The Geology and Paleontology of the Setana and Kuromatsunai Areas in Southwest Hokkaido, Japan

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(With tables 1–13, figs. 1–9 and plates 1–8)

Abstract

As the result of the studies, it was found that a significant unconformity separates the so-called Setana from the older rocks of the Neogene System in both the Setana and Kuromatsunai areas in southwest Hokkaido, that the so-called Setana of authors actually included rocks ranging from early Miocene to late Pliocene in age. The distinguished formations and members are characteristic in thier lithological and paleontological characteristics as well as in geological structure.

Correlation of the formations in the two areas is made with northern Honshu, especially of the oilfield region and with important localities in Hokkaido. Comparison of the formations correlated revealed significant similarity in lithology and paleontological features, which suggests their having been deposited in a similar or same sedimentary basin influenced.

Besides interpretation of the geological history of the Setana and Kuromatsunai areas, paleontological analysis of the molluscan and brachiopod fauna resulted in the distinguishing of a total 84 species of Mollusca and 4 of Brachiopoda. Among the former, 51 species are Pelecypoda (32 genera) and 33 are Gastropoda (27 genera). Among the molluscs, five species or subspecies are new to science.

From the molluscan fauna it is inferred that the age of the Chinkope and Nakanokawa formations is Pliocene and of the Kuromatsunai, Yakumo and Kunnui formations is Miocene.

From the uppermost marine formation in the Kuromatsunai area there were discovered fossils of molluscs suggesting either latest Pliocene or possibly earliest Pleistocene age.

Contents

Introduction

Although stratigraphical and paleontological studies of southwestern Hokkaido have progressed in recent years there still remain problems concerning the stratigraphical subdivision of the so-called Setana Series, previously accepted as of Pliocene age and of the paleontology. Since the Setana and Kuromatsunai areas are the main region of distribution of the so-called Setana Series and where details of its stratigraphical relationship with subjacent and superjacent stratigraphical units can be studied, they have been selected for interpretation of the problem.

Stratigraphical and paleontological studies show that the so-called Setana Series comprises rocks ranging from early Miocene to late Pliocene, and that the series includes two group with a significant unconformity between them.

In the present work clear cut stratigraphical subdivisions and the molluscan paleontology of the respective units were undertaken and the results are described.

Since paleontological works have been carried out by other authors, their results are mentioned and compared with the author's and correlation is made with previously published stratigraphical classifications.

Based upon the correlation from stratigraphical relationships, faunal analysis and lithological similarity, the writer made an attempt to interpret the physical conditions of the separated areas during the mentioned chronological range.

Because the nature of the chronological boundaries, particularly of the Mio-Pliocene and Plio-Pleistocene are of prime importance in the given interpretation, some remarks are given concerning them.

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Historical Review on the Geology and Paleontology

The works concerning the geology and paleontology of the Tertiary strata in southwest Hakkaido are given in this section.

A. Geology.

In 1892, Jimbo suggested that the diatom deposits in Setana-gun, Shiribeshi province may be Pliocene in age.

Watarase (1929) wrote on the tectonic lines in Hokkaido, with special attention to the ones in western Hokkaido. The Hakodate-Chiretsu Line of roughly north to south direction is the extension of the geosynclinal zone of North Japan. He notes that the structure of the Paleozoic rocks on both sides of the tectonic lines are remarkably differrent, and those of the Tertiary are parallel with the above-mentioned. This line developed at the end of the Neogene and the stress was from the north or northwest.

Nagao (1932) proposed a number of new stratigraphic names. He finds that upon the basement of granitic rocks, there is developed the Miocene Kunnui and

Yakumo formations unconformably covered with the Pliocene Kuromatsunai and Setana formations. He correlated the Kunnui formation to the Innai group, the Yakumo to the Ogasima group and the Kuromatsunai to Yuri group of the Akita Oil-fields in northeast Japan. He listed the fossils from the Setana formation and correlated them with the Takanosu group of the Akita Oil-field and the Daishaka formation of Aomori Prefecture.

Nagao and Sasa (1933–34) in their work on the Cenozoic strata and recent geological history of southwestern Hokkaido, gave details on the stratigraphic units making up the Neogene System. The fossils from the respective horizons are listed and correlation is undertaken between the different areas. They discussed the relation between diastrophism and volcanism in the present area as related with the stratigraphic subdivision and geological ages.

Fukutomi, Yajima and Rikugawa (1936) reported on the economical resources of Hokkaido and appended a geological map in the scale of 1 : 50,000.

Yajima and Rikugawa (1939) published an explanatory text to their geological map of the Oshamanbe Sheet in the scale of 1 : 100,000.

Matsui (1955) reported on the Neogene deposits in the vicinity of Pirika in Imagane-cho, and classified the Miocene Kunnui formation into seven parts designated as KI to K7, and states that KI, and K2 belong to the Yoshioka formation. This is covered with conformably by the Yakumo which is covered with the Kuromatsunai formation which he divided into three parts called M1–M3.

Fujie, Tanai, Matsui, Matsuno, Kakimi and Uozumi (1957), studied the sedimentary basins of the Cenozoic deposits of Hokkido. They claim that there is no evidence for an unconformity between the Yakumo and Kunnui formations, and that the Yakumo is conformable with the Kuromatsunai formation.

Uozumi and Fujie (1958), in their work on the correlation of the Neogene strata in Hokkaido mentioned the problems existing in the stratigraphy of southwestern Hokkaido.

Hashimoto (1958), in the explanatory text to the geological map of Hokkaido in the scale of 1 : 200,000, correlated the Setana Series with other parts of Hokkaido.

Minato and Hasegawa (1959), in their work on welded tuffs of Neppu, stated that the tuff beds of Nagao and Sasa are welded tuff and that the tuff was deposited at about 25,000 years ago.

Shimada and Yazaki (1959), described the geological structure and distribution of the rocks in the vicinity of Oshamanbe. The Kuromatsunai formation shows small folding with north to south axis of the anticlines and synclines. The next younger Setana shows smaller dip angles.

Kanno (1960), classified the rocks in the Setana area into, in ascending order, the Kunnui formation, Yakumo formation, Tanekawa formation and Setana formation. Of these, the upper part of the Yakumo is called the Meppu sandstone, and the upper part of Tanekawa formation is named the Tanekawa gray mudston member. He distinguished from the so-called Setana formation fossils belonging to the Yakumo, Tanekawa and Setana formation (proper). He made public the list of the fossil Pelecypods and Brachiopods from seven localities in the area.

B. Paleontology.

Matsumoto (1916) described the occurrence of *Desmostylus japonicus* from the Toshibetsu, Kunnui-mura, Iburi province, Hokkaido.

Yokoyama (1931) studied the Neogene shells collected from Karafuto and Hokkaido by Jimbo and Watarase. He listed 48 species from 12 localities in Karafuto and 63 species from 27 localities in Hokkaido, and 33 species from two localities of Kuromatsunai-mura and Tarukishi-mura in Suttu-gun, Hokkaido.

Nagao and Sasa (1933-34) listed 18 species of molluscs from the Kunnui formation, seven plant fossils, 22 of diatoms from the Kuromatsunai formation and 54 species of molluscs from the Setana formation.

Nomura and Hatai (1936) discussed the environments of the Nakanokawa beds of Setana series at Nakanokawa and Kaigarasawa, Kuromatsunai-mura, Suttu-gun.

Asano (1936) reported on the foraminifera from Kuromatsumai-mura, Suttu-gun, Hokkaido listed 102 species and subspecies from the Setana group at Kaigarasawa and Nakanosawa in Kuromatsunai-mura.

Asano (1937) studied the foraminifera from the Setana Beds of Kuromatsunai, Hanaishi and Setana districts in the southwestern part of Hokkaido.

Asano (1937) presented the details of the Pliocene foraminifera from the Setana Beds which was studied in 1936, he listed 121 species from 21 localities in the Kuromatsuhai, Hanaishi and Setana districts, and described seven new species.

Kanehara (1942) studied some molluscan remains from the Setana series of Hokkaido and from the Taga series of the Jôban coal-field of Iwaki. In his work, he described and figured four species, a new form of *Crepipatella*, a new variety of *Pododesmus*, *Tellina* and *Chlamys* which were collected from one locality, Yunosawa, Kuromatsunai-mura, Suttu-gun, Shiribeshi province, Hokkaido.

Kubota (1950) illustrated 17 species of pectinids from the Setana series in the Setana and Kuromatsunai areas, and described one new species and three new varieties.

Shirai (1960) made a geological survey of the Setana series distributed in the Kuromatsunai region and studied the foraminifera from 21 localities. He listed 95 species of foraminifera.

Kanno (1960) listed of the fossil Pelecypods and Brachiopods from seven localities in the Setana area.

Masuda (1960) stated that the geological age of the so-called Setana formation in part is Early Miocene.

Masuda and the present writer (1961) studied the Tertiary pectinids from the present area and discribed and figured five new species of *Chlamys*.

Part I. Geology

In this section the geology of two separate areas, namely, the Setana area and the Kuromatsunai area situated in the central part of Southwestern Hokkaido are described. The former area is the environs of Setana which occupies the central part and extends across the Oshima Peninsula in east or west directions, and the latter from Kuromatsunai in the central part and also extends across the peninsula in south to north direction as above-mentioned.

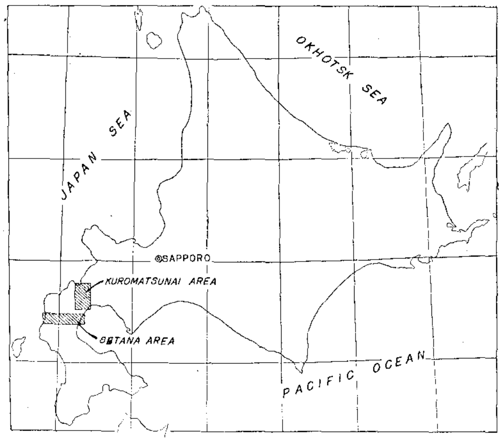

Fig. 1. INDEX MAP

I. Geology of the Setana area

The Setana area in which is the type locality of the so-called Setana series (Nagao and Sasa, 1934) has been studies both geologically and paleontologically, yet there remain problems still unsolved. It is not yet known what the Setana really comprises, the stratigraphical subdivision of its various parts, the chronological range of and kinds of fossils it yields, and the geological age is yet in question. In the following the stratigraphy will be described from the older to the younger units (**Table 1; Figs. 2–3**).

A. Pre-Tertiary

The rocks comprises granodiorite, hornfels and black slate; the latter is older than the former. The latters are of hornfels and black slate, the former a metamorphic facies distributed in the marginal portions of the intruded granodiorite. The distribution is along the upper course of the Toshibetsu River in the northern central part of the area on the eastern side of the intruded granodiorite. The black clayslate is intercalated with layers of graywacke, the general strike is almost N–S with the dips of about 70° towards the west. The clayslate is crushed and shows schistosity. No fossils are known from it.

The granodiorite intrudes the black clayslate and is distributed on the eastern

Table 1. Stratigraphical Classification of the Rocks Distributed in the Setana Area.

Age	Formation	Lithological characteristics	Thickness (in meters)
Holocene	Alluvial deposits	Gravel, sand and clay.	
		unconformity	
Pleistocene	Lower terrace deposits	Gravel, sand and clay.	15 – 20
		unconformity	
	Higher terrace deposits	Gravel, sand and clay.	20 – 25
		unconformity	
Late Pliocene	Minami-toshibetsu formation	Brownish gray fine sandstone intercalated with medium to coarse sandstone.	150 – 250
Early Pliocene	Chinkope formation	Upper with bluish gray fine to medium sandstone with gray siltstone and pebbly conglomerate. Lower with thick alternation of gray siltstone and gray medium to coarse sandstone, intercalated with conglomerate.	150 – 180
	Hanaishi conglomerate member	Conglomerate of pebble to cobble size, intercalated with medium or coarse sandstone.	
		unconformity	
Late Miocene	Kuromatsunai formation	Upper with gray lapilli tuff, gray tuffaceous siltstone and light yellowish tuff. Lower with gray tuffaceous massive siltstone, dark brownish gray scoria sandstone and light yellowish gray andesitic fine tuff.	100 – 400
Early Miocene	Yakumo formation	Upper with alternation of gray tuffaceous shale intercalated with gray tuffaceous medium grained sandstone and greenish gray siltstone, bluish gray tuffaceous siltstone and dark gray shale with gray tuffaceous siltstone layers. Middle with alternation of dark gray shale, tuffaceous siltstone and tuffaceous sandy siltstone; the lower with several thin gray hard shale layers. Lower with alternation of dark greenish gray tuffaceous shale, green tuffaceous medium grained sandstone and dark greenish gray tuffaceous siltstone with dark greenish gray lapilli tuff and light yellowish gray fine tuff beds.	0 – 700
	Kaigarabashi sandstone member / Kayano rhyolite member	Coarse arkose sandstone and conglomerate. / Rhyolite	30 – 1,150
	Kunhui formation	Blackish brown rhyolitic tuff breccia; alternation of dark green coarse tuff, light greenish gray fine compact tuff and alternation of gray siltstone and gray tuffaceous fine sandstone; alternation of light green tuff, brownish green laminated medium tuff with gray tuff, siltstone and gray hard shale, bluish green fine tuff and brownish green pumiceous coarse tuff; alternation of dark greenish gray medium grained sandstone and dark greenish gray fine sandstone with light green tuff, and sandy siltstone; alternation of green tuff, medium grained to coarse grained sandstone and greenish tuff breccia; dark green andesitic tuff breccia with greenish gray tuffaceous medium grained sandstone, and andesitic agglomerate; alternation of green rhyolitic tuff breccia and light green tuffaceous medium grained sandstone with gray tuffaceous siltstone and andesitic agglomerate.	
	Chinkopegawa andesitic agglomerate member	Upper with dark gray or black augite andesitic agglomerate and lower with porous dark or black augite andesitic lava altered by hydrothermal actions.	
	Kitaizawa conglomerate member	Conglomerate and arkose coarse sandstone.	
		unconformity	
Pre-Tertiary	Pre-Tertiary basements	Black slate, graywacke, hornfels and granodiorite.	

side of the Toshibetsu River and in the high hilly region in the north of the same river. There is an unconformity at the contact with Tertiary formations, but where in contact with the black claystate there is a hornfels zone. The granodiorite is also distributed in the east of the Hanaishi Station along the Setana Railway.

B. Neogene Tertiary formations

B-1. ***Kunnui formation.*** The type locality of the Kunnui formation is the cliff between the Chayagawa and Pirika Stations along the Setana Railway, but the original name is taken from Kunnui Station at the junction of the Setana Railway and the Hakodate Main Line. Here the formation is about 1,150 meters in thickness and the base is not exposed. It is overlain with conformity by the Yakumo formation.

The lowermost part of the formation is named ***Kitaizawa conglomerate member.*** This member has its type locality in the upper reaches of the Kitaizawa about four kilometers northeast of the Hanaishi Railway Station, Imaganecho. It is about 80 meters in thickness, and consists of an alternation of conglomerate and coarse grained sandstone. The conglomerate comprises rounded to subrounded pebbles to cobbles of andesite, granodiorite, hornfels and slate with a 1.5 to 2.0 meters thick granodiorite boulder conglomerate at the base. This alternation becomes thinner towards the upper part. The member is distributed along the eastern margin of the granodiorite in the east of Hanaishi Railway Station.

Chinkope-gawa andesitic agglomerate member. This member has its type locality in the upper reaches of the Chinkope River about two kilometers east of Chinkope, Imagane-cho. It is about 200 meters in thickness. Its base overlies with conformity the alternation of sandstone and siltstone of the formation, which in turn overlies the above mentioned member of arkose sandstone and conglomerate, all with conformity. The andesitic agglomerate consists of auginte andesite and the breccia range from ten to about 30 centimeters in diameter being cemented with andesitic tuff. This member forms an anticlinal structure at the type locality. Its distribution is confined to the eastern part of the field, south and east of the Setana Railway. The member grades laterally into the main part of the Kunnai formation and is local in distribution and development.

Upwards the member is covered with dark green andesitic tuff breccia intercalated with three to four meters thick greenish gray tuffaceous medium grained sandstone and two to two and a half meters thick augite andesite agglomerate. It is underlain with two to four meters thick thin alternation of green tuff breccia and light green tuffaceous medium grained sandstone intercalated with gray tuffacous siltstone and one to one and a half meters thick andesitic agglomerate.

The green tuff, sandstone and tuff breccia form an alternation of thick bedded and thin bedded layers and comprise the major part of the Kunnui formation; the details are shown in **Fig. 5.** This part of the formation is superposed on the Chinkope-gawa member with conformity and overlain by the ***Kayano rhyolite member*** in the eastern part of the field along the Setana Railway. The latter is distributed in north to south direction.

The major part of the formation attains about 700 meters in thickness and occurs only in the eastern part of the field east of the Toshibetsu River and west of the ***Kayano rhyolite member***. The general structure is of two anticlines in the areas south of Setana Railway and of faults in the northeast to northwest parts of distribution. The trends vary from northwest to southeast to east-west or northeast to southwest, and the dips vary from about 10 to less than 50 degrees and their directions change according to places.

The major part of the formation is covered in part with extruded rhyolite flows called the ***Kayano rhyolite member***. The locality of this member is the cliff of the Setana Railway about one kilometer east of Kayano. The rhyolite is gray, compact, and shows a metamorphic contact with the green tuff breccia below and is covered with conformity by the lower part of the Yakumo formation. The rhyolite extends in north to south direction and is cut by a fault of northwest-southeast trend along its middle part in longitudinal direction. This rhyolite is estimated to measure about 300 meters in general.

Kaigarabashi sandstone member. This member has its type locality in the cliff of the Meppu River about three kilometers from the mouth in the central area, and the lower is an arkose sandstone and conglomerate measuring about 80 meters in thickness. The arkose sandstone is coarse grained with sporadic distribution of andesite pebbles which are rounded to subrounded, being massive in the lower and laminated in the upper. The conglomerate comprises round to subround pebbles to cobbles of andesite, granodiorite, hornfels and slate with a 1.5 meters thick granodiorite boulder conglomerate at the base. The arkose sandstone and conglomerate form an alternation which become thinner towards the upper part. Molluscan fossils have been collected from the lowest part of the member along the Meppu River above mentioned. The fossils distinguished are, *Chlamys arakawai* (Nomura), *Ch. kumanodoensis* Musuda, *Ch. otukae* Masuda and Sawada, *Patinopecten kagamianus* (Yokoyama), *Placopecten setanaensis* (Kubota), *Pl. wakuyaensis* Masuda and *Nanaochlamys notoensis* (Yokoyama).

B-2. ***Yakumo formation***. The type locality is the vicinity of Yakumo-cho in the south of the present area. In the present area the Yakumo formation is defined by the rocks typically exposed along the Daishibunnai River about two kilometers east of Shibunnai, Imagane-cho in Setana-gun. Here it measures 750 meters in thickness, it is lies without break upon the Kunnui with conformity and underlies the Kuromatsunai formation. In the present area the rocks of the Yakumo comprise from the lower a thin alternation of greenish gray tuffaceous shale, green tuffaceous medium grained sandstone and dark greenish gray tuffaceous siltstone intercalated with dark greenish gray lapilli tuff and light yellowish fine andesitic tuff layers. The middle part consist of a thin alternation of dark gray shale, gray tuffaceous siltstone and gray tuffaceous sandy siltstone intercalated in the lower part with gray hard shale layers. The upper comprises a thick alternation of gray tuffaceous shale, bluish gray tuffaceous siltstone and dark gray hard shale intercalated with gray tuffaceous medium grained sandstone and gray tuffaceous siltstone layers. *Makiyama chitanii* occurs from the middle and upper parts, especially from the hard shale and siltstones. The formation in this locality strikes N 10°–30° E with dips of 20°–30° towards the west.

The distribution of the formation is wider than that of the underlying Kunnui, being found in the eastern part of the field in north-south distribution immediately west of the Kunnui Station at the junction of the Setana Line and the Hakodate Main Line, a small area in the northeast of the Pirika Station on the Setana Line, and in the east of the Toshibetsu River also in longitudinal extension. In the eastern area the formation has strikes of N 20°–30° E with dips of 30°–40° towards the southeast, however N 20° W with 40° eastward dips are also found. In the northern part of the Pirika Station the strike is N 10° E with dips of 30°–35° westwards on the eastern wing and of N 16° E with 20° eastward dips of the western wing. In the area west of the Toshibetsu River the strikes are almost N–S with dips of 25°–30° eastward along the eastern wing of the anticline and N 5°–6° W and dips of 8°–10° northwest along the western wing.

This formation overlies the granodiorite basement in the area about five kilometers northeast of Kami-meppu with unconformity and also with the same relation in the northwest of the Kami-hakaimappu River and also at about three kilometers northwest of Pirika Station. Elsewhere the formation is superposed upon the Kunnui with conformity.

Fossils from the formation are only the planktonic sponge called *Makiyama chitanii*.

B–3. ***Kuromatsunai formation.*** The type locality is along the Soibetsu River northwest of Kuromatsunai and two kilometers east of the same along the Shubuto River in the Kuromatsunai area. In the present area the typical exposures of the formation is the cliff of the Shimo-hakaimappu River at about three and a half kilometers northeast of Kami-meppu. Here it comprises in the lower, gray tuffaceoius siltstone intercalated with a thin scoria sandstone and light yellowish gray andesitic fine grained tuff layers. The upper part comprises gray andesitic lapilli tuff intercalated with gray tuffaceous siltstone and light yellowish gray tuff layers. The strike at this locality N 8° E with dips of 6° northwest in general and the formation here is cut with a fault trending N 35° W with the western side thrown down. Only *Makiyama chitanii* was found from the siltstone.

The formation is distributed from the easternmost part of the studied area in the north of the Kunnui Railway Station, on both sides of the Toshibetsu River, between Pirika and Shibunnai, and in the vicinity of Kami-hakaimappu in the central part and also in the north and south of Ishibuchi, Kitahiyama-cho in the eastern part of the area. In the western part of the area the general strikes N 17°–25° E with dips of 38°–50° SE, in the vicinity of Kami-hakaimappu the trends of N 7°–10° W with dips of 6°–10° SW occur, and along the Toshibetsu River between

Pirika and Shibunnai the strikes are N 16°–20° E with dips of 13°–20° NW for the eastern wing, the western wing strikes N 18° E with dips of 60° SE, and in the easternmost locality the strike is N 22°–33° E with dips of 30°–40° SE.

The Kuromatsunai is conformable to the subjacent Yakumo but is succeeded upwards with cunconformity by the basal conglomerate of the ***Hanaishi conglomerate member*** of the Chinkope formation, and terrace deposits.

B-4. ***Chinkope formation.*** The type locality is the cliffs of the Babagawa about four kilometers south of Imagane-cho. Here it is superposed with unconformity upon the Kuromatsunai and is covered with Minami-toshibetsu with conformity. At the type locality the Chinkope is about 150–180 meters in thickness and consists of two parts, the lower half begins with the ***Hanaishi conglomerate member*** followed upwards with a thick alternation of gray siltstone and gray medium to coarse grained sandstone intercalated with pebbly conglomerate, which are rounded to subrounded pebbles of andesite and hard shale. The upper half comprises bluish gray fine to medium grained sandstone intercalated with gray siltstone and pebbly conglomerate, which are of rounded to subrounded andesite and hard shale. The strike in the type locality is N 60° E and dips of 5° SE. No fossils have been found from the type locality.

The formation is distributed in the western half of the field in its larger part but is also found along the Toshibetsu River between Pirika and Shibunnai and along the easternmost marginal part of the field in the north and south of Kunnui Station. In the latter two regions the lower part or the Hanaishi conglomerate member only is distributed with the upper part missing. In the first mentioned area all parts of the formation are well developed and found on both sides of the Toshibetsu River.

The formation covers the Kuromatsunai with erosion unconformity and also the Kunnui where the Kuromatsunai is lacking. In places the unconformity is angular and elsewhere it is structural as will be mentioned in later.

Fossils of molluscs are found between Pirika and Shibunnai along the Toshibetsu River in the central part of the field. The stratigraphic position of the fossils are shown in **Fig. 5**, from which it can be noticed that their horizons are almost equivalent or nearly so where they occur.

B-5. ***Minami-toshibetsu formation.*** This formation is superposed on the Chinkope with conformity and is covered with unconformity by terrace deposits. The type locality is the road side cuttings between Minami-toshibetsu and Imagane-cho. Here it attains about 150–200 meters in thickness and comprises light brownish gray fine grained sandstone intercalated with brownish gray medium to coarse grained sandstone and with cross-lamination structures in its middle part. The strike at the type locality is N 30° W with dips of 6° SW.

The distribution of the formation is restricted to the small area south of Toshibetsu River with Ocharappe in its central part south of Imagane-cho. The structure in this area is a broad syncline with the western wing trending N 15°–

22° W with dips of 2°–10° toward the east and the eastern wing strikes N–S to N 8°–20° E with dips of 3°–5° NW although slight deviations due to local disturbances are found and the strike changes to N 71° E with 4° NW dips, N 15° E with 10° SE, N 60° E, 5° SW, N 30° W, 56° SW, and N 40° E with 4° NW dips. This shown the existence of undulating structures, probably reflected from an older preexisting structure. No fossils have been found from the formation.

C. Quarternary formations

Terrace deposits. Theses consist of sand and gravel sometimes with intercalated clay and are distributed at two levels here called the Higher terrace deposits and Lower terrace deposits. The deposits attain about 10–15 meters form the higher one and 10–15 meters for the lower one in thickness.

The higher terrace compirses gravel, sand and clay. The gravels are of pebble to cobble size, rounded to subrounded, andesite, slate, hornfels, quartzite, green tuff and hard shale. The distribution is at about the 70–220 meters level, extending from along the eastern side of the Toshibetsu River between Pirika and Shibunnai westwards to the vicinity of Imagane-cho and in the north where they become 100–150 meters in height above sea-level. Near the Japan Sea they are about 70–150 meters in height, their lower limit being higher along the coast than inland, which also is an evidence of some movement.

The lower terrace measures about 20 meters along the Funkawan and along the Toshibetsu River it attains about 15 meters in height, in the north and south of Imagane-cho it measures 15–50 meters in height, whereas in the south of Setana-cho it measures 15–60 meters in height. The sediments comprise gravels sand and clay, the gravels are pebble size, rounded to subrounded andesite, slate, hornfels, quatzite and hard shale.

D. Geological structure

The geological structure of the Setana area can be classified into unconformities, folding and faults as the major ones (**Fig. 4**).

D–1. ***Unconformities.*** These are found between the basement of granodiorite and the Kunnui formation (inclusive of the Kaigarabashi sandstone member and Kitaizawa conglomenate member), between the granodiorite and the Yakumo formation, between the granodiorite and the Kuromatsunai formation and the Hanaishi conglomerate member of the Chinkope formation, between the Kuromatsunai formation and the Hanaishi conglomerate member of the Chinkope formation, between the higher and lowest terraces and the Tertiary rocks.

In all cases the unconformity represents an erosive phase, whereas between the basement and Tertiary rocks it is also structural as it is between the Miocene Kuromatsunai formation and the Pliocene Chinkope formation and the same can be said for the one between the Pliocene Minami-toshibetsu and Chinkope formations and the deposits of Pleistocene age. Within the Cenozoic rocks the most significant structural unconformity occurs between the Pliocene and Pleistocene that is to say it is post-Chinkope and pre-higher terrace in age.

D–2. ***Folds.*** The folding structures compries anticlines and synclines aside from the homoclinal ones.

D–2–1. ***Anticlines.*** Three anticlines are found in the present field, two in the distribution area of the Kunnui formation and one in the area of the Yakumo formation.

Yamadayama anticline. This occurs in the western part of distribution of the Kunnui formation. This trend almost in north to south direction with slight divergence towards the east. Taking part in this folding are the Chinkopegawa andesitic agglomerate member of the Kunnui formation, the major part of the Kunnui and a part of the Yakumo formation. The eastern wing dips at about 10–20 degrees towards the east whereas the western wing at about 15–40 degrees towards the west. Southwards the axis of the anticline grades into the green pyroclastics of the Kunnui formation and northwards it is lost in the northern extension of the Chinkopegawa andesitic agglomerate member of the formation.

Chayagawa anticline. This occurs in the central part of distribution of the Kunnui formation almost parallel with the Setana Railway Line. The axis trends NWW–SSE and dies out it its northwestern and southeastern extensions, being lost in the green pyroclastics of the Kunnui formation. Taking part in the folding is the major part of the Kunnui and its Chinkopegawa member. The eastern wing dips at about 23–34 degrees towards the east or northeast whereas the western wing dips at about 24–26 degrees towards the southwest.

Kami-hakaimappu anticline. This extends almost parallel with the Toshibetsu River between Pirika and Kitasumiyoshi Station along the Setana Railway Line, trending in NNE–SSW then to SSW, its northern and southern extremities dies out into the homoclinal folding of the Yakumo formation. In the northern part of the anticline the eastern wing dips at about 25–30 degrees eastwards whereas the western wing dips at about 8–12 degrees westwards, the central part of the anticline has its eastern wing dipping at about 30 degrees eastwards and the western one at about 8 degrees westwards, whereas in the southern part of the anticline the eastern wing dips at 10–15 degrees eastwards except near the Hanaishi fault where the dip become 60 degrees, and the western wing dips at 10 degrees towards the west. The Yakumo, Kuromatsunai formations and Hanaishi conglomerate member of the Chinkope formation are folded.

D–2–2. ***Synclines.*** Four synclines can be recognized in the present field.

A syncline occurs in the Kunnui area between the Yamadayama and Chayagawa anticlines. Its axis trends northwest to southeast with divergence in the southern part towards the southwest.

Tsuribashi syncline. This occurs in the longitudinal valley incised by the Toshibetsu River between Pirika and Shibunnai. The axis is almost parallel with the Yamadapama anticline in its east and the Kami-hakaimappu anticline in the west. However, since its western side is cut by the Hanaishi fault of NNE–SSW trend the dips become steep near it measuring about 60–80 degrees.

Minami-kanahara syncline. This occurs in the southern part of the western area, extending in almost north to south direction with its northern extremity extending under or obliterated by the alluvial deposits and the southern extension has not been traced. The eastern wing dips at about 3–5 degrees westwards and the western one at about the same towards the east. Taking part in the movement are the Chinkope and Minami-toshibetsu formations.

Meppu syncline. This occurs in the immediate east of Imagane-cho and extends in southeast-southwest direction with the southern extremity extending under or obliterated with the alluvial deposits and the northern one into the homoclinal folded Kuromatsunai formation. The southeastern wing dips at about four degrees westwards and the western one at about five degrees eastwards. Both the Meppu and Minami-kanahara synclines are broadly folded and seem to be more of a warping than a true synclinal fold because the dip angles are very low and it is even difficult to determine the position of the axis in the field.

D–3. ***Faults.*** Faults are rather common in the present area and the major ones have been named because of their importance in the structure of the area.

Kunnui fault. This reverse faults occurs in the eastern part of the field west of the Kunnui Station on the Hakodate Main Railway Line. The strike is N 20°–25° W, with dip of 80°–85° NE and the western side is thrown down. This cuts both the Kayano rhyolite member of the Kunnai formation and the Yakumo formation. The alternating layers of the Yakumo formation are crushed, making a crushed zone of about four meters where the Yakumo is in contact with the rhyolite and where the fault cuts only the rhyolite the fault zone consists of brecciated and crushed volcanics measuring several meters in width. This fault shows that the Yakumo originally covered the Kayano rhyolite.

Kami-kunnui fault. This reverse fault occurs whithin the Kunnui formation at Chyagawa, its strike extending in N 35°–45° W with dips of more than 30° degrees with the southwestern side thrown down. Northwards the fault extends beyond the surveyd area and southwards it is lost in the massive green pyroclastics which show homoclinal folding.

Shibunnai fault. This reverse fault occurs on the eastern side of the Toshibetsu River extending in N 15°–20° E in the northern part and almost N–S in the northern part the dip is 80°–85° E, whereas in the southern part the dip is almost the same with the western side thrown down. By this fault the Kunnui, Yakumo, and Kuromatsunai formations and granodiorite are cut. Where the granodiorite and Kunnui formation are in contact, there is a nearly two meters wide crushed belt in which the Kunnui rocks are sheared with the shearing nearly parallel with the direction of the fault. Where the Yakumo and Kunnui are in fault contact, there is developed a crushed zone several meters in width in which the alternation of gray shale and siltstone of the Yakumo and the green pyroclstics of the Kunnui are radomly mixed, being crushed. Northwards the fault extends into the boundary between the Yakumo and Kunnui formations, whereas southwards the fault extends beyond the surveyed area.

Hanaishi fault. This is a fault extending longitudinally almost parallel with the Toshibetsu River between Pirika and Shibunnai. The strike in N 15°–20° E with dips of 80°–90° W and is a reverse fault with the western side thrust upon the eastern. This faults cuts the Yakumo, Kuromatsunai, and Chinkope formations and is situated near the core of the Tsuribashi syncline. The fault has a nearly 30 centimeters thick fault clay or a similarly thick crushed belt following its general trend.

