi formation. Few. Coll. No. 229.

2) Kokozura, Nakoso City. Kokozura formation. Few. Coll. No. 230.

Family CASSIDIDAE

Genus *Doliocassis* KURODA, 1933

Doliocassis KURODA, Iwanami Kôza, Geol. Paleont., Gastropoda and Lamellibranchiata, p. 25, 1933.

Shichiheia HATAI and NISIYAMA, Jour. Paleont., Vol. 23, No. 1, p. 93, 1949.

Type species (by monotypy), *Tonna* (*Doliocassis*) *yokoyamai* KURODA (=*Galeodea japonica* YOKOYAMA, 1923, non *Tonna japonica* DUNKER). Izumo (Shimane Prefecture), Miocene.

Shell like that of *Tonna*, but with peculiar tuberculated spirals.

Although the generic name of *Shichiheia* was preoccupied by *Doliocassis*, the comparisons and affinities with its allied genera were fully discussed by HATAI and NISIYAMA (1949) on the occasion of the establishment of the new genus, based on *Shichiheia etchuensis* HATAI and NISIYAMA from the Miocene of Toyama Prefecture as its generic type species. KURODA assigned this genus under the genus *Tonna*, but recently MAKIYAMA (1957) treated it as a distinct genus.

Doliocassis japonica (YOKOYAMA, 1923)

Pl. 19, Figs. 9, 10

1923 *Galeodea* (*Sconsia*) *japonica* YOKOYAMA, Jap. Jour. Geol. Geogr., Vol. 2, no. 1, p. 3-4, pl. 1, fig. 4.

1923 *Galaodea* (*Sconsia*) *japonica* YOKOYAMA, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 11, pl. 1, fig. 10.

1927 *Tonna japonica* (YOKOYAMA), MAKIYAMA, Mem. Coll. Sci. Kyoto, Imp. Univ., Ser. B, Vol. 3, no. 1, p. 73 (not *Dolium japonicum* DUNKER).

1933 *Phalium yokoyamai* NOMURA and HATAI, Jap. Jour. Geol. Geogr., Vol. 11, nos. 1-2, p. 50, pl. 8, figs. 1, 1a, 3, 7.

1949 *Shichiheia yokoyamai* (NOMURA and HATAI), HATAI and NISIYAMA, Jour. Paleont., Vol. 23, no. 1, p. 93, pl. 24, figs. 14-16.

Type data:—Lectotype is in the Geological Insitute, University of Tokyo.

Type locality:—Kagami, Kimachi, Shinji-machi, Yatsuka-gun, Shimane Prefecture. Miocene Fujina formation.

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
245	42	36 ×33	95°
„	32.5	27.5×22	90°

Remarks:—Two specimens from the Kokozura formation at hand can be safely identified to the named species by having the characteristic shape of whorls with the peculiar ornamentation. *Galeodea* (*Sconsia*) *japonica* YOKOYAMA from Tozenji, Yunami in the Joban coal-field, figured by YOKOYAMA

(1925) may be a young individual of the present species.

As the closely allied species of *D. japonica*, NOMURA and HATAI (1933, p. 52-53, pl. 8, figs. 2, 4, 5, 6, 8, 8a) described *Phalium yabei* from the Yanagawa Miocene in the Fukushima Prefecture and HATAI and NISIYAMA (1949, p. 93-94, pl. 24, figs. 1, 2, 7) described *Shichiheia etchuensis* from the Kurosedani Miocene in Toyama Prefecture. Comparing *japonica* and *yabei*, NOMURA and HATAI stated that *yabei* may be distinguishable from *japonica* "by having narrower interstitial grooves invariably with interstitial striae on the surface of the whorl."

Occurrence:—

1) Tozenji, Yunami, Sekinami, Kitaibaraki City. Kokozura formation. (Yokoyama)

2) Minamimae, Sekinami, Kitaibaraki City. Kokozura formation. Few. Coll. No. 245.

Order NEOGASTROPODA

Family MURICIDAE

Genus *Ocenebra* GRAY, 1847

Ocenebra (LEACH MS, 1818) GRAY, Ann. Mag. Nat. Hist., Vol. 20, p. 269, 1847.

Type species (by monotypy), *Murex "erinacea* MONTAGU". Recent, Europe.

Ocenebra tsuzurensis YOKOYAMA, 1924

Pl. 19, Fig. 12

1924 *Ocenebra tsuzurensis* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 3, p. 10, pl. 1, figs. 1-3.

Type data:—Lectotype (YOKOYAMA's pl. 1, fig. 1, here designated) and syntypes are in the Geological Institute, University of Tokyo.

Type locality:—In an eastward inclined shaft of the Tsuzura Coal-mine, Tsuzura, Uchigo City (Joban coal-field). Oligocene Iwaki formation.

Remarks:—One ill-preserved specimen was collected from Shimokawa, Kuroda Basin. But it is safely identified with YOKOYAMA's species from the Tsuzura Coal-mine in the Yumoto district. The present species resembles *O. ashiyaensis* NAGAO from the Waita formation of the Ashiya group in the Chikuho coal-field, Kyushu, but differs from that species by having more numerous subequal narrow spiral cords on the body whorl.

Occurrence:—Suzunosawa, Shimokawa, Tabito-mura. Iwaki formation. Rare. Coll. No. 352.

Family BUCCINIDAE

Genus *Ancistrolepis* DALL, 1895

Ancistrolepis DALL, Proc. U.S. Nat. Mus., Vol. 17, p. 709, 1895.

Type species (by original designation), *Chrysodomus eucosmis* DALL, 1891. Recent, Bering Sea.

Ancistrolepis yudaensis OTUKA, 1934

Pl. 19, Fig. 11

Ancistrolepis yudaensis OTUKA, Bull. Earthq. Res. Inst., Tokyo Imp. Univ., Vol. 12, pt. 3, p. 630-631, pl. 50, fig. 88.

Type data:—ERI Reg. No. 1574.

Type locality:—Yuda, Kintaichi-mura, Ninohe-gun, Iwate Prefecture (Loc. 4 in fig. 2 of the original paper, 1934).

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
242	40+	26×21	48°
„	50+	29	—

Remarks:—Two broken specimens are at hand; one preserves three and a half whorls and the other two whorls. However, the characteristic features of the shape of whorl profile and the spiral ornamentation of the present collection serve to easily identify OTUKA's named species from the Ninohe Miocene. *Ancistrolepis yudaensis* is closely related with some of the living species of *Ancistrolepis* in the northern Pacific, such as *A. magnus* (DALL), *A. magnus uritai* KURODA, *A. damon* (DALL), *A. damon polygramma* DALL and *A. unicus* (PILSBRY). The present species differs from the above-mentioned ones figured by KURODA (1931), by having more or less convex area above the shouldered keel and the not defined second shoulder keel near the suture.

Occurrence:—Sea-cliff of Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Few. Coll. No. 242.

Ancistrolepis yamanei KANEHARA, 1937

Pl. 19, Fig. 14

1937 *Ancistrolepis yamanei* KANEHARA, Bull., Imp. Geol. Surv. Japan, Vol. 27, no. 1, p. 13-15, pl. 1, figs. 1, 2; pl. 3, fig. 7.

Type data:—Types were destroyed by a fire during the World War II.

Type locality:—In the Nagakura Coal-mine (now Iwasaki Coal-mine of the Joban Coal-Mining Company), Iwasaki, Joban City (Joban coal-field). Miocene Mizunoya formation.

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
243	9.0+	ca. 45	45°

Remarks:—Single ill-preserved specimen with the outer lip is at hand. The original specimens described by KANEHARA were derived from the Mizunoya formation, however, the subsequent occurrence of this species from other units remains unknown. The examined specimen occured from the Honya formation in the Yumoto district has the characteristic features of the named species in its whorl profile and ornamentation. *Ancistrolepis yamanei* is closely related with *A. grammatus* (DALL) and *A. kinoshitai* (KURODA), now living in the Japanese waters. Comparisons of these living species to the present fossil one from the Joban coal-field were already stated by the original author.

Occurrence:—Igamesaku, Nagasaki, Ena-machi, Iwaki City. Honya formation. Rare. Coll. No. 243.

Ancistrolepis eguchii KAMADA, n. sp.

Pl. 19, Figs. 13a, b

Shell rather small, turreted with five whorls separated by distinct suture. One and half nuculear whorls smooth. Succeeding whorls ornamented with three prominent keel-like angulated spiral cords; uppermost one above shoulder weaker than two equi-strength cords; fourth keel-like spiral cord appear on body whorl but disappear under suture in penultimate whorl. Base sculptured with seven spiral cords and third of them from upper appears only intersticial secondary fine cord. Interspaces nearly flat-bottomed, much wider than cords and with faint vertical striae of growth. Siphonal canal recurved.

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
IGPS 79392	23	14	65°

Remarks:—One nearly perfect and two broken specimens from the Honya formation at Ena, Iwaki City were examined. The present new species closely resembles *Ancistrolepis trochoideus* (DALL), a living species collected by the research vessel "Albatross" from off Yokohama at depth of 440 and 600 fathoms. It also commonly occurs from the Pliocene rocks in the southern Kwanto region and was well figured by SUZUKI (1935) and OZAKI (1950). This also resembles *A. trochoidius tokoyodaensis* OZAKI (1950) from the Pliocene Iioka formation in Choshi City, Chiba Prefecture. But, *A. eguchii* is distinguishable from these Pliocene forms by not possessesing the secondary interstitial threads sculptured between the primary keel-like cords. *A. masudaensis* NOMURA from the

Masuda shell-beds in Yamagata Prefecture is distinguishable from the present new one by having wider and rounded spiral cords.

The specific name of this new species is dedicated to Dr. Motoki EGUCHI of the Department of Mining, Faculty of Technology, Tohoku University, for his contributions to the geological studies in the Joban coal-field and his constant encouragments.

Occurrence:—Northwestern end of Ena, Ena-machi, Iwaki City. Honya formation. Few. IGPS Coll. Cat. No. 79392.

Genus *Japelion* DALL, 1916

Japelion DALL, Proc. Biol. Soc. Washington, Vol. 29, p.8, 1916; Proc. U. S. Nat. Mus., Vol. 54, p. 225, 1918.

Type species (by original designation), *Buccinum hirasei* PILSBRY, 1901. Recent, Japan.

Japelion yabei KAMADA, 1955

Pl. 20, Figs. 18a, b

1955 *Japelion yabei* KAMADA, Venus, Vol. 18, no. 3, pp. 185-188, pl. 3, fig. 1, 2.

Type data:—IGPS Coll. Cat. No. 74005 (monotypy).

Type locality:—In a valley west of Kozawa, Kamioka-kami, Sekinami, Kita-ibaraki City (Joban coal-field). Miocene Mizunoya formation.

Remarks:—The present species is readily distinguishable from the living species of the genus by the more flat-sided body and penultimate whorls and by the abruptly curved peripheral area of the body whorl. Since KAMADA described the named species as new to science based on a single specimen from the Mizunoya formation in the Nakoso district, no supplementary specimens have been discovered not only from the Joban coal-field but also from the Tertiary deposits in Japan other than from the type locality.

Occurrence:—Only from the type locality. Mizunoya formation.

Genus *Neptunea* BOLTEN, 1798

Neptunea BOLTEN, Mus. Boltenianum, p. 115, 1798.

Type species (by subsequent designation, COSSMANN, 1901), *Murex antiquus* LINNÉ.