Shimo-hakaimappu fault. This fault extends from the Meppu Mine southwestwards to the south cliff of Meppu, therefrom westwards to beyond Kasugai in Imagane-cho. The strike changes from N 40°–50° E with unknown dip in the western part. By this reverse fault the Yakumo, Kuromatsunai, and the Chinkope formations join in the movement. The fault has a nearly ten meters wide crushed zone in which siltstone and hard shales are deformed. The northern extension of the fault is lost into the homoclinal structure of the Kuromatsunai formation and southwestwards it is covered in party by the alluvial deposits.

Tomayachi fault. This fault occurs in the western part of the field in the vicinity of Tomayachi, Kitahiyama-cho. The strike is N 30°–40° W with dip almost vertical and the western side is thrust upon the eastern. From that the siltstone of the Kuromatsunai formation are distorted, cracked and show differences in dips it is judged that is or the western side was thrust upon the Chinkope formation which does not show such features. Southeastwards the fault extends into the homoclinal structure of the Chinkope formation and northwestwards the fault extends under the alluvial deposits.

Makomanai fault. This fault occurs in the northwest of the one just mentioned, extending from Nabezaka in Kitahiyama-cho southwards in the same township, the trend being N 30°–35° E with dips almost vertical and is thought to be a normal fault with the eastern side thrown down. This fault cuts the Kunnui and Kuromatsunai formations and the Yakumo formation is missing here. The northwards extension is covered with terrace deposits and the southern part is covered with alluvial deposits to reappear near Ishibuchi in Kitahiyama-cho where the Kunnui and Kuromatsunai formations without the development of the Yakumo are in contact. Further southwards the fault extends under the alluvial deposits. The fault is determined from the differences in strike and dip, the missing of the Yakumo formation which is superposed on the Kunnui formation with conformity in other areas, and by the abrupt change in rock facies near the contact.

The ages of folding of the anticlinal and synclinal structures and judged to be post-Minamitoshibetsu and pre-terrace deposits or Plio-Pleistocene in age. The faults on the other hand are judged to be pre-Kuromatsunai, and post-Minamitoshibetsu in age or Mio-Pliocene and Plio-Pleistocene. The homoclinal bedding may be associated with both folding and faults, so far as the dips near the latter are concerned.

E. Igneous activity.

The oldest ingeous activity in the present area is represented by the large masses of granodiorite rocks exposed in different parts of the field as already stated. These are batholithic rocks which intruded the clayslates probably of Paleozoic age and formed at the contact areas hornfels.

The Chinkopegawa andesitic agglomerate member of the Kunnui formation. The next ingeous activity is the andesite agglomerate intercalated in the Kunnui formation, which occurs in the lower part. Its distribution is restricted to the eastern part of the field. It is associated with augite andesite lava flows and also tuff-breccia.

Kayano rhyolite. This flow occurs in the upper part of the Kunnui formation in the eastern part of the field and is distributed in roughly north to south direction. A small dike of rhyolite occurs at about 2.5 kilometers north-northeast of the Hanaishi Station along the Setana Railway Line cutting the lower part of the Kunnui formation. This is thought to have been formed at the same time as the Kayano rhyolite although the areas of distribution are different.

Dikes of andesite and basalt are found in the western part of the field, and both cut the lower part of the Kunnui formation. These dikes trend in almost north to south direction, the andesite one occurring about 500 meters north of Setana-cho and at about 600 meters south of Soikoshi in Kitahiyama-cho, and the basalt dike is found at about 300 meters east of Ishibuchi in the same township.

From the above it is evident that the period of igneous activity can be dated as pre-Tertiary (granodiorite), post-Kunnui or Kunnui (Kayano rhyolite and rhyolite dike), post-Kunnui (andesite and basalt dikes) or late Kunnui time.

F. Summary of the geological history of the Setana area.

After batholithic intrusion of the granodiorites into the pre-existing clayslates and the development of hornfels along the contact zone, the present area was uplifted and subjected to a long period of subaerial denudation. It is upon the eroded surface that the Tertiary sediments were deposited.

The deposition of the Miocene rocks in the present area commenced with the first marine transgression. This first penetration of marine waters was associated with violent volcanic eruptions in the eastern part of the field of thick accumulations of green pyroclastics intercalated with augite andesite flows and their agglomerates as well as tuff breccias. In the eastern part of the field there was periodic invasions of the sea which deposited siltstones and sandstone layers in which the planktonic sponge *Makiyama chitanii* (Makiyama) occurs sporadically.

Continued volcanic eruptions resulting in the thick accumulations of pyroclastic deposits ended with an eruption of rhyolite flows and dikes. And this period is considered to have been one of gradual subsidence leading to the flooding of the whole area and the deposition of the Yakumo formation, which although not fossiliferous, yielded some fossils. Continued sinking of the area and the development of siltstone, sandstone and tuffaceous layers of the Yakumo also preserved such planktonic sponges as *Makiyama chitanii* (Makiyama) and some benthonic foraminifers, although molluscan fossils are not common.

During deposition of the Yakumo formation it is thought that the center of the sedimentary basin was subjected to change, that is to say, the central area was gradually uplifted and the basin migrated both westwards, the maximum subsidence being in the west, and this period of instability continued throughout the Miocene as may be seen from the distribution of the Kuromatsunai formation, which finds its area of distribution chiefly in the west of the areas of distribution of the older formations with which it is conformable.

Gradual subsidence continued throughout the larger part of the Kuromatsunai time being continuous with that of the earlier stages and the basin shifted slightly westwards although the one occupied by the Yakumo was still flooded. During the latter part of the Kuromatsunai time the whole area seems to have commenced gradual uplift leading finally to complete uplift whereby the land surface was eroded and this marks the Miocene to Pliocene break in the present area.

During the uplift of the Kuromatsunai deposits and regression of the seas it is inferred that considerable crustal movements occurred in association such as tilting and faulting although no intense folding seems to have taken place at this time.

Upon the eroded surface of the Kuromatsunai and worn out areas adjacent to the granodiorite mountains there occurred another marine transgression by which the initial phase of the Chinkope formation was deposited, being represented by the Hanaishi conglomerate member of the formation. The areas in which the Chinkope formation was deposited is considered to have extended over the whole are from the present day Japan Sea to Funka-wan, but whether the area in which the Kunnui formation is distributed was entirely covered with the Chinkope seas is questionable because that area may have been retained as a land at that time, being the source of the sediments making up the formation.

This Pliocene sea brought into the present area a rich marine fauna represented by many scallops (**Tables 2–5**), foraminifers, brachiopods and others. However, this sea was not long-lasting because there seems to have occured gradual emergence of the flooded area soon after the deposition of the Hanaishi conglomerate member in the east-central part of the field gradually towards the western part, that is to say, the central eastern part was emerging whereas the western part was still submerged and subjected to sedimentation leading to the development of the major part of the Chinkope formation and the whole of the Minami-toshibetsu formation, which is also of marginal origin. Throughout the Pliocene the seas were of neritic nature as may be deducted from the molluscan fauna, excellent development of cross-bedding structures and coarse grained sediments which all reveal the instability of the area the nature of the source rocks and the depth of the seas.

Gradual uplift and regression of the seas was beginning at the time of deposition of the Minami-toshibetsu formation, which appears to be a regressive facies.

Table 2. List of the Molluscan Fossil from the Setana and Kuromatsunai areas.

Area	Setana Area																									Kuromatsunai Area															
Formation	Kunnui F.		Hanaishi Conglomerate Member														Chinkope Formation									Kaigarabuchi Conglomerate Member								Nakanokawa Formation							So. Fm.
Genus and Species / Locality Number	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Amathina nobilis A. Adams																																							C		C
Homalopoma amusitatum (Gould)																																				A		C	A		
Turbo sp																										R															
Littorina (Litorivaga) brevicula (Philippi)									R																																
Turritella (Neohaustator) nipponica Yokoyama																																			F						
Turritella (Neohaustator) fortilirata habei Kotaka						C			C		C																														
Bittium yokoyamai Otuka			F																																						
Cerithium kochi Philippi			C																																C			A	A		
Scala (Boreoscala) aomoriensis (Iwai)																										C															
Scala (Boreoscala) yabei echigonum (Kanehara)									R																														R		
Cingulina cingulata (Dunker)																																							F		
Crepidula grandis Middendorff																																							F		
Tectonatica janthostoma (Deshayes)											C											C													A				A		
Trophonopsis (Austrotrophon) candelabrum Reeve																																				R					
Trophonopsis (Boreotrophon) sasae Sawada n. sp			F																																						
Nucella cf. *freycinetti* (Deshayes)																																							R		
Mitrella (Mitrella) burchardi (Dunker)																																							F		
Plicifusus yanamii (Yokoyama)																																							R		
Neputunea iwaii Hatai, Masuda and Suzuki																			R	F																					
Barbitonia arthritica (Bernardi)																																							R		
Barbitonia arthritica hirosakiensis (Iwai)																										R															
Buccinum leucostoma Lischke			F																																						
Hinia (Tritonella) japonica (A. Adams)																																						A	F		
Latirus (?) sp																																						R			
Volutomitra hataii Sawada n. sp			F																																						
Admete japonica lischkei (Yokoyama)																																			F				A		
Granotoma kotakae Sawada n. sp																																							R		
Antiplanes contraria (Yokoyama)																						F											C								
Antiplanes (Rectiplanis) sanctiioannis (Smith)											R																														
Oenopota kagana toyotsuensis Sawada n. subsp			R																																						
Oenopota kuromatsunaiensis Sawada n. sp																																			F				F		
Eocylichna musashiensis (Tokunaga)																																						R	R		
Acila (Truncacila) insignis (Gould)									C	A	C	C								R			C	R											R	C	R	R	F	R	
Acila (Truncacila) nakazimai Otuka									C			C								C	C														C	C					
Yoldia (Cnesterium) johanni Dall																																			A						
Arca boucardi Jousseaume													R												C													R		A	
Pseudogrammatodon dalli (Smith)																									R									R	R	A		R		C	
Glycymeris (Glycymeris) yessoensis (Sowerby)													R																							C	C	A		C	A
Limopsis tokaiensis Yokoyama																			A	C	C														A						
Modiolus difficilis (Kuroda and Habe)									R																																
Mytilus grayanus Dunker																																		R						C	A
Polynemamussium alaskense (Dall)			C																						R													F			
Chlamys arakawai (Nomura)		R																																							
Chlamys chinkopensis Masuda and Sawada				C	A																																				
Chlamys cosibensis (Yokoyama)				C																	F					C						C	C								
Chlamys daishakaensis Masuda and Sawada			F												F	C										A		A					A		C	C			A	A	
Chlamys islandica erythrocomata (Dall)				C	A	R	R							F								C		R		F	C			A	F										
Chlamys kumanodoensis Masuda	A	A																																							
Chlamys nipponensis Kuroda																																									C
Chlamys osugii Kubota																										A															
Chlamys otukae Masuda and Sawada		C																																							
Chlamys tamurae Masuda and Sawada																																									
Placopecten setanaensis (Kubota)	A	A																	A																						
Placopecten wakuyaensis Masuda		C																																							
Swiftopecten swiftii (Bernardi)									F					F	F	F	R																	C		A		F	C	R	A
Nanaochlamys notoensis (Yokoyama)		C																																							
Patinopecten kagamianus (Yokoyama)		C																																				C			
Patinopecten tokunagai (Yokoyama)			C												F								F																		A
Patinopecten tokyoensis (Tokunaga)																																									
Patinopecten yessoensis (Jay)					F				A						F			C															F		A	A	A	A		C	
Lima (Acesta) goliath Sowerby							F									R										R		R			R										
Monia macroschisma (Deshayes)								R				C	F			C									C	A	R	A	C							R				C	A
Monia macroschisma ezoana (Kanehara)																																				R					R
Monia umbonata (Gould)																																				F					R
Astarte (Tridonta) alaskensis Dall										R			R				R	R		F	R				C									F							
Astarte (Tridonta) borealis (Schumacher)																																						F			C
Venericardia (Cyclocardia) crebricostata (Krause)																R		R		R														C		A	R	C	C		
Venericardia (Cyclocardia) paucicostata (Krause)			F													R		R		R					R											A		A			R
Felaniella usta (Gould)																																		A	F	F					
Lucinoma annulatum (Reeve)																																							C		
Clinocardium californiense (Deshayes)																																							A		
Papyridea (Fulvia) kurodai Hatai and Nisiyama																																				F			F		
Exocallista brevisiphonata (Carpenter)												R								R					C				R					A		A	R	C	A	A	R
Saxidomus purpuratus (Sowerby)																																						R		C	
Liocyma fluctuosa (Gould)																																						F			
Callithaca (Protocallithaca) adamsi (Reeve)																																									
Psammocola cfr. *kazusaensis* (Yokoyama)																																							R		
Spisula (Spisula) sachalinensis (Schrenck)																																							R		
Macoma (Macoma) incongrua (v. Martens)									R		R		R			R																						R	R		
Macoma (Macoma) tokyoensis Makiyama																R						R													A			R			
Panope japonica A. Adams																																							R		F
Myadora proxima (Smith)																																									R
Plectodon (Plectodon) ligula (Yokoyama)																																				A			A		
Hemithyris psittacea woodwardi (A. Adams)																																									
Terebratalia coreanica (Adams and Reeve)																C																				F	F		A		
Terebratalia gouldii (Dall)																																				R	R				
Coptothyris grayi (Davidson)		F																																							

Frequency (Individuals): R (Rare), 1; F (Few) 2-5; C (Common), 6-10; A (Abundant), more than 11.

Continued uplift resulted in the whole once flooded area becoming land whose surface was incised and drained by several streams or rivers. These land drainages are considered to have resulted in the formation of the terrace deposits and also of the alluvial deposits now extensively distributed along the drainages of the present streams in the Setana area.

During the Miocene stage the first major sinking or sedimentary basin was developed in the eastern part of the area whereafter it gradualy migrated westwards, shifting finally to the present coast lines of the Japan Sea and of Funka-wan, the former in the west and the latter in the east. The major migrations seem to have been accompanied with uplift of the previously water covered area and also associated with crustal disturbances as faults.

Crustal disturbances in the present area seem to have first commenced with marine transgression and subsidence associated with volcanic activity which indicated the opening of the Miocene in the present area. The next crustal disturbance seems to have been at the end of the Miocene when marine regression associated with relative uplift of the land occurred and this was associated with faulting but not intense folding. However, at the end of the Pliocene or after the deposition of the Minami-toshibetsu formation there occurred marine, regression associated with relative uplift of the land and faulting as well as intense folding by which the entire once flooded area become land with high relief and may have made a complex mountainland. Although evidence of crustal movement continuing to the present day could not be found, it is evident that erosive and depositional forces are still active as shown by the development of extensive alluvial deposits and broad shores facing the Japan Sea and of a narrow but probably upbuilt shore fringing Funka-

Table 3. Pliocene Scallops from the Setana and Kuromatsunai Areas

Areas / Fossil Scallops / Formations	Setana area		Kuromatsunai Area		
	Ha	Ch	Kab	Na	So
Polynemamussium alaskensis (Dall)	*	*		*	
Chlamys chinkopensis Masuda and Sawada	*				
Chlamys cosibensis (Yokoyama)	*	*	*		
Chlamys daishakaensis Masuda and Sawada	*	*	*	*	
Chlamys islandica erythrocomata (Dall)	*	*	*		
Chlamys nipponensis Kuroda					*
Chlamys osugii Kubota			*		
Chlamys tamurae Masuda and Sawada		*			
Swiftopecten swiftii (Bernardi)	*	*		*	*
Patinopecten tokunagai (Yokoyama)	*	*		*	
Patinopecten tokyoensis (Tokunaga)					*
Patinopecten yessoensis (Jay)	*	*	*	*	

Ha: Hanaishi conglomerate member of the Chinkope formation; Ch: Chinkope formation; Kab: Kaigarabuchi conglomerate member of the Nakanokawa formation; Na: Nakanokawa formation; So: Soibetsugawa formation.

Table 4. Molluscan fauna from the Chinkope formation in the Setana area and the Nakanokawa formation in the Kuromatsunai area.

Area	Setana area									Kuromatsunai area						
Formation	Chincope formation									Nakanokawa formation						
Fossils / Locality number		24	23	22	21	20	19	18	17	8	7	6	5	4	3	2
Amathina nobilis A. Adams												A		C	C	
Komalopoma amusitatum (Gould)											F				A	
Turritella (Neohaustator) nipponica Yokoyama											C			A		
Cerithium kochi Philippi															A	
Scala (Boreoscala) yabei echigonum (Kanehara)															R	
Cingula cingulata (Dunker)															F	
Amathina nobilis (A. Adams)														F		
Crepidula grandis Middendorff															F	
Tectonatica janthostoma (Deshayes)						C					A				A	
Trophonopsis (Austrotrophonicandelabrum Reeve												R				
Nucella cf. *freydinettiu* (Deshayes)															R	
Mitrella (Mitrella) burchardi (Dunker)															F	
Plicifusus yanamii (Yokoyama)																
Neputuner iwaii Hatai, Masuda and Suzuki			R			F									R	
Barbitonia arthritica (Bernardi)															R	
Hinia (Tritonella) japonica (A. Adams)														A	F	
Latirus (?) sp														R		
Adamete japonica lischkei (Yokoyama)											F				A	
Granotoma kotakae Sawada n. sp															R	
Antiplanes contraria (Yokoyama)						F										
Oenopota kuromatsunaiensis Sawada n. sp											F				F	
Eocylichna musashiensis (Tokunaga)														R	R	
Acila (Truncacila) insignis (Gould)				R			C	R			R	C	R	R	F	R
Acila (Truncacila) nakazimai Otuka				C	C						C	C				
Yoldia (Cnesterium) johanni Dall											A					
Arca boucardi Jousseaume									C					R		A
Pseudogrammatodon dalli (Smith)									R	R	R	A		R		C
Glycymeris (Glycymeris) yessoensis (Sowerby)													C	A		C
Limopsis tokaiensis Yokoyama			A	C		C					A					
Mytilus grayanus Dunker										R						C
Polynemamussium alaskensis (Dall)									R					F		
Chlamys cosibensis (Yokoyama)					F											
Chlamys daishakaensis Masuda and Sawada											C				A	A
Chlamys islandica erythrocomata (Dall)						C		R								
Chlamys tamurae Masuda and Sawada			A													
Swiftopecten swiftii (Bernardi)	R									C		A			C	R
Patinopecten tokunagai (Yokoyama)							F									
Patinopecten yessoensis (Jay)		C									A	A	A			C
Monia macroschisma (Deshayes)									C	C		R				C
Monia macroschisma ezoana (Kanehara)												R				
Monia umbonata (Gould)												F				
Astarte (Tridonta) alaskensis Dall	R	R		F	R				C	F						
Astarte (Tridonta) borealis (Schumacher)														F		
Venericardia (Cyclocardia) crebricostata (Krause)		R		R						C		A		C	C	
Venericardia (Cyclocardia) paucicostata (Krause)		R		R					R	A		A		A		
Felaniella usta (Gould)											F	F				
Lucinoma annulatum (Reeve)																
Clinocardium californiense (Deshayes)															A	
Papyridea (Fulvia) kurodai Hatai and Nisiyama												F				
Ezocallista bravisiphonata (Carpenter)				R					C	A		A	R	C	A	A
Saxidomus purpuratus (Sowerby)														R		C
Liocyma fulctuosa (Gould)														F		
Callithaca (Protocallithaca) adamsi (Reeve)															R	
Psamacola cfr. *kazusaensis* (Yokoyama)															R	
Spisula) sachalinensis (Schrenck)															R	
Macoma (Macoma) incongrua (V. Martens)											C			R		
Macoma (Macoma) tokyoensis Makiyama						R					A			R		
Myadora proxima (Smith)															R	
Hemithyris psittacea woodwardi (A. Adams)												A			A	
Terebratalia coreanica (Adams and Reeve)												F	F		A	
Terebratalia gouldii (Dall)												R	R			

Frequency (Individuals): R(Rare), 1; F(Few), 2-5; C(Common), 6-10; A(Abundant), more than 11.

Table 5. Molluscan fauna from the Hanaishi conglomerate member of the Chinkope formation in the Setana area and the Kaigarabuchi conglomerate member of the Nakanokawa formation in Kuromatsunai area.

Area	Setana area														Kuromatsunai area							
Formation	Hanaishi conglo. member of the Chinkope formation														Kaigarabuchi conglo. mem. of the Nakanokawa f.							
Fossils / Locality number	39	38	37	36	35	34	33	32	31	30	29	28	27	26	16	15	14	13	12	11	10	9
Turbo sp.															R							
Littorina (*Littorivaga*) *brevicula* (Philippi)							R															
Turritella (*Neohaustator*) *fortilirata habei* Kotaka				C			C		C													
Bittium yokoyamai Otuka	F																					
Cerithium kochi Philippi	C																					
Scala (*Boreoscala*) *aomoriensis* (Iwai)															C							
Scala (*Boreoscala*) *yabei echigonum* (Kanehara)							R															
Tectonatica janthostoma (Deshayes)									C													
Trophonopsis (*Boreotrophon*) *sasae* Sawada n. sp.	F																					
Barbitonia arthritica hirosakiensis (Iwai)															R							
Buccinum leucostoma Lischke	F																					
Volutomitra hataii Sawada n. sp.	F																					
Antiplanes contraria (Yokoyama)																						C
Antiplanes (*Rectiplanis*) *sanctiioannis* (Smith)									R													
Oenopota kagana toyotsuensis Sawada n. sp.	R																					
Acila (*Truncacila*) *insignis* (Gould)							C	A	C	C												
Acila (*Truncacila*) *nakazimai* Otuka							C															
Arca boucardi Jousseaume											R											
Glycymeris (*Glycymeris*) *yessoensis* (Sowerby)											R											
Modiolus difficilis Kuroda and Habe							R															
Polynemamussium alaskensis (Dall)	C																					
Chlamys chinkopensis Masuda and Sawada		C	A																			
Chlamys cosibensis (Yokoyama)		C													C						C	C
Chlamys daishakaensis Masuda and Sawada	F												F	C	A		A					A
Chlamys islandica erythrocomata (Dall)		C	A	R	R							F			F	C			A	F		
Chlamys nipponensis Kuroda																			F	F		
Chlamys osugii Kubota															A							
Swiftopecten swiftii (Bernardi)							F					F	F	F								
Patinopecten tokunagai (Yokoyama)	C												F									
Patinopecten yessoensis (Jay)			F				A						F									F
Lima (*Acesta*) *goliath* Sowerby					F									R	R		R			R		
Monia macroschisma (Deshayes)						R				C	F		C	C	A	R	A	C				
Astarte (*Tridonta*) *alaskensis* Dall								R			R											
Venericardia (*Cyclocardia*) *crebricostata* (Krause)														R								
Venericardia (*Cyclocardia*) *paucicostata* (Krause)	F													R								
Ezocallista brevisiphonata (Carpenter)										R								R				
Macoma (*Macoma*) *incongrua* (v. Martens)							R		R		R			R								
Macoma (*Macoma*) *tokyoensis* Makiyama														R								
Terebratalia coreanica (Adams and Reeve)														C								

Frequency (Individuals): R (Rare), 1; F (Few), 2–5; C (Common), 6–10; A (Abundant), more than 11.

wan. From these features it is considered that uplift may still be continuing in the present area.

II. Geology of the Kuormatsunai area

The township of Kuromatsunai occupies the central part of this area which stretches roughly northwest to southeast with Funka-wan in the former to the Japan Sae in the latter. This area, called Kuromatsunai area, was chosen particularly because it includes the type locality of the Kuromatsunai formation and shows the distribution of most of the stratigraphic units already described in the Setana area. In the Kuromatsunai area the following stratigraphical units have been recognized (**Table 6**), and their descriptions are given below.

A. Pre-Tertiary basements

The basement rocks in the present area comprise granodiorite, which is distributed in the northeastern part of this field where it is overlian with unconformity by the Garogawa andesitic agglomerate member of the Kuromatsunai formation on its eastern and western sides, and with the Kaigarabuchi conglomerate member of the Nakanokawa formation on its northern and southern sides also with unconformity.

B. Neogene Tertiary formation

B-1. ***Kunnui formation.*** The rocks of the Kunnui formation consist of rhyolitic tuff breccia and andesite flows and its agglomerate. The type locality of the Kunnui formation is in the Setana area and typical rocks such as the thick accumulations of green pyroclastic with interbedded siltstone and sandstone layers so not occur in the present area. However, the Kayano rhyolite in the uppermost part of the Kunnui in the Setana area is represented by rhyolitic tuff breccia below the Yakumo formation with conformity in the upper reaches of the Soibetsu River west of the Nakanokawa in Kuromatsunai-cho ; this has been given no formal name in this area.

Futamata andesite. The type locality is the cliffs along the Futamata River in the west of Futamata in Oshamanbe-cho. Here the andisite consists of dark greenish gray augite-andesite flows and agglomerate more than 200 meters in thickness. This andesite continues from about one kilometer southwest of Inaho pass in slightly arcuate from southwards to near Furano along the eastern side of the Futamata fault.

The Futamata andesite is refered to a part of the Kunnui and is thought to correspond to the Chinkopegawa andesitic agglomerate in the lower part of the Kunnui formation in the Setana area.

B-2. ***Yakumo formation.*** The type locality was already mentioned and will not be repeated in this place. In the present field the Yakumo comprises from the lower a thin alternation of dark gray hard shale and gray tuffaceous siltstone intercalated with light greenish gray andesitic tuff and light brownish green medium grained sandstone, the middle of thick alternation of gray tuffaceous siltstone and

Table 6. Stratigraphical Classification of the Rocks Distributed in the Kuromatsunai Area

Age.	Formation	Lithological characteristics	Thickness (in meters)
Holocene	Alluvial deposits	Gravel, sand and clay.	
		unconformity	
Pleistocene	Lower terrace deposits	Gravel, sand and clay.	15 – 20
		unconformity	
	Higher terrace deposits	Gravel, sand and clay.	20 – 25
		unconformity	
	Younger volcanics	Two-pyroxine andesite, andesitic agglomerate and ash.	150
		unconformity	
Late Pliocene	Soibetsugawa formation	Brownish gray fine sandstone, brownish gray medium to coarse sandstone, and cross-laminae.	90 – 95
Early Pliocene	Nakanokawa formation	Upper with bluish gray siltstone and lignite layers, and lower of alternation of bluish gray siltstone with lignite layer, bluish gray medium sandstone and conglomerate beds.	250 – 280
	Kaigarabuchi conglomerate member	Conglomerate of pebble to cobble size.	
		unconformity	
Late Miocene	Garogawa andesitic agglomerate member	Dark gray of black two-pyroxene andesitic aggglomerate with light yellowish gray andesitic fine tuff beds, dark gray or black coarse scoria sandstone and dark gray andesitic tuff breccia beds.	160 – 850
	Kuromatsunai formation	Upper with alternation of dark gray or black scoria sandstone and bluish gray tuffaceous siltstone with dark gray tuffaceous shale and light yellowish gray andesitic fine tuff beds. Middle with alternation of gray or black scoria sandstone and bluish gray tuffaceous siltstone with light yellowish gray andesitic fine tuff deds. Lower with alternation of dark gray or black scoria sandstone and bluish gray tuffaceous siltstone, and dark gray hard shale beds.	
Early Miocene	Yakumo formation	Upper with alternation of dark gray hard shale, gray tuffaceous siltstone and dark brownish gray medium scoria sandstone. Middle with alternation of gray tuffaceous siltstone and dark gray hard shale and gray tuffaceous siltstone with light greenish gray andesitic fine tuff beds. Lower with alternation of dark gray hard shale and gray tuffaceous siltstone with light green gray andesitic fine tuff and light brownish green medium tuffaceous sandstone.	400+
	Kunnui formation	Light greenish gray tuff breccia with brownish gray medium sandstone beds.	260+
		fault	
	Futamata andesite	Greenish gray altered augite andesite.	
		unconformity	
Pre-Tertiary	Pre-Tertiary basement	Granodiorite.	

thin alternation of dark gray hard shale and gray tuffaceous siltstone intercalated with light greenish gray andesitic fine grained tuff, and the upper of a thin alternation of dark gray hard shale, gray tuffaceous siltstone and dark brownish gray medium grained scoria sandstone. The siltstone in the middle and upper have yielded *Makiyama chitanii* (Makiyama) only.

The formation lies upon the rhyolitic tuff breccia of the Kunnui formation in the southwestern part of the field and is in fault contact with the Futamata andesite which is referred to the Kunnui formation. The distribution of this formation is rather limited, being the northwestern part of the field from about 5.0 kilometers southwest of Nakanokawa from where it is distributed in southward direction, being covered in places with the Shamanbedake volcanics. Its southern limit of distribution in this northwestern area is about five kilometers southwest of Kuromatsunai-cho. Here the formation has a strike of N 20° W for the anticlinal axis and the eastern wing dips at about 20°–23° E and the western one dips at about 12°–14° towards the west. On its eastern flank the Kuromatsunai is superposed with conformity.

In the southwestern area of distribution the formation is in fault contact with the Futamata andesite of the Kunnui formation and the Garogawa andesitic agglomerate member of the Kuromatsunai formation. In this area the general strike in N 20°–22° W with dips of 24°–26° NE and of N 10°–20° E with dips 25°–40° SE, showing that the area is disturbed by the faults bounding it from other units.

Only *Makiyama chitanii* has been found from the siltstone of this formation.

B–3. ***Kuromatsunai formation.*** The type locality is the cliff of the Soibetsu River at about 4.5 kilometers southwest of Kuromatsunai-cho in Suttu-gun. Here the formation is about 120 meters in thickness and lies upon the Yakumo with conformity and is covered with unconformity by the Nakanokawa. At the type locality the formation is subdivided into two parts, the upper consisting of the ***Garogawa andesitic agglomerate member*** and the lower of normal sedimentaries. The rocks in the type locality consist of in the lower part of the thin alternation of dark gray scoriaceous medium grained sandstone and bluish gray tuffaceous siltstone intercalated with dark gray hard shale, the middle part of a thick alternation of dark gray to black scoria medium grained sandstone and bluish gray tuffaceous siltsone intercalated with light yellowish gray andesitic fine grained tuff, and upper part with a thin alternation of dark gray to black scoriaceous medium grained sandstone and bluish gray tuffaceous siltstone intercalated with dark gray tuffaceous shale and light yellowish gray andesitic fine grained tuff. This is overlain with conformity by the Garogawa andesitic agglomerate member, which is dark gray to black, two pyroxene andesitic agglomerate intercalated with light yellowish gray andesitic fine grained tuff, dark gray to black two pyroxene andesite lava, dark gray to black scoria coarse grained sandstone and dark gray andesitic tuff breccia.

At the type locality there is a synclinal structure with the axis trending N 15°–20° W, and the western wing strikes N 30° W with dips of 20° NE and the eastern wing strikes at N 30° E with dips of 35° SW.

This formation, especially the lower half is distributed from the type locality southwards in belt form to 4.5 kilometers southwest of Kuromatsunai-cho, but is cut at two places and covered by the Shamanbedake volcanic detritus. Along this area it is covered with the Garogawa andesitic agglomerate member. It is also found about two kilometers northeast of Kuromatsunai-cho from where it extends southwards to one kilometer north of Kamiutasai forming there an anticlinal structure whose axis trends NNE–SSW, its eastern wing strikes N 35° W with dips of 30°–35° NE and the western wing strikes at about N 20°–22° E and dips at about 65°–70° NW. The Garogawa member shows belt form distribution along the southern part of the western wing whereas along the eastern wing the Garogawa member is missing and the Nakanokawa is superposed upon the Kuromatsunai with unconformity.

It is also distributed from about 700 meters north of Shimobabasawa from where it extends southwards to 1.5 kilometers south of Toyohoro, its eastern side being limited by the Toyohoro fault and the western one dipping under the Nakanokawa with unconformity. The general strike of the formation in this area N 10°–20° W with dip of 25°–30° SW. The Garogawa member is missing in this area.

The Kuromatsunai is also found in the southwestern part of the field from 1.5 kilometers north of Kurioka from where it extends southwestwards to 4.5 kilometers southsouthwest of Oshamanbe-cho but is interrupted by the Futamata fault. Here the formation makes an anticline with axis trending roughly northeast to southwest. The strike along the eastern wing is N 10°–35° W with dip of 50°–60° SE, the western wing trends N–S with deviation towards the west and the dip is about 20°–50° W.

Only *Makiyama chitanii* has been found from the siltstones of the formation. In the just mentioned area the Garogawa andesitic agglomerate member occurs on its western side whereas on its eastern the Nakanokawa is superposed upon it with unconformity.

B–4. ***Nakanokawa formation***. This formation is subdivided into two parts, the lower consisting of the Kaigarabuchi conglomerate member and the upper of the major part of the formation. This formation overlies the Kuromatsunai with unconformity and is covered with Soibetsugawa with conformity. The just mentioned unconformity is a significant one as will be mentioned later.

The type locality of the Nakanokawa is the cliff of the Soibetsu River, 3.5 kilometers southwest of Nakanokawa. Here it is about 230 meters in thichness and is divisible into two parts, of which the lower comprises the ***Kaigarabuchi conglomerate member***. The type locality of the member is the cliff of the Shubuto River about 500 meters southwest of Kaigarabuchi, Kuromatsunai-cho. Here it comprises a 150 meters thick alternation of conglomerate of pebble to cobble size rounded to subrounded andesite, siltstone and hard shale with brownish gray medium to coarse grained sandstone. In the lowermost part is a three meters thick boulder conglomerate of rounded to subrounded boulders of andesite about one meter in diameter.