Neptunea ezoana TAKEDA, 1953

Pl. 20, Fig. 19

1953 *Neptunea ezoana* TAKEDA, Studies on Coal Geol., No. 3, p. 52-53, pl. 2, figs. 1, 3, 6.
1958 *Neptunea ezoana* TAKEDA, MATSUI, Trans. Proc. Palaeont. Soc. Japan, N. S. No. 30, p. 206, pl. 30, fig. 4.

Type data:—UH Reg. No. 10883 (Holotype) and Nos. 10882, 10881, 10887-9 and 10891 (Paratype).

Type locality:—UH. Loc. No. T76-K. Tikupenninai creek, Kushiro Province, Hokkaido. Oligocene Charo formation ?

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
353	38	26.5×23.5	52°

Remarks:—Single specimen collected from the 5th pit of the Yumoto colliery, Joban Coal-mine in the Yumoto district is very similar to the named species. The embryonal whorl and the anterior canal being lost, the last five whorls are preserved. The greater part of the test is also destroyed and four main ribs are impressed on the internal mould. In the penultimate whorl, the fifth rib from the upper appears closely near the lower sutures. The test on the last whorl (body whorl ?) is ornamented with five spiral ribs and seven interstitial ribs between main ribs of which two are subsutural ones.

The holotype of the present species occurred from the Kushiro coal-field, Hokkaido. The geological distribution of this species are, according to TAKEDA, M_2 (Upper Nisisakutan formation) and M_3 (Aragai) in south Sakhalin, and T_2 (Omagari), T_2' (Tyaro) and T_3 (Nuibetsu) in eastern Hokkaido. These formations are all equivalent to the Poronai shale in central Hokkaido. The discovery of this species in the Joban coal-field extends its distribution to the main island of Japan.

Occurrence:—In the 5th pit of Yumoto colliery, Joban Coal-mine, Yumoto-machi, Joban City. Iwaki formation. Rare. Coll. No. 353.

Genus *Buccinum* LINNÉ, 1758

Buccinum LINNÉ, Syst. Nat., Ed.. 10, p. 734, 1758.

Type species (by subsequent designation, MONTFORT, 1810), *Buccinum undatum* LINNÉ. Recent, north Atlantic.

Buccinum kurodai KANEHARA, 1937

Pl. 20, Figs. 1a, b

1929 *Buccinum leucostoma* var. *sachalinensis* YOKOYAMA, Jour. Fac. Sci. Imp. Univ. Tokyo, Vol. 2, pt. 9, p. 382-383, pl. 72, figs. 1, 2.

1935 *Buccinum "sachalinense* YOKOYAMA", KURODA, Venus, Vol. 5, nos. 2-3, p. 159 (not *Buccinum sakhalinensis* DALL, 1907).

1937 *Buccinum kurodai* KANEHARA, Bull. Geol. Surv. Japan, Vol. 27, no. 1, p. 12-13, pl. 4, figs. 1-3.

Type data:—Both YOKOYAMA's and KANEHARA's specimens were destroyed by a fire during the World War II.

Type locality:—In the "Upper Sandstone" (Nutoyo Beds of the river Uini North Sakhalin (Karafto).

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
246	57	33×28	52°

Remarks:—KURODA (1935) once pointed out that YOKOYAMA's *sachalinensis* is not a variety of *Buccinum leucostoma* (LISCHKE) and that *sakhalinensis* is a homonym of DALL's species. Subsequently, therefore, KANEHARA (1937) gave a new name to YOKOYAMA's fossil materials from North Sakhalin as *kurodai*, and referred his specimen from the Mizunoya formation in the Joban coal-field to it.

Although the supplementary material was not obtained from the Mizunoya formation, a single excellent one with the outer lip slightly broken was fortunately found from the Honya formation. The careful observation about the new material at hand shows that the most of the spiral threads are bipartite, and, therefore, the number of these spirals of the present specimen is seemingly much more than those of the type specimens figured by YOKOYAMA. But, if the surface of the shell becomes water worn before burial in the sediment, the bipatite spiral threads may be easily eroded to appear broad flat-topped ones.

Comparisons with the related living species were already fully discussed by KURODA and KANEHARA. There is no known fossil species closely related with the present one at the present time.

Occurrence:—Yagawase cliff, Iino, Taira City. Honya formation. Rare. Coll. No. 246.

Family NASSARIIDAE

Genus *Nassarius* DUNMÉRIL, 1805

Nassarius DUNMÉRIL, Zool. Analytique, p. 166, 1806.

Type species (by monotypy), *Buccinum arcularia* LINNÉ, 1758. Recent, Philippine Islands.

Nassarius simizui OTUKA, 1934

Pl. 21, Figs. 2, 3

1934 *Nassarius simizui* OTUKA, Bull. Earthq. Res. Inst., Tokyo Imp. Univ., Vol. 12, pt. 3, p. 631, pl. 50, fig. 85-87.

1936 *Nassarius* (*Alectrion*) *simizui* OTUKA, NOMURA and HATAI, Saito Ho-on Kai Mus., Res. Bull. No. 10, p. 139.

Type data:—ERI Reg. No. 1576 (monotype).

Type locality:—Siratori, Fukuoka-machi, Ninohe-gun, Iwate Prefecture (Loc. 7 in fig. 2 of the original paper, 1934). Miocene Shiratori formation.

Dimensions (in mm.):—

Coll. No.	Height	Diameter
287	15	7.8
„	13.5	7.5
„	11	6.4
„	10.5	5.4
„	10	5.7
Average	12	6.6

Remarks:—The referred specimens of the named species abundantly occur from the Numanouchi formation, especially at Tsunatori near Onahama in Iwaki City. The axial ribs of the specimens at hand are 20-21 in number on the body whorl and 17-18 on the penultimate whorl. The subsutural cord is granulated and the next lower spiral cord is finest of all.

The present species differs from *Nassarius kometubus* OTUKA by having a larger shell with distinct granulated subsutural cord. OTUKA (1934) assigned *N. simizui* to the subgenus *Hinia*, while *N. kometubus* to *Zeuxis*. However, both fossil species seem to be closely related to the living *Nassarius* (*Zeuxis*) *caelatus* (A. ADAMS) in many respects.

Occurrence:—

1) Tsunatori near Onahama harbor, Iwaki City. Numanouchi formation. Abundant. Coll. No. 287.

2) Kogayano-tsutsumi, Takaku, Taira City. Numanouchi formation. Common.

Nassarius kometubus OTUKA, 1934

Pl. 20, Figs. 2-5

1934 *Nassarius* (*Zeuxis*) *kometubus* OTUKA, Bull. Earthq. Res. Inst., Tokyo Imp. Univ., Vol. 12, pt. 3, p. 631, pl. 51, figs. 109, 110a, b.

Type data:—ERI Reg. No. 1588 (monotype).

Type locality:—Shiratori, Fukuoka-machi, Ninohe-gun, Iwate Prefecture (Loc. 7 in fig. 2 of the original paper, 1934). Miocene Shiratori formation.

Dimensions (in mm.):—

Coll. No.	Height .	Diameter
285	7.4	5.6
„	7.2	4.2
„	6.5	3.8
„	6.2	3.8
„	5.5	3.6
„	5.0	3.3
„	3.6	2.5
286	12.0	6.2
„	7.2	3.6
Average	6.7	4.1

Remarks:—Many well preserved specimens from the massive siltstone of the Honya formation are characterized by their very small size and by the peculiar ornamentation on the shell. They are identical with the original figures and description based on a specimen from the Ninohe district, Iwate Prefecture. Although the Ninohe specimen measured 4 mm. in height and 2.5 mm. in diameter, the Joban specimens are slightly larger than the holotype and attain about 12 mm. in height. The outer lip of the present specimen at hand is crenated within by seven minute denticles.

Occurrence:—

1) Northwestern end of Ena, Ena-machi, Iwaki City. Honya formation. Abundant. Coll. No. 285.

2) Hieda, Shimokajiro, Ena-machi, Iwaki City. Honya formation. Common. Coll. No. 286.

Genus *Molopophorus* GABB, 1869

Molopophorus GABB, Pal. California, Vol. 2, p. 156.

Type species (by monotypy), *Bullia* (*Molopophorus*) *striata* GABB, 1869. Tejon, Eocene; Tejon, California.

Molopophorus watanabei OTUKA, 1937

Pl. 20, Fig. 8

1937 *Molopophorus watanabei* OTUKA, Jap. Jour. Geol. Geogr., Vol. 14, nos. 2-3, p. 170-171, pl. 16, figs. 5-7.

1955 *Molopopholus watanabei* OTUKA, HIRAYAMA, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, no. 29, p. 119, pl. 4, figs. 21, 22.

Type data:—Type specimens were destroyed by a fire during the World War II.

Type locality:—Osaruda, Ono, Yotsukura-machi (Joban coal-field). Oligocene Iwaki formation.

Dimensions (in mm.):—

Coll. No.	Height	Diameter
354	22.5	14.2×11.2
„	20.0	13.0×10.8

Remarks:—The present species was originally reported by OTUKA from the Iwaki formation in the Joban coal-field. Although OTUKA reported that *M. watanabei* was collected from three localities, the exact localities are all unknown to the writer.

In the Joban coal-field, the present species ranges up into the Asagai formation, as already mentioned by HATAI and KAMADA (1950, p. 65) and also by HIRAYAMA (1955, p. 119). Besides this species, HIRAYAMA described *M. rara* HIRAYAMA from the Asagai formation in the Futaba district in this coal-field.

It is noteworthy that as already mentioned by OTUKA (1937, p. 171), *Nassa* sp. reported by NAGAO (1928, p. 112, pl. 17, fig. 26) from the Yamaga formation of the Ashiya group in the Chikuho coal-field, Kyushu, is closely similar to *watanabei*. NAGAO reported *Molopophorus*? sp. from the Yamaga formation, but precise features are uncertain.

The genus *Molopophorus* is quite common in the West Coast Oligocene in North America and may be present in the Eocene of the Paris Basin, according to STEWART (1926, p. 389). WEAVER (1942) listed 11 species, one subspecies and two varieties of this genus in Oregon and Washington, which range from middle Eocene (Umpqua formation) to middle Miocene (Astoria formation). In Japan, four species are reported from various localities and their geologic range is restricted to the Oligocene. They are as follows:

Species and author	Formation	Area
M. watanabei OTUKA, 1937	Iwaki	Joban coal-field
M. kushiroensis TAKEDA, 1953	Shitakara	Eastern Hokkaido
M. rara HIRAYAMA, 1955	Asagai	Joban coal-field
M. nipponicus KANNO, 1958	Ushikubitoge	Chichibu Basin

Occurrence:—

1) Yumoto colliery, Joban Coal-mine, Yumoto-machi, Joban City. Iwaki formation. Few. Coll. No. 354

2) Oyamada, Hisanohama-machi. Asagai formation. Few. Coll. No. 355.

Family VOLUTIDAE

Genus *Fulgoraria* SCHUMACHER, 1817

Fulgoraria SCHUMACHER, Essai Nouv. Syst. Vers. Test., pp. 73, 242, 1817.

Type species (by subsequent designation, Gray, 1847), *Voluta rupestris* GME-

LIN, 1791 (=*Fulgoraria chinensis* SCHUMACHER, 1817). Recent, China Sea.

Fulgoraria tokunagai (KANEHARA, 1937)

Pl. 21, Figs. 4-8

1937 *Psephaea tokunagai* KANEHARA, Bull. Imp. Geol. Surv. Japan, Vol. 27, no. 1, p. 16-18, pl. 2, figs. 2-5.

Type data:—Type specimens were destroyed by a fire during the World War II.

Type locality:—Iwasaki colliery (formerly Nagakura Coal-mine), Joban Coal-Mining Company, Nagakura, Joban City (Joban coal-field). Miocene Mizunoya formation.

Remarks:—Although no collection was made from the Mizunoya formation, a large, nearly complete specimen of more than 150 mm. in length and 53 mm. in diameter occured from the Honya formation. The detailed comparisons with the allied species and some discussions about the named species were done by the original author.

Occurrence:—

1) Kamikuramochi, Iwaki City. Honya formation. Rare. Coll. No. 253.

2) Hieda, Shimokajiro, Ena-machi, Iwaki City. Honya formation. Few. Coll. No. 254.

Family CANCELLARIIDAE

Genus *Cancellaria* LAMARCK, 1799

Cancellaria LAMARCK, Mem. Soc. Hist. Nat. Paris, p. 71, 1799.

Type species (by monotypy), *Voluta reticulata* LINNÉ, 1758. Recent, Florida and West Indies.

Cancellaria rara AOKI, 1954

Pl. 20, Figs. 6, 7

1954 *Cancellaria rara* AOKI, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 3, no. 17, p. 38, pl. 2, fig. 17.

Type data:—TKD Reg. No. 5925 (Holotype).

Type locality:—Cliff of small valley, Donosaku, Kamikatayose, Kabeya, Taira City (Joban coal-field). Miocene Kabeya (Honya) formation.

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
255	16	10 ×9	55°
„	14	9.5×8	54°

Remarks:—Two well preseved specimens from the Honya formation at hand are identified to those from the type locality. This is a small sized shell characterized by the tuberculated band-like spiral keel and sculptured by conspicuous longitudinal threads running obliquely to the suture on the area above the shoulder. The longitudinal threads become to disappear towards the basal part of the body whorl. The present species is quite similar to *C. hukusimana* NOMURA and HATAI (1936, p. 134, pl. 17, figs. 6a, 6b) from the Miocene Tanagura formation at Nishigoto, Tanagura-machi, Fukushima Prefecture, but differs from the latter by possessing the above-mentioned characters.

Occurrence:—Tangozawa, Taira City. Honya formation. Few. Coll. No. 255.

Family TURRIDAE

Genus *Megasurcula* CASEY, 1904

Megasurcula CASEY, Trans. Acad. Sci, St. Louis, Vol. 14, p. 147, 1904.

Type species (by subsequent designation, GRANT and GALE, 1931), *Pleurotoma* (*Surcula*) *carpenteriana* GABB, 1865. "Post-Pliocene" of Santa Barbara, California.

Megasurcula yokoyamai (OTUKA, 1934)

Pl. 20, Figs. 13a, b

1925 *Pleurotoma* sp. YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, art. 5, p. 8, pl. 1, fig. 9.

1934 *Surculites yokoyamai* OTUKA, Bull. Earthq. Res. Inst., Tokyo Imp. Univ., Vol. 12, pt. 3, p. 628, pl. 50, fig. 92.

1935 *Surculites* (*Megasurcula*) *yokoyamai* OTUKA, NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 73, pl. 6, fig. 4.

Type data:—ERI Reg No. 1551.

Type locality:—Yuda, Kobayashi, Kintaichi-mura, Ninohe-gun, Iwate Prefecture. (Loc. 11 in fig. 2 of the original paper, 1934). Miocene Lower Kadonosawa series.

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
234	30.0	15.8×14.5	54°
235	ca. 32	17.0×15.5	55°
236	20+	14	—

Remarks:—A nearly perfect specimen from Kokozura possesses about 14 distinct oblique nodes on the carina in each whorls which are separated from each other by somewhat variable interspaces. In the same specimen,

the upper area above the carina is concave and sculptured with about 12 spiral threads of nearly equal strength. The base below the carina is sculptured with about 36 spiral threads of which the middle 15 are represented by a pair of threads with considerable strength and the intersticial fine striae.

The nodes of the other specimens from Izura and Yunami, both in Kitaibaraki City, are indistinct as similar as those of YOKOYAMA's specimen from Izura figured in his pl. 1, fig. 9, under the name of *Pleurotoma* sp.

Although the Joban specimens at hand are rather small in size compared with the type from the Ninohe district, Iwate Prefecture, the characteristic features of the named species described by OTUKA are well recognized.

As to related species of *Megasurcula yokoyamai*, the following forms were described from the Miocene rocks in Japan: *Surculites* (*Megasurcula*) *siogamensis* NOMURA (1935, p. 223, pl. 17, figs. 3, 4) from Shiogama and also from the Moniwa shell beds (NOMURA, 1940, p. 44, pl. 3, figs. 9a, b), both in Miyagi Prefecture; *Surculites yokoyamai elongatus* HATAI (1940, p. 117, figs. 3, 4) from Tanagura in Fukushima Prefecture, associated with *M. yokoyamai* OTUKA (NOMURA and HATAI, 1936, p. 134, pl. 17, figs. 13a, 13b); *Surculites rara* NOMURA and ONISI (1940, p. 185, pl. 17, fig. 8) from the Sennan district in Miyagi Prefecture and *Surculites* (*Megasurcula*) *osawanoensis* TSUDA (1959, p. 96, pl. 6, figs. 2a-b, 3) from the Kashio alternation of the Yatsuo group in Toyama Prefecture. These species or subspecies are probably identified with *M. yokoyamai*, but precise discussion will be retained until more materials are obtained, because the detailed individual variation of *M. yokoyamai* is still unknown at the present time.

Occurrence:—

1) Cliff behind the shipyard, Onahama, Iwaki City. Nakayama formation. Few. Coll. No. 237.

2) Kokozura, Nakoso City. Kokozura formation. Rare. Coll. No. 234.

3) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Rare. Coll. No. 235.

4) Yunami, Sekinami-machi, Kitaibaraki City. Kokozura formation. Coll. No. 236.

Genus *Riuguhdrillia* OYAMA, 1951

Riuguhdrillia OYAMA, Bull. Biogeogr. Soc. Japan, Vol. 15, no. 2, p. 4, footnote 2, 1951; Venus, Vol. 17, no. 3, p. 153, 1953.

Type species (by original designation), *Pleurotoma* (*Genota*) *engonia* WATSON, 1881. Recent, off Enoshima, Sagami Bay, Japan at the depth 345 fathoms. See plate 20, figure 12, of *R. engonia*.

Like *Bathytoma*, but, distinguishable by having no or feeble spiral sculpture except peripheral carina. Beads on carina not conspicuous. (OYAMA, 1953).

Riuguhdrillia oyamae KAMADA, n. sp.

Pl. 20, Figs. 9-11

Shell rather small, short fusiform with six whorls, body whorl about three fifths of shell length. Uppermost two embryonal whorls smooth and convex; succeeding whorls provided with strong peripheral carina in middle part of whorl; area above carina slightly concave and subvertically flat below it. Spiral threads feeble but somewhat distinct on base which are separated with narrow grooves; cheveron-shaped riblets sculptured by lines of growth and its apex lying on carina. Outer lip thin, with deep sinus lying also on carina; and well rounded below sinus inner lip covered by smooth thin callous deposits. Canal short, open and slightly recurved.

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
IGPS 79393*	16	10 × 9.5	44°
„	19	11 ×10.2	40°
„	17.5	11 ×10	46°
248	21.2	11.4×11	42°
„	16	9.4× 9.2	38°
Average	17.9	10.6×10.0	42°

* Holotype.

Remarks:—The genus *Riuguhdrillia* is represented by two known species, namely; *R. engonia* (WATSON) which is living today in the Sagami Bay and also occurs from the Pleistocene rocks in Chiba Prefecture, and *R. mediocarinata* (YOKOYAMA) which was originally described based on the specimens from the Pliocene Nojima formation in Yokohama City and also from the Pleistocene rocks in Chiba Prefecture (OYAMA, 1953). The characteristic features of the shell with strong peripheral carina of the present new species are very similar to those of the above-mentioned two species, but *R. oyamae* is distinguishable therefrom by possessing a smaller shell and shorter siphonal canal compared with the other.

The new specific name is dedicated to Dr. Katsura OYAMA in honor of his particular attention of the genus *Riuguhdrillia*.

Occurrence:—

1) Yagawase cliff, Iino, Taira City (Type locality). Honya formation. Few. IGPS Coll. Cat. No. 79393.

2) North of Taira rail-road station, Shiroyama, Taira City. Honya formation. Few. Coll. No. 248.

Genus *Turricula* SCHMACHER, 1817

Turricula SCHUMACHER, Ess. d'un Nouv. Syst., p. 217, 1817.
Type species (by monotypy), *Turricula flammea* SCHUMACHER, 1817.

Turricula atsukoae KAMADA, n. sp.

Pl. 20, Figs. 14-17

Shell small, turreted; whorls ten in number, separated with distinct suture, each whorl angulated in profile, angle situated at lower part in early whorls and gradually ascending toward penultimate whorl. Nuculear whorls three, rounded, smooth. Post-nuculear whorls ornamented with faint spiral striations and distinct oblique costae numbering 12 on penultimate whorl and 10 on first post-nuculear whorl. Cheveron-shaped growth lines distinct on body whorl and its apex lying just above angle. Aperture suboblique, fusiform, narrowed to open narrow canal.

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
IGPS 79394*	21	7.5×7.2	24°
„	21	8.0×7.2	27°
„	13.5	5.8×5.4	30°
295	23	8.5×8.0	26°
296	15	6.0×5.6	29°
Average	18.7	7.2×6.7	27°

Remarks:—The present new species is closely similar to *Turricula osawanoensis* TSUDA (1959, p. 95, pl. 6, figs. 1a, b) from the Miocene Kurosedani formation in Toyama Prefecture, but differs therefrom by the less number of the axial costae on each whorl. This species is restricted in its occurrence to the Kokozura formation in the Nakoso district and the Numanouchi formation in the Yumoto district.

The new specific name is given to the name of my daughter, Atsuko KAMADA who was born on June 24th, 1959.

Occurrence:—

1) Kokozura, Nakoso City (Type locality). Kokozura formation. Few. IGPS Coll. Cat. No. 79394.

2) Izura, Otsu-machi, Kitaibaraki City. Kokozura formation. Rare. Coll. No. 295.

3) Tsunatori near Onahama, Iwaki City. Numanouchi formation. Rare. Coll. No. 296.

Family CONIDAE

Genus *Chelyconus* MÖRCH, 1852

Chelyconus MÖRCH, Cat. conchyl. quae reliq. D. Alphonso d'Aguirra & Gades, Comes de Yoldi, p. 69, 1852.

Type species (by subsequent designation, COSSMANN, 1896), *Conus testudinarius* MARTINI. Recent, West Africa.

Shell of varying size, moderately slender, spire high, conical. Siphonal notch broad, very shallow. Siphonal fasciole broad, bulging. Outer lip flat or slightly concave. Sculpture (of type species) consisting of obscure spiral threads at base of body whorl. (WOODRING)

Chelyconus tokunagai (OTUKA, 1934)

Pl. 21, Figs. 1a, b, c

1934 *Conus tokunagai* OTUKA, Bull. Earthq. Res. Inst., Tokyo Imp. Univ., Vol. 12, pt. 3, p. 632, pl. 50, figs. 83, 84.

Type data:—ERI Reg. No. 1593 (Holotope).

Type locality:—Nisatai, Fukuoka-machi, Ninohe-gun, Iwate Prefecture (Loc. 3 in figure 2 of the original paper). Miocene Lower Kadonosawa series.