At the type locality of the formation the Kaigarabuchi conglomerate member occurs in the lower part, being superposed upon the Kuromatsunai with unconformity. The major part of the formation or that above the member begins with an alternation of bluish gray siltstone, bluish gray medium grained sandstone and pebbly conglomerate of rounded to subrounded pebbles of andesite and hard shale, this is overlain with bluish gray siltstone intercalated with one lignite layer. This formation is overlain with the Soibetsugawa with conformity at the type locality.

The general strike of the Nakanokawa at the type locality, N 7°–10° W with dips of 10°–12° NE. From the type locality the formation is distributed in belt from southwards to the Futamata fault at about 2.5 kilometers southsouthwest of the Inao pass. By this fault the formation is displaced northwards from where it is distributed slightly in arcuate form southwards to 3.5 kilometers southsouthwest of Oshamanbe-cho. Throughout this belt like area of distribution the formation shows strikes of N 10°–30° W with dips of 10°–15° NE in the northern part, of N 20°–50° W with dips of 15°–20° NE in the northern part of the southern area, N 20°–40° E with dips of 10°–35° SE. Although the dips are generally homoclinal the strikes show some divergence.

The formation is also formed in the eastern central part of the field forming there anticlinal and synclinal structures with axis trending northwest to southeast. The general strikes of the formation in this area confirm almost with the trends of the folding axis and the dips of them vary within the range of 10–20 degrees in general except near the fault. Nearing the fault the strata dip at angles as high at 70 degrees.

In the just mentioned area the Nakanokawa and Soibetsugawa formation are both found and these lie upon the Kuromatsunai formation either with unconformity or with fault contact, in the former case the Kuromatsunai formation forms the core of the anticline and in the latter it is in fault contact with the Nakanokawa, in the western and eastern parts of this area respectively. In the northern part of this central area the Nakanokawa and Soibetsugawa formations are covered with unconformity by the terrace deposits under which they dip with trends of about N 30°–10° W and dips of about 15°–30° NE, although the former vary according to places and become N 20° E with westwards dips of about 30° because of being near a faulted area.

The Nakanokawa formation is also distributed in the northeastern part of the field where its Kaigarabuchi conglomerate member lies directly upon the granodiorite and also upon the Garogawa andesitic agglomerate member of the Kuromatsunai formation. The Nakanokawa formation and its member trend about N 10° W in the south and N 20° E in the north, showing a shallow synclinal structure and the dips in both north and south are about 10–20 degrees. Eastwards the Nakanokawa formation is covered with unconformity by the terrace deposits.

Fossils of molluscs and others occur from the Nakanokawa formation as shown in **Tables 4** and **7**.

B–5. ***Soibetsugawa formation.*** The type locality along the Soibetsu River at about 1.5 kilometers southwest of Nakanokawa, Kuromatsunai-cho. It is about 90 meters in thickness and comprises brownish gray fine grained sandstone intercalated with brownish gray medium to coarse grained sandstone in the lower and with crosslaminated sandstone in the middle part, and of fine grained sandstone in the upper part. Fossil molluscs occur from the upper part of the formation as shown in **Table 5**.

This formation is distributed only in the vicinity of its type locality and is superposed upon the Nakanokawa with conformity and overlain with unconformity by the terrace deposits. The trend of its rocks are N 35°–40° W with dips of about 5° in the southwestern part, but change to N 5°–30° E in the northern part with dips of about 5°–10° towards the northwest, thus showing a small basin structure.

Table 7. Molluscan fauna from the Soibetsugawa formation in the Kuromatsunai area. (Loc. No. 1)

Amathina nobils A. Adams	R
Glycymeris (*Glycymeris*) *yessoensis* (Sowerby)	A
Polynemamussium alaskensis (Dall)	A
Chlamys nipponensis Kuroda	C
Swiftopecten swiftii (Bernardi)	A
Patinopecten tokyoensis (Tokunaga)	A
Monia macroschisma (Deshayes)	A
M. macroschisma ezoana (Kanehara)	R
M. umbonata (Gould)	R
Astarte (*Tridonta*) *borealis* (Schumacher)	C
Venericardia (*Cyclocardia*) *paucicostata* (Krause)	R
Ezocallista brevisiphonata (Carpenter)	R
Panopa japonica A. Adams	F
Plectodon (*Plectodon*) *ligula* (Yokoyama)	R

Frequency (Individuals): R (Rare), 1; F (Few), 2–5; C (Common), 6–10; A (Abundant), more than 11.

C. Quarternary formations

C–1. ***Shamanbedake and Kuromatsunaidake volcanics.*** These volcanics are distributed in the areas of their type localities. The Shamanbedake is in the western central part of the present area and the Kuromatsunaidake is in the southeastern part. The former and latter comprise the same kind of two-pyroxene andesite flows and its agglomerate and volcanic ash. The Shamanbedake volcanics cover in part the Futamata andesite member of the Kunnui formation in its southern part, the Yakumo and Kuromatsunai formations along the eastern border and also in part the Garogawa andesitic agglomerate member of the kuromatsunai formation. The Kuromatsunaidake volcanics cover the Garogawa andesitic agglomerate member of the Kuromatsunai formation, a part of the major part of the same formation, the Nakanokawa formation and its Kaigarabuchi conglomerate member, but not the Soibetsugawa formation. The Shamanbedake and Kuromatsunaidake volcanics are not covered with any sedimentaries, even by the higher terraces.

C–2. ***Terrace deposits.*** The terrace deposits are classified into lower and higher, the latter being about 80–180 meters and the former 10–60 meters in heights. The higher one comprises gravel, sand and caly measuring 10–15 meters in thickness. The gravels are pebble to cobble size, rounded to subrounded, andesite, slate, hornfels, quartzite and hard shale. The lower terrace comprises gravels, sand and clay, about 10–15 meters in thickness. The gravels comprise pebble to cobble size, rounded to subrounded andesite, slate, hornfels, and hard shale.

The higher terrace is distributed in dissected form on the southern slope of the Kuromatsunaidake, sporadically at Inao pass in Kuromatsunai-cho and at about three kilometers southeast of Kuromatsunai-cho. It also occurs sporadically in the north of Shiraigawa, extensively in the north of Kami-babasawa from where it extends northwards along the western slope of the Horobetsudake in the northern part of the field, and along the western slope border of Taiheizan where it also has broad distribution. The areas of distribution of the higher terraces and the lower terraces are not the same. In the southern part of the field the lower terraces are developed in the north and northwest of Oshamanbe-cho, in a narrow area only along the western part of the Hakodake Main Railway Line both north and south of the Futamata Railway Station, sporadically along the southwestern and northern slopes of the Kuromatsunaidake, more extensively in the area from Inao pass northwards to the Suttsu bay being more extensive and continuous along the western than the eastern side of the broad valley through which the railway line passes.

The alluvial deposits are now found bordering the drinages or filling the valleys distributed within the present area.

D. Geological structures

The geological structures of the present area comprise faults, folding and unconformities.

D–1. ***Unconformities.*** These are found between the granodiorite basement and the Garogawa andesitic agglomerate member of the Kuromatsunai formation, between the granodiorite and the Kaigarabuchi conglomerate member of the Nakanokawa formation, between the Kuromatsunai formation and the younger Nakanokawa formation (inclusive of the Kaigarabuchi conglomerate member), between the Shamanbedake and Kuromatsunaidake volcanics and the Tertiary rocks, and between the valcanics and higher terraces and the lower terraces.

In all cases the unconformity represents an erosive phase, whereas between the granodiorite and Tertiary rocks it is also structural as it is between the Miocene Kuromatsunai formation and the Pliocene Nakanokawa formation and the same can be said for the one between the Pliocene Soibetsugawa and Nakanokawa formations and the deposits of Pleistocene age. Within the Cenozoic rocks the most significant structural unconformity is post-Soibetsugawa and pre-Shamanbedake Kuromatsunaidake Volcanics in age.

D–2. ***Folds.*** Folding structures are anticlinal and synclinal folds which may be rather broad to somewhat narrow aside from the homoclinal foldings.

Kyoritsu syncline. This occurs in the southeastern marginal part of the field. The axis trends northeast to southwest with the dips of the eastern wing being about 15 degrees towards the west and ones of the western wing dipping at about 10 degrees eastwards. The norhtern extension is covered with the high terrace deposits and its southern one is covered with the alluvial deposits.

Sakaibara anticline. This small anticline occurs in the immediate west of the one just mentioned and almost with similar trend of its axis, the dips of its wings are about 10 degrees, but become steeper in the northern part where it is thought to plunge and southwestwards it may flare upwards.

Furano anticline. This occurs in the northwest of Oshamanbe-cho and its axis like the Kyoritsu syncline is northeast to southwest with the Kuromatsunai formation, its Garogawa andesitic agglomerate member and the Kaigarabuchi conglomerate member of the Nakanokawa formation partaking in the folding. The eastern wing dips eastwards at 18–68 degrees whereas its western one at 15–60 degrees westwards, being steeper in general near the axis. The northern extension is cut by a small northeast-southwest directed fault and its southern one is thought to be cut by the Futamata fault, which is a major reverse fault.

Kurioka syncline. This occurs in the west of the just mentioned anticline and with axis quite parallel. The northern and southern extensions of this axis become obliterated, the northern dying out into the agglomerate facies and the latter probably cut by the Futamata fault. The eastern wing dips at about 35 to 64 degrees westwards whereas the western at 30°–60° eastwards, the dips being stronger than the aforementioned anticline in general.

Warabitai syncline. This is of sigmoidal trend along the margin of the valley between Futamata in the south and the south of Kuromatsunai-cho in north although it is cut by the Futamata fault in the west of the Inao pass. Being sigmoidal the trend changes from northwest to southeast in the north then to southwest. Its northward extension is covered with the lower terrace deposits and its southern one is covered with the Shamanbedake volcanics. Throughout its distribution on the eastern wing dips at 10–20 degrees and the eastern one at 8–30 degrees eastwards, the dips changing locally due to local crustal disturbances. The Nakanokawa formation is folded by this syncline.

Nakanokawa syncline. This occurs in the northwest of the just mentioned syncline. Its axis trends in northnorthwest to southsoutheast almost parallel with the southern part of the just mentioned syncline and the northern extension is covered with the lower terrace deposits and its southern one is cut by the Futamata fault. The east wing dips at about 10–15 degrees westwards while the western one at 20–28 degrees eastwards because of disturbances.

Neppu anticline. This occurs in the northeast of the syncline just mentioned and east of the Futamata fault and of the town of Kuromatsunai. Its axis trends in northnorthwest to southsoutheast almost parallel with the northern part of the aforemented syncline and the dips of its western wings are stronger than the eastern one. The eastern wing dips at about 20–30 degrees eastwards while the western one at 65–70 degrees westwards because of disturbances.

Nakazato syncline. This occurs in the immediate east of the syncline just mentioned and almost with similar trend although of linear extention because the latter is covered in its north by alluvial deposits and the former by the lower terrace deposits. However, southwards the extends of both syncline and anticline are covered with alluvial deposits. The eastern wing of the Nakazato anticline dips at about 10–20 degrees westwards and the western one at about the same towards the east. By the syncline and anticlines just mentioned the Kuromatsunai formation and its Garogawa andesitic agglomerate member and the Nakanokawa formation and its Kaigarabuchi conglomerate member are folded, whereas the higher terrace deposits are not affected by the movement.

A small anticline of northwest-southeast trend and western wing of 10 and the eastern of about 20 degrees to the west and east respectively is found in the western marginal part of the west of Kuromatsunai-cho. The southern extension is covered by the Shamanbedake volcanics and the northern one has not been traced.

Synclinal and anticlinal foldings are found along the upper course of the Soibetsu River with trends of northwest-southeast, but could not traced for any noteworthy distance. The syncline with dips of about 25°–30° for its wings occurs in the Garogawa andesitic agglomerate of the Kuromatsunai formation, and the anticline also in the same member but with the next younger Kaigarabuchi conglomerate member also affected. The anticline has lower dip on its eastern side and steeper ones on its western, the latter being about 25–30 degrees westwards and the former about 20 degrees eastwards, thereon eastwards the structure becomes homoclinal.

A shallow basin like structure occurs in the area of distribution of the Soibetsugawa formation and this is thought to have had relation with the folding of post-Pliocene-pre-Pleistocene age. A similar shallow or another broadly downwarped partially synclinal structure occurs in the northeastern part of the field, the Nakanokawa formation being folded.

All of the folding structures show nearly the same trends at least in the northern half of the field, whereas in the southern half of the field they are characteristically northeast-southwest in general and all are thought to have been developed penecontemporaneously. The shallow synclinal structure in the southeastern part of the field has its axis trend similar to the ones in the southern part of the field and dissimilar with those in the northern western half of the field. The interrelationship of these trends, where similar or dissimilar may be of significance in attempting interpretation of the tectonic of the area.

D–3. **Faults.** Minor faults in the present area are generally associated with the major ones which have been named as shown in the annexed map.

Futamata fault. This fault extends from the southern to northern extremities of the present field. Throughout its extension the strike change considerably because it is a reverse fault with angles of 60–65 degrees towards the west. The stratigraphic units affected by this fault are the Futamata andesite member of the Kunnui, the Garogawa andesitic agglomerate member of the Kuromatsunai, the major part of the same formation, the Yakumo, the Nakanokawa and its Kaigarabuchi conglomerate member and the Soibetsugawa, whereas all deposits younger than the Tertiary deposits are undisturbed, showing that the age of this fault is post-Soibetsugawa and pre-Shamanbedake and Kuromatsunaidake volcanics and the terrace depotits, thus being post-Pliocene-pre-Pleistocene in age. The Futamata fault accompanies a 15–20 meters wide crushed zone of rocks along its extension. The Futamata fault cuts the Kuromatsunaigawa fault in the central western part of the field at about 1.7 kilometers southeast of Warabitai. The fault trends in N 50°–60° W with dips 60–65 degrees to the northeast and is a reverse fault with the northeastern side thrust upon the southwestern one. There is a nearly 20 meters wide crushed zone. This fault is covered in its northwestern extension by the Shamanbedake volcanics and its southeastern extremity is cut by the Futamata fault as already mentioned. It may be added that the Garogawa andesitic agglomerate member of the Kuromatsunai formation is also deformed.

Igarashi fault. This fault occurs in the northern part of the field at about one kilometer west of Igarashi in Kuromatsunai-cho. The general strike of this fault is N 20° W with dips almost vertical with the eastern side thrown down. By this fault the Garogawa andesitic agglomerate member of the Kuromatsunai formation, the Nakanokawa formation and its member are disturbed whereas the terrace deposits cover the southeastern extension of the fault. The fault is pre-terrace and post-Nakanokawa in age.

Toyohoro fault. This one occurs in the central part of the field at about 500 meters west of Toyohoro in Kuromatsunai-cho. Its trend is N 20°–25° W with dips of 80°–85° SW, its northern extension is covered by the Kuromatsunaidake volcanics. The fault cuts the Kuromatsunai, Nakanokawa and its member and is almost parallel with the axis of the anticlines and synclines developed in this area. There is a nearly ten meters wide crushed zone along the fault.

Another minor fault which is indicated in the geological map but not named occurs in the southern part of the field at about 2.5 kilometers northwest of Kurioka, Oshamanbe-cho. Its trend is N 60° E with dips almost vertical and with the northern side thrown down. The northeastern extension of this fault is covered with alluvial deposits and its southwestern extension is lost in the Garogawa andesitic agglomerate member of the Kunnui formation. There are several meters wide crushed zone along this fault. The Kuromatsunai and its Garogawa member and the Kaigarabuchi conglomerate member of the Nakanokawa are cut by this fault.

All of these fault are judged to be post-Pliocene to pre-Pleistocene in age, being developed probably at nearly the same time as the anticlinal and synclinal foldings and prior to the eruptions of the Shamanbedake and Kuromatsunaidake volcanics.

E. Summary of the geological history of the Kuromatsunai area

The basement granodiorite rocks occupy only a small area in the northeastern part of the field and have only the Futamata andesite member of the Kunnui formation as the Tertiary formations in this area.

Following the intense volcanic activity which lead to the deposition of the Futamata andesite member of the Kunnui formation cover almost the entire southwestern part of the field, there seems to have been a gradual westward tilting of the area which was transgressed by shallow seas. These shallow waters filled and formed the basin of deposition of the marine Yakumo formation which had free connection with the open sea as may be judged by the occurrence of the planktonic sponge called *Makiyama chitanii* (Makiyama).

The marine transgression was interrupted by another more intense volcanic eruption leading to the development of the widespread Garogawa andesitic agglomerate member of the Kuromatsunai formation nearly throughout the entire area, covering in part even the Yakumo formation. This agglomerate which interfingers in its upward parts with the lower part of the major portion of the Kuromatsunai formation was followed by continued subsidence of the area in which the major part of the Kuromatsunai was deposited. The Kuromatsunai yields abundant foraminifers, the planktonic sponge already mentioned but is very poor in its molluscan fauna. During this stage the center of the sedimentary basin is thought to have been near the central part of the present field and to have extended in southwestward direction where it may have been shallower.

After a short period of uplift of the sedimentary basin and associated with minor crustal disturbances, the whole area was subjected to subsidence with the center of the sedimentary basin being formed in the area previously occupied with the basin of the Kuromatsunai formation. With the transgression of the Pliocene sea there was deposited the Kaigarabuchi conglomerate member, the basal part of the Nakanokawa formation. In the conglomerate member there have been found abundant molluscan remains particularly of the pectinids, which shows that the seas were not only shallow but also with clear bottom. Continued subsidence of the sedimentary basin lead to the buiding of the major part of the Nakanokawa formation.

During the deposition of the upper part of the Nakanokawa formation in the sedimentary basin which is considered to have been near the central part of the present field, there had already commenced shifting of the basin towards the northwest and it is in this newly formed basin that the Soibetsugawa formation was deposited. During shifting of the sedimentary basin there had already commenced uplift of the southern area and southern parts of the field where the Soibetsugawa formation is missing.

After deposition of the Soibetsugawa formation there occurred extensive uplift associated with folding, faulting and extensive erosion of the entire area. This period of crustal disturbance is dated at post-Pliocene-pre-Pleistocene in good accordance with the geological history of Southwestern Hokkaido and Northeastern Honshu. This eroded area was subjected to violent volcanism of the Shamanbedake and Kuromatsunaidake volcanics and almost at the same time there had already been brought into existence some drainages on the land surface. These drainages are considered to have resulted in the deposition and construction of both the high and lower level river terraces. From the distributions of the heights of the higher and lower river terraces it appears that some warping had continued to the present day.

III. Summary of the geological history of the Kuromatsunai and Setana areas in southwestern Hokkaido

The geological history of the two areas, both of which are situated in the central part of southwestern Hokkaido may be as given in the following lines.

1. Gradual submergence of the peneplaned land surface which exposed the Paleozoic clayslates and hornfels intruded with younger granitic rocks.

2. Partial marine transgression indicated by marine scallops near Meppu of the Kunnui formation, and extensive volcanism resulting in deposition of thick pyroclastic deposits interbedded with flows and andesite lava and agglomerate as well as of their tuff breccia.

3. Continued subsidence of both areas leading to deposition of the Yakumo formation which had free connection with the open sea ; the seas were with islands and some barriers of older rocks.

4. Second period of intense volcanism of andesitic agglomerate in the lower parts of the Kuromatsunai formation in both areas and continued subdidence resulting in deposition of siltstone, sandstone, and tuffaceous sediments forming the major part of the formation. Free connection with the open sea still continued.

5. Uplift of both areas and withdrawl of the seas and a short disturbances (faults) particularly in the Setana area and less so in the Kuromatsunai area.

6. Subsidence of the land and marine transgression bringing into both areas a very rich scallop fauna associated with many other kinds of univalves and bivalves. These shallow waters had many islands and barriers of preexisting rocks by which the distributions of the marine fauna was differentiated and the sediments subjected to considerable lateral variations in facies as well as vertically in thickness.

7. Gradual uplift of the two areas and shifting of the sedimentary basin

northwards resulting in small sedimentary basins as mere relics of the major developments of the Nakanokawa and Chinkope formations in the Kuromatsunai and Setana areas respectively.

8. Uplift of the entire region of both areas associated with strong folding, faulting and followed with subaerial denudation by which the land surface of probably high relief was again lowered.

9. Intense outbursts of volcanic activity and the development of Shamanbedake and Kuromatsunaidake in the Kuromatsunai area and of tuffaceous depotits in the Setana area where are also found volcanic rocks having good development and rather extensive distribution.

10. Continued uplift of the areas resulting in the formation of the higher and lower level river terraces. This uplift was accompanied with local warping resulting in the differences in heights of the two terraces levels within their areas of distribution.

IV. Geological Age of the Stratigraphic Units and Correlation with Northeast Honshu

In this section the geological ages of the basement rocks of clay slate, hornfels and granodiorite are left out of consideration and emphasis is given only to the rocks refered to the Tertiary System of the Setana and Kuromatsunai areas. Since the same stratigraphic names can be used for the formations in the two areas they will be treated together whereas because the Pliocene formations have been given different stratigraphic names they will be dealt with separatley.

The geological age of the Kunnui formation which is the lowest stratigraphic unit of the Tertiary System in the two areas can be determined only in part because the major part of the formation comprise pyroclastic sediments interbedding agglomerate or lava flows of andesite. From the basal part of the formation just above the unconformity separating it from the granodiorite basement there have been discovered many scallops (**Table 8**) among which characteristic and important

Table 8. Molluscan fauna from the Kaigarabashi sandstone member of the Kunnui formation in the Setana area

	Loc. no.	
	40	41
Chlamys arakawai (Nomura)		R
Ch. kumanodoensis Masuda	A	A
Ch. otukae Masuda and Sawada		C
Patinopecten kagamianus (Yokoyama)		C
Placopecten setanaensis (Kubota)	A	A
Pl. wakuyaensis Masuda		C
Nanaochlamys notoensis (Yokoyama)		C

Frequency (Individuals): R (Rare), 1; F (Few), 2–5; C (Common), 6–10; A (Abundant), more than 11.

ones for age determination are recognized.

From these scallops (**Table 8**) and their distributions in the Tertiary System of Japan and from their situations in the geological column it is evident that they indicate the early Miocene Series. For this reason it may be safe to say that the Kunnui at least its lower part is early Miocene in age, whereas its unfossiliferous greater part has yielded no paleontological evidence by which the precise age can be determined.

The green pyrocalstic facies interbedding flows of lava and agglomerate of andesites and with marine fossils at its lower part is a characteristic feature found in many early Miocene formation of the Japanese Islands, particularly of Northeast Honshu, where Kitamura (1959) has done extensive work.

The Yakumo formation which is superposed upon the Kunnui formation with conformity is also of pyroclastic nature so far as its origin is concerned, but differs considerably from the Yakumo formation in having abundant normal sedimentaries as sandstones, siltstones, which may be tuffaceous, conglomeratic, muddy or calcaleous according to places and horizons within the formation. However, unlike the Kunnui formation which yielded abundant scallops, the Yakumo is almost devoid of megafossils.

The Kuromatsunai formation in both areas yielded foraminifers and the planktonic sponge *Makiyama*, but no other megafossils have been found by the writer. Although the lower part of the formation still shows evidence of subsidence, the upper part is a regressive phase ending with the uplift of the formation and regression of these as form the two areas. The foraminifers from this formation have been described by several persons and the age is considered to correspond to the Kitaura formation of the Oga Peninsula in Akita Prefecture, Northeast Honshu, or to be late Miocene.

Separated with unconfomity from the Kuromatsunai formation is the Nakanokawa formation in the Kuromatsunai area and the Chinkope formation in the Setana area. Both of these formations are fossiliferous and their yield of scallops is noteworthy. From the fossils (**Table 4**, **Table 7**) of these two formations which have similar relation to their underlying stratigraphic units as well as with the superjacent ones, it is inferred that the age is Pliocene.

Based upon these fossils it is quite evident that their molluscan fauna may be equivalent with the Daishaka fauna in southwestern Aomori Prefecture, the Hamada fauna in the Shimokita Peninsula in the same Prefecture and probable also with a part of the Wakimoto and Shibikawa formations in the Oga Peninsula in Akita Prefecture, all in Northeast Honshu. Details of the correlation between central Southwestern Hokkaido and Northern Honshu will be given later.

From the early Pliocene age of the Nakanokawa and Chinkope formations which are superposed upon the Kuromatsunai formation with unconformity, it is certain that the latter is older than the formers and therefore pre-Pliocene in age. Also from that the Kunnui formation is early Miocene and Yakumo and Kuromatsunai formations are inserted between the Kunnui and Nakanokawa formations and its correspondents, it is evident that those two formations are of Miocene age. Because of the foraminifers from the Kuromatsunai formation indicating a late Miocene age, it can be inferred that the Yakumo formation may belong to a horizon near to the middle Miocene.

Because the molluscan fauna of the Soibetsugawa formation and its correspondent in the Setana area yielded *Patinopecten tokyoensis* (Tokunaga), it is judged that those two formations may belong to late Pliocene if actually not to the Pleistocene. They are considered to belong to late Pliocene for several reasons, one of which is the significant unconformity between those two formations and the younger deposits in the areas. The crustal disturbance indicated by the unconformity is significant not only in Southwest Hokkaido and Northeast Honshu, but also in other areas within the Japanese Islands. Another reason is that the fully mature specimens of *Patinopecten tokyoensis* date back to late Pliocene and range up into the Pleistocene, and is known to occur from the Shibikawa formation in the Oga Peninsula in Akita Prefecture, in sediments situated below the significant unconformity already referred to.

Thus as already mentioned above, the geological ages of the respective formations or members distinguished in the two areas can be determined from paleontological evidence, stratigraphical position within the geological column of the area, geological structure and interstratigraphical relationships and from the significance of the unconformity within Southwestern Hokkaido and also in Northern Honshu.

The writer made an attempt to correlate the Tertiary strata developed in the southwestern part of Hokkaido with those in the northern part of Honshu. Since the northern part of Honshu consists of Tertiary sediments such as geosynclinal and epicontinental, direct comparison is rendered defficult.

Neogene deposipts are well developed in Southeastern Hokkaido, and these correspond to the those well developed in Northern Honshu and extend farther southwards to Kyushu.

In southern Honshu the Neogene deposits may be classified into two major groups of geosynclinal and epicontinental environments. The former are typically developed along the eastern borderland of the Japan Sea and those of the latter occupy the western borderland of the Pacific Ocean.

It is thought best to treat the geosynclinal and epicontinental sedimentary envilonments separately and then correlate them with one another based upon control sections.

A. Geosynclinal sedimentary environment

In Akita Prefecture which is one of the important centers of the oil-fields in Northwest Honshu, opinions have diverged to some extent concerning the stratigraphical sequence and their grouping. Recently Huzioka (1959) established for the strata developed on the Oga Peninsula, Akita Prefecture, the sequence shown in **Table 9**.

Table 9. Stratigraphic Sequence of the Cenozoic Deposits of the Oga Peninsula, Akita Prefecture (after K. Huzioka, 1959)

Geological age	Stratigraphy			Crustal movements
Recent	Alluvial deposits			
		unconformity		
Pleistocene	Terrace deposits	Megata volcanics	Kampu volcano	
		unconformily		
	Katanishi formation (40 m)			
		unconformity		Folding and faulting
Late Pliocene	Sibikawa formation (130 m+)		Toga pumice beds	
		unconformity		Folding and faulting
		Wakimoto form. (780 m)		
Early Pliocene	Funakawa group	Kitaura form. (400 m)		Upheaval
		Funakawa form. (600–865 m)		
Late Miocene		Onnagawa form. (195–300 m)		Geosynclinal
		Nishikurosawa form. (20–150 m)		Subsidence, folding and faulting
Middle Miocene	Daijima group	unconformity		
		Daijima form. (250 m+)		
		unconformity		
		Monzen form. (900 m)		
		Shinzan rhyolite (300 m)		
		Shiosenomisaki conglomerate sandstone (60 m)		
Early Miocene	Monzen group	Kamo lavas (300 m)		
		Kuriiwa lava (250 m)		
		Akashima form. (200 m)		
		Nyudozaki ig. rock		
		Akashima lavas		
		unconformity		
Pre-Tertiary	Adamellite			

It may be added that previously the Geological Survey of Japan (1956) used the name of Takanosu group to include the Shibikawa formation, the name of Yuri group for the Wakimoto and Kitaura formations, the name of Ogashima group for the Funakawa-, Onnagawa-, and Daijima formations, and the name of Innai group for the Monzen group given in the above table. Huzioka's classification is interesting in that he makes no reference to the subdivisions of previous workers, removes the Wakimoto and Kitaura formations from the Yuri group which he does not recognize and refers them to his Funakawa group regardless of that the groups contains the Funakawa formation. He proposed a new group called the Daijima and includes into it the Nishi-kurosawa and Daijima formations which are separated by an unconformity and retain the same name as that of the group. This procedure causes considerable confusion in stratigraphic terminology.

In 1959, Kitamura classified the Neogene strata of the Oga Peninsula into eight stages, each of which is numbered. His classification differs considerably from that of Hujioka (1959) in that he recognizes no unconformity between the Daijima and Nishi-kurosawa formation, inserts a new unit called the Minami-hirasawa tuff (50 m) between the Onnagawa and Funakawa formations, and uses the name of Nishioga group for what Huzioka calls the Monzen group.

With regard to the strata developed in the Oga Peninsula, Akita Prefecture,

Table 10. Correlation of the Tertiary Formations Developed in Akita and Yamagata Prefectures with their Stages (after N. Kitamura, 1959)

Age \ Area			Oga Peninsula Akita Prefecture	Shonai Area Yamagata Prefecture	Yokote Basin Akita Prefecture	Shinjo Basin Yamagata Prefecture
Tertiary	Pliocene	VII	Shibikawa Formation 130	Shonai Group 400		Funagata Formation 100; Shibokuroyama Form. 120
Tertiary	Pliocene	VI	Wakimoto Formation 600	Jozenji Formation 250; Kannonji Formation 250	Nunomata Formation 200	Motoaikai Formation 320; Yamuka Formation 250
Tertiary	Miocene	V	Kitaura Formation 550 - 600	Maruyama Formation 270; Tateyama Formation 300	Kabasawa Formation 150 - 200	Sakekawa Formation 200; Nakawatari Formation 250; Noguchi Formation 130 - 200
Tertiary	Miocene	IV	Funakawa Formation 650	Kitamata Formation 500	Ioka Formation 150 - 200	Furukuchi Formation 400
Tertiary	Miocene	III	Minamihirasawa tuff 50; Onnagawa Formation 150	Kusanagi Formation 150 - 350	Niiyama Formation 600 - 700	Kusanagi Formation 450
Tertiary	Miocene	II	Nishikurosawa Formation 250; Daijima Formation 500	Kamigo Group 300 - 500	Sugota Formation 150; Innai Formation 300 - 500	Okawa Formation; Nakanomatagawa Formation
Tertiary	Miocene	I	Nishioga Group	Atsumi Group 1200 - 1500 ?	Nozoki Formation 600	Nozoki Formation 600 - 900
Pre-Tertiary			Granitic Rocks	Granitic Rocks	Granitic Rocks	Granitic Rocks

the Wada Basin and Yokote Basin also in Akita Prefecture, and in the Shônai Area and Sinjô Basin in Yamagata Prefecture, the present writer follows Kitamura (1959) and reproduces his correlation table as shown in **Table 10**.

The characteristic features of the Neogene formations developed in the Prefectures of Akita and Yamagata, which also are found in Aomori and Niigata Prefectures are briefly outlined in the following lines.

Everywhere the lowest of the Neogene formations are found to be unconformable to basement rocks which may consist of granite as in parts of Yamagata, Akita and Niigata Prefectures, of unknown Paleozoic sedimentaries as in parts of Aomori and Niigata Prefectures, or of rocks of unknown geological age as the pyrocalastics in Sado Island, Niigata Prefecture, the sediments of doubtful age in parts of Akita and Aomori Prefectures.

It is upon this basement that the first marine transgression took place to deposits conglomerate, sandstones with interbedded siltstones accompanied with thick pyroclastic deposits and volcanic effusives with which they may interfinger in part. These sediments, distinguished into formations are referred to the Stages I and II of Kitamura (1959). These formations are characterized with *Lepidocyclina japonica* Yabe, *L. katoi* Hanzawa, *Miogypsina kotoi* Yabe, *Echinolampas yoshiwarai* P. de Loriol, *Chlamys kaneharai* (Yokoyama), *Nanaochlamys notoensis* (Yokoyama), *Dosinia chikuzenensis* Nagao, *Vicarella tyosenica* Yabe and Hatai, and numerous other marine molluscs. The *Comptoniphyllum-Liquidambar* flora of wide distribution in Japan also belongs here. The *Eostegodon pseudo-latidens* (Yabe), *Stegolophodon miyakoae* Hatai and other mammals also occur in this position.

Stage III of Kitamura is not rich in fossils, but fish scales are common throughout, foraminifers of such genera as *Martinottiella*, *Cyclammina*, the sponge *Makiyama*, molluscs as *Flavamussium* and others are characteristic because of their wide and rather uniform distribution. Marine diatoms have been recorded by Kanaya (1959) from this stage.