Dimensions (in mm.):—

Coll. No.	Height	Diameter	Apical angle
233	41.0	20.6×17.0	83°
„	19.0+	9 × 8	—

Remarks:—OTUKA compared this fossil species with the *Conus pauperculus* SOWERBY, living in the temperate waters of Japan, which is now assigned to the genus *Chelyconus*. *Ch. fulmen* (REEVE), also living in the Japanese waters and further south, is an another related species. *Ch. tokunagai* differs from these living species by having a higher spire and more distinct spiral cords at the base of the body whorl.

A single adult and an imperfect juvenile shells from Kokozura at hand can be referred to the named species. Owing to their shells having turned to soft chalky substances, the spiral cords developing on the body whorls are not prominent and it is scantily seen only at its base and on the inner lip. However, the shapes of the whorl possess the characteristic features of the named species.

Occurrence:—Kokozura, Nakoso City. Kokozura formation. Few. Coll. No. 233.

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Plate 1

Explanation of Plate 1

(All figures in natural size, unless otherwise stated.)

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Fig. 3. *Solemya* (*Acharax*) *tokunagai* YOKOYAMA. Loc. Shiroyama, Taira City. Honya formation. Coll. No. 86. 37

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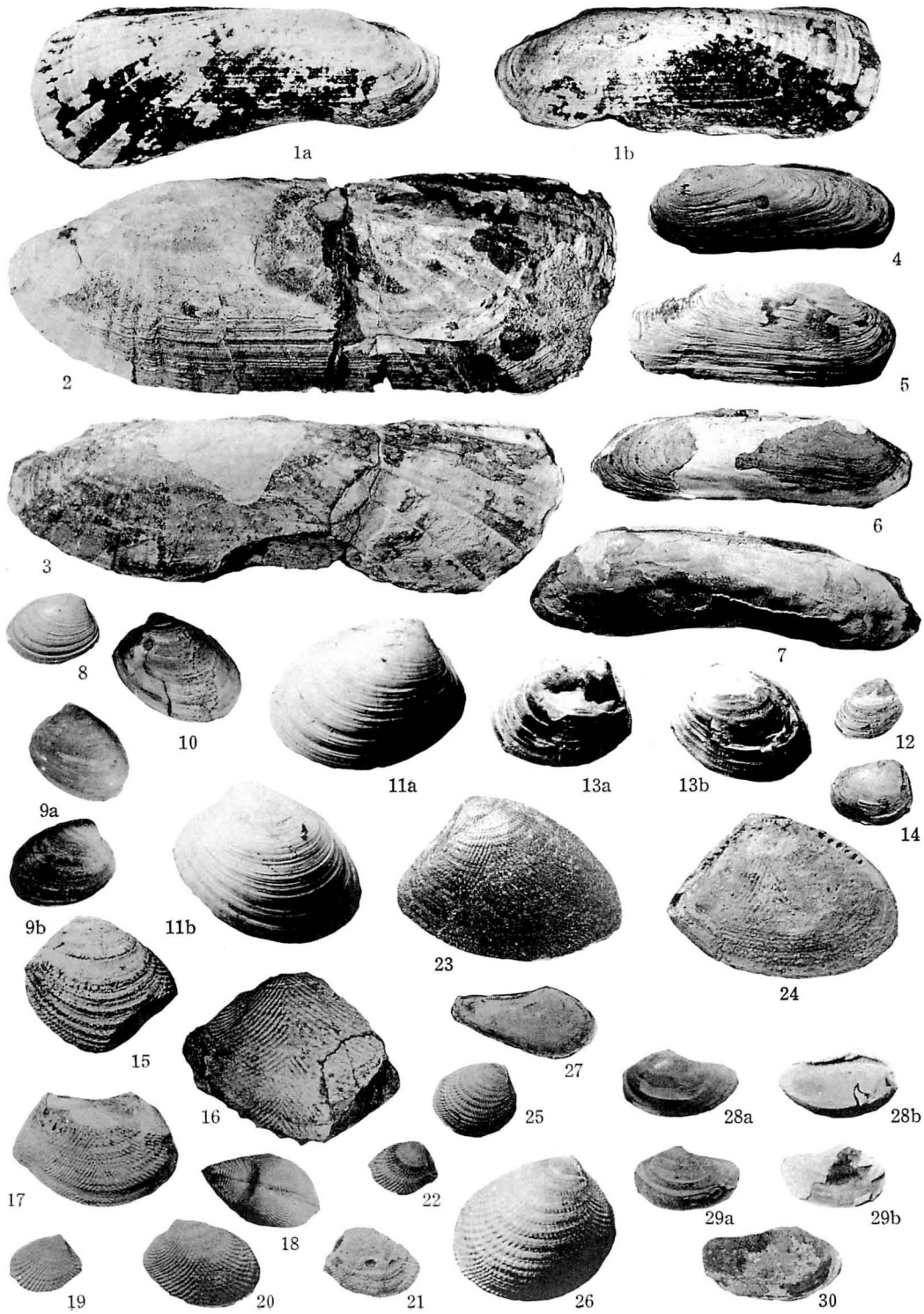
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Plate 2

Explanation of Plate 2

(All figures in natural size, unless otherwise stated.)

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Figs. 1, 2, 5. *Saccella confusa toyomaensis* KAMADA, n. subsp. Figs. 1, 2, Holotype. Loc. Numanouchi harbor, Toyoma-machi, Taira City. Numanouchi formation. IGPS Coll. Cat. No. 79376. (Fig. 2, ×2.) 50