In the next stage designated by the number IV, there occurs such fossils as *Cardium iwashiroense* Nomura, *Serripes yokoyamai* Otuka, *Thracia hitosaoensis* Nomura, *Cultellus izumoensis* Yokoyama, *Mya cuneiformis* (Böhm) and others. *Conchocele nipponica* Yabe and Nomura, *Yoldia hurukutiensis* Nomura and Zinbo, *Yoldia aokii* Nomura and Zinbo may also be mentioned.

In the kitaura formation and its equivalents along the eastern borderland of the Japan Sea which in stage V of Kitamura (1959) there occur *Lucinoma hanezawaensis* Nomura and Zinbo, abundant species of *Serripes*, many Buccinids, *Linthia yoshiwarai* P. de Loriol, many foraminifers, and the correspond plant fossils inclued *Acer pictum* Thumb., *Glyptostrobus europaeus* Heer, *Fagus americana* Sweet, *Liquidambar formosana* Hance, besides many others.

The Wakimoto and its correlative formations have yielded abundant fossils at several well known localities and correspond to Stage VI of Kitamura. Foraminifers are abundant almost everywhere and the molluscan fossils are such as *Acila* *insignis* (Gould), *Anadara ommaensis* (Yokoyama), *Turritella saishuensis* Yokoyama, besides many others. Plant fossils corresponding to this stage are such as *Alunus japonica* Sieb. et Zucc., *Carpinus honsyuensis* Endô, *Fagus japonica* Maxim., *Juglans cinerea* L. and others.

In stage VII, which is the Shibikawa formation, foraminifers, molluscs and other fossils are at places commonly found.

Being of geosynclinal character the sediments deposited in the environment show rather uniform distribution although there exist change in the sedimentary facies, but within recogniziable limits. Further the fossil fauna of the respective stratigraphic units show fairly wide distribution. Most intense change in the lithological facies and faunal elements occur in the marginal parts of the geosynclinal environment as already pointed out by Kotaka (1958).

As pointed out by Hatai and Kotaka (1961), the evidence for distinguishing between the Miocene and Pliocene may be arranged into several categories as of volcanism associated with marine regression and transgression which are intimately related with uplift and subsidence, differences in the faunal elements composing the different assemblages, and local diastrophic movements. Such features are mutual to all of the areas of the geosynclinal sediments. These differences can be recognized even where no unconformity separates the formations brought into consideration as on the Oga Peninsula, Akita Prefecture, where the boundary of the Miocene and Pliocene falls between the Kitaura and Wakimoto formations. Although no stratigraphical break is observed there, evidence for uplift of the Kitaura and subrequest subsidence of the Wakimoto without appearing above sealevel is a good example of local diastrophism in the form of gradual uplift followed by subsidence and a renewed marine transgression associated with the westward migration of the sedimentary basin. Where unconformities exist and a sharp break in the faunal assemblage occur as in part of the marginal areas of the geosynclinal seas, distinction between the ages and evidence for drawing the Miocene-Pliocene boundary is rendered more simple.

B. Epicontinental sedimentary environment

The epicontinental sedimentary environment is developed along the western borderland of the Pacific particularly in Northern Honshu. In this area especially in the envions of Sendai City there are deloped typical epicontinental deposits, which have been classified by Hanzawa et al. (1953) into the following way, modified according to the recent field data of the members of the Institute of Geology and Paleontology, Tohoku University, as shown in **Table 11**.

Although some modifications have been made in the stratigraphic sequence of the different rocks, especially of the Yumoto tuff, Hayama green tuff and of the Moniwa formation, the stratigraphic positions of the fossils remain unaltered. Therefore, we may take into consideration the fossils already reported by Nomura (1935, 1938), Yabe and Hatai (1938), Okutsu (1955) and others concerning the paleontology of Sendai and the environs. Since full faunal and floral lists have

Table 11. Stratigraphic classification on the Tertiary Strata in Sendai and the Environs (according to Hanzawa, et al., 1953. Hatai, 1960, Shibata, 1961)

Geological age		Stratigraphy
Recent		Alluvial deposits
		------------ unconformity ------------
Pleistocene		Terrace deposits (1-5 m)
		------------ unconformity ------------
		Aobayama formation (5-30 m)
		------------ unconformity ------------
Late Pliocene	Sendai group	Dainenji formation (30-130m)
		Yagiyama formation (20-30 m)
		Hirosegawa tuff (12-15 m)
		Kitayama formation (1-10 m)
		------------ unconformity ------------
Early Pliocene		Tatsunokuchi formation (30-60 m)
		Kameoka formation (15-20 m)
		Mitaki andesite (200 m)
		------------ unconformity ------------
Late Miocene		Shirasawa formation (330 m)
		------------ unconformity ------------
Early Miocene	Natori group	Tsunaki formation (130 m) / Yumoto formation (150 m)
		Hatatate formation (130 m)
		Moniwa sandstone member / Tsukinoki formation (60-130 m)
		Takadate andesite (60-250 m)
		------------ unconformity ------------
		Pre-Tertiary rocks

been already published by Hanzawa et al. (1953) of the respective stratigraphic units developed in and around Sendai City, repetition of them seems not necessary and only the more important or characteristic ones will be given for the sake of the discussion to follow.

The Moniwa member of the Hatatate formation has yielded *Lepidocyclina japonica* Yabe, *Chlamys kaneharai* (Yokoyama), *Placopecten akihoensis* (Matsumoto), *Nanaochlamys notoensis* (Yokoyama), *Sinum yabei* Otuka, *Apollon yabei* Nomura and Hatai, and numerous other Mollusca. In the Hatatate there occur such as *Clinocardium shinjiense* (Yokoyama), *Lyropecten kagamianus* (Yokoyama), and others. Whereas in the terrestrial facies with which the Takadate andesite interfingers, there occur such plants as the *Comptoniphyllum-Liquidambar* flora and mammals as *Eustegodon pseudolatidens* Yabe and *Stegolophidon miyakoae* Hatai. Foraminifera are also common in the Hatatate, from where Takayanagi (1952) has recorded such as *Marsinulina sendaiensis* Asano, *Nonion nicobarense* Cushman, *Sigmomorphina notoensis* Asano beside numerous others. Crustaceans, Porifera, Echinoidea and Mollusca are common aside from the Foraminifera in this formation.

The Tsunaki formation into which the Yumoto tuff and Hayama green tuff are included has yielded such as *Anadara ninohensis* (Otuka), *Glycymeris matumoriensis* Nomura and Hatai, *Chlamys crassivenia* (Yokoyama), *Neptunea hukusimensis* Nomura and Hatai beside others.

It is quite evident these epicontinental molluscan and others are typical Miocene elements, generally referred to horizons of the middle to early Miocene. Unconformably superposed upon these Miocene marine sediments is the Shirasawa formation, a lacustrine deposit which has yielded numerous plant fossils studied by Okutsu (1955).

The important plants from the Shirasawa are such as *Glyptostrobus europeus* Heer, *Sequoia sempervirens* Endl., *Fagus americana* Sweet, *F. paleocrenata* Endô and Okutsu, *F. lanceolata* Okutsu, *Liriodendron honsyuensis* Endô, *Sassafras yabei* Endô and Okutsu, *Hydrangea sendaiensis* Okutsu, *Acer Nomurai* Okutsu, *A. yabei* Endô and Okutsu, and numerous others (180 species being known to occur). This flora is of late Miocene age and is quite different from the flora of the Sendai group, mentioned in the following lines.

The Sendai group in its lowest part has yielded plant fossils from the Kameoka formation and the interesting or important ones are such as, *Sequoia japonica* Endô, *Taxodium distichum* Rich., *Pseudosasa purpurascens* Makino, *Alnus japonica* Seib. et Zucc., *Carpinus laxiflora* Bl., *Acer pictum* Thunb., and a number of others among the recorded 51 species. This plant bearing formation is superposed with a marine formation which has yield the well known *Fortipecten takahashii* (Yokoyama), a large scallop which extends its range northwards to Saghalien, being restricted everywhere as known to the early Pliocene deposits.

The marine formation just mentioned is the Tatsunokuchi formation and has yielded abundant thick shelled, large size molluscs among which *Anadara tatsunokutiensis* Nomura and Hatai, *Glycymeris gorokuensis* Nomura, *Clinocardium pseudofastosum* Nomura, *Dosinia tatsunokutiensis* Nomura, *Pitar sendaica* Nomura, *Ezocallista brevisiphonata* (Carpenter), beside other are characteristic. These fossils are known from early Pliocene deposits but not from those assigned to the late Miocene or to ones younger than the middle Pliocene. Therefore they bave been generally accepted as belonging to the early Pliocene.

Fossils of marine and land plants also occur in the formations younger than the Tatsunokuchi formation, but since they are not related with the probblem of the boundary between the Miocene and Pliocene, at least directly, they can be omitted from the discussion.

Since the Pliocene Sendai group lies on the Shirasawa, Tsunaki and Hatatate formations it is evident that an unconformity exists between it and the older rocks. Also there can be found many faults cutting the older but not the Sendai group, and the dip of the strata underlying the Sendai group are steeper, thus it is evident that local diastrophic movement occurred in the Sendai area. The volcanism associated with the uplift and folding of the pre-Sendai group seems not to have been intense at least from the view of development of flows, because such are not common. However, with the renewed transgression the volcanic activity associated therewith was in the form of lava flows, agglomerates and tuffs, thus being more intense compared with the upper parts of the pre-Sendai group series. The differences in the flora, for example *Fagus americana* Sweet occur in the pre-Sendai group but not in the Sendai group even though other species of that genus are common. The molluscan fauna is remarkably different and there are only a few in common, and these mutual ones extend their range to the present and thus may be considered as species having little or no relation to changes in thermal conditions.

From the foregoing lines it is evident that the boundary between the Miocene and Pliocene deposits may be drawn at the base of the Sendai group and at the top of the Shirasawa formation. The evidences in corporated into the determination of the time-boundary are in good agreement with the data observed in the geosynclinal environment where unconformities are not common at the said boundary line. For such reasons it is interpreted that the Wakimoto is equal to the Kameoka plus the Tatsunokuchi formation in age and may be ascribed to the Pliocene, while the Kitaura and Shirasawa are taken to be equivalent deposits of different facies, the former marine and the latter terrestrial.

Accepting that the boundary between the Miocene and Pliocene can be drawn at the aformentioned stratigraphic position, the relation between the geosynclinal and epicontinental sediments may be correlated as shown in **Table 12.**

Since the relation of the strata developed in the two different major sedimentary environments has been outlined on the foregoing pages, it now becomes necessary to show the relation of the deposits developed in Southwestern Hokkaido with those of Northern Honshu.

From the relationships of the stratigraphic sequences established by different authors in Southwestern Hokkaido it is quite evident that the one of the present writer may be used for the correlation between Southwest Hokkaido and Northern Honshu as shown in **Table 13.**

The above given correlation between Southwest Hokkaido and Northeast Honshu is established from faunal evidence, stratigraphic succession and diastrophic movements. And in the following will be given the evidences for the geological ages of the respective formations and then a summary of the geological history of Southwest Hokkaido as related with Northeast Honshu.

Table 12. Correlation of the Geosynclinal and Epicontinental Sediments of the eastern Borderland of the Japan Sea and the western one of the Pacific Ocean in Northern Honshu

		Oga peninsula Akita Prefecture (Fujioka, 1959)	Sendai Miyagi Prefecture (Hanzawa, et al., 1953, Hatai, 1960, Shibata, 1961)
Rec.		Alluvial deposits	Alluvial deposits
Pleisto-cene		Terrace deposits; Megata volcanics; Kampu volcano	Aobayama formation
		Katanishi formation	
Pliocene	Late	Shibikawa formation	Dainenji formation
			Yagiyama formation
			Hirosegawa tuff
			Kitayama formation
	Early	Wakimoto formation	Tatsunokuchi formation
			Kameoka formation
			Mitaki andesite
Miocene	L.	Kitaura formation	Shirasawa formation
	Early	FunaKawa formation	Tsunaki formation; Yumoto formation
		Onnagawa formation	Hatatate formation; Tsukinoki formation
		Nishikurosawa formation	
		Daijima formation	Moniwa sandstone member
		Monzen formation	Takadate andesite
		Akashima formation	
Pre-Ter.		Pre-Tertiary rocks	Pre-Tertiary rocks

Age	Region: Setana Area, Southwest Hokkaido	Kuromatsunai Area, Southwest Hokkaido	Oga Peninsula, Akita Prefecture	Sendai Area, Miyagi Prefecture	Ajigasawa Area, Aomori Prefecture	Shimokita Peninsula, Aomori Prefecture	Ichinohe Area, Iwate Prefecture
	SAWADA, Y., (present paper)		FUJIOKA, K., 1959	HANZAWA, S. et al., 1953 (modified)	KITAMURA, N., 1957	HANZAWA, S., 1954 a IWAI, J., KITAMURA, N. and FUJII, K., 1959	KITAMURA, N., 1954
Pliocene, Late	Minamitoshibetsu Formation 150-200	Soibetsugawa Formation 90-95	Shibikawa Formation 130 +	Dainenji Formation 30-130 Yagiyama Formation 20-30 Hiroségawa Tuff 12-15 Kitayama Formation 1-10			
Pliocene, Early	Chincope Formation 150-180 Hanaishi Conglomerate Member (75-120)	Nakanokawa Formation 250-280 Kaigarabuchi Conglomerate Member (30-250)	Wakimoto Formation 780 +	Tatsunokuchi Formation 30-60 Kameoka Formation 15-20 Mitaki Andesite 200	Narusawa Formation 100 +	Handa Formation 150 + Sunagomata Formation 150-400	Togawa Formation 20 + Shimotomai Formation 100 ±
Miocene, Late	Kuromatsunai Formation 100-400	Garogawa Andesitic Aggl. Member 160-650 Kuromatsunai Formation 160-650	Kitaura Formation 400 +	Shirasawa Formation 330	Maido Formation 400	Sarugamori Formation 120 Tomari Andesitic Aggl. 350 ±	Suenomatsuyama Formation 200-300 Andesite
Miocene, Early	Yakumo Formation 0-750	Yakumo Formation 400	Funakawa Formation 600-865	Tsunaki Formation 130 Yumoto Form. 150	Akaishi Formation 700	Gamanosawa Formation 350	Kadonosawa Formation 100-200 Shikonai Shale Mem. Shiratori Member
			Onnagawa Formation 195-300	Hatadate Formation 130	Ōdōji Formation 300		
	Kunnui Formation 30-1150	Kunnui Formation 260	Nishikurosawa Formation 20-150 Daijima Formation 260 +	Tsukinoki F. 60-130 Moniwa S.S. Mem.	Tanosawa Formation 600	Yagen Formation 800-1000	Yotsuyaku Formation 60-400
			Monzen Group: Monzen Formation 900 Akashima Formation 200	Takadate Andesite 300	Ōdose Formation 300 +		Kiseitōge Andesite
Pre-Tertiary	Pre-Tertiary Rocks						

Table 13. Correlation of the Tertiary Formation of Southwest Hokkaido and Northeast Honshu

Part II. Paleontology

Systematic Description

Phylum Mollusca

Class Gastropoda

Family Amaltheidae

Genus ***Amathina*** Gray, 1842

Type-species: *Patella tricarinata* Linné, 1758. Recent, Indo-Pacific Region.

Amathina nobilis A. Adams, 1867

Pl. 5, figs. 6–7, Pl. 7, fig. 2

Amathina nobilis A. Adams, 1842, p. 312, pl. 19, fig. 27; Tryon, 1886, vol. 8, p. 133, pl. 40, fig. 91; Yokoyama, 1931, p. 194, pl. 11, Fig. 4; Kira, 1959, p. 30, pl. 13, fig. 4.

Dimensions (in mm):

Specimen	Height	Length	Length of aperture
no. 10–6a	10.5	19.5	5.5×5.6

Remark:—The species was first described from Cape Notora, South Saghalien. It agrees with the present one in shape and sculpture of the shell. *Amathina tricarinata* (Linné) also resembles the present form, but it is distinguishable therefrom in the tricarinate surface sculpture and is a representative of the southern seas.

Geologic and geographic distribution:—Pliocne to Recent. Northern Japan Sea and the Sea of Okhotsk.

Occurrence:—Loc. 4 (few) of the Nakanokawa formation.

Family Turbinidae

Subfamily Liotiinae

Genus ***Homalopoma*** Carpenter, 1864

Type-species: *Turbo sanguinea* Linné, 1758. Recent, Mediterranean and Adriatic Sea.

Homalopoma amussitatum (Gould), 1861

Pl. 4, figs. 15–16.

Turbo amussitata Gould, 1861, vol. 8.
Trochus (Gibbula) corallinus Smith, 1875, p. 109.
Collonia purpurascens Dunker, 1882, p. 129, pl. 12, figs. 1–3.
Leptothyra amussitata, Pilsbry in Tryon, 1891, vol. 10, p. 250, pl. 55, figs. 71, 72; Yokoyama, 1920, p. 85, pl. 5, fig. 21; Taki in Hirase, 1951, pl. 75, fig. 1; Okada and Taki, 1960, p. 177, pl. 82, fig. 13.
Leptothyra purpurascens, Yokoyama, 1920, p. 86, pl. 5, fig. 22,

Dimensions (in mm):—

Specimen	Height	Diameter	Height of aperture
no. 10–13	7.0	8.0	2.7
no. 2804–5	11.2	10.1	3.5

Remarks:—Several good specimens, some of them preserve the original light pinky coloration.

Geolagic and geographic distribution:—Pliocene to Recent. Pacific and Japan

Sea sides of Northern Honshu and Hokkaido to off Saghalin.

Occurrence :—Loc. 3 (abundant), Loc. 4 (common) and Loc. 6 (abundant) of the Nakanokawa formation.

Subfamily Turbininae

Genus ***Turbo*** Linné, 1758

Type-species (Subsequent designation by Montfort, 1810): *Turbo petholatus* Linné, 1758. Recent, Indo-Pacific Region.

Turbo sp.

Pl. 7, figs. 16–17.

Remarks :—One broken specimen was obtained from the conglomerate of the Kaigarabuchi conglomerate member of the Nakanokawa formation at the river cliff of Kaikarazawa, three kilometers west of Kaikara, Rankoshi-mura, Isoya-gun. Although two and a falf volutions are preserved, the present form is characterized by its low spire and body whorl sculptured with 12 closely arranged spiral cords, wider than the interspaces, square in profile and subequal in strength, the penultimate one with five spiral cords, narrrower than their interspaces and the umbilicus which is covered with rather thick funicle. The aperture could not be examined.

Turbo setosus Gmelin (Sowerby, 1887; Tryon, 1888; Kira, 1959) is closely allied to the present one, but it differs from the latter by its numerous spiral cords on the last whorl. *Turbo argyrostomus* Linné (Sowerby, 1887; Tryon, 1888; Taki, 1954; Kira, 1959) is an allied species of the present one but it differs by its numerous spirsl cords which become stronger on the shoulder and base of the body whorl with squamated interspaces and lack of umbilicus.

The present form is characterized by its spiral cording and the feature of the suture. Although we have no species identifiable with the present form, either fossil or Recent, the writer reserves the proposal of a new specific name because of its unfavorable state.

Geologic distribution :—Pliocene.

Occurrence :—Loc. 16 (rare) of the Nokanokawa formation.

Family Littorinidae

Genus ***Littorina*** Férussac, 1821

Type-species (Subsequent designation by Rang, 1829): *Turbo littoralis* Linné. Recent, North Pacific Region.

Subgenus ***Littorivaga*** Dall, 1918

Type-species: *Littorina (Littorivaga) sitkana* Philippi, 1846. Recent, North Pacific Region.

Littorina (***Littorivaga***) ***brevicula*** (Philippi), 1844

Pl. 5, figs. 15–16.

Littorina brevicula Philippi, 1844, p. 166 (*fide* Reeve, 1857); Reeve, 1957, vol. 10, *Littorina*, pl. 10, figs. 51a–b.

Littorina sitchana var. *brevicula*, Tryon, 1888, p. 241, pl. 41, fig. 89, pl. 45, fig. 12 (not pl. 41,

fig. 90).
Leptothyra cf. *paucicostata*, Yokoyama, 1920, p. 86, pl. 5, fig. 5 (not Dall, 1871).
Littorivaga brevicula, Kuroda in Honma, 1931, p. 71, pl. 9, figs. 64, 65.
Littorina (*Littorivaga*) *brevicula*, Nomura, 1938, p. 272, pl. 38. figs. 1a–b; Taki in Hirase, 1951, pl. 79, fig. 8; Taki and Oyama, 1954, pl. 6, fig. 15; Okada and Taki, 1960, p. 170, pl. 80, fig. 4.

Dimensions (*in mm*) :—

Specimen	Height	Diameter	Height of aperture
no. 33–8	5.5	5.5	2.5

Remarks :—A small, slightly swollen specimen with slightly fractured round aperture. It is characterized by its low spire with small nucleus and two whorls, the body whorl which is about four times of that of the spire in height, surface with three more or less prominent spiral cords and two rather fine spirals on both sides of the abapical prominent cords with three or four very fine interstitial spiral striae.

The present species resembles *Leptothyra paucicostata* Dall (Tryon, 1888), but differs by having more or less prominent callus tubercle at the end of the columella.

Geologic and geographic distribution :—Pliocene to Recent. Kurile Islands to Formosa, and Philippines.

Occurrence :—Loc. 33 (rare) of the Chinkope formation.

Family Turritellidae Woodward
Subfamily Turritellinae Woodward
Genus ***Turritella*** Lamarck, 1799

Type-species: *Turbo terebra* Linné, 1758. Recent, Indo-Pacific Region.

Subgenus ***Neohaustator*** Ida, 1952

Type-species: *Turritella nipponica* Yokoyama, 1920. Pliocene, Koshiba formation of the Miura Peninsula, Kanagawa Prefecture.

Turritella (***Neohaustator***) ***nipponica*** Yokoyama, 1920

Pl. 3, figs. 9–10.

Turritella nipponica Yokoyama (in part), 1920, p. 71, pl. 4, fig. 16 (not figs. 17–19).
Turritella (*Neohaustator*) *nipponica*, Ida, 1952, p. 48, pl. 5, figs. 12, 13.
non *Turritella nipponica*, Yokoyama, 1925*c*, p. 13, pl. 2, fig. 8 (=*Turritella* (*Neohaustater*) *iwakiensis* Kotaka, 1951); Yokoyama, 1925*d*, p. 13, figs. 4, 5 (=*Turritella* (*Hataiella*) *omurai* Kanehara, 1937); Kanehara, 1942*a*, p. 131, pl. 3, figs. 11a–b, 13a–b, 16a–b (=*Turritella* (*Neohaustator*) *nomurai* Kotaka, 1951).

Dimensions (*in mm*) :—

Specimen	Height	Diameter	Height of aperture
no. 2905–4a	23.2	10.5	3.5

Remarks :—A single specimen. The geographical distribution is limited to the Tôhoku Region. The occurrence of the form form the present area, therefore, is important, and the migration route of it during the Pliocene time in northern Japan must be reconsidered.

Geologic and geographic distribution :—Pliocene to Recent. Only known from the off the Sanriku coast, Miyagi and Iwate Prefecture.

Occurrence :—Loc. 7 (few) of the Nakanokawa formation.

Turritella* (*Neohaustator*) *fortilirata habei Kotaka, 1952

Pl. 2, figs. 5, Pl. 3, fig. 8.

Turritella fortilirata multilirata Kotaka (in part) (non Adams and Reeve, 1849), 1951, p 6, pl. 1, figs. 2, 3.
Turritella fortilirata habei Kotaka (n. n. for *multilirata* Kotaka, 1951), 1952, no. 4, p. 87.
non *Turritella fortilirata multilirata* Kotaka (non Adams and Reeve, 1849), no. 3, p. 71, pl. 11, figs. 3, 4, (figured specimen only) (= *Turritella* (*Neohaustator*) *huziokai* Ida, 1950).
Turritella (*Neohaustator*) *fortilirata habei*, Kotaka, 1960, p. 73, pl. 4, figs. 2, 4–8.

Dimensions (*in mm*) :—

Specimen	Height	Diameter	Height of aperture
no. 33–7a	77.4	23.2	13.5

Remarks: Several fractured specimens are in the collection. The present form was formerly reported as *Turritella nipponica* Yokoyama or *Turritella fortilirata* Sowerby by many authors, however, Kotaka (1951, 1952) discriminated the present subspecies from the species now living off the coast of eastern Hokkaido and occurring from the Pliocene Takikawa formation of central Hokkaido by the differences in the whorl profile and the secondary spiral cording. The present form is the northern representative of the south western region.

Geologic and geographic distribution :—Pliocene to Recent. Japan Sea coast of Hokkaido.

Occurrence :—Loc. 31 (common), Loc. 33 (common) and Loc. 36 (common) of the Chinkope formation.

Family Cerithidae

Genus ***Bittium*** Leach (in Gray), 1847

Type-species: *Strombiformis reticulatus* da Costa, 1863. Recent. Eastern Atlantic.

Bittium yokoyamai Otuka, 1936

Pl. 2. figs. 10–11

Bittium binodulosum Yokoyama, 1926a, p. 270, pl. 32, fig. 15 (non Yokoyama, 1920).
Bittium yokoyamai Otuka, 1936, p. 733, pl. 42, fig. 12.

Dimensions (*in mm*) :—

Specimen	Height	Diameter	Height of aperture
no. M 10–3a	13.0	3.9	2.1
no. M 10–3b	12.5	3.5	ca. 2.0

Remarks :—Thr present species was first discriminated by Otuka (1936) from *Bittum binodulosum* Yokoyama, 1920, from the Koshiba Pliocene of the Muira Peninsula, Kanagawa Prefecture, in having rather large shell and smaller apical angle. The present form agrees with Otuka's species in the shell size, the surface sculpture and the apical angle. *Bittium binodulosum* Yokoyama recorded and illustrated from the Sawane Pliocene of Sado Island, Niigata Prefecture (Yokoyama, 1926) is conspecific with the present species in outline and the sculptures, but the one from the Onma Pliocene in the environs of Kanazawa City, Ishikawa Prefecture (Yokoyama, 1927) is quite different from the present species in the surface sculptures.

Geologic distrvbution :—Pliocene.

Occurrence :—Loc. 39 (few) of the Chinkope formation.

Genus ***Cerithium*** Bruguiére, 1789

Type-species : *Cerithium nodulosum* Bruguiére, 1789. Recent. Indo-Pacific Region.

Subgenus ***Proclava*** Thiele, 1929

Type-species : *Cerithium pfefferi* Dunker, 1877. Recent, Indo-Pacific Region.

Cerithium* (*Proclava*) *kochi Philippi, 1848

Pl. 2, figs. 17.

Cerithium kochi Philippi, 1848, Zeitsch, fur Malak., vol. 5 (non *vidi*, *fide* Kuroda and Habe 1952); Philippi, 1851, p. 2. pl. 1, fig. 3; Sowerby, 1855, vol. 2, Monogr. *Cerithium*, p. 853, pl. 176, figs. 13, 14; Tokunaga, 1906, p. 24, pl. 1, fig. 49; Nomura, 1935*e*, p. 181; Nomura and Zinbo, 1936, p. 260; Taki in Hirase, 1951, pl. 83, fig. 5.
Vertagus kochi, Reeve, 1866, vol. 15, Monogr. *Vertagus*, pl. 5, figs. 26a–b.
Cerithium (*Vertagus*) *kochi*, Tryon, 1887, vol. 9, p. 147, pl. 28, figs. 48, 49.
Cerithium (*Clava*) *kochi*, Yokoyama, 1922, p. 71, pl. 3, fig. 13.
Cerithium (*Proclava*) *kochi*, Otuka, 1935*a*, p. 858, pl. 54, fig. 78; Taki and Oyama, 1954, p. 10, pl. 23, figs. 13; Oyama, 1957, *Cerithium*, pl. 1, figs. 3, 4; Oyama, 1958, *Cerithium*, pl. 2, fig. 6.
Proclava kochi, Okada and Taki. 1960, p. 165, pl. 78, fig. 20.

Dimensions (*in mm*) :—

Specimen	Height	Diameter	Height of aperture
no. 38–24	29	6.0	3.5
no. 10–11	21.5	6.0	—
no. 2905–12	ca. 24.5	6.5	—

Remarks :—Several Specimens. The general feature of the spire and ornamentations on the surface of the whorls and state of the columellar allocate the present form to Philippi's *kochi*. According to Okada and Taki (1960) the present species is said to dwell on the sandy bottom in the low tidal zone.

Geologic and geographic distribution :—Pliocene to Recent. Northern Honshu to the Southwestern Tropical region.

Occurrence :—Loc. 3 (abundant), Loc. 4 (abundant) and Loc. 7 (common) of the Nakanokawa formation; Loc. 39 (common) of the Chinkope formation.

Family Scalidae

Genus ***Scala*** Bruguiére, 1792

Type-species : *Turbo scalaris* Linné, 1758. Recent, China, Australia, Moluccas.

Subgenus ***Boreoscala*** Kobelt, 1902

Type-species : *Turbo* (*Clathrus*) *groenlandica* (Chemnitz) Reeve, 1874. Recent, Newfoundland, Greenland.

Scala* (*Boreoscala*) *aomoriensis (Iwai), 1959

Pl. 2, fig. 24.

Epitonium (*Boreoscala*) *aomoriensis* (Iwai), 1959, p. 48, pl. 1, figs. 14a–b, 15a–b.

Remarks :—Several slightly swollen and fractured specimens. The interspaces between the longitudinal riblets are narrower in the present one than in Iwai's specimen. This species resembles *Scala* (*Boreoscala*) *yabei echigonum* (Kanehara)

(1940), but by its whorls being sculptured with stout, elevated and distinctly recurved axial varices and its interspaces much broader than the varix, and the distinct spiral threads on the surface of the whorls.

Geologic distribution :—Pliocene.

Occurrence :—Loc. 16 (common) of the Nakanokawa formation.

Scala* (*Boreoscala*) *yabei echigonum (Kanehara), 1940

Pl. 1, figs. 19–20, Pl. 5, figs. 12.

Epitonium (*Boreoscala*) *yabei echigonum* Kanehara, 1940, p. 14, pl. 6, figs. 6a–b; Kanehara, 1940, p. 130, pl. 12, figs. 13–16.

Dimensions (*in mm*) :—

Specimen	Height	Diameter	Length of aperture
no. 33–6a.	ca. 71.0	ca. 8.5	ca. 4.0
no. 38–26	ca. 22.5	10.5	5.5

Remarks :—The present subspecies resembles *Scalaria groenlandica* figured and described by Reeve in 1874, but it differs from the present one by lacking the keel that bounds the basal disc. *Epitonium angulatosimile* Otuka (1935) is an allied species of the present one, but has faint and fewer spiral threads on the ultimate whorl.

Geologic distribution :—Pliocene.

Occurrence :—Loc. 3 (rare) of the Nakanokawa formation; Loc. 33 (rare) of the Chinkope formation.

Family Pyramidellidae

Genus ***Cingulina*** A. Adams, 1860

Type-species: *Cingulina circinata* A. Adams, 1860. Recent, Japan.

Cingulina cingulata (Dunker), 1860

Turbonilla cingulata Dunker, 1860, p. 239 (*fide*, Dall and Bartsch, 1906); Dunker, 1861, p. 16, pl. 1. fig. 10.

Turbonilla (*Cingulina*) *cingulata*, Tryon, 1886, vol. 8, p. 338, pl. 76, fig. 35; Dall and Bartsch 1906, p. 344, fig. 1; Yokoyama, 1927*a*, p. 453, pl. 51, fig. 6.

Dimensions (*in mm*) :—

Specimen	Height	Diameter	Height of aperture
no. 38–39a	ca. 10.0	2.2	ca. 1.0
no. 38–39b	8.0	1.8	ca. 0.8
no. 38–39c	5.5	1.5	ca. 0.5

Remarks :—Three speciemens. The whorls are chracterized by the three prominent, rounded, spiral cords arranged in subequal interspaces. There is a slight difference in the rather slender and straight sided spire of the shell compared with that of the living one.

Geologic and geographic distribution :—Pliocene to Recent. The fossil form is also known from the Pleistocene deposits of the Bôsô Peninsula, Chiba Prefecture. Honshu, Shikoku and Kyushu.

Occurrence :—Loc. 3 (few) of the Nakanokawa formation.

Family Calyptraeidae

Genus ***Crepidula*** Lamarck, 1977

Type-species: *Patella fornicata* Linné, 1758. Recent, Atlantic and Gulf Coast of North America.

Crepidula grandis Middendorff, 1801

Pl. 3, figs. 14–15.

Crepidula aculeata, Tryon, 1866, vol. 8, p. 128, pl. 37, fig. 33 (in part).
Crepidula grandis, Oldroyd, 1927, p. 116; Kuroda in Honma, 1931, p. 73, pl. 10, fig. 73; Kinoshita and Isahaya, 1934, p. 6, pl. 3, fig. 25: Taki in Hirase, 1951, pl. 89, fig. 15; Habe, 1958, p. 11, pl. 3, fig. 17, pl. 5, figs. 5, 6; Kira, 1959*c*. p. 33, pl. 13, fig. 3; Okada and Taki, 1960, p. 163, pl. 77, fig. 9.