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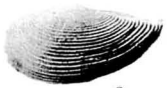
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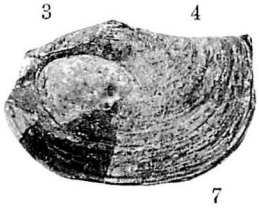
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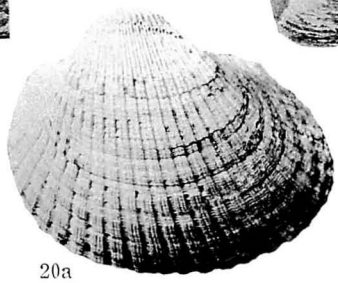
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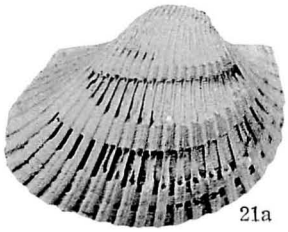
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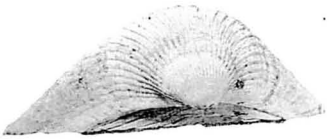
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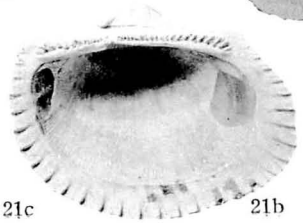
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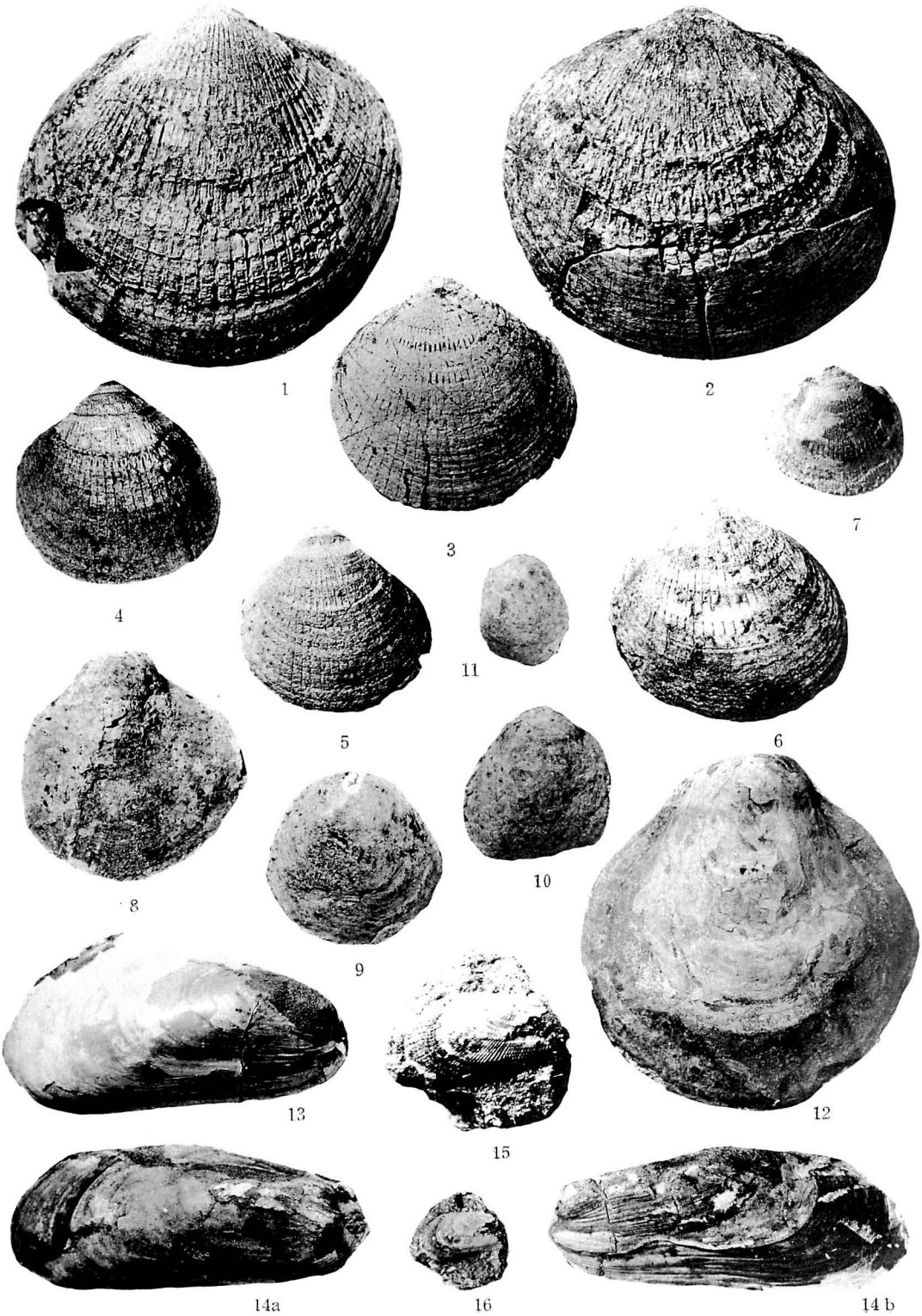
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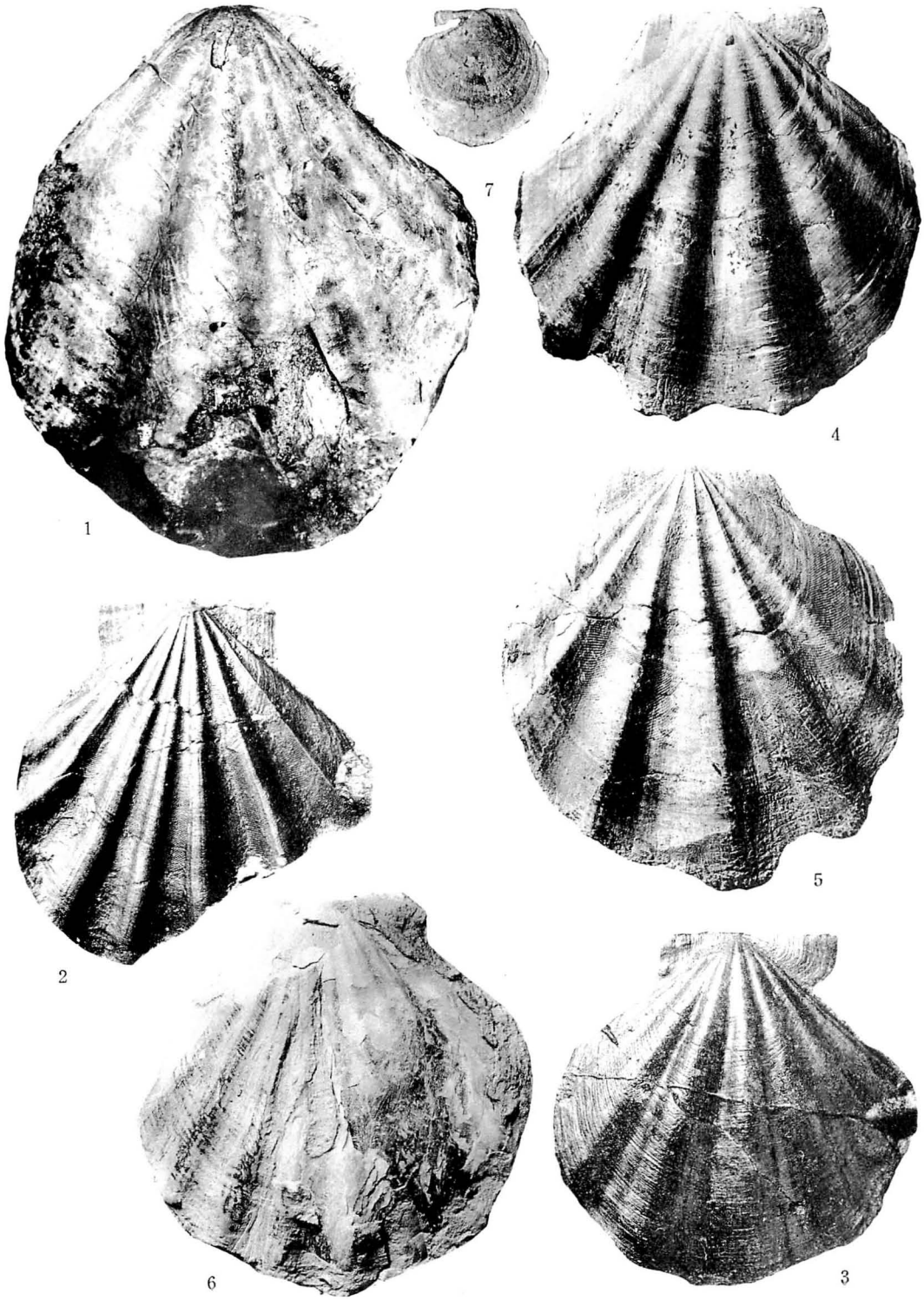
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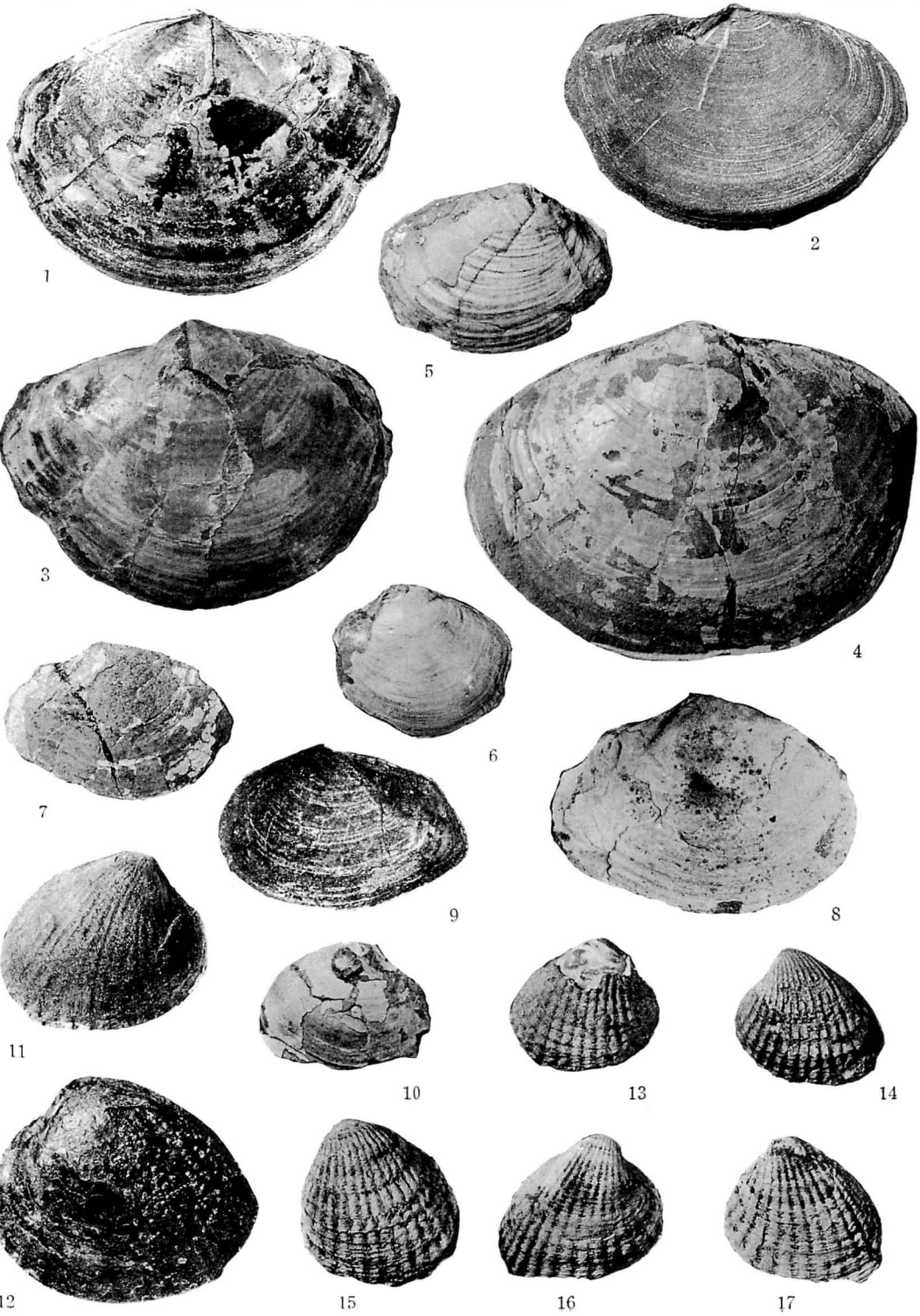
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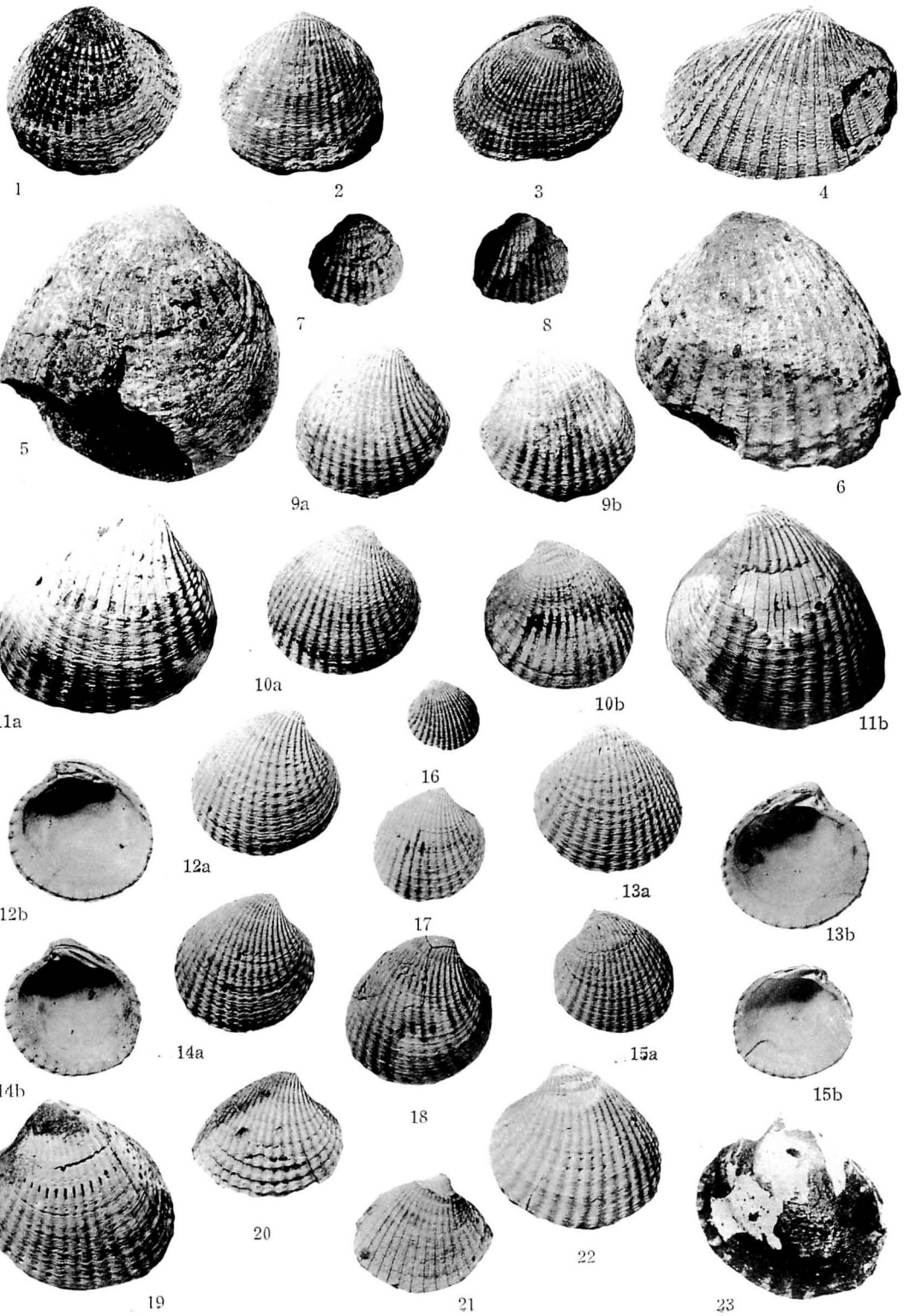
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Explanation of Plate 8

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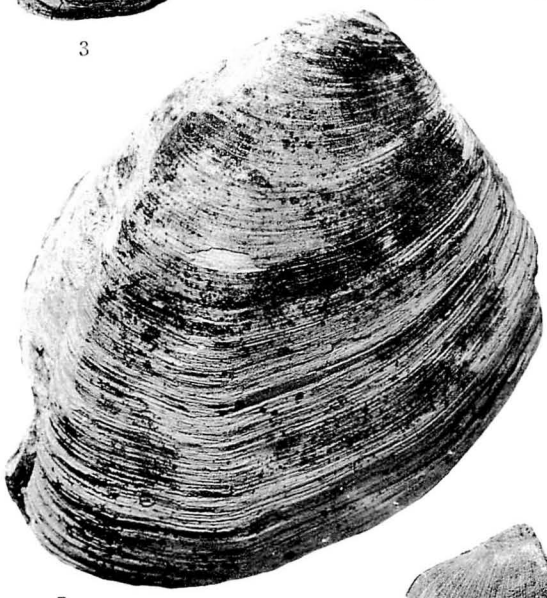