Dimensions (*in mm*) :—

Specimen	Length	Height	Breadth
no. 38–9a	49.8	49.8	36.0

Remarks :—This species is characterized by its slipper shape, very small, prominent and curved beak, and the internal septum which is solid and nearly half of the longer diameter of the aperture. The present species is related to *C. navia* Yokoyama (1925) from the Pliocene Shigarami formation of North Nagano, but the latter species differs from the former in having the radial riblets on the shell surface and the shell smaller than the present one. *C. jimboana* Yokoyama (1931) resembles the present species, but has the parallel margins of the shell, of which "Breadth" is nearly equal to the "Height" or half of the "Length".

Geologic and geographic distribution :—Miocene to Recent. Northern Honshu, Hokkaido, Saghalien, Alaska and Arctic Sea.

Occurrence :—Loc. 3 (few) of the Nakanokawa formation.

Family Naticidae

Subfamily Naticinae

Genus ***Tectonatica*** Sacco, 1890

Type-species: *Natica tectura* Bonelli. Pliocene of Italy.

Tectonatica janthostoma (Deshayes), 1839

Pl. 5, figs. 13–14.

Natica janthostoma, Philippi, 1853, p. 53, pl. 8, fig. 8; Reeve, 1855, vol. 9, *Natica*, pl. 13, sp. 79; Sowerby, 1855, vol. 5, p. 82, pl. 457, fig. 52; Yokoyama, 1920, p. 76, pl. 5, figs. 3, 4.
Natica clausa janthostoma, Tryon, 1886, vol. 8, p. 31, pl. 9, fig. 68.
Cryptonatica janthostoma, Dall, 1921, p. 164, pl. 14, fig. 12.
Natica (*Tectonatica*) *janthostoma*, Kinoshita and Isahaya, 1934, p. 7, pl. 4, fig. 27; Nomura and Hatai, 1935*c*, p. 128, pl. 9, fig. 4.
Tectonatica janthostoma, Habe, 1958*c*, p. 13, pl. 1, fig. 23.

Dimensions (*in mm*) :—

Specimen	Height	Diameter	Height of aperture
no. 38–38a	11.0	12.0	7.5
no. 38–38b	8.2	8.5	6.0
no. M13–1	13.0	10.5	7.0
no. 2905–1a	13.0	12.5	7.5
no. 2905–1b	20.0	ca. 17.5	ca. 10.9

Remarks :—Abundant and well preserved specimens are in the collection. Although all of the specimens are small or medium in size, the character of the funicle easily distinguishes them from Kuroda and Habe's (1949) *janthostomoides*, the southern type of the group in the Recent community.

Geologic and geographic distribution :—Pliocene to Recent. Akkeshi Bay (Hokkaido) to Bering Sea.

Occurrence : Loc. 3 (abundant) and Loc. 7 (abundant) of the Nakanokawa formation ; Loc. 20 (common) and Loc. 31 (common) of the Chinkope formation.

Family Muricidae

Subfamily Muricinae

Genus ***Trophonopsis*** Buquoy, Dautzenberg and Dallfus, 1882

Type-species : *Murex muricata* Montagu, 1803. Recent, Atlantic Coast of England, France and Mediterranean Sea.

Subgenus ***Austrotrophon*** Dall, 1902

Type-species (Subsequently designated by Grant and Gale, 1931) : *Trophon cerrosensis* Dall, 1891. Recent, Off Cerros Island, Lower California.

Trophonopsis (***Austrotrophon***) ***candelabrum*** Reeve, 1847

Pl. 7, figs. 4–5.

Fusus candelabrum Reeve, 1847, vol. 4, Monogr., *Fusus*, pl. 19, sp. 79 ; Adams and Reeve, 1850, Moll. Voy. Samarang (*non vidi*, *fide* Reeve. 1847).

Trophon clathratus, Tryon (in part), 1880, vol. 2, p. 140, pl. 31, fig. 317.

Trophon candelabrum, Sowerby, 1880, vol. 4, Monogr., *Trophon*, pl. 404, fig. 11.

Trophon subclavatus Yokoyama, 1920, p. 60, pl. 3, figs. 2, pl. 6, figs. 13, 14 ; Yokoyama, 1923*b*, p. 64, pl. 3, fig. 2.

Trophonopsis candelabrum, Kanehara, 1942*a*, p. 130.

Trophonopsis (*Boreotrophon*) *candelabrum*, Hatai and Nisiyama, 1952, p. 259 ; Kira, 1959, p. 60, pl. 24, fig. 4 ; Okada and Taki, 1960, p. 196, pl. 89, fig. 4.

Trophon (*Austrotrophon*) *candelabrum*, Taki and Oyama, 1954, p. 20, pl. 4, fig. 2, pl. 7, figs. 13, 14, pl. 23, fig. 2.

Dimensions (*in mm*) :—

Specimen	Height	Diameter	Height of aperture
no. 2804–13	20.0	9.0	10.5
no. M10–1a	44.0	ca. 22.0	ca. 20.0

Remarks :—Two well preserved specimens. One of them has very large shell and rather sharp angle of the varices on the shoulder compared with the typical form of the species.

Geologic and geograpihc distribution :—Pliocene to Recent. Pacific coast of the northern Honshu, Northern Japan Sea.

Occurrence :—Loc. 6 (rare) of the Nakanokawa formation ; Loc. 39 (rare) of the Chinokope formation.

Subgenus ***Boreotrophon*** P. Fischer, 1884

Type-species : *Murex clathratus* Linné, 1758. Recent, Arctic Region.

Trophonopsis (***Boreotrophon***) ***sasae*** Sawada, n. sp.

Pl. 2, figs. 12–13.

Description :—Shell medium in size, elongate ovate-fusi-form, with rather long curved anal canal. Protoconch with a globose nucleus and two and a half volutions which are smooth on younger but sculpture in adult with sharp, rounded varices with no angle at shoulder, ten varices on the body whorl, sharp separated widely from one another; penultimate whorl with well defined longitudinals and fine spiral interstitial striations; four weak spirals on body whorl among which abapical one weakest and appearing rather later, base with six to seven spirals. Aperture elongately oval in form, canal rather long and curved, height of aperture and canal subequal with that of spire.

Holotype :—MEMIT*, Reg. No. 60001. *Paratype* :—MEMIT, Reg. No. 60002.

Dimensions (in mm) :—

Specimen	Height	Diameter	Height of aperture
no. 60001 (Holotype)	23.0	10.5	11.0
no. 60002 (Paratype)	23.5	12.0	13.0

Remarks :—The present form is sometimes confused with water worn specimens of *Trophonopsis* (*Austrotrophon*) *candelabrum* (Reeve) in the shape, but the present one is distinguished from the latter in having spiral sculpture and varices without angles at the shoulder. It seems that the state of the varices in this group of gastropods is very important in classification and according to Wenz (1941), the roundness or angles of the varices in the genus of *Trophonopsis* are important criterion of subgeneric value. Another specimen differs from the holotype in having stronger spirals, larger shell and a thin callous deposit on inner lip. In the younger stage the longitudinals are somewhat stronger and incipient beads are formed at the intersection of the spirals and longitudinals but these become weaker and disappear with growth. This difference may be included within the range of variation of a single species.

The type species of the subgenus, *Boreotrophon clathratus* (Linné) (Reeve, 1847; Tryon, 1880) is somewhat similar to the present one, but the true *clathratus* has no spiral sculptures. In 1902, Dall discriminated *Trophon beringi* (Oldroyd, 1927; Grant and Gale, 1931) from *Boreotrophon clathratus* (Linné) but his species is different in having a short and broad shell. The species in named after Dr. Yasuo Sasa Professor of Geology, Hokkaido University, who has written many articles on the geology of Hokkaido.

Geologic distribution :—Pliocene.

Occurrence :—Loc. 39 (few) of the Chikope formation.

Genus ***Nucella*** (Bolten) Röding, 1798

Type-species (Subsequent designation by Dall, 1909): *Buccinum filosa* Gmelin, 1792. =*Buccinum lapillus* Linné, 1758. Recent.

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* MEMIT :—Abbreviation for Mining Engineering Department, Muroran Institute of Technology, Muroran, Hokkaido.

Nucella* cf. *freycineti (Deshayes), 1839

Pl. 4, figs. 1–2.

Compared with:

Purpura freycinetii, Reeve, 1846, vol. 3, *Purpura*, pl. 10, fig. 51; Lischke, 1871, p. 40, pl. 4, figs. 15–19.

Thais (*Nucella*) *freycinetii*, Dall, p. 571.

Ploytropa freycineti, Habe, 1961, p. 51, pl. 26, fig. 10.

Dimensions (*in mm*):—

Specimen	Height	Diameter	Height of aperture
no. 38–37	10.5	5.3	5.5

Remarks:—The present form is characterized by its low spire with two prominent spirals and one fine secondary spiral which occurs on the first post-nuclear whorl and becomes scaly on the body whorl, forming a node-like elevation with prominent longitudinal ribs, and by the long and narrow aperture with weakly and closely rugated outer lip, canal with thin callus deposits. The present form is allied to *Nucella freycinetii* (Deshayes) (Reeve, 1846; Lischke, 1871; Dall, 1915; Habe, 1961), but differs from the latter in having a higher spire with distinctly elevated axial ribs which become scaly on the body whorl and with longer and narrower aperture. *Nucella freycyneti heyseans* (Dunker) (Habe, 1961) resembles the present form, but has distinct axial ribs which become scaly on the body whorl and longer and narrower aperture. *Pollia mollis* (Gould) illustrated by Taki (1961) resembles the present form, but Taki's form has the excavation situated on the inner side of the canal fasciole.

Geologic distribution:—Pliocene.

Occurrence:—Loc. 3 (rare) of the Nakanokawa formation.

Family Pyrenidae

Genus *Mitrella* Risso, 1826

Type-species (Subsequent designation by Cox, 1927): *Mitrella flaminea* Risso, 1826=*Murex scripta* Linné, 1758. Recent, Mediterranean.

Mitrella burchardi (Dunker), 1877

Pl. 1, fig. 17.

Amycla Burchardi Dunker, 1877, Malak. Blat., vol. 24, p. 67 (non *vidi*, *fide* Dunker, 1882); Dunker, 1882, p. 55, pl. 4, figs. 3, 4.

Columbella (*Mitrella*) *Burchardi*, Tryon, 1883, vol. 5, p. 129, pl. 49, fig. 17.

Columbella (*Atilia*) *burchardi*, Yokoyama, 1920, p. 59, pl. 3, fig. 7.

Mitrella Burchardi, Kinoshita and Isahaya, 1934, p. 9, pl. 5, fig. 41; Taki and Oyama, 1954, p. 20, pl. 4, fig. 7; Habe, 1958*c*, p. 27, pl. 1, fig. 17; Okada and Taki, 1960, p. 193, pl. 88, fig. 19.

Dimensions (*in mm*):—

Specimen	Height	Diameter	Height of aperture
no. 38–23	11.8	1.0	5.5

Remarks:—The present single specimen coincides well with the description and figures of the original author, especially the varicose fold of the outer lip and fine spiral ornamentation on the body whorl. Kira (1959) stated that his species has no dentitions on the inner periphery of the outer lip, the figure shows the smooth surface of the body whorl, Kira's specimen is, therefore, considered to be a different species.

Geologic and geographic distribution :—Pliocene to Recent. Pacific side of Japan and further north to the Okhotsk Sea.

Occurrence :—Loc. 3 (few) of the Nakanokawa formation.

Family Buccinidae

Genus ***Plicifusus*** Dall, 1902

Type-species: *Fusus kroyeri* Möller, 1842, Recent, Greenland, Bering Sea, Labrador, Banks of Newfoundland (*fide* Tryon, 1881), Hokkaido, Saghalien, Japan Sea.

Plicifusus yanamii (Yokoyama), 1926

Pl. 2, figs. 20–21.

Bela yanamii Yokoyama, 1926*a*, p. 261, pl. 32, fig. 11.
Lora yanamii, Nomura and Hatai, 1935*c*, p. 123, pl. 13, fig. 2; Nomura, 1937, p. 174, pl. 24, figs. 11a–b.
Plicifusus yanamii, Hatai and Nisiyama, 1952, pp. 174, 211.
Mohnia yanamii Makiyama, 1958, pl. 44, fig. 11.

Dimensions (in mm) :—

Specimen	Height	Diameter	Height of aperture
no. 38–27	20.5	9.5	ca. 11

Remarks :—The present form agrees quite well with the original description and the illustration of *Plicifusus yanamii* (*Bela yanamii* Yokoyama, 1926) in size, shape and surface sculpture. *Plicifusus yanamii tenuis* Hatai and Nisiyam from the Onma formation of Ishikawa Prefecture (Hatai and Nisiyama, 1938) is an allied form, but it can be distinguished in having rather slender spire of the shell.

Geologic distribution :—Pliocene.

Occurrence :—Loc. 3 (rare) of the Nakanokawa formation.

Genus ***Neptunea*** Bolten Röding, 1798

Type-species (Subsequent designation by Cossmann, 1901): *Murex antiqua* Linné, 1758. Recent, Atlantic.

Neptunea iwaii Hatai, Masuda and Suzuki, 1961

Pl. 2, figs. 8–9.

Neptunea iwaii Hatai, Masuda and Suzuki, 1961, p. 29, pl. 3, figs. 15a–b.

Remarks :—Although the present specimens lack the protoconch, the anal and outer lip of the aperture and the majority of the penultimate whorl, the shape of the spire and whorls, and the surface sculpture can be examined. The present one resembles *Neptunea frater* Pilsbry (1901) now living off Northeast Honshu and the Kanto Region, but can be distinguished from it in the arrangement and order of the appearance of the spiral sculptures on the surface of the whorls. The most important difference between the two forms mentioned above is the stage of the appearance of the secondary spiral cords in the younger shells; in the present species, the secondary spiral cords between each primary cord appear to occur in a rather younger stage of growth of the shell than *frater*.

Geologic distribution :—Pliocene.

Occurrence :—Loc. 22 (few) and Loc. 23 (rare) of the Chinkope formation.

Genus ***Barbitonia*** Dall, 1916

Type-species: *Fusus arthriticus* Bernardi, 1858. Recent, Japan and Northern Pacific Region.

Barbitonia arthritica (Bernardi), 1858

Pl. 1, fig. 18, Pl. 2, fig. 25.

Fusus arthriticus Bernardi, 1858, p. 386, pl. 12, fig. 3 (*non vidi, fide* Yokoyama, 1922); Valenciennes, 1858, p. 761 (*non vidi, fide* Dunker, 1882).
Tritonium (*Fusus*) *arthriticum*, 1867, Schrenck, p. 421.
Neptunea arthritica, Lischke, 1869, p. 37; Brauns, 1881, p. 28, pl. 2, fig. 1; Dunker, 1882, p. 14.
Fusus arthriticus, Sowerby, 1880, Fusus, p. 88, pl. 415, fig. 121.
Neptunea despecta fornica, Tryon (in part), 1881, vol. 3, p. 116, pl. 47, figs. 262–264.
Neptunea despecta, Tokunaga (non Linné), 1906, p. 7.
Chrysodomus arthriticus, Yokoyama, 1922, p. 53, pl. 2, fig. 12.
Barbitonia arthritica, Wenz, 1941, p. 1163, fig. 3308.
Neptunea (*Barbitonia*) *arthritica*, Kira, 1959, p. 71, pl. 27, fig. 17; Okada and Taki, 1960, p. 193, pl. 88, fig. 16.

Dimensions (*in mm*) :—

Specimen	Height	Diameter	Height of aperture
no. 38-25	20.5	9.5	12.0

Remarks :—A single well preserved young specimen is in the collection.

Geologic and geographic distribution :—Pliocene to Recent. Northern Honshu to Hokkaido, north to the Okhotsk Sea.

Occurrence :—Loc. 3 (rare) and Loc. 6 (rare) of the Nakanokawa formation; Loc. 39 (rare) of the Chinkope formation.

Barbitonia arthritica hirosakiensis (Iwai) 1959

Neptunea arthritica hirosakiensis Iwai, 1959, p. 50, pl. 1, figs. 17a–b.

Remarks :—An imperfect shell is now at hand. This form is characterized by the large protoconch, narrowly elongated spire and smooth surface of the whorls. These characteristics assign the present form to Iwai's *arthritica hirosakiensis* of the Pliocene Higashimeya formation distributed in the environs of Hirosaki City, Aomori Prefecture.

Geologic distribution :—Pliocene.

Occurrence :—Loc. 16 (rare) of the Nakanokawa formation.

Genus ***Buccinum*** Linné, 1758

Type-species (Subsequent designation by Montfort, 1810): *Buccinum undatum* Linné, 1758. Recent, North Sea.

Buccinum leucostoma Lischke, 1872

Pl. 2, fig. 1, Pl. 7, fig. 3.

Buccinum leucostoma Lischke, 1872 (*non vidi, fide* Lischke, 1874), Mal. Blätt., vol. 19, p. 101; Lischke, 1874, p. 38, pl. 1, figs. 7, 8; Hirase, 1908, p. 3, pl. 26, fig. 42; Yokoyama, 1920, p. 55, pl. 2, fig. 2; Kinoshita and Isahaya, 1934, p. 10, pl. 7, fig. 51; Taki in Hirase, 1951, pl. 104, fig. 1; Kira, 1959, p. 69, pl. 26, fig. 1.

Dimensions (in mm) :—

Specimen	Height	Diameter	Height of aperture
no. M10-2a	27.3	16.5	ca. 11.5

Remarks :—The shell is of medium size, and lacks its protoconch and younger whorls. Judging from the general features of the whorls, spire and preserved surface sculpture, the present specimen is a variant of *leucostoma*.

Geologic and geographic distribution :—Pliocene to Recent. Pacific side of Northern Honshu and Southern Hokkaido.

Occurrence :—Loc. 39 (few) of the Chinkope formation.

Family Nassariidae

Genus ***Hinia*** Leach, 1847

Type-species (Subsequent designation by Cossmann, 1901): *Buccinum reticulata* Linné, 1758. Recent, European Region.

Subgenus ***Tritonella*** A. Adams, 1853

Type-species: *Tritonium incrassatum* Müller, 1776. Recent, European Seas.

Hinia (Tritonella) japonica (A. Adams), 1851

Pl. 5, figs. 18–19.

Nassa japonica A. Adams, 1851, p. 110; Lischke 1874, p. 37, pl. 2, figs. 20–23.
Nassa (Hima) japonica, Yokoyama, 1920, p. 56, pl. 3, figs. 5a–b.
Nassarius (Tritonella) japonicus, Otuka, 1935*b*, p. 870, pl. 53, fig. 37.
Nassarius (Hima) japonicus, Kanehara, 1940, p. 17, pl. 4, figs. 4a–b.
Nassarius japonicus, Taki in Hirase, 1951, pl. 106, fig. 12.
Tritia (Tritonella) japonica, Taki and Oyama, 1954, p. 22, pl. 4, figs. 5a–b.
Tritia (Reticunassa) japonica, Kira, 1959, p. 73, pl. 28, fig. 13; Okada and Taki, 1960, p. 193, pl. 88, fig. 14.
non *Nassa japonica*, Reeve, 1855 (non Reeve, 1851), vol. 8, Monogr., *Nassa*, pl. 29, fig. 192.

Dimensions (in mm) :—

Specimen	Diameter	Height of aperture
no. 10–12a	10.0	3.2
no. 10–12b	9.0	3.0
no. 10–12c	ca. 10.0	ca. 3.5
no. 10–12d	7.5	2.0
no. 38–39a	8.5	2.2
no. 38–39b	7.5	2.1

Remark :—Many well preserved specimens. The present form agrees with the illustrations of Lischke (1874), a living form of Tokyo Bay, but slightly differs from the living one illustrated by Kira (1959) in having somewhat prominent axial ribs and interspaces. The present specimens also coincide with the fossil ones from the younger Cenozoic deposits in Japan.

Geologic and geographic distribution :—Pliocene to Recent. Matsushima Bay on the Pacific side and Toyama Bay on the Japan Sea side, and further south to Shikoku, Kyushu, and Formosa.

Occurrence :—Loc. 3 (few) and Loc. 4 (abundant) of the Nakanokawa formation.

Family Fasciolariidae

Subfamily Fasciolariinae

Genus ***Latirus*** Montfort, 1810

Type-species: *Latirus suranticus* Montfort, 1810=*Murex gibulus* Gmelin, 1792, Recent, Australia.

Latirus (?) sp.

Pl. 4, fig. 9, Pl. 5, figs. 4.

Remarks :—Although the present form may belong to the named genus based upon the shape of the shell and the characters of the surface sculptures, precise generic and specific discrimination is reserved until additional specimens are obtained.

Geological distribution :—Pliocene.

Occurrence :—Loc. 4 (rare) of the Nakanokawa formation.

Family Volutidae

Genus ***Volutomitra*** H. and A. Adams, 1853

Type-species: *Mitra grönlandica* Möller, 1842. Recent, Arctic Atlantic Ocean.

Volutomitra hataii Sawada, n. sp.

Pl. 2, figs. 18–19.

Description :—Shell medium in size, spire fusiform, composed of protoconch and five whorls. Protoconch of one smooth, globose whorl with small nucleus. Whorls five, slightly convex in profile, whorl surface rather smooth, minutely spirally striated on younger whorls, but become obsolete with growth of spire. Body whorl sculptured with rather distinct growth lines, aperture elongate oval in shape and longer than half of total length, outer lip simple. Callus rather thicker on columellar lip than on parietal one. Canal straight and rather wide, with well marked siphonal fasciole. Collumella with four-folds among which second and third ones rather stronger than others, rather distinct. Nucleus slightly eroded.

Holotype :—MEMIT, Reg. No. 60003. *Paratype* :—MEMIT, Reg. No. 60004.

Dimensions (in mm) :—

Specimen	Height	Diameter	Height of aperture
no. 60003 (Holotype)	20.0	9.0	11.0
no. 60004 (Paratype)	20.5	8.5	11.5

Remarks :—The paratype specimen has only three columellar folds, but judging from the other characteristics, it is conspecific with the holotype. The type species of the genus which is known from the Arctic region of the Atlantic Ocean (Reeve, 1843; Sars, 1878; Sowerby, 1880) is very similar to the present one but the former is distinguishable from the latter by having a rather convex round whorl, larger proportion of diameter to the total length of the shell and minutely spiral striations on the early whorls. His *Volutomitra alaskana* Dall, 1602 is also allied to the present one, but it differs by having a large shell with minute spiral striations on the surface, and a more larger proportion of diameter to the total length of the shell. The species is named after Dr. Kotora Hatai, Professor of Paleontology, Tohoku University, who has written many articles on the Paleontology of Japan.

Geologic distribution :—Pliocene.

Occurrence :—Loc. 39 (few) of the Chinkope formation.

Family Cancellariidae

Genus ***Admete*** Kroyer, 1842

Type-species: *Admete crispa* Möller, 1842. Recent, Circumpolar Region.

Admete japonica lischkei (Yokoyama), 1926

Pl. 6, fig. 28.

Cancellaria lischkei Yokoyama, 1926*a*, p. 264, pl. 32, figs. 16, 17.
Admete japonica, Hatai and Nisiyama, 1952, p. 182 (non Smith, 1879).
Admete japonica lischkei, Makiyama, 1958, pl. 44, figs. 16, 17.
Admete lischkei, Iwai, 1959, p. 51, pl. 1, figs. 5a-b.

Dimensions (*in mm*) :—

Specimen	Height	Diameter	Height of aperture
no. 38-6a	10.0	5.1	3.1
no. 38-36b	9.1	5.0	3.0
no. 38-36c	7.5	4.0	2.6
no. 38-36d	6.0	3.8	2.3

Remarks :—The present subspecies was first proposed by Yokoyama as a new species of the genus *Cancellaria*, but in 1952 Hatai and Nisiyama transfered it to *Admete*, and considered it as synonymous with the species *japonica* Smith from Ojika Bay of Wakamatsu Island of the Goto Islands, Minami-Matsura-gun, Nagasaki Prefecture. The present subspecies is somewhat similar to *japonica* as pointed out by Hatai and Nisiyama, but Smith's species has rather prominent and broad longitudinal ribs on the surface of the whorls compared with the present form which has rather narrow longitudinal ribs and sharp and prominent spiral cords. The writer, therefore, accepts Makiyama's opinion (1958), and allocates the present form into the subspecies of *japonica*.

Geologic distribution :—Pliocene.

Occurrence :—Loc. 3 (abundant) and Loc. 7 (few) of the Nakanokawa formation.

Family Turridae

Subfamily Brachytominae

Genus ***Granotoma*** Bartsch, 1941

Type-species (Subsequent designation by Bartsch, 1941): *Bela krausei* Dall, 1886. Recent, Bering Sea.

Granotoma kotakae Sawada, n. sp.

Pl. 1, figs. 21-22.

Description :—Shell medium in size, elongate fusiform, spire rather slender with protoconch of small, smooth younger whorls, and five sculptured ones. Whorls, convex with strong shoulder on adapical one third of whorls, decussate sculptures with closely spaced prominently elevated growth lines, more or less deep sinus on shoulder of whorls, very fine spiral threads at adapical half of each whorl, three distinct and rather broad spiral cords at abapical half, and both form decussate sculptures, last and penultimate whorls partly form nodulose sculptures. Base of body whorl slightly convex, ornamented with five spirals and numerous grouth lines, aperture elongated fusiform, outer lip rather thin with narrow but rather deep sinus on shoulder of whorls, callus very thin, anal canal broad.

Holotype :—MEMIT, Reg. No. 60005.

Dimensions (*in mm*) :—

Specimen	Height	Diameter	Height of aperture
no. 60005	17.0	7.5	7.5

Remarks :—The present species is characterized by its spire with distinct shoulder, decussate sculptures with numerous growth lines, and fine and closely spaced spiral threads at the adapical half, three narrower than their interspaces, and by the spiral cords at the abapical half of the whorls. The present species resembles *Grantoma dissoluta* (Yokoyama) (1920) from the Pliocene Sawane formation of Sado Island, but can be distinguished by its rather round whorls sculptured with oblique, slightly curved backward longitudinal ribs which are generally separated by rather wide interspaces and the fine spirals which are numerous and most distinct in the valleys, and cut the ribs so as to render the spaces between the spirals finely nodulose. The specific name is dedicated to Dr. Tamio Kotaka, Tohoku University, who has written many articles on the Paleontology of the Cenozoic formations of Japan.

Geologic distribution :—Pliocene.

Occurrence :—Loc. 39 (rare) of the Chinkope formation.

Subfamily Turrinae

Genus ***Antiplanes*** Dall, 1902

Type-species : *Pleurotoma* (*Sucrula*) *perversa* Gabb, 1865. Post-pliocene of San Pedro, Los Angeles County, U.S.A.

Antiplanes contraria (Yokoyama), 1926

Pl. 2, figs. 14–15.

Pleurotoma contraria Yokoyama, 1926*b*, p. 383, pl. 44, figs. 2a–b.
Antiplanes kamchatica, Otuka (non Dall, 1919), 1935*b*, p. 873.
Antiplanes perversa contaria, Otuka, 1936, p. 734, pl. 42, fig. 11.
Antiplanes contraria, Taki in Hirase, 1951, pl. 115, fig. 11 (only left fig., right fig. *Antiplanes kamchatica* Dall, 1919); Kira, 1959, p. 90, pl. 35, fig. 2; Iwai, 1959, p. 52, pl. 1, figs. 13a–b; Okada and Taki, 1960, p. 193, pl. 88, fig. 5 (non Yokoyama, 1926 *Antiplanes kamchatica* Dall, 1919).

Dimensions (*in mm*) :—

Specimen	Height	Diameter	Height of aperture
no. M13-a	43.0	15.0	16.2
no. 301-5a	48.5	17.0	20.0

Remarks :—The specimen from near Tsuribashi, Imagane-cho, Setanagun is almost complete except for the outer lip of the aperture, eleven and a half volutions are preserved, and the other four specimens lack their protoconchs, but the shape of the whorls, the sutures and the depth of the sinus of the growth lines well agree with Yokoyama's *contraria*. *Antiplanes perversa* Gabb, know from the west coast of North America is very similar to the present species, but is distinguishable from the present one in having rather more slender spire. *Antiplanes kamchatica* Dall (1919) is also, sometimes, confused with the present species, but the present one has a smooth shell except for the growth line traces, rather slender spire and rather narrow aperture.

Geologic and geographic distribution :—Pliocene to Recent. Northern Honshu to Hokkaido.

Occurrence :—Loc. 9 (common) of the Nakanokawa formation : Loc. 20 (few) of the Chinkope formation.

Subgenus ***Rectiplanis*** Bartsch, 1944

Type-species : *Pleurotoma* (*Antiplanes*) *santarosana* Dall, 1920, Recent, California.

Antiplanes (***Rectiplanis***) ***sanctaioannis*** (Smith), 1875

Pl. 4, fig. 10, Pl. 5, fig. 17.

Pleurotoma sanctaioannis Smith, 1875, p. 416.
Antiplanes yessoensis Dall, 1925, p. 4, pl. 21, fig. 3.
Pleurotoma sadoensis Yokoyama, 1926*a*, p. 259, pl. 13, fig. 16 ; Otuka, 1949, p. 306, pl. 13, fig. 16.
Antiplanes sadoensis, Nomura, 1937*b*. p. 174, pl. 24, figs. 5a–b.
Spirotropis (*Antiplanes*) *sadoensis*, Kanehara, 1940, p. 19, pl. 4, figs. 2a, 2b.
Rectiplanis sanctaioannis, Hatai and Nisiyama, 1952, p. 170, p. 232.
Antiplanes (*Rectiplanes*) *sanctaioannis*, Habe, 1958*c*, p. 30.
Antiplanes (*Rectiplanes*) *sadoensis*, Chinzei, p. 117, pl. 9, figs. 6–9.

Dimensions (*in mm*) :—Specimen	Height	Diamerer	Height of aperture
no. 31–1	30.1	10.5	12.8

Remerks :—The present form is similar to *Antiplanes perversa* Gabb of western North America but the latter is a sinistral shell. According to the original description of Smith (1875) *sanctioannis* is said to have smooth shell surface, but obsolete alternations of wide and narrow spiral striae cover the surface of the whorls. Although *Antiplanes thaleaea* (Dall, 1902), a Recent species of California (*fide* Dall, 1925) is also similar to the present one, the furrowed sutures and the presence of the selenizone-like sculpture on the whorl surface at the bottom of the sinus distinguish the former from the latter. In 1925 Dall described *Antiplanes yessoensis* from the south coast of Hokkaido, judging from the original description and figure, his species is assumed to be synonymous with the present species.

Geologic and geographic distribution :—Pliocene to Recent. Hokkaido.

Occurrence :—Loc. 31 (rare) of the Chinkope formation.

Genus ***Oenopota*** Mörch, 1852

Type-species (Subsequent designation by Dall, 1919) : *Fusus pleulotomaria* Couthouy, 1839. Recent, Massachusetts Bay.

Oenopota kagana toyotsuensis Sawada, n. subsp.

Description :—Shell medium in size, elongate fusiform, spire rather slender with protoconch of small, smooth globose nucleus and one smooth younger whorl, and sculptured with five whorls. Whorls convex, first nepionic whorl with three fine spiral striae equally spaced, these become obsolete instead and disappear on succeeding whorls; longitudinal ribs 13 on body whorl and slightly inclined opischoclinally. Aperture elongated fusiform, outer lip with shallow sinus on its adapical, callus very thin, anal canal distinct but short.

Holotype:—MEMIT, Reg. No. 60006.

Dimensions (*in mm*):—

Specimen	Height	Diameter	Height of aperture
no. 60006	16.0	6.0	7.0

Remarks:—The present subspecies is distinguishable from the species in the rather slender spire and smaller proportion of the height of aperture to the total height. *Plicifusus yanamii tenuis* Hatai and Nisiyama (1939) from the Onma formation of Ishikawa Prefecture resembles the present one but differs by its distinct spiral cords at the base, smaller proportion of the height of aperture to the total height, and its outer lip with shallow sinus. The specific name is originated from the geographic name of the type locality of the present form.

Geologic distribution:—Pliocene.

Occurrence:—Loc. 39 (rare) of the Chinkope formation.

Oenopota kuromatsunaiensis Sawada, n. sp.

Pl. 3, fig. 7, Pl. 4, figs. 19–21.

Description:—Shell medium in size, elongate fusiform, spire slender with protoconch of small, smooth globose nucleus and one young whorl with three fine spiral striae, and five whorls. Whorls, convex, with round axial ribs extremely elevated at shoulder and obsolete near distinctly abapical to suture continues with these main ribs, spirals become broad and extremely low with growth and it becomes fine threads. Aperture elongated fusiform, outer lip with distinct sinus at shoulder, callus very thin, anal canal rather short and straight.

Holotype:—MEMIT, Reg. No. 60007. *Paratype*:—MEMIT, Reg. No. 60008, 60009, 60010.