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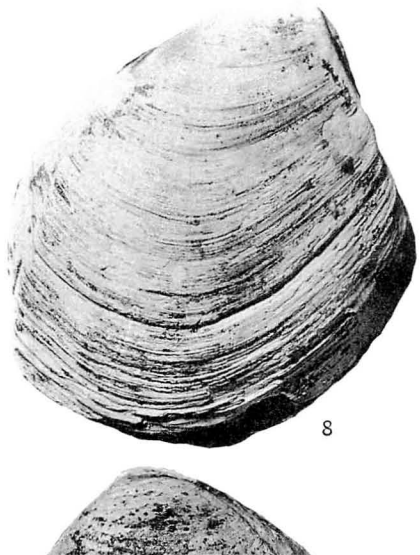

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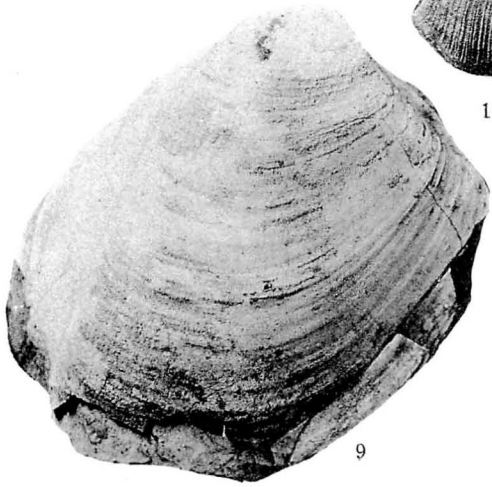

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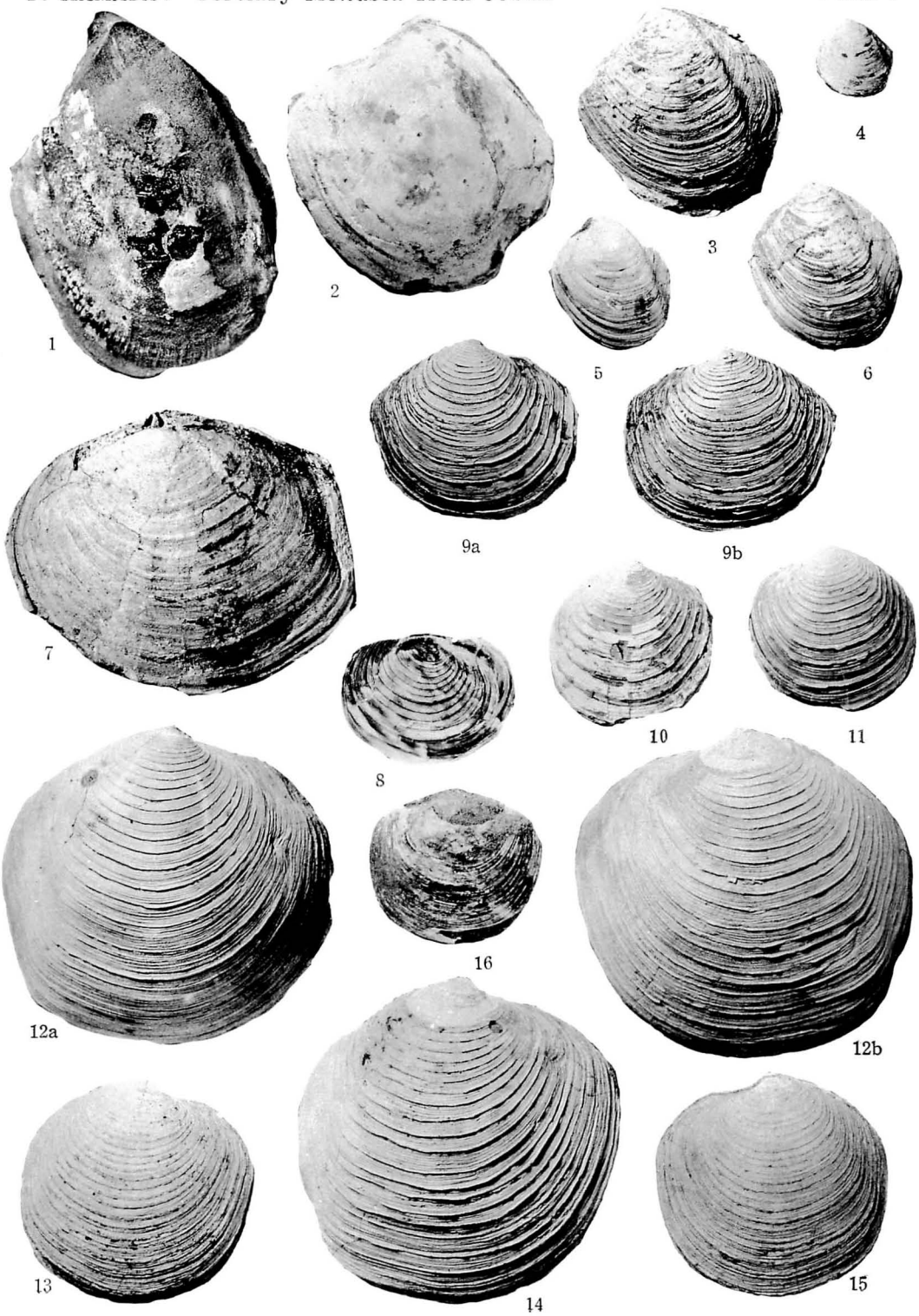
Plate 9

Explanation of Plate 9

(All figures in natural size.)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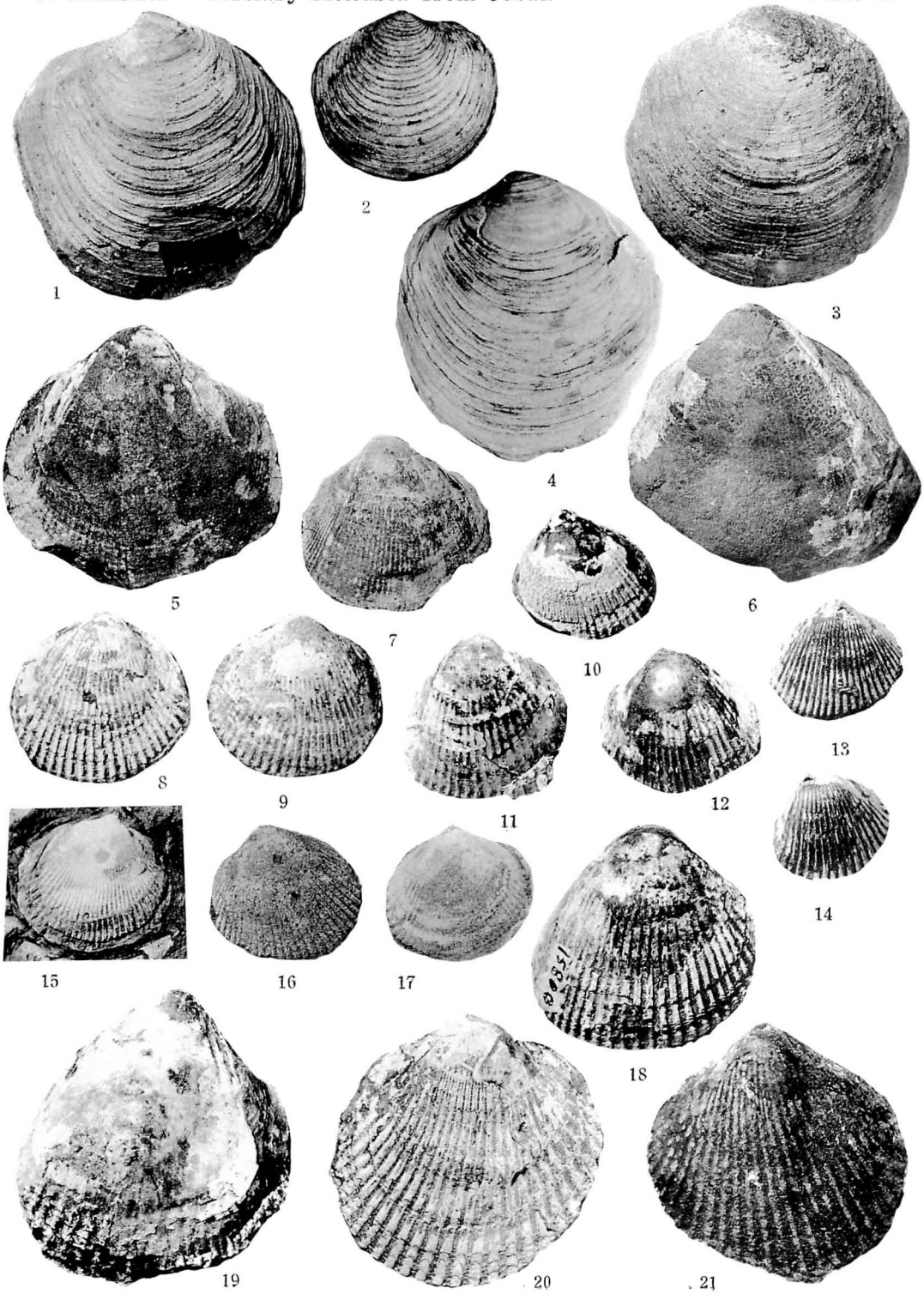
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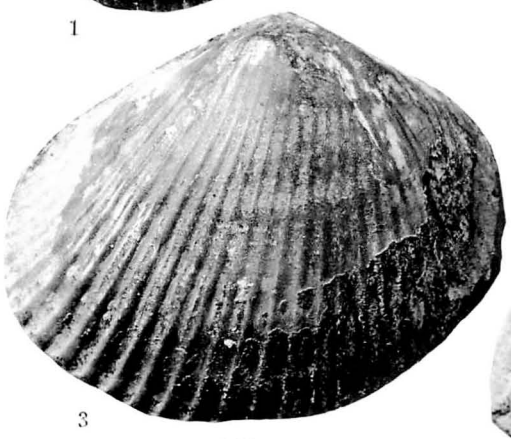

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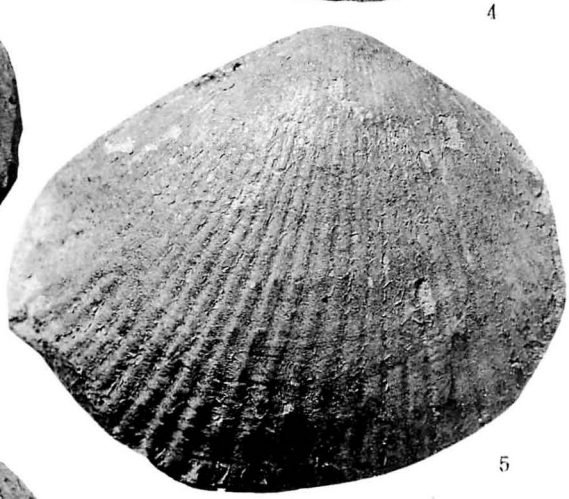

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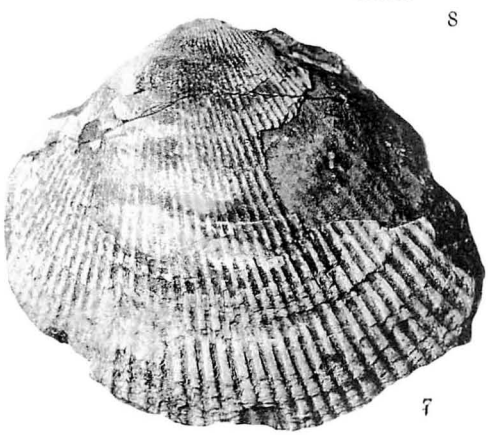