Dimensions (*in mm*):—

Specimen	Height	Diameter	Height of aperture
no. 60007 (Holotype)	14.5	6.0	5.5
no. 60008 (Paratype)	17.0	ca. 11.0	7.0
no. 60009 (Paratype)	6.2	ca. 6.5	6.0
no. 60010 (Paratype)	ca. 12.5	ca. 5.0	5.0

Remarks:—The present form resembles *Propebela turricula* Montagu (Bartsch, 1941), but differs by its protoconch with three fine spiral striae and the spiral cords which become broad and extremely low with growth and by the axial ribs which become obsolete near the suture. *Granotoma kotakae* Sawada is similar to the present new species in the shape and the surfece sculpturs of the whorls, but the former has the protoconch with smooth younger whorls and the spire with decussate sculptures with numerous growth lines, and fine and closely spaced spiral threads at the adapical half, three rather narrow spiral cords at the abapical half of the whorls and form nodulose sculpture on the last and penultimate whorls. The other speicmens of this species differ from the holotype in having many axial ribs on the last whorl (three or four) and slightly less elevated shoulder, but this difference may be included within the range of variatin of a single species. The specific name is originated from the geograpical name of the type locality of the present form.

Geologic distribution :—Pliocene.

Occurrence :—Loc. 3 (few) and Loc. 7 (few) of the Nakanokawa formation.

Family Schphanderidae

Genus ***Eocylichna*** Kuroda and Habe, 1952

Type-species: *Cylichna braunsi* Yokoyama, 1920. Pliocene, the Naganuma formation of the Miura Peninsula, Kanagawa Prefecture.

Eocylichna musashiensis (Tokunaga), 1906

Pl. 6, fig. 32

Bulla cylindracea, Brauns, 1881, p. 35 (non Pennant, 1776).

Cylichna musashiensis Tokunaga, 1906, p. 32, pl. 2, fig. 12; Yokoyama, 1920, p. 27, pl. 1, fig. 4; Yokoyama, 1922, p. 27, pl. 1, fig. 10.

Eocylichna musashiensis Kuroda and Habe, 1952, p. 55; Hatai and Nisiyama, 1952, p. 196; Habe, 1961, p. 91, pl. 43, fig. 16.

Dimensions (in mm) :—

Specimen	Height	Diameter
no. 38–29	7.0	3.0
no. 10–15	6.5	2.7

Remarks :—In 1906 Tokunaga proposed the name *musashiensis* for Brauns's (1881) *cylindracea* from the environs of Tokyo. Kuroda and Habe proposed a new genus *Eocylichna* in 1952 based upon *Cylichna braunsi* Yokoyama (1920) from the Pliocene Naganuma formation of a road-side cutting at Naganuma, Totsuka Ward, Yokohama City, Kanagawa Prefecture, and allocated Tokunaga's *musashiensis* into this new genus. The present speices is closely allied to *Adamnestia Japonica* (A. Adams) (Habe, 1961), but it can be distinguished from the latter by its distinct folds on the columella lip and the apex sunken into a pit encircled by steeply elevated margin.

Geologic and geographic distribution :—Pliocene to Recent. Japan Sea coast of Honshu and Kyushu.

Occurrence :—Loc.3 (rare) and Loc. 4 (rare) of the Nakanokawa formation.

Class Pelecypoda

Family Nuculidae

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

Type-species (Subsequent designation by Stoliczka, 1871): *Nucula divaricata* Hinds, 1843. Recent, Northern and Tropical Pacific.

Subgenus ***Truncacila*** Grant and Gale, 1931

Type-species (Original designation): *Nucula castrensis* Hinds, 1843. Recent, Sitka, Alaska.

Acila (*Truncacila*) *insignis* (Gould), 1861

Pl. 6, figs. 30–31.

Nucula (*Acila*) *insignis* Gould, 1861, p. 36 (*fide* Schenck, 1936); Kuroda, 1929, vol. 1, no. 3, p. 7, Appendix p. 8, fig. 5; Nomura and Hatai, 1935*a*, p. 49.

Nucula insignis, Tokunaga, 1906, p. 56; Yokoyama, 1911, p. 4; Yokoyama, 1920, p. 179, pl. 19, figs. 7, 8.

Acila (*Truncacila*) *insignis*, Schenck, 1936, p. 99, pl. 11, figs. 1–8, 12, text-fig. 7; Nagao and Huzioka, 1941, p. 120, pl. 29, figs. 22, 22a; Habe, 1951, p. 20; Ozaki, 1958, p. 107, pl. 22, figs. 2, 3; Yamamoto and Habe, 1958, p. 2, pl. 2, fig. 6; Habe, 1958*a*, p. 243, pl. 12, fig. 8; Habe, 1960, p. 2, pl. 1, fig. 1.

Dimensions (*in mm*) :—

Specimen	Length	Height	Width or Depth	Valve
no. 2804–1a	13.0	12.0	7.8	intact
no. 2804–1c	14.0	14.5	4.2	left
no. 33–3c	21.0	17.5	10.0	intact

Remarks :—The morphological characters of the present species are; shell rather small in size, elongated oval in outline, surface with regulary diverging fine ribs, and lack the ear-like process at the posterior end of the dorsal margin. On some of the present specimens, the radial ribs become obsolete near the posterior-ventral margin. But it is judged to be merely individual variation among the present species.

Geologic and geographic distribution :—Pliocene to Recent. All around Japan from Kyushu to Southern Hokkaido.

Occurrence :—Loc. 2 (rare), Loc. 3 (few), Loc. 5 (rare), Loc. 6 (common), and Loc. 7 (rare) of the Nakanokawa formation; Loc. 18 (rare), Loc. 19 (common), Loc. 22 (rare), Loc. 30 (common), Loc. 31 (common), Loc. 32 (abundant) and Loc. 33 (common) of the Chinkope formation.

Acila (*Truncacila*) *nakazimai* Otuka, 1939

Acila (*Truncacila*) *nakazimai* Otuka, 1939, p. 24, pl. 2, figs. 11, 12; Nagao and Huzioka, 1941, p. 126, pl. 29, figs. 5–9.

Remarks :—According to the original author this species is characterized by "its rather large, moderately thick, elongate-oval shell outline", "vertically arranged three middle adductor scars on the inner surface of both valves", and "a weak long narrow S-shaped ridge runs from umbone to slightly upper center of inner surface" of the left valve. These characteristic features are observed in the specimens at hand.

Geologic distribution :—Pliocene.

Occurrence :—Loc. 6 (common) and Loc. 7 (common) of the Nakanokawa formation; Loc. 21 (common), Loc. 22 (common), Loc. 30 (common) and Loc. 33 (common) of the Chinkope formation.

Family Nuculanidae

Genus *Yoldia* Möller, 1842

Type-species (Subsequent designation by Gardner, 1916): *Nucula arctica* Möller non Gray, Recent, Greenland.

Subgenus ***Cnesterium*** Dall, 1898

Type-species: *Yoldia scissurata* Dall, 1897. Recent, St. Paul, Kodiak Island, Alaska.

Yoldia (Cnesterium) johanni Dall, 1925

Yoldia (Cnesterium) johanni Dall, 1925, p. 32, pl. 29, fig. 7; Habe, 1951, p. 26, fig. 27; Kira, 1959, p. 108, pl. 41, fig. 13.
Yoldia johanni, Kuroda, 1929, vol. 1, no. 4, Appendix p. 12, no. 42, fig. 16; Nomura, 1935*b*, p. 104, pl. 5, fig. 3.
Yoldia cf. *johhani*, Yokoyama, 1932, p. 16, pl. 3, fig. 1.
Yoldia cooperi ochotoensis Otuka, 1934, p. 609, pl. 47, figs. 17, 18 (not of Khomenko, 1930).
Cnesterium johanni, Habe, 1955, p. 2, pl. 2, fig. 9; Habe, 1958*a*, p. 251, pl. 7, fig. 4; Yamamoto and Habe, 1958, p. 3, pl. 2, fig. 5, pl. 4, fig. 1.

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 2905-8a	11.0	8.2	—	right
no. 2905-8b	21.0	11.5	—	right

Remarks:—The present species has the posterior end slightly rostrate and recurved and the basal margin evenly arcuate. It is characterized by its middle part of shell-surface which is covered by striae oblique to the growth lines. This species is closely allied to *Yoldia (Cnesterium) keppeliana notabilis* Yokoyama (Otuka, 1936), but the latter has a shell with narrowed posterior end which is turned, whereas the former has a broad posterior which is not turned upwards. The concentric grooves on the shell surface of the latter reach the anterior margin.

Geologic and geographic distribution:—Pliocene to Recent (Japan). Japan Sea, Okhotsk Sea and northern Japan.

Occcurence:—Loc. 2 (common), Loc. 4 (rare), Loc. 6 (abundant), Loc. 7 (rare) and Loc. 8 (rare) of the Nakanokawa formation; Loc. 17 (rare) of the Chinkope formation.

Family Arcidae

Genus ***Arca*** Linnaeus, 1758

Type-species: *Arca noae* Linné, 1758. Recent, Mediterranean Sea.

Arca boucardi Jousseaum, 1894

Pl. 6, figs. 3–4.

Arca boucardi Josseaum, 1894, The Humming Bird, 4, fig. 14 (*fide* Yamamoto and Habe, 1958); Kanehara, 1942*a*, p. 130, pl. 3, figs. 9a–b; Taki in Hirase, 1951, pl. 2, fig. 1; Yamamoto and Habe, 1958, p. 4, pl. 4, fig. 6; Habe, 1960, p. 2, pl. 5, fig. 12.
Arca kobeltiana Pilsbry, 1904, p. 559, pl. 40, figs. 16–19.
Arca rectangularis Tokunaga, 1906, p. 61, pl. 3, figs. 23a–b.

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 10-7a	30.5	15.5	8.0	right

Remarks:—The present species is chracterized by having an ark shape, the radial ribs which are bifurcate near the beak on the posterior area, and the flat and wide ligamental area between the umbones, the prominent chevron-shape ligamental grooves. The dorsal hinge line is straight and bear many small teeth.

Geologic and geographic distribution:—Pliocene to Recent. Formosa to Hokkaido, common in northern Japan.

Occurrence :—Loc. 2 (abundant) and Loc. 4 (rare) of the Nakanokawa formation; Loc. 17 (common) and Loc. 29 (rare) of the Chinkope formation.

Genus ***Pseudogrammatodon*** Arkell, 1930

Type-species: *Arca adversidentata* Deshayes, 1860. Recent, Chaussy.

Peudogrammatodon dalli (Smith), 1885

Parallelodon obliquatus, Yokoyama, 1920, p. 170, pl. 18, figs. 9–11 (not pl. 17, fig. 6); Yokoyama, 1922, p. 191.

Pseudogrammatodon dalli, Nomura and Hatai, 1935*a*, p. 4, pl. 2, figs. 14a–b; Nomura and Hatai, 1936*a*, p. 119, pl. 13, fig. 9; Habe, 1951, p. 34, fig. 50; Yamamoto and Habe, 1958, p. 2, pl. 2, fig. 13.

Pseudogrammatodon dalli obliquata, Kanehara, 1942a, p. 120, pl. 3, figs. 2a–b.

Dimensions (*in mm*) :—

Specimen	Length	Height	Depth	Valve
no. 2804–11a	29.5	15.5	5.5	right
no. 2804–11b	28.0	14.5	5.5	left

Remarks :—The shell is transversely and longly ovate with the narrower end directed anteriorly, strongly inequilateral, with the posterior side three times as long as the anterior. Surface somewhat depressed in the middle, radiately ribbed, the ligamental area is narrow; dentition consists generally of three subhorizontal, parallel, transversely striated teeth in the posterior portion and two in the anterior, with a few crenular teeth behind the anterior horizontal ones. The middle of the three posterior teeth is longest and the lower one the shortest.

Geologic and geographic distribution :—Miocene to Recent. Northern and Central Japan.

Occurrence :—Loc. 6 (abundant) of the Nakanokawa formation.

Family Glycymeridae

Genus ***Glycymeris*** Da Costa, 1778

Type-species: *Glycymeris orbicularis* Da Costa, 1778=*Arca glycymeris* Linné, 1758. Recent, England.

Subgenus ***Glycymeris*** s.s.

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

Pl. 4, figs. 12–13.

Pectunculus yessoensis, Yokoyama, 1920, p. 168, pl. 18, figs. 1, 2; Yokoyama, 1922, p. 189, pl. 16, figs. 6, 7; Yokoyama, 1925*a*, p. 20, pl. 4, fig. 4.

Pectunculus rotundus, Yokoyama, 1920, p. 167, pl. 17, figs. 10, 11 (non Dunker, 1882).

Glycymeris yessoensis, Kuroda, vol. 1, no. 6, Appendix p. 20; Makiyama, 1930, p. 192, text-figs. 1–9; Kuroda, 1933, p. 51, text-fig. 31; Kinoshita and Isahaya, 1934, p. 12, pl. 9, fig. 63; Nomura and Hatai, 1935*c*, p. 93, pl. 9, fig. 14; Nomura and Hatai, 1936*a*, p. 118, pl. 13, fig. 8; Habe, 1951, p. 41, figs. 65, 66; Habe, 1955, p. 3, pl. 2, figs. 1, 2; Taki and Oyama, 1957, pl. 19, figs. 1, 2, pl. 36, figs. 6, 7; Habe, 1958*a*, p. 256, pl. 12, fig. 16; Iwai, 1959, p. 55, pl. 2, figs. 5a–b; Kira, 1959, p. 113, pl. 44, fig. 10; Habe, 1960, p. 3, pl. 1, figs. 6, 7.

Glycymeris (*Glycymeris*) *yessoensis*, Ozaki, 1958, p. 113, pl. 23, fig. 6; Okada and Taki, p. 91, pl. 46, fig. 2.

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 36-4a	52.8	49.6	13.0	right
no. 36-4b	52.7	50.0	12.2	left
no. 36-4c	52.2	47.8	12.3	right
no. 36-4d	53.0	47.0	13.0	left

Remarks:—The present specimens are common along the coast of Northern Japan. This species is characteristic in the rather flattened valve with regular and distinct radial ribs and the characteristic cheveron shaped sculptures in the ligamental area. There are two types of shell outline, some of them are the rounded and equilateral, but others are not and unequilateral being a little longer along the postero-dorsal margin than the antero-dorsal one, and most of them are of the former. Several specimens of the latter from Loc. 1 of the Soibetsugawa formation have more elongated shell outline than the specimens from other regions.

Geologic and geographic distribution:—Upper Miocene to Recent. Northern and Central Honshu.

Occurrence:—Loc. 1 (abundant) of the Soibetsugawa formation; Loc. 2 (common), Loc. 4 (abundant), Loc. 5 (common) and Loc. 6 (ccmmon) of the Nakanokawa formation.

Family Limopsidae

Genus ***Limopsis*** Sassi, 1827

Type:species: *Arca aurita* Brocchi.

Limopsis tokaiensis Yokoyama, 1910

Pl. 6, figs. 7–8.

Limopsis tokaiensis Yokoyama, 1910, p. 1, pl. 9, figs. 1, 3, 5–7; Yokoyama, 1920, p. 172, pl. 18, figs. 14–16; Yokoyama, 1926, p. 307; Makiyama, 1927, p. 28; Habe, 1951, p. 44; Ozaki, 1958, p. 111, pl. 11, fig. 6; Iwai. 1959, p. 55, pl. 2, figs. 8a–b, 9a–b.

Dimensions (in mm):—

Specimen	Length	Height	Deptn	Valve
no. M13-1a	22.0	23.0	6.0	right
no. 96-3b	16.0	15.9	4.0	left
no. 96-3c	15.0	13.0	4.0	left
no. 96-3d	13.0	12.0	3.2	right
no. 96-3g	6.5	6.0	1.5	left

Remarks:—This species is distinguishable from the allied ones by the strongly unequilateral, oblique, ovate to oblong, compressed and somewhat elongate form of the shell. It is also characterized by its ligamental pit, which is very broadly triangular with the breadth thrice the height, and is simply bounded by two shallow grooves on both sides of the triangle. *Limopsis pelagica* Smith (Nomura and Hatai, 1935) is similar, but differs in having a more prominent beak, less oblique shell and conspicuous posterior wing.

Geologic and geographic distribution:—Pliocent Cnetral Japan and northwards.

Occurrence:—Loc. 7 (abundant) of the Nakanokawa formation; Loc. 20 (common), Loc. 22 (common) and Loc. 23 (abundant) of the Chinkope formation.

Family Mytilidae

Genus ***Modiolus*** Lamarck, 1799

Type-species (Subsequent designation by Gray, 1847): *Mytilus modiolus* Linné, 1758. Recent, European Seas.

Modiolus difficilis (Kuroda and Habe), 1950

Modiola modiolus, Yokoyama, 1920, p. 145, pl. 11, fig. 21 (non Linnaeus, 1758); Yokoyama, 1925*a*, p. 15, pl. 2, fig. 2.
Volsella modiolus, Kinoshita and Isahaya, 1934, pl. 10, fig. 71.
Volsella difficilis Kuroda and Habe, 1950, pl. 30; Taki in Hirase, 1951, pl. 18, fig. 9; Habe, 1955, p. 4, pl. 4, figs. 1, 2.
Volsella (*Volsella*) *difficilis*, Habe, 1951, p. 50; Taki and Oyama, 1954, pl. 12, fig. 21.
Modiolus difficilis, Kira, 1959, p. 116, pl. 45, fig. 21; Habe, 1960, p. 3, pl. 1, fig. 11, pl. 5, fig. 5.
Modiolus (*Modiolus*) *difficilis*, Okada and Taki, 1960, p. 87, pl. 44, fig. 1.

Remarks:—The present species is characterized by its thick shell, anteriorly situated beak. the parallel sides in the posterior portion and straight ventral margin. The present one resembles *Modiolus nitidus* (Reeve) (Okada and Taki, 1960), but is distinguishable by having a thick shell and straight ventral margin.

Geologic and geographic distribution:—Miocene to Recent. Northern Honshu, Hokkaido, Saghalien and the Kuriles.

Occurrence:—Loc. 33 (rare) of the Chinkope formation.

Genus ***Mytilus*** Linnaeus, 1758

Type-species (Subsequently designated by Anton, 1839): *Mytilus edulis* Linnaeus, 1758. Recent, Cosmopolitan.

Mytilus grayanus Dunker, 1853

Pl. 2, fig. 22.

Mytilus grayanus Dunker, 1853, p. 84; Lischke, 1871, pl. 145; Dunker, 1882, p. 221; Clessin in Martini u. Chemnitz, 1890, vol. 8, pt. 3, p. 68, pl. 7, figs. 1, 2; Yokoyama, 1925*c*, p. 25, pl. 2, fig. 10; Yokoyama, 1925*a*, p. 15, pl. 2, fig. 1; Yokoyama, 1926*a*, p. 135, pl. 20, fig. 1; Kinoshita and Isahaya, 1934, p. 13, pl. 9, fig. 68; Nomura and Hatai, 1935*c*, p. 109; Taki in Hirase, 1951, pl. 17, fig. 4; Kira, 1959, p. 116, pl.45, fig. 22; Okada and Taki, 1960, p. 90, pl. 45, fig. 1.
Mytilus giganteus, Yokoyama, 1920, p. 145, pl. 11, fig. 20.
Mytilus (*Crenomytilus*) *grayanus*, Habe, 1960, p. 4, pl. 1, figs. 14, 15.

Dimensions (*in mm*):—

Specimen	Length	Height	Depth	Valve
no. 36-3a	82.5	ca. 148.5	29.0	left

Remarks:—The present species is characterized by the heavy, thick shell, the acute and prosogyrate beak and arcuate a anterior dorsal margin. It is similar to *Mytilus corscus* Gould (Okada and Taki, 1960), but differs by the acute and prosogyrate beak and the arcuate dorsal margin. The ligamental area of *grayanus* is broader than *corscus*.

Geologic and geographic distribution:—Miocene to Recent. Northern Japan, Saghalien, Philippines.

Occurrence:—Loc. 1 (abundant) of the Soibetsugawa formation; Loc. 2 (common) and Loc. 8 (rare) of the Nakanokawa formation.

Family Pectinidae

Subfamily Propeamussiinae

Genus *Polynemamussium* Habe, 1951

Type-species: *Pecten intuscostatus* Yokoyama, 1920. Pleistocene Miyata formation of Kanagawa Prefecture.

Polynemamussium alaskense (Dall), 1872

Pecten (*Pseudoamussium* ?) *alaskensis* Dall, 1872, p. 155, pl. 16, fig. 4.
Pecten alaskensis, Küster and Kobelt in Martini und Chemnitz, vol. 7, pt. 2, p. 245, pl. 64, figs. 7, 8.
Pecten (*Propeamussium*) *alaskensis*, Arnold, 1906, p. 133, pl. 53, figs. 2, 2a; Oldroyd, 1924, p. 63, pl. 12, fig. 3.
Propeamussium alaskense, Dall, 1921, p. 20, pl. 1, fig. 2; Kinoshita and Isahaya, 1934, p. 14, pl. 11, fig. 78.
Pecten (*Pseudoamussium*) *intuscostatus*, Nomura and Hatai, 1935c, p. 104, pl. 11, figs. 9, 10 (non Yokoyama, 1920).
Polynemamussium alaskense, Itoigawa, 1958, pl. 1, fig. 3.

Remarks:—This species is characterized by the thin, fragile, compressed shell with regularly densely lamellated, fine concentric growth lines, and auricles with distinct byssal notch in the right valve, and by the left valve having slightly inflated, finely scaled radial threads, finely scaled, fine intercalary threads and concentric growth lines. It is allied to *Pecten* (*Propeamussium*) *riversi* Arnold (1906), but it differs from the latter by its right valve with less developed internal ribs and the left valve having more prominently imbricated radial ribs.

Geologic and geographic distribution:—Pliocene to Recent. Pacific side of Japan, Japan Sea and Bering Sea to Panama Bay.

Occurrence:—Loc. 4 (few) of the Nakanokawa formation; Loc. 17 (rare) and Loc. 39 (common) of the Chinkope formation.

Subfamily Pectininae

Genus *Chlamys* (Bolten) Röding, 1798

Type-species (Subsequent designation by Herrmannsen, 1846): *Pecten islandicus* Müller, 1776. Recent, Iceland.

Chlamys arakawai (Nomura), 1935

Pl. 6, fig. 20.

Pecten islandicus, Matsumoto, 1930, p. 104, pl. 40, fig. 9 (non Müller, 1776).
Pecten (*Pecten*) *arakawai* Nomura, 1935c. p. 41, pl. 4, figs. 1, 2.
Pecten (*Chlamys*) *arakawai*, Nomura, 1940, p. 17, pl. 2, figs. 1–3.
Coralichlamys shigemai Hirayama, 1954, p. 51, pl. 3, fig. 2.
Chlamys arakawai, Masuda, 1954, p. 150, pl. 19, figs. 1–6.

Dimensions (*in mm*):—

Specimen	Length	Height	Depth	Valve
no. 74-3a	44.2	54.2	6.0	left

Remarks:—The present species is characterized by having moderately inflated shell which is higher than long, with about 28 imbricated, flatly round-topped radial ribs nearly equal to their interspaces in breadth and fine intercalary threads, and by the auricle being larger and longer anteriorly than the posterior. It resembles *Chlamys ingeniosa* (Yokoyama) (1929), but it can be distinguished by the larger number of radial ribs and broader interspaces.

Geologic distribution :—Early to Middle Miocene.

Occurrence :—Loc. 40 (rare) of the Kunnui formation.

Chlamys chinkopensis Masuda and Sawada, 1961

Pl. 4, figs. 3–4.

Chlamys chinkopensis Masuda and Sawada, 1961, p. 21, pl. 4, figs. 6, 7.

Dimensions (in mm) :—

Specimen	Length	Height	Depth	Valve
no. 42–3a	65.9	72.5	14.9	right

Remarks :—Many well preserved specimens are in the collection.

Geologic and geographic distribution :—Pliocene to Recent. Off Paramushiro Island, Kurile Islands.

Occurrence :—Loc. 37 (abundant) and Loc. 38 (common) of the Chinkope formation.

Chlamy cosibensis (Yokoyama), 1911

Pl. 6, fig. 24.

Pecten cosibensis Yokoyama, 1911, p. 4, pl. 1, figs. 3, 4; Yokoyama, 1920, p. 156, pl. 13, figs. 7, 8; Yokoyama, 1923, p. 7, pl. 1, fig. 5.

Pecten tigerrinus, Yokoyama, 1911, p. 3, pl. 1, figs. 11, 12 (non Müller, 1776); Yokoyama, 1920, p. 153, pl. 14, figs. 5, 6 (non Müller, 1776).

Pecten swiftii Yokoyama, 1920, p. 154, pl. 14, fig. 11 (non Bernardi, 1858).

Pecten heteroglyptus var. *cosibensis*, Yokoyama, 1926*b*. p. 304, pl. 33, figs. 6, 7.

Chlamys cosibensis, Kuroda and Honma, 1930, p. 36, pl. 3, fig. 12.

Chlamys swiftii etchegoini, Otuka, 1935*b*, p. 886, pl. 55, fig. 140 (non Anderson, 1905).

Pecten (*Pallium*) *cosibensis*, Nomura and Hatai, 1935*c*, p. 97, pl. 12, figs. 5–9, pl. 13, figs. 4–7.

Pecten (*Pallium*) *heteroglyptus*, Nomura and Hatai, 1935*c*, p. 99, pl. 11, fig. 7 (non Yokoyama, 1926).

Chlamys islandica var. *swiftii* form *etchegoini*, Kubota, 1950, p. 15, pl. 8, fig. 54, pl. 9, fig. 68, (non Anderson, 1905).

Chlamys cosibensis cosibensis, Masuda, 1959*b*, p. 122, pl. 13, figs. 1–9.

Dimensions (in mm) :—

Specimen	Length	Height	Depth	Valve
no. 66–1a	39.6	42.7	1.8	right
no. 66–1b	55.0	56.3	—	left

Remarks :—This species is allied to *Chlamys swiftii* (Bernardi) Schrenck, 1867), but is distinguishable by its posteriorly contorted shell which is much higher than long, smaller apical angle, triangular anterior auricle, hinge with rather simple cardinal crura and rather flat hinge plate.

Geologic distribution :—Middle Miocene to Pliocene.

Occurrence :—Loc. 9 (common) and Loc. 16 (common) of the Nakanokawa formation; Loc. 21 (few) and Loc. 39 (common) of the Chinkope formation.

Chlamys daishakaensis Masuda and Sawada, 1961

Pl. 1, fig. 1, Pl. 4, fig. 11.

Pecten (*Pecten*) *iwakianus*, Nomura and Hatai, 1935*c*, p. 102, pl. 12, fig. 3, pl. 13, fig. 8 (non

Yokoyama, 1925).
Chlamys (Chlamys) iwakiana, Kanehara, 1942*b*, p. 137, pl. 15, fig. 5, pl. 16, fig. 6 (non Yokoyama, 1925).
Chlamys hastatus iwakiana, Kubota, 1950, p. 14, pl. 8, fig. 52, pl. 9, fig. 64 (non Yokoyama, 1925).
Chlamys iwakiana, Itoigawa, 1958, pl. 1, fig. 12 (non Yokoyama, 1925).
Chlamys daishakaensis Masuda and Sawada, 1961, p. 23, pl. 4, figs. 8, 9.

Dimensions (in mm) :—

Specimen	Length	Height	Depth	Valve
no. 7-1b	91.0	99.5	21.1	right
no. 7-1c	78.9	88.1	20.0	right
no. 38-5a	31.3	36.0	5.5	right
no. 38-5b	63.4	71.1	15.5	left
no. 66-2a	102.0	119.9	—	right

Remarks :—Abundant well preserved specimens were collected from several localities in the present area. The present species is characterized by having ratner thick, subequilateral shell with about 24, elevated, prominent, imbricated radial ribs which are accompanied with fine radial threads, narrow anterior auricle which is much larger and longer than the posterior and very deep byssal notch in the right valve, and with the very similarly sculptured left valve.

Geologic distribution :—Late Miocene to Pliocene.

Occurrence :—Loc. 2 (abundant), Loc. 3 (abundant), Loc. 6 (common), Loc. 7 (common), Ioc. 9 (abundant), Loc. 14 (abundant) and Loc. 16 (abundant) of the Nakanokawa formation ; Loc. 26 (common), Loc. 27 (few) and Loc. 39 (few) of the Chinkope formation.

Chlamys islandica erythrocomata (Dall), 1907

Pl. 4, figs. 8.

Pecten (Chlamys) erythrocomatus Dall, 1907, p. 170.
Chlamys erythrocomata, Kinoshita and Isahaya, 1934, p. 14, pl. 11, fig. 75.
Chlamys islandica, Kubota, 1950, p. 96, pl. 8, fig. 53, pl. 9, fig. 65 (non Müller, 1776).
Chlamys islandica var. *pilikaensis* Kubota, 1950, p. 97, pl. 8, fig. 56, pl. 9, figs. 67-71.
Chlamys (Chlamys) islandica erythrocomata, Habe, 1951, p. 73, figs. 140, 141.
Chlamys islandica erythrocomata, Kira, 1955, p. 124, pl. 49, fig. 13 ; Oyama, 1958, *Chlamys* (5), figs. 4, 5.

Dimensions (in mm) :—

Specimen	Length	Height	Width or Depth	Valve
no. 42-1a	73.9	81.5	16.9	right
no. 42-1b	68.3	72.1	9.0	left
no. 42-1c	75.1	78.0	26.4	intact
no. 42-2a	75.2	80.0	15.0	right
no. 42-2b	74.3	77.4	12.2	left
no' 25-1a	78.2	82.2	18.9	right

Remarks :—*Chlamys islandica* var. *pilikaensis* described by Kubota from the present area in 1950, and characterized by its irregular radial ribs gathered into several fascicular bundles may be referred to the present species. According to Dall (1907, p. 170), the present species differs from *islandica* in the following details. "From *islandica* its radii are smaller, keeled and minutely spinose instead of smooth and flat on top and laterally rounded ; the minor reticular sculpture is more oblique and rough, the channels between the radii relatively wider; the radii themselves are gathered obscurely into fascicular bundles, which as a whole are rasied like wide obsolete ribs". *Chlamys cosibensis* (Yokoyama) (1911) is an allied species of the present one, but is distinguishable from the latter by the larger shell, more radial ribs, and much less distinct concentric constrictions.

Geologic and geographic distribution:—Pliocene to Recent. North Pacific, Bering Sea and Okhotsk Sea.

Occurrence:—Loc. 11 (few), Loc. 12 (abundant), Loc. 15 (common), Loc. 16 (few) and Loc. 20 (common) of the Nakanokawa formation; Loc. 18 (rare), Loc. 28 (rare), Loc. 35 (rare), Loc. 36 (rare), Loc. 37 (abundant) and Loc. 38 (common) of the Chinkope formation.

Chlamys kumanodoensis Masuda, 1953

Pl. 1, fig. 12, Pl. 6, figs. 21–23

Chlamys kumanodoensis Masuda, 1953, p. 85, pl. 8, figs. 9–11

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 74-4a	47.5	50.1	9.0	right
no. 74-4b	28.1	32.0	4.8	right
no. 74-4c.	28.0	30.5	5.0	left

Remarks:—The present species is characterized by the moderately thick and convex shell with about 50 smooth radial ribs which are much broader than their interspaces, rarely divide into two or three riblets, and faint, fine, concentric growth lines, undulations by the rest of growth, and auricle much longer anteriorly than posterior, furnished with deep byssal notch. It resembles *Chlamys cosibensis heteroglypta* (Yokoyama) (1926), but it is distinguishable from the latter by its many and rather smooth and flated radial ribs.

Geologic distribution:—Early Miocene.

Occurrence:—Loc. 40 (abundant) and Loc 41 (abundant) of the Kunnui formation.

Chlamys nipponensis Kuroda, 1932

Pl. 1, figs. 8–9.

Pecten laetus, Lischke, 1869, p. 169, pl. 12, figs. 6, 7 (non Gould, 1861); Küster and Kobelt in Martini und Chemnitz, vol. 7, p. 134, pl. 37, figs. 4, 5 (non Gould, 1861); Yoshiwara, 1902, p. 143, pl. 2, figs. 4a–b (non Gould, 1861); Tokunaga, 1906, p. 65, pl. 4, fig. 2 (non Gould, 1861); Yokoyama, 1920, p. 152, pl. 14, figs. 1, 2 (non Gould, 1861).
Chlamys farreri nipponensis Kuroda, 1932, vol. 3, no. 2, Append., p. 91; Kuroda, 1933, p. 55, fig. 37; Habe, 1960, pl. 5, figs. 16, 17.
Chlamys farreri akazara Kuroda, 1932, vol. 3, no. 2, p. 92, fig. 105.
Chlamys nippoenesis, Taki in Hirase, 1951, pl. 13, fig. 4; Kira, 1955, p. 99, pl. 49, fig. 11; Oyama, 1957, *Chlamys* (2), figs. 3, 4, *Chlamys* (3), figs. 2, 4–6.
Chlamys nippoensis akazara, Oyama, 1957, *Chlamys* (2), figs. 5, 6, *Chlamys* (3), fig. 3.
Chlamys (*Chlamys*) *nipponensis*, Ozaki, 1958, p. 115, pl. 20, fig. 2.

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 36-9a	—	36.8	6.0	right
no. 36-9b	4.25	—	—	left

Remarks:—The present one is closely related to *Chlamys farreri* (Jones and Preston) (Kuroda, 1932), but it can be distinguished from *nipponensis* by its very unequal radial ribs which are more prominently scaled in the right valve. *Chlamys iwakiana* (Yokoyama) (1925) is a closely allied species, but the present one differs from *iwakiana* by its less inflated right valve, larger number of somewhat unequal radial ribs which bi- or tri-furcated.

Geologic and geographic distribution:—Late Pliocene to Recent. Pacific and Japan Sea.

Occurrence:—Loc. 1 (common) of the Soibetsugawa formation.

Chlamys osugii Kubota, 1950

Pl. 1, fig. 4, Pl. 3, fig. 6.

Chlamys islandica var. *osugii* Kubota, 1950, p. 16, pl. 8, fig. 57.

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 66-4a	71.0	63.5	ca. 7.0	right
no. 66-4b	57.5	53.0	7.0	right
no. 66-4c	50.5	47.0	7.5	left
no. 66-4d	74.0	69.0	—	left

Remarks:—*Chlamys chinkopensis* Masuda and Sawada (1961) is closely allied to the present species, but it differs from the present one by its fewer number of radial ribs which usually divide into two parts. Some of the present specimens show subequilateral shape and radial ribs compared with Kubota's type specimen.

Geologic distribution:—Pliocene.

Occurrence:—Loc. 16 (abundant) of the Nakanokawa formation.

Chlamys otukae Masuda and Sawada, 1961

Pl. 1, figs. 6-7.

Chlamys sp., Otuka, 1935*b*, p. 887, pl. 55, fig. 142.
? *Patinopecten* sp., Hirayama, 1954, p. 55, pl. 3, fig. 6.
Chlamys cf. *hataii* Masuda and Akutsu, 1956, p. 131, pl. 20, figs. 7-9.
Chlamys otukae Masuda and Sawada, 1961, p. 19, pl. 4, figs. 1-5.

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 73-1c	42.0	44.1	8.0	right
no. 73-1d	41.7	43.0	6.8	right

Remarks:—The present species closely resembles *Chlamys kumanodoensis* Masuda (1953), but it can be distinguished from the latter by its more elevated, flatly round-topped and fewer number of radial ribs of the valve.

Geologic distribution:—Early to Middle Miocene.

Occurrence:—Loc. 40 (common) of the Kunnui formation.

Chlamys tamurae Masuda and Sawada, 1961

Pl. 1, fig. 2, Pl. 4, fig. 18.

Chlamys tamurae Masuda and Sawada, 1961, p. 27, pl. 4, figs. 12-15.

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 96-1a	—	35.5	4.9	right
no. 96-1b	28.4	36.0	5.1	right

Dimensions (*in mm*) :—

Specimen	Length	Height	Depth	Valve
no. 96-1c	—	—	5.5	right
no. 96-1d	ca. 33.5	—	ca. 3.5	right

Remarks :—The present species is similar to *Chlamys opuntia* (Dall) (1898), but it is distinguishable from the latter by the undivided radial ribs which are narrower than the interspaces and folded surface. *Chlamys mollita* (Reeve) (1853) is an allied species of the present one, but it differs from the latter by its sub-orbicular and equilateral shell, larger apical and angle and unfolded surface.

Geologic distribution :—Pliocene.

Occurrence :—Known only from the type locality (Loc. 23, abundant) of the Chinkope formation.

Genus ***Placopecten*** Verrill, 1897

Type-species: *Pecten clintonius* Say, 1824. Miocene Yorktown formation of St. Marys, Maryland, U.S.A.

Placopecten setanaensis (Kubota), 1950

Pl. 1, figs. 25–26.

Pecten (*Placopecten*) *setanaensis* Kubota, 1950, p. 184, pl. 7, figs. 1–4; Kubota, 1950, p. 96, pl. 9, fig. 63.

Dimensions (*in mm*) :—

Specimen	Length	Height	Depth	Valve
no. 74-5a	81.5	84.0	—	left
no. 74-5b	—	68.7	6.0	right
no. 74-5c	54.0	54.0	—	right

Remarks :—Abundant well preserved specimens were collected from the arkose medium-grained sandstone of the Kunnui formation. This species is characteristic and known only from the present locality. The present species closely resembles *Placopecten protomollitus* (Nomura, 1935), but the former differs from the present one by having larger shells with imbricated intercalarly threads in the right valve, and finely imbricated radial ribs and intercalary threads in the left valve.

Geologic distribution :—Early Miocene.

Occurrence :—Loc. 40 (abundant) and Loc. 41 (abundant) of the Kunnui formation.

Placopecten wakuyaensis Masuda, 1956

Pl. 1, fig. 10.

Placopecten wakuyaensis Masuda, 1956, p. 23, pl. 3. figs. 1–4.

Dimensions (*in mm*) :—

Specimen	Length	Height	Depth	Valve
no. 74-2b	ca. 81.0	ca. 83.0	ca. 9.1	right
no. 74-2c	ca. 30.5	—	ca. 3.7	left

Remarks :—Several large slightly swollen and fractured valves, and young small valves are at hand. The present species is characterized by the moderately thick, compressed and oribicular shell with about 22, faint, very low, round-topped radial ribs which are much broader than their interspaces and obsolete towards ventral margin, apical angle of about 100° and a little larger anterior auricle furnished with wide and shallow byssal notch.

Geologic distribution :—Early Miocene.

Occurrence :—*Loc.* 40 (common) of the Kunnui formation.

Genus ***Swiftopecten*** Hertlein, 1935

Type-species: *Pecten swiftii* Bernardi, 1858, Recent, Northern Japan.

Swiftopecten swiftii (Bernardi), 1858

Pl. 1, fig. 3, Pl. 2, fig. 3, Pl. 3, fig. 4.

Pecten swiftii, Schrenck, 1867, p. 487, pl. 21, figs. 1–3; Kochibe, 1882, p. 75, pl. 5, fig. 2; Küster and Kobelt in Martini und Chemnitz, 1888, vol. 7, pt. 2, p. 142, pl. 40, fig. 3; Yoshiwara, 1902, p. 144, pl. 2, figs. 6a–b; Yokoyama, 1925*c*, p. 27; Yokoyama, 1926*b*, p. 303, pl. 37, figs. 5, 6.

Pecten (*Pallium*) *swiftii*, Grant and Gale, 1931, p. 171, pl. 10, figs. 5, 6; Nomura and Hatai, 1935*c*, p. 98, pl. 9, fig. 8, pl. 10, figs. 3, 4, pl. 11, fig. 8, pl. 13, figs. 8.

Chlamys swiftii, Kinoshita and Isahaya, 1934, p. 14, pl. 10, fig. 74; Taki in Hirase, 1951, pl. 12, fig. 5.

Chlamys islandica var. *swiftii*, Kubota, 1950, p. 12, pl. 9, figs. 66, 67.

Chlamys swifti, Habe, 1951, p. 74, fig. 150; Habe, 1955, p. 6, pl. 2, fig. 7; Kira, 1955, p. 99, pl. 49, fig. 14.

Chlamys (*Swiftopecten*) *swifti*, Habe, 1958, pl. 12, fig. 18; Habe, 1960, p. 4, pl. 1, fig. 16.

Chlamys (*Swiftopecten*) *swiftii*, Masuda, 1959*a*, p. 87, pl. 9, figs. 1–7.

Swiftoecten swiftii, Masuda, 1960, p. 380, pl. 39, figs. 9, 10.

Dimensions (*in mm*) :—

Specimen	Length	Height	Depth	Valve
no. 38-1a	75.2	89.0	16.5	right
no. 38-1b	63.0	72.8	14.5	left
no. 38-1c	50.1	63.5	10.0	left
no. 38-1d	14.0	15.8	2.0	right
no. 7-2a	50.0	61.0	19.0	left
no. 36-1a	23.2	27.2	3.6	left

Remarks :—Abundant and well preserved specimens are in the collection. The present species is characterized by the rather large and thick shell with apical angle of about 70°, four rather prominent, round-topped radial ribs which are broader than their interspaces, rather distinct fine network on the whole surface of the right valve, and by the left valve having conspicuously nodosed radial ribs. The present one is closely similar to *Swiftopecten swiftii kindlei* (Dall) (1920), but it differs from the latter by the concentric waves.

Geologic and geographic distribution :—Middle Miocene to Recent. Northern Honshu, Hokkaido, Kurile Islands, Saghalien, West coast of Amurland, Mamiya Strait, North-western Korea, Korea Strait, Off Alaska.

Occurrence :—Loc. 1 (abundant) of the Soibetsugawa formation; Loc. 2 (rare), Loc. 3 (common), Loc. 4 (few), Loc. 6 (abundant) and Loc. 8 (common) of the Nakanokawa formation; Loc. 24 (rare), Loc. 25 (few), Loc. 26 (few), Loc. 27 (few), Loc. 28 (few) and Loc. 33 (few) of the Chinkope formation.

Genus ***Nanaochlamys*** Hatai and Masuda, 1953

Type-species: *Pecten notoensis* Yokoyama, 1929. Miocene Nanao formation of Ishikawa Prefecture.

Nanaochlamys notoenssi (Yokoyama), 1929

Pl. 3, fig. 1.

Pecten notoensis Yokoyama, 1929, p. 4, pl. 3, figs. 1–4, pl. 4, figs. 1, 2, pl. 5, fig. 1.
Pecten natoriensis Matsumoto, 1930, p. 104, pl. 40, figs. 10, 11.
Pecten natoriensis subovalis Matsumoto, 1930, p. 105, pl. 40, fig. 12.
Pecten natoriensis inequilateralis Matsumoto, 1930, p. 105, pl. 40, figs. 13, 14.
Velopecten survivans Matsumoto, 1930, p. 106, pl. 40, figs. 16–18.
Pecten (Pecten) notoensis, Nomura and Zinbo, 1935, p. 161, pl. 15, fig. 27.
Pecten (Chlamys) notoensis, Nomura, 1940, p. 18, pl. 1, figs. 4–7.
Chlamys islandica notoensis, Kubota, 1950, p. 17, pl. 9, fig. 74.
Nanaochlamys notoensis, Hatai and Masuda, 1953, p. 77, pl. 7, figs. 1–7; Masuda, 1960, p. 378, figs. 1–5.

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 74–6a	80.0	79.5	24.0	right

Remarks:—This species is characterized by having rather large, thick shell which is flat in earlier stage of left valve, forming an angle of about 90° at apex and six, prominent, rounded smooth or finely straited radial ribs which becoming numerous ventrally by bifurcation. The young shell of this species is difficult to distinguish from the one of *Swiftopecten swiftii* (Bernardi) (Masuda, 1960), but it differs from the latter by having larger apical angle, not contorted shell and narrower byssal area.

Geologic distribution:—Early Miocene.

Occurrence:—Loc. 40 (common) of the Kunnui formation.

Genus ***Patinopecten*** Dall, 1898

Type-species: *Pecten caurinus* Gould, 1850. Recent, California, U.S.A.

Patinopecten kagamianus (Yokoyama), 1923

Pl. 3, fig. 13.

Pecten kagamianus Yokoyama, 1923*a*, p. 8, pl. 1, figs. 1a–b; Nomura and Ônisi, 1940, p. 190, pl. 19, fig. 4.
Pecten plicicostulatus Matsumoto, 1930, p. 105, pl. 40, fig. 15.
Pecten (Pecten) kagamianus, Nomura, 1940, p. 16, pl. 2, fig. 15.
Pecten (Lyropecten) kagamianus, Kubota, 1950. p. 14, pl. 9, fig. 62.
Patinopecten kagamianus kagamianus, Masuda, 1958, p. 274, pl. 40, figs. 4, 5.

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 74–1a	145.5	144.2	15.3	right
no. 74–1b	32.5	34.0	4.9	left
no. 74–1c	26.0	28.5	2.9	left
no. 74–1d	29.5	30.5	4.1	left

Remarks:—The present one is similar to *Patinopecten yamasakii* (Yokoyama) (1925), but the latter has a fewer number of low and rather flat radial ribs which tri- or bifurcate and a few or several intercalary threads in the right vavle.

Geologic distribution:—Early Miocene.

Occurrence: Loc. 40 (common) of the Kunnui formation.

Patinopecten tokunagai (Yokoyama), 1911

Pl. 7, fig. 1.

Pecten tokunagai Yokoyama, 1911, p. 4, pl. 1, fig. 2; Yokoyama, 1920, p. 158, pl. 12, fig. 1.
Pecten plebejus Yokoyama, 1926*b*, p. 305, pl. 36, figs. 1, 2.

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 25-3a	ca. 124.1	ca. 123.0	ca. 6.5	left

Remarks:—A slightly swollen and partly fractured left valve is at hand. The present species is characterized by its nearly flat and slightly concaved inwards shell with rather distinct, low, fine radial ribs which are much narrower than the interspaces and distinct in upper part of disc but become obsolete towards ventral margin, and distinct network on the whole surface in the left valve. The present species is closely allied to *Patinopecten yessoensis* (Jay) (1857), but it differs from the latter by the left valve which has distinct, low, very fine radial ribs which tend to become obsolete towards ventral margin and characteristic network on the whole surface.

Geologic distribution:—Pliocene.

Occurrence:—Loc. 4 (common) of the Nakanokawa formation; Loc. 19 (few), Loc. 27 (few) and Loc. 39 (common) of the Chinkope formation.

Patinopecten tokyoensis (Tokunaga), 1906

Pl. 7, fig. 21.

Pecten plica, Brauns, 1881, p. 48, pl. 7, fig. 30 (non Linné, 1761).
Pecten tokyoensis Tokunaga, 1906, p. 65, pl. 5, figs. 1-10; Yokoyama, 1920, p. 158, pl. 14, figs. 7, 8.
Pecten (Patinopecten) tokyoensis, Kuroda, 1933, p. 55, fig. 36; Niino, 1936, p. 359, pl. 3, figs. 1-4, pl. 4, figs. 1-21; Kubota, 1950, p. 13, pl. 8, fig. 51.
Patinopecten (Pecten) tokyoensis, Niino, 1952, pl. 4, figs. 1-4.
Patinopecten (Patinopecten) tokyoensis, Ozaki, 1958, p. 117, pl. 20, fig. 7.

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 36-2a	130.1	ca. 135.0	22.0	right
no. 36-2b	—	—	ca. 14.5	left
no. 36-2c	14.8	15.8	1.8	right
no. 36-2d	10.2	11.3	1.1	left

Remarks:—Abundant well preserved specimens were collected from the fine grained sandstone of the Soibetsugawa formation in the present area. This species is characterized by its large shell with eight to nine round-topped, rather low, broad radial ribs which divide into several unequal riblets and usually tend to become obsolete towards the ventral margin in the right valve, and by the left valve having slightly inflated somewhat curved upwards, rather low, roof-like shaped radial ribs which are narrower than their interspaces.

Geologic distribution:—Late Pliocene to Pleistocene.

Occurrence:—Loc. 36 (abundant) of the Soibetsugawa formation.

Patinopecten yessoensis (Jay), 1857

Pl. 3, fig. 5, Pl. 7, fig. 10.

Pecten yessoensis Jay, 1857, p. 393, pl. 3, figs. 3, 4, pl. 4, figs. 1, 2; Schrenck, 1867, p. 484, pl. 20, figs. 1–4; Lischke, 1869, p. 165, pl. 10, figs. 3, 4; Küster and Kobelt in Martini und Chemnitz, 1888, vol. 7, pt. 2, p. 139, pl. 38, fig. 7; Yoshiwara, 1902, p. 142, pl. 1, figs. 2a–b; Yokoyama, 1911, p. 2, pl. 1, figs. 13, 14; Yokoyama, 1920, p. 159, pl. 13, figs. 14, 15; Yokoyama, 1931, p. 195, pl. 11, fig. 9; Taki in Hirase, 1951, pl. 14, fig. 1.

Pecten (*Patinopecten*) *yessoensis*, Kuroda. 1932, vol. 3, no. 2, Append., p. 99, fig. 110; Kinoshita and Isahaya, 1934, p. 14, pl. 11, fig. 77; Kubota, 1950, p. 13, pl. 8, fig. 50; Oyama, 1958, *Pecten*, figs. 3–11.

Pecten (*Patinopecten*) *plebejus*, Kubota, 1950, p. 13, pl. 9, fig. 61 (non Yokoyama, 1926).

Patinopecten yessoensis, Habe, 1951, p. 82, fig. 161; Habe, 1955, p. 7, pl. 14, fig. 6; Kira, 1955, p. 99, pl. 49, fig. 16; Habe, 1960, pl. 5, fig. 13.

Dimensions (*in mm*) :—

Specimen	Length	Height	Depth	Valve
no. 38–2a	26.0	27.1	3.1	right
no. 38–2b	24.5	26.0	2.8	left
no. 38–2c	120.0	119.8	24.1	right
no. 38–2d	130.0	126.0	9.2	left

Remarks :—This species is characterized by its large shell, right valve having usually with 21 to 28, rather low, flatly round-topped, smooth radial ribs which are somewhat broader than their interspaces, and by the left valve having nearly flat or slightly inflated or rarely concaved inward. According to Kinoshita (1937) the number of radial ribs of the right valve from Hokkaido varies from 15 to 32, 21 to 24 being the frequent number, and that of the left valve varies from 13 to 31 and the most frequent number is 20. The number of radial ribs of the present specimens varies from 21 to 28 and 22 to 24 are the frequent number. The present species is a very common scallop in Northern Japan.

Geologic and geographic distribution :—Pliocene to Recent. Pacific and Japan Sea.

Occnrrence :—Loc. 2 (common), Loc. 4 (abundant), Loc. 5 (abundant), Loc. 6 (abundant), Loc. 8 (abundant) and Loc. 9 (few) of the Nakanokawa formation; Loc. 24 (common), Loc. 27 (few), Loc. 33 (abundant) and Loc. 37 (few) of the Chinkope formation.

Family Linidae

Genus ***Lima*** Bruguieré, 1797

Type-species: *Ostrea lima* Linné, 1758. Recent, Indo-Pacific.

Subgenus ***Acesta*** H. and A. Adams, 1858

Type-species: *Ostrea excavata* Fabricius, 1779. Recent, Norwegen.

Lima (***Acesta***) ***goliath*** Sowerby, 1883

Lima goliath Sowerby, 1883, p. 30, pl. 7, fig. 3; Yokoyama, 1920, p. 147, pl. 16, figs. 7, 8; Yokoyama, 1925*c*, p. 26, pl. 2, figs. 1, 4; Yokoyama, 1927*b*, p. 188, pl. 50, fig. 1; Taki in Hirase, 1951, pl. 16, fig. 4; Habe 1951, p. 88, figs. 176, 177.

Lima (*Acesta*) *goliath*, Oyama, 1943, p. 39, pl. 3, figs. 1a–b, pl. 14, fig. 8.

Lima (*Acesta*) *goliath yagenensis*, Ozaki, 1958, p. 117, pl. 12, fig. 6 (non Otuka, 1939).

Acesta goliath, Yamamoto and Habe, 1958, p. 16, pl. 3, figs. 13, 14, pl. 4, fig. 16; Kira, 1960, p. 129, pl. 52, fig. 10; Habe, 1960, p. 4, pl. 5, fig. 9.

Remarks :—A swollen and fractured right valve of which dimensions are unknown is in the collection. The present species is characterized by its somewhat obliquely ovate and rather flattened shell with straight antero-dorsal margin, broadly rounded postero-dorsal one and anteriorly situated umbo with 104° umbonal angle; and the deeply excavated cardinal area.

Geologic and geographic distribution :—Early Miocene to Recent. Northern and Central Honshu.

Occurrence :—Loc. 11 (rare), Loc. 14 (rare) and Loc. 16 (rare) of the Nakanokawa formation; Loc. 26 (rare) and Loc. 35 (few) of the Chinkope formation.

Family Anomiidae

Cenus ***Monia*** Gray, 1850

Type-species (Subsequent designation by Kobelt, 1881): *Anomia zealandica* Gray, 1843. Recent, New Zealand.

Monia macroschisma (Dashayes), 1839

Pl. 6, figs. 1–2.

Anomia macroschisma, Philippi, 1850, p. 132, pl. 1, fig. 4.
Placunanomia macroschisma, Reeve, 1859, vol. 11, pl. 2, fig. 7.
Placunanomia alope, Reeve, 1859, vol. 11, pl. 3, figs. 11a–b.
Placunanomia cepio, Reeve, 1859, vol. 11, pl. 3, figs. 12a–b.
Placunanomia macroschisma, Fischer, 1887, p. 932, pl. 16, fig. 4.
Monia macroschisma, Arnold, 1909, p. 75, pl. 14, fig. 1; Arnold and Anderson, 1910, p. 110, pl. 36, fig. 1.
Pododesmus macroschisma, Oldroyd, 1924, p. 65, pl. 26, figs. 1a–b; Grand and Gale, 1931, p. 241, pl. 12, figs. 3, 4a–b; Nomura, 1935*c*, p. 48; Nomura and Hatai, 1935*c*, p. 109, pl. 9, figs. 2, 3.
Anomia densicostulata Yokoyama, 1925*a*, p. 16, pl. 2, fig. 3.
Placunanomia ingens Yokoyama, 1925*a*, p. 16, pl. 4, fig. 1.
Placunanomia macroschisma, Yokoyama, 1926*b*, p. 301, pl. 35, figs. 7, 8.
Pododesmus (*Monia*) *macroschisma*, Kuroda in Honma, 1931, p. 40, pl. 3, fig. 16, pl. 4, fig. 18; Kuroda, 1932, vol. 3, no. 4, Append., p. 121, figs. 134, 135: Kinoshita and Isahaya, 1934, p. 13, pl. 9, fig. 66; Nomura and Hatai, 1937, p. 131, pl.19, figs. 7, 8.
Monia macrochisma, Habe, 1951, p. 90: Habe, 1955, p. 8, pl. 7, figs. 16, 17; Habe, 1958*a*, p. 271, pl. 12, fig. 20; Kira, 1959, p. 118, pl. 46, fig. 9; Okada and Taki, 1960, p. 75, pl. 38, fig. 6; Habe, 1960, p. 5, pl. 3, figs. 15, 16.

Dimensions (*in mm*) :—

Specimen	Length	Height	Width or Depth	Valve
no. 36–6a	58.0	57.5	13.0	right
no. 36–6b	57.5	56.7	10.5	left
no. 25–2	63.0	62.5	25.0	intact

Remarks :—Several well preserved intact and isolated valves were collected from several localities in the present area. This is a well-known cold water form and fossils are also not rare in the Tertiary deposits of Northeast Honshu and Hokkaido. *Anomia chinensis* Philippi (1850) is closely allied to the present one, but differs from the latter by having two muscle scars and one byssal scar.

Geologic and geographic distribution :—Miocene to Recent. Northern Honshu, Hokkaido to the North Pacific.

Occurrence: Loc. 1 (abundant) of the Soibetsugawa formation; Loc. 2 (common), Loc. 6 (rare), Loc. 8 (common), Loc. 13 (common), Loc. 14 (abundant), Loc. 15 (rare) and Loc. 16 (abundant) of tle Nakanokawa formation; Loc. 26 (common), Loc. 27 (common), Loc. 29 (few), Loc. 30 (common) and Loc. 34 (rare) of the Chinkope formation.

Monia macroschisma ezoana (Kanehara), 1942

Pl. 2, fig. 26.

Pododesmus macroschisma (Deshayes) var. *ezoanus* Kanehara, 1942, p. 136, pl. 15, figs. 1, 2, pl. 16, fig. 1; Hatai and Nisiyama, 1952, p. 131.

Dimensions (in mm) :—

Specimen	Length	Height	Width or Depth	Valve
no. 36-7	42.0	44.2	15.0	intact
no. 2804-12	39.0	45.9	12.8	left

Remarks :—The present form is characterized by the development of fine but distinct, very close-set radial striations, which are partly restricted in occurrence between the thicker radial ribs of nearly the same apperance as that of the species, but in the greater part of the shell surface covering even the surface of the ribs give a rough appearance. The present form was just described by K. Kanehara (1942) from the Pliocene of the present area as a variety of *Pododesmus macroschisma*. This is the first record of the present form from localities other than the type locality (Yunosawa, Kuromatsunai-cho, Suttsu-gun, Hokkaido).

Geologic distribution :—Pliocene (Nakanokawa and Soibetsugawa formations).

Occurrence :—Loc. 1 (rare) of the Soibetsugawa formation; Loc. 6 (rare) of the Nakanokawa formation.

Monia umbonata (Geould), 1861

Pl. 1, figs. 13–14.

Placunanomia umbonata Gould, 1861, p. 39 (*fide* Habe, 1958).
Anomia sematana, Yokoyama, 1922, p. 177, pl. 14, figs. 20, 21.
Anomia lunulata, Yokoyama, 1922, p. 177, pl. 14, figs. 22, 23.
Pododesmus (Monia) radiatus, Nomura and Zinbo, 1936, p. 288, pl. 11, figs. 5a–b.
Monia radiata, Habe, 1951, p. 90, figs. 182–185.
Monia umbonata, Kuroda, 1953, vol. 1, no. 24, p. 199, pl. 27, fig. 14, pl. 28, fig. 19; Yamamoto and Habe, 1958, p. 19, pl. 3, fig. 9; Habe, 1958*a*, p. 271, pl. 12, figs. 12, 19; Okada and Taki, 1960, p. 75, pl. 38, fig. 5.

Dimensions (in mm) :—

Specimen	Length	Height	Depth	Valve
no. 36-8a	21.3	22.1	2.0	left
no. 2804-3a	27.5	25.0	4.0	left
no. 2804-3b	20.0	19.1	2.5	left

Remarks :—Several well preserved shells are in the collection. The specimens examined are nearly circular, flat and thin, the fine concentric striations cover the shell surface and low radial ribs develop near the shell margin, the flat beak is situated slightly inward from the shell margin and one muscle scar and one byssal scar is on the inside of the left valve.

Geologic and geographic distribution :—Pliocene to Recent. Northern Honshu to Kyushu. Japan Sea.

Occurrence—:Loc. 1 (rare) of the Soibetsugawa formation; Loc. 6 (few) of the Nakanokawa formation.

Family Astaritdae

Genus ***Astarte*** Sowerby, 1816

Type-species (Subsequent designation by Stoliczka, 1871): *Astarte lurida* Sowerby, 1916. Jurassic, Foxhill Quarries, Gloucester, England.

Subgenus ***Tridonta*** Schumacher, 1817

Type-species: *Tridonta borealis* Schumacher, 1817. Recent, Polar Sea.

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

Pl. 6, fig. 18.

Astarte alaskensis Dall, 1903, p. 944, pl. 63, fig. 2; Dall, 1921, p. 30; Oldroyd, 1924, p. 106, pl. 13, fig. 20; Grant and Gale, 1931, p. 268, pl. 13, figs. 3a–b; Nomura and Hatai, 1935*c*, p. 113, pl. 7, figs. 6, 7; Otuka, 1935, p. 890, pl. 57, fig. 195; Otuka, 1939, p. 27, pl. 2, figs. 1, 2.
Astarte sulcata, Yokoyama, 1926*b*, p. 298, pl. 37, figs. 9, 10 (non Da Costa, 1778).

Remarks:—Several broken specimens are in the collection. The present specimen is characterized by its about 20, regular very distinct, coarse concentric lines and wide and concave-bottomed interspaces between concentric lines.

Geologic and geographic distribution:—Pliocene to Recent (Pleistocene of Herscal Island, Alaska). Herscal Island, Arctic Coast; Southern Bering Ser, the Aleutians and south to Puget Sound (Dall), Japan Sea.

Occurrence:—Loc. 8 (few) of the Nakanokawa formation; Loc. 17 (common), Loc. 21 (rare), Loc. 22 (few), Loc. 24 (rare), Loc. 25 (rare), Loc. 29 (rare) and Loc. 32 (rare) of the Chinkope formation.

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

Pl. 6, fig. 29.

Astarte borealis, Dall, 1903, p. 941; Yokoyama, 1922, p. 163, pl. 10, fig. 11; Oldroyd, 1924, p. 106; Yokoyama, 1926*b*, p. 298, pl. 37, figs. 2, 3; Yokoyama, 1931, p. 6, no. 196; Grant and Gale, 1931, p. 267; Kinoshita and Isahaya, 1934, p. 15, pl. 11, fig. 79; Nomura and Hatai 1935*c*, p. 114, pl. 10, figs. 1, 2, 7; Iwai, 1959, p. 57, pl. 2, figs. 3a–b.
Astarte (*Tridonta*) *borealis*, Hatai and Nisiyama, 1952, p. 31; Habe, p. 162, pl. 23, figs. 18, 19.

Dimensions (*in mm*):—

Specimen	Length	Height	Depth	Valve
no. 36–5a	33.0	29.2	7.2	left
no. 36–5b	29.4	27.0	8.9	right
no. 10–4a	57.0	—	—	right

Remarks:—The present species resembles *A. aomoriensis* Nomura and Hatai (1935) and *A. hakodatensis* Yokoyama (1920), but it differs from the latter by the somewhat elongate shape, surface sculpture with more distinct concentric lines and the somewhat forwardly directed beak. The present one differs from *A. arctica* Gray (Dall, 1903), in having longer shell, more convexity and sooth surface. *A. alaskensis* (Nomura and Hatai, 1935) is distinguishable from the present one in having about 12 regular and coarse concentric lines.

Geologic and geographic distribution:—Pliocene to Recent (Japan); Miocene of Alaska. Bennet Island, Polar Sea; North Europe and the Baltic, Atlantic, Iceladn and Greenland, and south of Massachusetts Bay (in 15 to 100 fathoms). Bering Sea and Strait (Dall).

Occurrence :—Loc. 1 (common) of the Soibetsugawa formation; Loc. 4 (few) of the Nakanokawa formation.

Family Carditidae

Genus ***Venericardia*** Lamarck, 1801

Type-species (Subsequent designation by Schmidt, 1818): *Venus imbricata* Gmelin, 1790. Eocene of the Paris Basin.

Subgenus ***Cyclocardia*** Conrad, 1867

Type-species: *Cardita borealis* Conrad, 1832. Recent, Circumboreal, Northern Pacific.

Venericardia (***Cyclocardia***) ***crebricostata*** (Krause), 1885

Pl. 2, fig. 27, Pl. 6, figs. 13–15.

Venericardia crebricostata Krause, 1885, p. 30, pl. 3, fig. 4 (*fide* Otuka, 1939).
Venericardia (*Cyclocardia*) *crebricostata*, Otuka, 1939, p. 28, pl. 2, figs. 3, 4; Habe, 1951, p. 108, figs. 210–212; Okada and Taki, 1960, p. 70, pl. 35, fig. 15.

Dimensions (*in mm*) :—

Specimen	Length	Height	Depth	Valve
no. 10–9a	12.2	11.2	5.5	right
no. 38–15a	26.5	23.2	14.4	intact
no. 10–2a	30.0	25.5	16.0	intact

Remarks :—This species is related to *V.* (*C.*) *ferruginea* (Clessin in Martini und Chemitz, 1888), but differs in having a small shell with more acute postero-ventral margin and larger convexity. It also resembles *V.* (*C.*) *paucicostata* (Krause) (Habe, 1959) but is easily discriminated in having a rather compressed and subtrigonal shell outline, a larger number of radial ribs on the surface, and a narrow depression of the anterior margin of the small beak.

Geologic and geographic distribution :—Pliocene to Recent. Monterey (California), Alaska to Nemuro (Hokkaido).

Occurrence :—Loc. 3 (common), Loc. 4 (common), Loc. 5 (rare), Loc. 6 (abundant) and Loc. 8 (common) of the Nakanokawa formation; Loc. 22 (rare), Loc. 24 (rare) and Loc. 26 (rare) of the Chinkope formation.

Venericardia (***Cyclocardia***) ***paucicostata*** (Krause), 1885

Pl. 6, figs. 9–12.

Cardita borealis paucicostata Krause, 1885, p. 30, pl. 3, fig. 5 (*fide* Habe, 1955).
Venericardia (*Cyclocardia*) *crebricostata*, Habe, 1951, p. 108, figs. 210–212.
Venericardia (*Cyclocardia*) *paucicostata*, Habe, 1955, p. 9, pl. 2, figs. 22, 23; Kira, 1955, p. 131, pl. 52, fig. 21.
Cyclocardia paucicostata, Yamamoto and Habe, 1959, pl. 6, figs. 22, 23.

Dimensions (*in mm*) :—

Specimen	Length	Height	Depth	Valve
no. M10–9	15.1	15.5	4.1	left
no. M10–10	15.5	16.5	6.0	left

Remarks :—The present species may be a close ally of *V.* (*C.*) *ferruginea* (Clessin in Martini und Chemnitz, 1888), but the former is distinguishable from the latter in point of the larger number of its radial ribs, and more rounded postero-ventral corner *V.* (*C.*) *kiiensis* (Sowerby) (Okada and Taki, 1960) resembles the present species, but the former has an elongate shell with more acute postero-ventral margin and granular radial ribs.

Geologic and geographic distribution :—Pliocene to Recent. Bering Sea; Kurile Islands and Hokkaido.

Occurrence :—Loc. 1 (rare) of the Soibetsugawa formation; Loc. 4 (abundant) Loc. 6 (abundant) and Loc. 8 (abundant) of the Nakanokawa formation; Loc. 17 (rare), Loc. 22 (rare), Loc. 24 (rare), Loc. 26 (rare) and Loc. 39 (few) of the Chinkope formation.

Family Ungulinidae

Genus ***Felaniella*** Dall, 1899

Type-species: *Felania usta* Gould, 1861. Recent, Japan.