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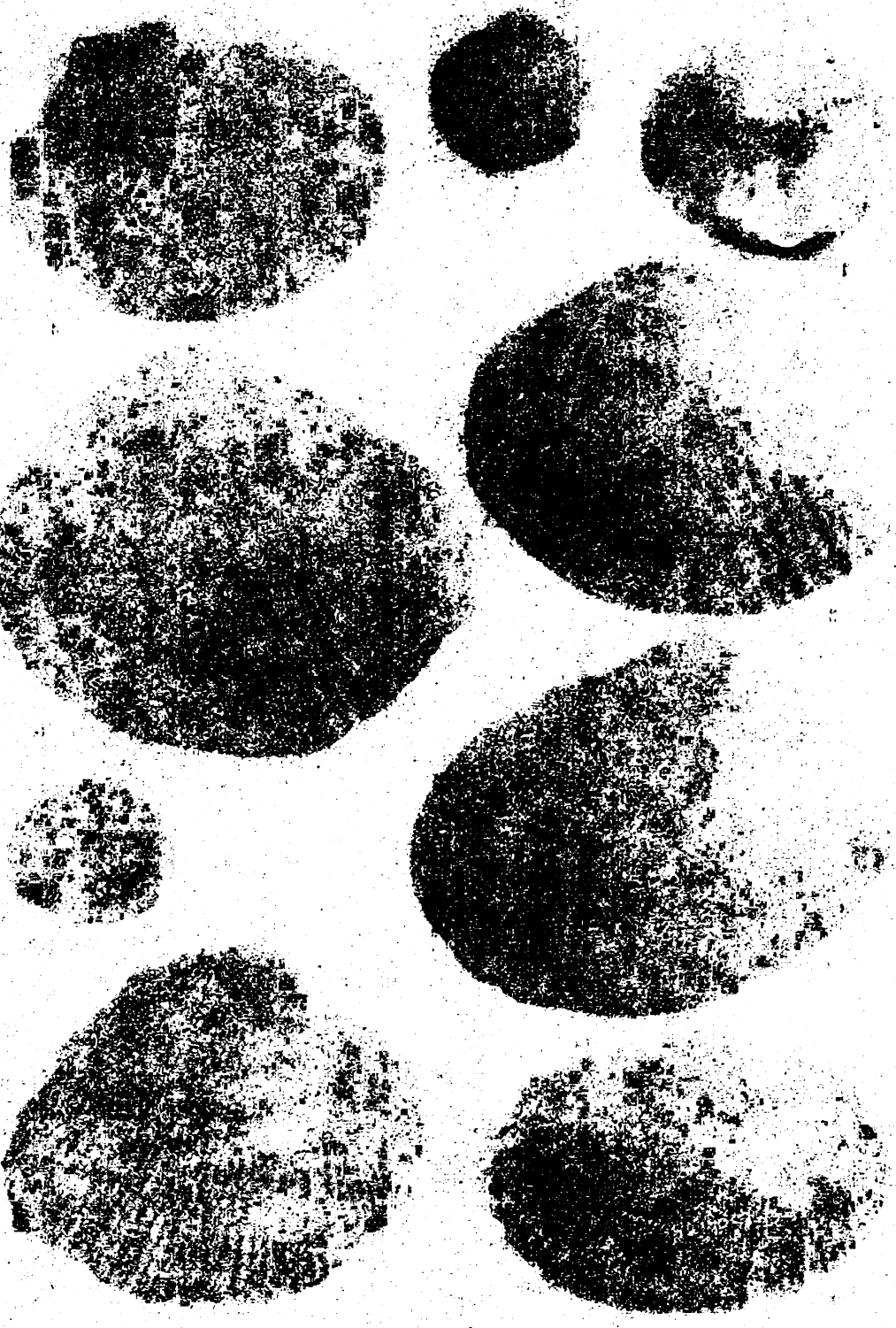

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(All figures in natural size.)

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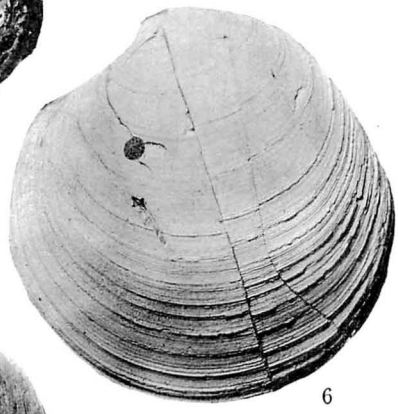

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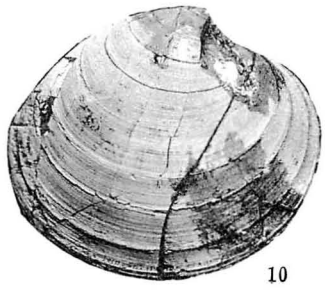

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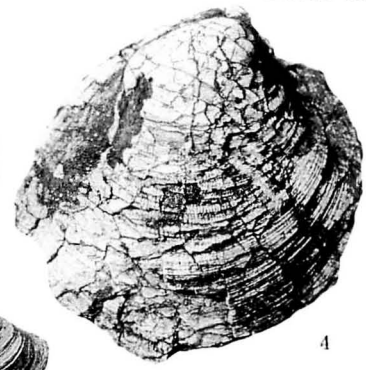
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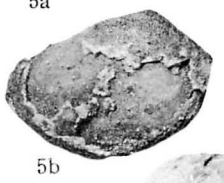
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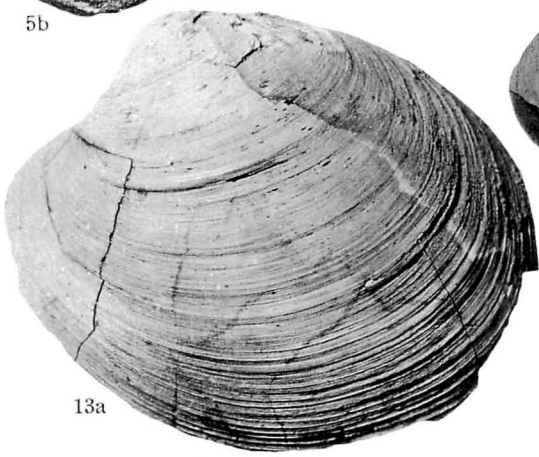
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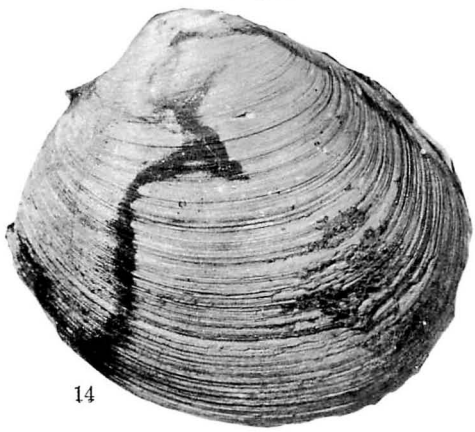
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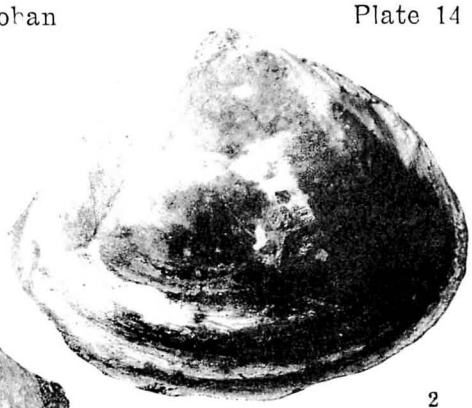

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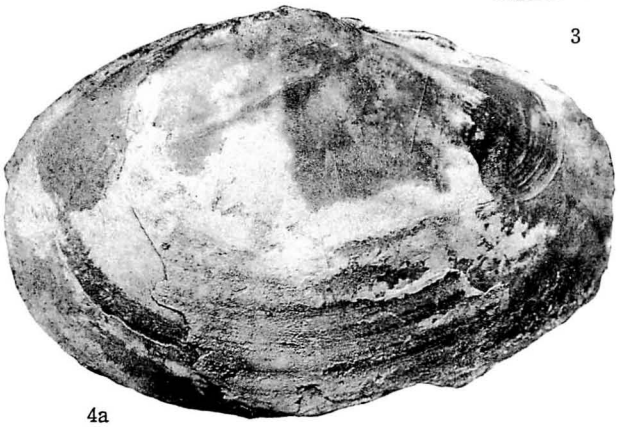

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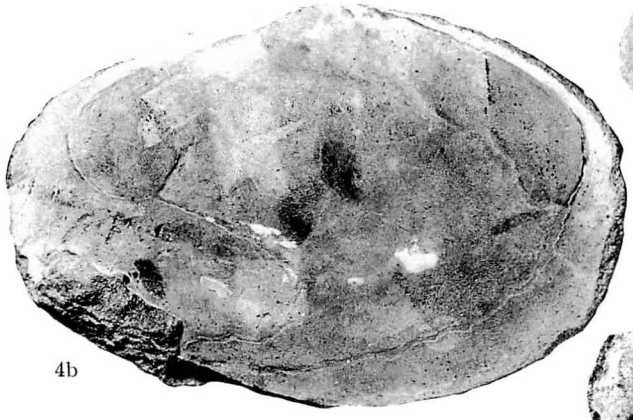

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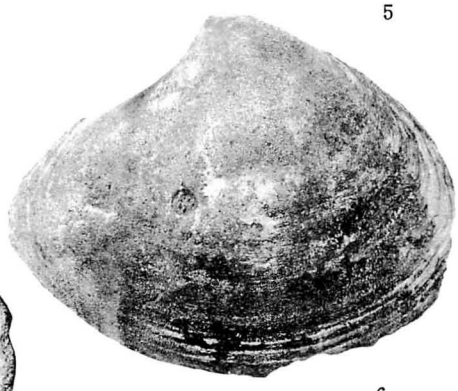

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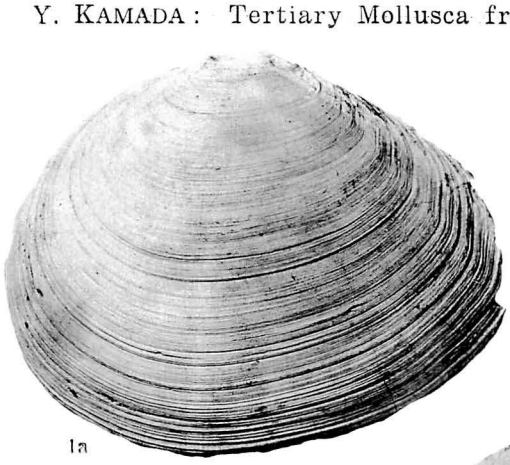

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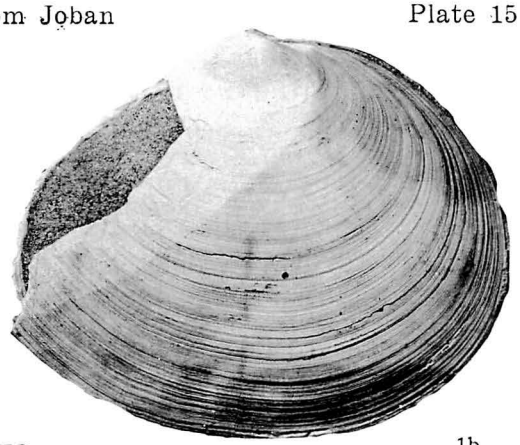

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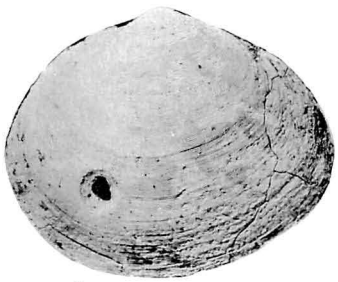

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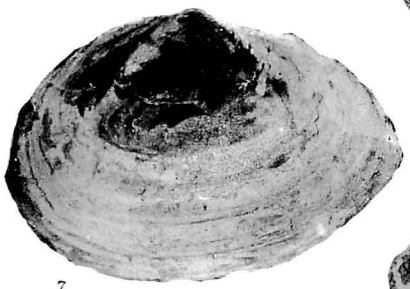

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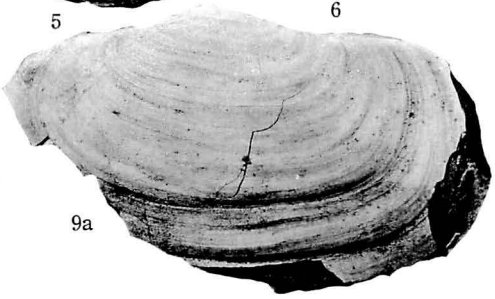
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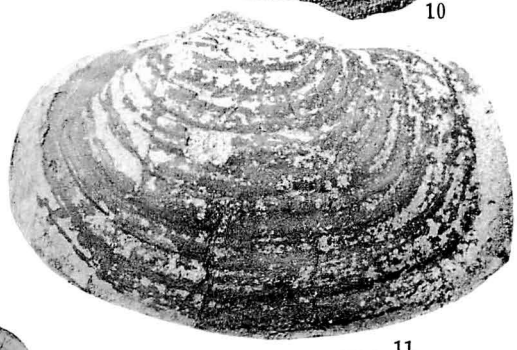
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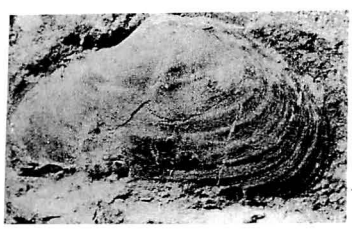
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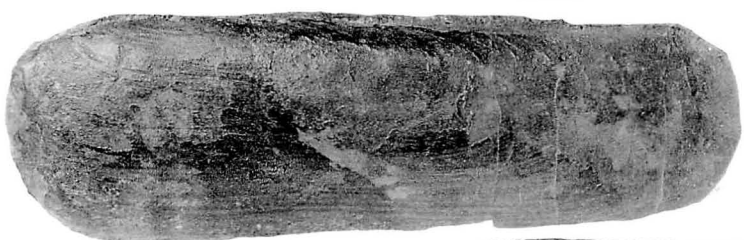

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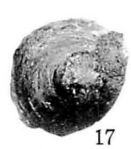
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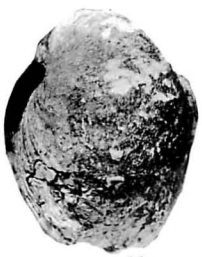
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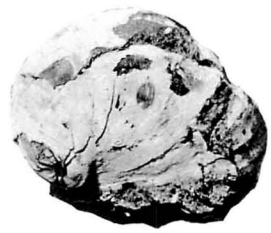
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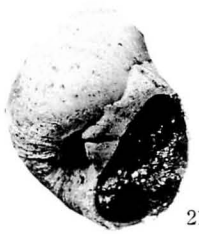
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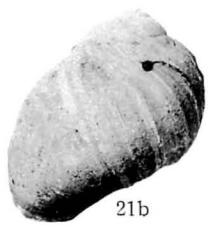
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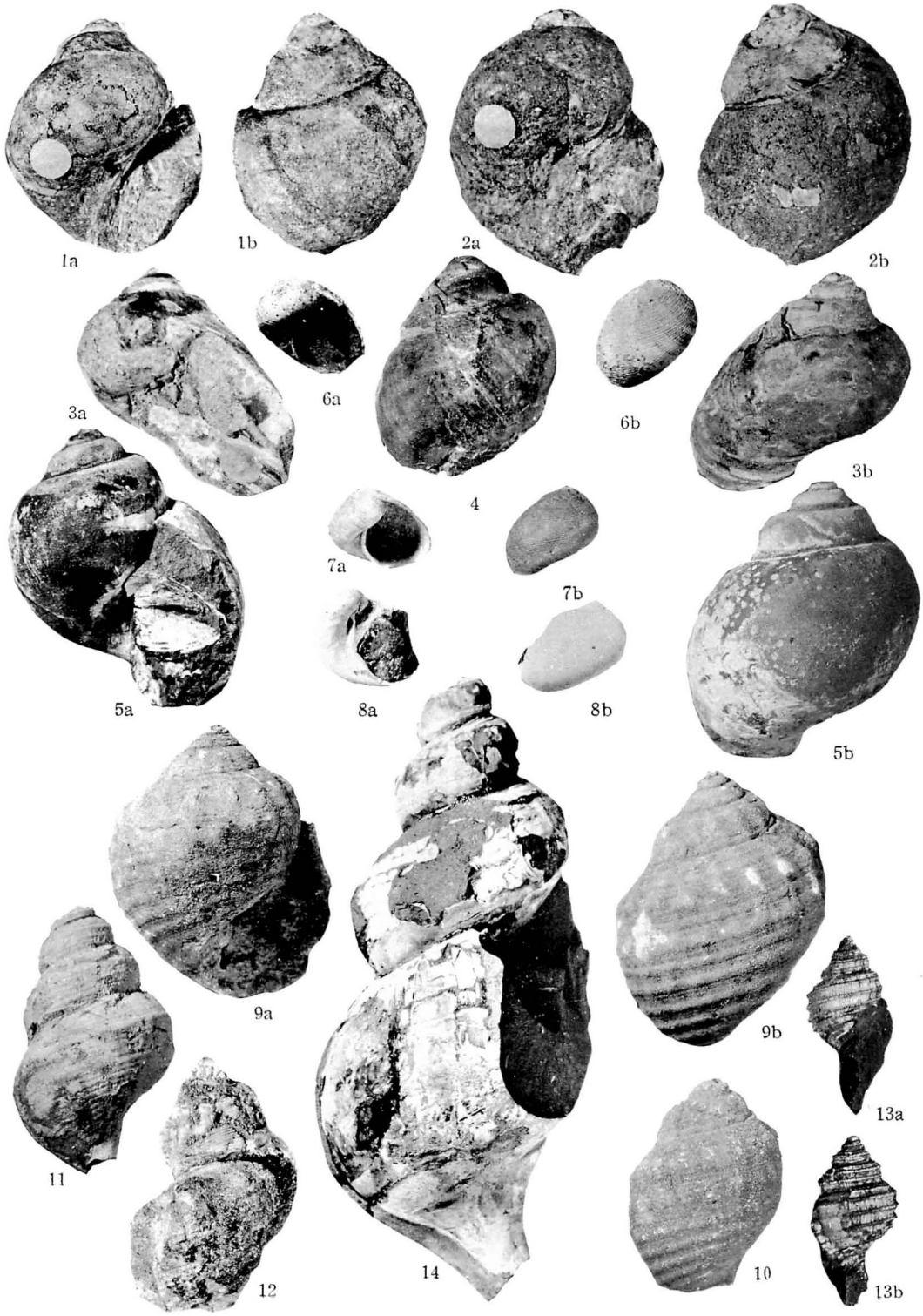
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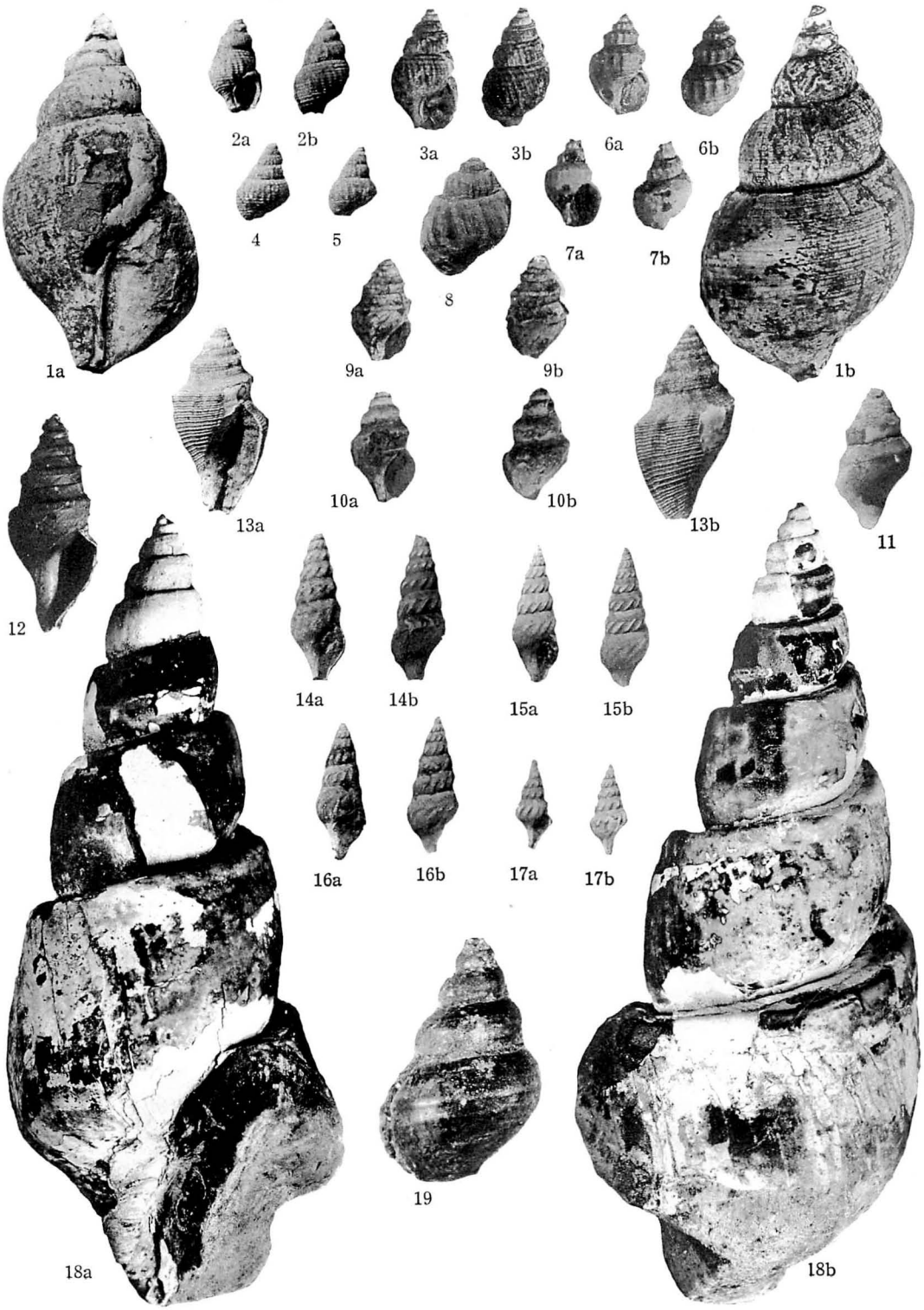
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