Felaniella usta (Gould), 1861

Pl. 6, figs. 25–26.

Mysis (*Felania*) *usta*, Gould, 1862, p. 170.

Diplodonta usta, Yamakawa, 1909, p. 14, figs. 1–10; Yokoyama, 1920, p. 130, pl. 9, figs. 14–16; Yokoyama 1922, p. 159, pl. 13, fig. 3.

Diplodonta (*Felaniella*) *usta*, Kuroda, 1931, p. 49, pl. 5, fig. 27; Taki and Oyama, 1954, pl. 10, figs. 14–16.

Felaniella usta, Habe, 1951, p. 124, figs. 256, 257; Kira, 1959, p. 132, pl. 52, fig. 31; Habe, 1960, p. 6, pl. 4, figs. 12, 13.

Dimensions (*in mm*) :—

Specimen	Length	Height	Depth	Valve
no. 2804-9	10.5	9.7	2.0	left
no. 2905-11	15.0	12.5	—	left

Remarks :—The present one is closely allied to *Joannisiella cumingi* (Hanley) (Habe, 1951), but the latter has a curved beak, whereas that of the former has not.

Geologic and geographic distribution :—Miocene to Recent. Northern and Central Japan.

Occurrence :—Loc. 6 (few) and Loc. 7 (few) of the Nakanokawa formation.

Family Lucinidae

Genus ***Lucinoma*** Dall, 1901

Type-species: *Lucina filosa* Stimpson, 1851. Recent, Newfoundland to North Florida and the Gulf States.

Lucinoma annulatum (Reeve), 1850

Pl. 6, figs. 16–17.

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

Lucinoma annulata, Habe, 1951, p. 129, figs. 277, 278; Kira, 1959, p. 133, pl. 53, fig. 2; Yamamoto and Habe, 1959, p. 90, pl. 6, figs. 24, 25.

Lucinoma annulatum, Oyama, 1960, *Lucinoma* (1), figs. 13–15.

Dimensions (*in mm*):—

Specimen	Length	Height	Depth	Valve
no. 38–13c	29.5	26.7	7.3	right
no. 38–13d	—	—	9.2	left
no. 38–13e	ca. 30.3	ca. 28.1	9.1	right

Remarks:—The present one is closely similar to *Lucinoma spectabilis* (Yokoyama) (1920), but differs from the latter by its more smaller size, rough and irregular concentric lines. It also resembles *Lucinoma acutilineatum* (Conrad) (Ozaki, 1958), but can be distinguished from the latter in having rougher concentric lines and more distinct posterior radial sulcus.

Geologic and geographic distribution:—Miocene to Recent. Kyushu to Honshu; Alaska to Southern California (after Abbott, 1953).

Occurrence:—Loc. 3 (common) of the Nakanokawa formation.

Family Cardidae

Genus ***Clinocardium*** Keen, 1936

Type-species: *Cardium nuttalli* Conrad, 1838. Recent, Northern Pacific.

Clinocardium californiense (Dehayes), 1839

Pl. 2, fig. 7.

Cardium californiense Deshayes, 1839, p. 360 (*fide* Grant and Gale, 1931); Tokunaga, 1906, p. 50, pl. 3, figs. 9a–b; Yokoyama, 1920, p. 127, pl. 9, fig. 10.
Cardium pseudo-fossile Reeve, 1844, vol. 2, pl. 10, fig. 52.
Cardium (*Cerstoderma*) *californiense*, Dall, 1921, p. 39, pl. 14, fig. 8; Oldroyd, 1924, p. 143, pl. 2, fig. 3; Kinoshita and Isahaya, 1934, p. 15, pl. 11, fig. 78; Nomura, 1935*b*, p. 111, pl. 6, fig. 4; Taki in Hirase, 1951, pl. 29, fig. 5.
Laevicardium (*Cerastoderma*) *californiense*, Grant and Gale, 1931, p. 309, pl. 19, fig. 16.
Clinocardium californiense, Habe, 1951, p. 150, figs. 334, 335; Habe, 1955, p. 11, pl. 1, fig. 5; Kira, 1959, p. 138, pl. 55, fig. 4; Yamamoto and Habe, 1959, p. 93, pl. 7, fig. 21; Habe, 1960, p. 7, pl. 3, fig. 12.

Remarks:—*Clinocardium uchidai* (Habe) (Kira, 1959) is allied to the present one, but the former is distinguishable from the latter in point its many radial ribs which are crossed by concentric growth lines, and two cardinal teeth.

Geologic and geographic distribution:—Miocene to Recent. Northern Honshu; Hokkaido; Kurile Islands; Saghalien and Kamtchatka.

Occurrence:—Loc. 3 (abundant) of the Nakanokawa formation.

Genus ***Papyridae*** Swainson, 1840

Type-species (Subsequent designation by Gray, 1847): *Cardium soleniforme* Bruguière 1789.

Subgenus ***Fulvia*** Gray, 1853

Type-species: *Cardium apertum* Bruguière, 1792.

Papyridea (***Fulvia***) ***kurodai*** Hatai and Nisiyama, 1952

Pl. 1, figs. 15–16.

Papyridea (*Fulvia*) *nipponica*, Yokoyama, 1926*b*, p. 294, pl. 34, fig. 16.
Papyridea (*Fulvia*) *kurodai*, Hatai and Nisiyama, 1952, p. 105; Makiyama, 1960, pl. 46, fig. 16.

Dimensions (in mm) :—

Specimen	Length	Height	Depth	Valve
no. 38–16a	ca. 79.0	63.0	—	left
no. 38–17a	40.0	28.1	8.5	right

Remarks :—*Papyridea* (*Fulvia*) *nipponica* was first described by Yokoyama (1924) from the Asagai formation in the Jôban Coal Field and compared with *Papyridea harrimani* Dall from Alaska. According to Yokoyama, the differences between *nipponica* and *harrimani* are the number of ribs, that is, the former has about 50 ribs and the latter 35, subsequently Makiyama (1934) collected perfect specimens from the Asagai sandstone at Yotsukura and stated that his specimen coincides with Dall's description and figure. Moreover, he stated that the ribs of his specimens vary from 35 to 50 and shells are not more transverse than *harrimani*. In 1952, Hatai and Nisiyama stated that Yokoyama's *nipponica* from the Asagai formation (1924) may be conspecific with *harrimani* Dall. Yokoyama described and figured (1926) a fine perfect left valve from the Pliocene Sawane formation in Sado Island, under the specific name *nipponica*. According to his description and figure his specimen with 50 radiating ribs is closely similar to *nipponica* from the Asagai sandstone (1926), but the shape and strength of the radial ribs are somewhat diffeerent from one another. Thus Hatai and Nisiyama (1952) proposed a new name for Yokoyama's *nipponica* from the Sawane formation as *kurodai*. The full discription of *kurodai* is already given by Yokoyama as *nipponica*, so that the new name of Hatai and Nisiyama's *kurodai* is of course valid. Makiyama also revised Yokoyama's specimens from Sado Island to *kurodai* in 1960.

A right valve from the Nakanokawa formation is characterized by unequilateral shape of which posterior dorsal margin is horizontal, about 48 radiating ribs which are roof-shaped and distinct on the most part of the shell, and four to five ribs in the posterior area are very distinct and coarse.

Geologic and geographic distribution :—Pliocene. Sado Island, Jôban Coal-Field.

Occurrence :—Loc. 3 (few) and Loc. 6 (few) of the Nakanokawa formation.

Family Veneridae

Genus ***Ezocallista*** Kira, 1959

Type-species: *Saxidomus brevisiphonata* Carpenter, 1850. Recent, Vancouver, Canada.

Ezocallista brevisiphonata (Carpenter), 1865

Pl. 5, figs. 8–9.

Saxidomus brevisiphonata Carpenter, 1865, p. 203 (*fide* Nomura, 1938).
Meretrix (*Callista*) *chinensis*, Yokoyama, 1922, p. 140, pl. 11, fig. 5.
Macrocallista brevisiphonata, Makiyama, 1927, p. 48; Nomura, 1938, p. 259, pl. 36, figs. 1, 2a–b. 3.
Macrocallista (*Paradione*) *brevisiphonata*, Kuroda in Honma. 1931, p. 56, pl. 8, figs. 53, 54.
Callista brevisiphonata, Kinoshita and Isahaya, 1934, p. 16, pl. 12, fig. 87; Taki in Hirase, 1951, pl. 34, fig. 4; Habe, 1955, p. 12, pl. 3, figs. 7, 8; Yamamoto and Habe, 1959, p. 94, pl. 8, figs. 8, 9; Habe, 1960, p. 7, pl. 3, figs. 5, 6.
Ezocallista brevisiphonata, Kira, 1959, p. 141, pl. 56, fig. 4.

Callista (*Callista*) *brevisiphonata*, Okada and Taki, 1960, p. 59, pl. 30, fig. 11.

Dimensions (*in mm*) :—

Specimen	Length	Height	Width or Depth	Valve
no. 38–6a	98.3	80.0	53.8	intact
no. 38–7a	99.0	80.0	24.0	right

Remarks :—The present species resembles *Callista chinensis* (Holten) (Kira, 1959), but it differs from the latter by the larger shell, the rather narrower lunule, and by the stronger and more distinct concentric ribs of the surface.

Geologic and geographic distribution :—Pliocene to Recent. Northern Honshu, Hokkaido, Kurile Island, Saghalien and Martime Province of Russia.

Occurrence :—Loc. 1 (rare) of the Soibetsugawa formation; Loc. 2 (abundant), Loc. 3 (abundant), Loc. 4 (common), Loc. 5 (rare), Loc. 6 (abundant), Loc. 8 (abundant) and Loc. 13 (rare) of the Nakanokawa formation; Loc. 17 (common), Loc. 22 (rare) and Loc. 30 (rare) of the Chinkope formation.

Genus ***Saxidomus*** Conrad, 1837

Type-species: *Saxidomus nuttalli* Conrad, 1837. Recent, Northern Pacific.

Saxidomus purpuratus (Sowerby), 1852

Pl. 7, fig. 6.

Tapes purpuratus Sowerby, 1852, vol. 2, p. 692, pl. 150, figs. 124, 125.
Saxidomus purpuratus, Lischke, 1869, p. 127, pl. 4, figs. 4, 5; Brauns, 1881, p. 40, pl. 5, fig. 20; Yokoyama, 1920, p. 127, pl. 9, figs. 8, 9; Yokoyama, 1922, p. 153, pl. 12, fig. 9; Kinoshita and Isahaya, 1934, p. 16, pl. 12, fig. 88; Taki in Hirase, 1951, pl. 37, fig. 1; Ozaki, 1958, p. 128, pl. 23, fig. 1; Yamamoto and Habe, 1959, p. 95, pl. 7, figs. 7, 8; Kira, 1959, p. 142, pl. 56, fig. 9; Habe, 1960, p. 7, pl. 3, figs. 1, 2.

Dimensions (*in mm*) :—

Specimen	Length	Height	Depth	Valve
no. 10–5a	—	36.1	12.2	left

Remarks :—The present one is easily distinguished from other venerid by having four cardinal teeth even in the young stage.

Geologic and geagraphic distribution :—Pliocene to Recent. Kyushu, Shikoku, Honshu, Hokkaido and Korea.

Occurrence :—Loc. 2 (common) and Loc. 4 (rare) of the Nakanokawa formation.

Genus ***Liocyma*** Dall, 1870

Type-species: *Venus fluctuosa* Gould, 1841. Recent, North Atlantic and Arctic Oceans.

Liocyma fluctuosa (Gould), 1841

Pl. 1, figs. 27–28, Pl. 7, figs. 11–12.

Venus fluctuosa Gould, 1841, p. 87, fig. 5 (non *vidi fide* Grant and Gale, 1931).
Liocyma fluctuosa, Dall, 1870, p. 256 (non *vide*, *fide* Habe, 1951).

Dimensions (*in mm*) :—

Specimen	Length	Height	Depth	Valve
no. 10–1	35.0	26.5	15.5	intact

Remarks :—Three forms are, hitherto, known from the Japanese waters, among which *Liocyma fluctuosa* (Gould) is identical with the present from in the shape of the shell and the detailed surface features. *Liocyma aniwana* Dall (Habe, 1955) is also a closely allied from but it can be distinguished from the present from in having rather low shell and slender posterior margin.

Geologic and geographic distribution :—Miocene of Alaska, Pliocene and Recent. Okhotsk coast of Hokkaido.

Occurrence :—Loc. 4 (few) of the Nakanokawa formation.

Genus ***Callithaca*** Dall, 1902

Type-species : *Tapes tenerrima* Carpenter, 1856. Recent, Panama.

Callithaca (Protocallithaca) adamsi (Reeve), 1850

Pl. 5, figs. 1–2.

Venus adamsi Reeve, 1950, vol. 14, pl. 17, fig. 77.
Venus rigida, Yokoyama, 1927*a*, p. 430, pl. 50, figs. 3, 4 ; Matsumoto, p. 96, pl. 39, fig. 3.
Protocallithaca adamsi, Nomura, 1937, p. 10, pl. 3, figs. 4a–b.
Callithaca adamsi, Habe, 1951, p. 180, figs. 391, 392 ; Okada and Taki, 1960, p. 63, pl. 32, fig. 5.
Protothaca adamsi, Taki in Hirase, 1951, pl. 41, fig. 2.
Protothaca (Callithaca) adamsi, Taki and Oyama, 1954, p. 44, pl. 47, figs. 3, 4 ; Ozaki, 1958, p. 129, pl. 22, fig. 1.
Callithaca (Protocallithaca) adamsi, Habe, 1955, p. 14, pl. 5, figs. 1, 2 ; Kira, 1959, p. 143, pl. 56, fig. 19 ; Yamamoto and Habe, 1959. p. 98, pl. 7, fig. 16 ; Habe, 1960, p. 8, pl. 2, figs. 5, 6.

Dimensions (in mm) :—	Specimen	Length	Height	Depth	Valve
	no. 38–11	72.3	78.5	49.0	intact

Remarks :—This species is characterized by having a large thick shell with distinct and lamellate growth lines crossed by numerous fine and close-set radial striations, obsolete crenulation in the inner ventral margin and th deep pallial sinus.

Geologic and geographic distribution :—Pliocene to Recent. Hokkaido and Northeastern Honshu ; Saghalien.

Occurrence :—Loc. 3 (rare) of the Nakanokawa formation.

Family Asaphidae

Genus ***Psammocola*** Blainville, 1824

Type-species (Subsequent designation by Sacco, 1901) : *Psammocola cespertinalis* Blainville, 1842. Tertiary of Italy.

Psammocola cf. ***kazusensis*** (Yokoyama), 1922

Compared with :
Psammocola kazusensis Yokoyama, 1922, p. 136, pl. 9, fig. 4.

Remarks :—An imperfect right valve is in the collection.

Geologic and geographic distribution : Pliocene to Recent. Northern Honshu and Hokkaido.

Occurrence :—Loc. 3 (rare) of the Nakanokawa formation.

Family Mactridae

Genus ***Spisula*** Gray, 1837

Type-species (Subsequent designation by Gray, 1847) : *Cardium solidum*, Linné, 1758.

Subgenus ***Spisula***, s.s.

Spisula* (*Spisula*) *sachalinensis (Schrenck), 1867

Pl. 5, figs. 10–11.

Mactra sachalinensis Schrenck, 1867, p. 575, pl. 23, figs. 3–7; Tokunaga, 1906, p. 39, pl. 2, figs. 25a–b; Kuroda, 1947, p. 1216, fig. 3453.
Mactra sachalinensis imperialis, Yokoyama, 1922, p. 129, pl. 7, figs. 9, 10.
Mactra semiana Yokoyama, 1925*a*, p. 11, pl. 4, fig. 5.
Spisula sachalinensis, Kuroda in Honma, 1931, p. 62, pl. 8, fig. 52; Habe, 1951, p. 194, figs. 453, 454; Taki in Hirase, 1951, pl. 51, fig. 1; Habe, 1955, p. 16, pl. 5, figs. 8, 9.
Mactra (Spisula) sachalinensis, Kinoshita and Isahaya, 1934, p. 18, pl. 14, fig. 101.
Spisula (Pseudocardium) sachalinensis, Okada and Taki, 1960, p. 55, pl. 28, fig. 7; Habe, 1960, p. 8, pl. 4, figs. 16, 17.

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 38–19a	103.5	85.0	30.0	left

Remarks:—This species is characterized by the, large, thick and triangular shell, very rough unequal and irregular concentric grooves on the surface and large and broad resilifer pit. These characteristic features are observed in the present specimen.

Geologic and geographic distribution:—Miocene to Recent. Northern Honshu, Hokkaido and Saghalien.

Occurrence:—Loc. 3 (rare) of the Nakanokawa formation.

Family Tellinidae

Genus ***Macoma*** Leach, 1819

Type-species: *Macoma tenera* Leach, 1819 (=*Tellina calcarea* Gmelin, 1791). Recent, North America.

Subgenus ***Macoma***, s.s.

Macoma* (*Macoma*) *incongrua (v. Martens), 1865

Pl. 6, fig. 19.

Tellina rotundata, Reeve, 1867, vol. 17, pl. 27, fig. 146.
Tellina inquinata, Lischke, 1871, p. 117, pl. 10, figs. 12, 13.
Tellina incongrua, Römer in Martini und Chemnitz, 1871, vol. 10, pt. 4, p. 225.
Macoma dissimilis, Yokoyama, 1920, p. 116, pl. 7, figs. 19, 20 (non Martens, 1865).
Macoma inquinata, Yokoyama, 1920, p. 117, pl. 8, figs. 1, 2 (non Deshayes, 1854).
Macoma incongrua, Oldroyd, 1924, p. 170, pl. 42, fig. 10; Oinomikado, 1934, p. 356, pl. 8, figs. 16, 17, text-figs. 8, 9; Nomura, 1935*d*, p. 218, pl. 17, figs. 36, 37; Taki in Hirase, 1951, pl. 45, fig. 3; Kira, 1959, p. 155, pl. 59, fig. 18.
Macoma (Macoma) incongrua, Habe, 1952, p. 219, fig. 546; Taki and Oyama, 1954, pl. 8, figs. 19, 20, pl. 9, figs. 1, 2; Okada and Taki, 1960, p. 50 pl. 25, fig. 4.

Dimensions (in mm):—

Specimen	Length	Height	Depth	Valve
no. 33–5a	—	33.1	—	left
no. 102–1	19.5	13.5	—	left
no. 2905–10a	23.8	15.5	—	right
no. 290510b	16.5	12.5	—	left

Remarks:—Several partly fractured specimens are in the collection.

Geologic and geographic distribution :—Miocene to Recent. Japan and North America within the North Pacific regions.

Occurrence :—Loc. 4 (rare) and Loc. 7 (common) of the Nakanokawa formation; Loc. 26 (raae), Loc. 29 (rare), Loc. 31 (rare) and Loc. 33 (rare) of the Chinkope formation.

Macoma* (*Macoma*) *tokyoensis Makiyama, 1927

Pl. 7, figs. 22–23.

Tellina nasuta var. *dissimilis*, Lischke, 1871, p. 115, pl. 10, figs. 15–17 (non Martens, 1865).
Tellina (*Macoma*) *dissimilis*, Martini und Chemnitz, 1888, vol. 10, pt. 4, p. 232, pl. 44, figs. 12–14 (non Martens, 1865).
Macoma nasuta, Tokunaga, 1906, p. 45, pl. 3, figs. 2a–b (non Conrad, 1837).
Macoma dissimilis, Yokoyama, 1922, p. 143, pl. 10, fig. 4 (non Martens, 1865); Yokoyama, 1925*c*, p. 20, pl. 5, fig. 9 (non Martens, 1865); Yokoyama 1925*d*, p. 9, pl. 1, fig. 19 (non Martens, 1865); Yokoyama, 1926*a*, p. 133, pl. 16, fig. 4 (non Martens, 1865); Yokoyama, 1926*b*, p. 221, pl. 28, fig. 10 (non Martens, 1865).
Macoma tokyoensis Makiyama, 1927, p. 50; Oinomikado, 1934, p. 355, figs. 1–3; Numura, 1935*a*, p. 88, pl. 4, fig. 12; Taki in Hirase, 1951, pl. 45, fig. 1; Makiyama, 1957, pl. 20, fig. 9, pl. 22, fig. 19; Makiyama, 1958, pl. 34, fig. 4, pl. 39, fig. 10; Ozaki, 1958, p. 133, pl. 23, fig. 5; Yamamoto and Habe, 1959, p. 104, pl. 14, figs. 9–11; Kira, 1959, p. 155, pl. 59, fig. 19.
Macoma (s.s.) *tokyoensis*, Taki and Oyama, 1954, pl. 30, fig. 4; Itoigawa, 1958, pl. 2, fig. 3.

Dimensions (in mm) :—

Specimen	Length	Height	Depth	Valve
no. 10–3a	42.5	30.5	8.0	left
no. 2905–9a	ca. 58.0	ca. 39.5	ca. 9.5	right

Remarks :—Several intact and isolated valves are in the collection.

Geologic and geographic distribution :—Miocene to Recent. Northeast Honshu to Kyushu.

Occurrence :—Loc. 4 (rare) and Loc. 7 (abundant) of the Nakanokawa formation; Loc. 20 (rare) and Loc. 26 (rare) of the Chinkope formation.

Family Hiatellidae

Genus ***Panope*** Menard, 1807

Type-species: *Panope aldrovandi* Menard, 1807. Recent, Mediterranean Sea.

Panope japonica A. Adams, 1850

Panope generosa, Brauns, 1881, p. 36, pl. 3, fig. 14 (non Gould, 1850); Yokoyama, 1922, p. 121, pl. 6, figs. 14, 15 (non Gould, 1850); Yokoyama 1925*c*, p. 16, pl. 6, fig. 6 (non Gould, 1850).
Panope japonica, Kuroda in Honma, 1931, p. 65, pl. 8, fig. 56; Kinoshita and Isahaya, 1934, p. 18, pl. 15, fig. 105; Nomura and Hatai, 1935*a*, p. 20, pl. 15, figs. 2a–b; Nomura, 1938, p. 263, pl. 36, figs. 7a–b; Taki in Hirase, 1951, pl. 53, fig. 6; Habe, 1952, p. 233, figs. 603, 608; Habe, 1955, p. 21, pl. 5, figs. 5, 6, pl. 6, fig. 12; Ozaki, 1958, p. 134, text-figs. a–b; Tomizawa in T. and K. Yagi, 1958, p. 388, pl. 10, fig. 43; Kira, 1959, p. 162, pl. 61, fig. 16; Habe, 1960, p. 10, pl. 2, figs. 3, 4.

Remarks :—This species is one of the most widely distributed species in the Neogene and latter deposits in Japan.

Geologic and geographic distribution :—Miocene to Recent. Hokkaido to Setouchi in Japan, ? North America from Puget Sound to San Diego, California.

Occurrence :—Loc. 1 (few) of the Soibetsugawa formation.

Family Myochamidae

Genus ***Myadora*** Gray, 1840

Type-species: *Pandora brevis* Sowerby, Recent, Indo-Pacific region.

Myadora proxima (Smith), 1880

Pl. 7, figs. 13–14.

Myodora proxima Smith, 1880, p. 586, pl. 53, figs. 8, 8a–b; Habe in Kuroda, 1950, p. 27, pl. 4, figs. 1–3 (non figs. 19–21); Okada and Taki, 1960, p. 43, pl. 22, fig. 8.
Myodora triangularis Dunker, 1882, p. 181, pl. 7, figs. 11, 12.

Dimensions (*in mm*):—

Specimen	Length	Height	Depth	Valve
no. 38–28	14.5	11.5	13.5	left

Remarks:—A well preserved left valve is in the collection. The present species is closely allied to *Myadora fluctuosa* Gould (Habe, 1952), bnt it differs from the latter having a broader apical angle (98°) and higher shell outline.

Geologic and geographic distribution:—Pliocene to Recent. Kyushu, Shikoku and Honshu.

Occurrence:—Loc. 3 (rare) of the Nakanokawa formation.

Family Cuspidariidae

Genus ***Plectodon*** Carpenter, 1864

Type-species: *Plectodon scabra* Carpenter, 1864.

Subgenus ***Plectodon*** s.s.

Plectodon (***Plectodon***) ***ligula*** (Yokoyama), 1922

Pl. 6, figs. 5–6,

Cuspidaria ligula Yokoyama 1922, p. 169, pl. 14, figs. 3, 4; Kuroda, 1, 1948, vol. 15, no. 1, p. 23, pl. 2, figs. 11, 11a; Taki and Oyama, 1954, pl. 3, figs. 3, 4.
Plectodon (*Plectodon*) *ligula*, Habe, 1952, p. 276.

Dimensions (*in mm*):—

Specimen	Length	Height	Depth	Valve
no. 36–11	6.1	4.2	1.3	left

Remarks:—A small left valve is in the collection. The present species is closely allied to *Cuspidaria chinensis* (Griffith and Pidgeon) (Kuroda, 1948), but the latter differs from the former by having longer and rather convex shell with longer rostrum, and the absence of the keel running from beak to postero-ventral corner.

Geologic and geographic distribution:—Pliocene to Recent. Southern and Central Honshu.

Occurrence:—Loc. 1 (rare) of the Soibetsugawa formation.

Phylum Brachiopoda

Class Teleotremata

Family Rhynchonellidae

Genus ***Hemithyris*** d'Orbigny, 1847

Type-species: *Anomia psittacea* Gmelin, 1792. Recent, Mari Groenlandiae.

Hemithyris psittacea woodwardi (A. Adams), 1863

Pl. 1, fig. 23, Pl. 3, figs. 11–12, Pl. 5, fig. 3.

Rhynchonella woodwardi A, Adams, 1863, p. 100.
Rhynchonella psittacea woodwardi, Davidson, 1887, p. 168, pl. 24, figs. 12, 13; Yokoyama, 1922, p. 200, pl. 17, fig. 13.
Hemithyris psittacea woodwardi, Yokoyama, 1925*a*, p. 22, pl. 1, fig. 7; Yokoyama, 1926, vol. 1, pt. 8, p. 310; Hayasaka, 1931, vol. 3, no. 1, p. 2, fig. 2; Hayasaka, 1932, p. 4, pl. 1, figs. 2a–c, pl. 2, figs. 2a–b; Nomura and Hatai, 1936*b*, p. 186; Hatai, 1936*a*, p. 66; Hatai, 1937, p. 64; Hatai, 1940, p. 203, pl. 6, figs. 50, 51, 55–63, 68, 74–76; Makiyama, 1958, pl. 25, fig. 7.

Dimensions (*in mm*);—

Specimen	Length	Height	Depth	Valve
no. 38–21a	ca. 14.0	16.2	4.2	dorsal
no. 2804–7	22.0	19.3	12.0	intact
no. 2804–9	ca. 14.8	20.0	6.5	dorsal

Remarks:—The intact well preserved fractured specimens are in the collection.

Geologic and geographic distribution:—Miocene to Recent. Seas around Japan (*fide* Hatai, 1940).

Occurrence:—Loc. 3 (abundant) and Loc. 6 (abundant) of the Nakanokawa formation.

Family Terebratellidae

Subfamily Dallininae

Section Transversae

Genus ***Terebratalia*** Beecher, 1893

Type-species: *Terebratalia transversa* Sowerby, 1846. Recent,Puget Sound, Washington.

Terebratalia coreanica (Adams and Reeve), 1850

Pl. 1, fig. 24.

Terebratella coreanica, Davidson, 1852, p. 367 (*fide* Hatai, 1940); Reeve, 1861, vol. 13, pl. 7, figs. 28a–b; Schrenck, 1867, p. 468, pl. 18, fig. 7; Lischke, 1869, p. 181; Davidson, 1871, p. 304, pl. 31, figs. 4, 5 (*fide* Hatai, 1940); Hatai, 1940, p. 276, pl. 2, figs. 1–9, 11, 20, 21, pl. 3, figs. 36, 47–49, 54.
Terebratella bouchardi Davidson, 1852, p. 367 (*fide* Hatai, 1940); Davidson, 1852, pl. 14, figs. 4–7 (*fide* Hatai, 1940).

Dimensions (*in mm*):—

Specimen	Length	Height	Depth	Valve
no. 38–14a	ca. 57.0	ca. 58.0	ca. 21.0	ventral
no. 38–14b	ca. 55.0	ca. 58.0	ca. 31.0	dorsal
no. 2804–8	29.5	28.9	12.2	intact
no. 24–1a	ca. 33.5	29.5	10.5	ventral
no. 24–1b	35.8	28.2	11.0	ventral
no. 24–1c	36.0	25.5	13.5	intact

Remarks:—Abundant well preserved and partly fractured specimens were colledted from several localities in the present area.

Geologic and geographic distribution:—Miocene to Recent. Gulf of Tartiary, Tsingtao and Shantung, China, Hokkaido, Tsugaru Strait to Chiba on the Pacific side, Korea Strait north to the Tsugaru Strait on the Japan Sea Side (*fide* Hatai, 1940).

Occurrence :—Loc 3 (abundant), Loc. 5 (few) and Loc. 6 (few) of the Nakanokawa formation; Loc. 26 (common) of the Chinkope formation.

Terebratalia gouldi (Dall), 1891

Pl. 7, fig.7.

Terebratella gouldi Dall, 1891, p. 167, pl. 4, figs. 4, 5; Pilsbry, 1895, p. 153, pl. 11, figs. 7, 8.

Terebratalia gouldi, Dall 1895, p. 729, pl. 7, fig. 5; Hayasaka, 1922, p. 150, pl. 7, fig. 5; Nagao and Sasa, 1934, p. 232; Nomura and Hatai, 1936*b*, p. 178, pl. 18, figs. 14, 15, p. 192, pl. 19, figs. 10–12; Hatai, 1936*c*, p. 305, pl. 35, fig. 27; Hatai, 1940, p. 285, pl. 7, figs. 23, 24; Makiyama, 1958, pl. 49, fig. 4.

Terebratulina quantoensis Yokoyama, 1910, p. 2. pl. 5, figs. 4–9; Yokoyama, 1920, p. 183, pl. 19, figs. 19–24; Hayasaka, 1922, p. 148, pl. 7, figs. 23, 24.

Remarks :—An intact and a fractured specimens are in the collection.

Geologic and geographic distribution :—Miocene to Recent. Coast of Kii, north of Tokyo Bay on the Pacific, and Japan Sea and Hakodate in the Japan Sea side. Probable extending further southward in deep water (*fide* Hatai, 1940).

Occurrence :—Loc. 5 (rare) and Loc. 6 (rare) of the Nakanokawa formation.

Genus ***Coptothyris*** Jackson, 1916

Type-species: *Terebratula grayi* Davidson, 1852. Recent, Korea Strait.

Coptothyris grayi (Davidson), 1852

Pl. 5, fig. 5.

Terebratula (Waldheimia) grayi, Reeve, 1860, vol. 13, pl. 2, figs. 5a–c.

Waldheimia grayi, Adams, 1863, p. 99 (*fide* Hatai, 1940); Davidson, 1871, p. 304, pl. 31, figs. 7, 8 (*fide* Hatai, 1940); Davidson, 1887, p. 54, pl. 10, figs. 1–4; Tokunaga, 1906, p. 69, pl. 4, figs. 8a–b.

Eudesia grayi, Pilsbry, 1895, p. 152; Yokoyama, 1922, p. 199, pl. 17, figs. 11, 12.

Waldheimia elongata Tokunaga, 1906, p. 69, pl. 4, figs. 9a–b.

Pereudesia grayi, Hayasaka and Nomura, 1922, p. 29.

Pereudesia grayi var. *transversa* Hayasaka, 1922, p. 154, pl. 8, figs. 13, 14.

Terebratalia smithi, Hayasaka, 1922, p. 151, pl. 8, fig. 6 (non Arnold, 1909).

Terebratalia smithi var. *brevis* Hayasaka, 1922, p. 151, pl. 8, fig. 7.

Coptothyris sinanoensis Kuroda in Honma, 1930, p. 89, pl. 13, figs. 117, 118.

Coptothyris grayi aomoriensis, Hayasaka, 1932, p. 9, pl. 1, figs. 5a–b, 6, 7.

Coptothyris grayi, Nomura and Hatai, 1934, p. 13, pl. 1, figs. 1–8; Hatai, 1936*b*, p. 81, pl. 14, figs. 11–14, 18, 19; Nomura and Hatai, 1937, p. 144, pl. 21, figs. 1, 2; Hatai, 1940, p. 302, pl. 3, figs. 17, 50, 53, 55–60, pl. 4, figs. 43, 48; Taki and Oyama, 1954, pl. 37, figs. 11, 12.

Dimensions (in mm) :—

Specimen	Length	Width	Depth	Valve
no. 74-7a	22.5	—	6.0	dorsal
no. 74-7b	30.3	33.1	10.0	ventral

Remarks :—Two rather swollen and isolated dorsal and ventral valves are in the collection.

Geologic and geographic distribution :—Miocene probably Oligocene to Recent. Kyushu to the Tsugaru Strait of the Japan Sea, Hokkaido, south to central Japan on the Pacific side of Japan (*fide* Hatai, 1940).

Occurrence :—Loc. 40 (few) of the Kunnui formation.

FIG. 2, GEOLOGICAL MAP OF THE SETANA AREA

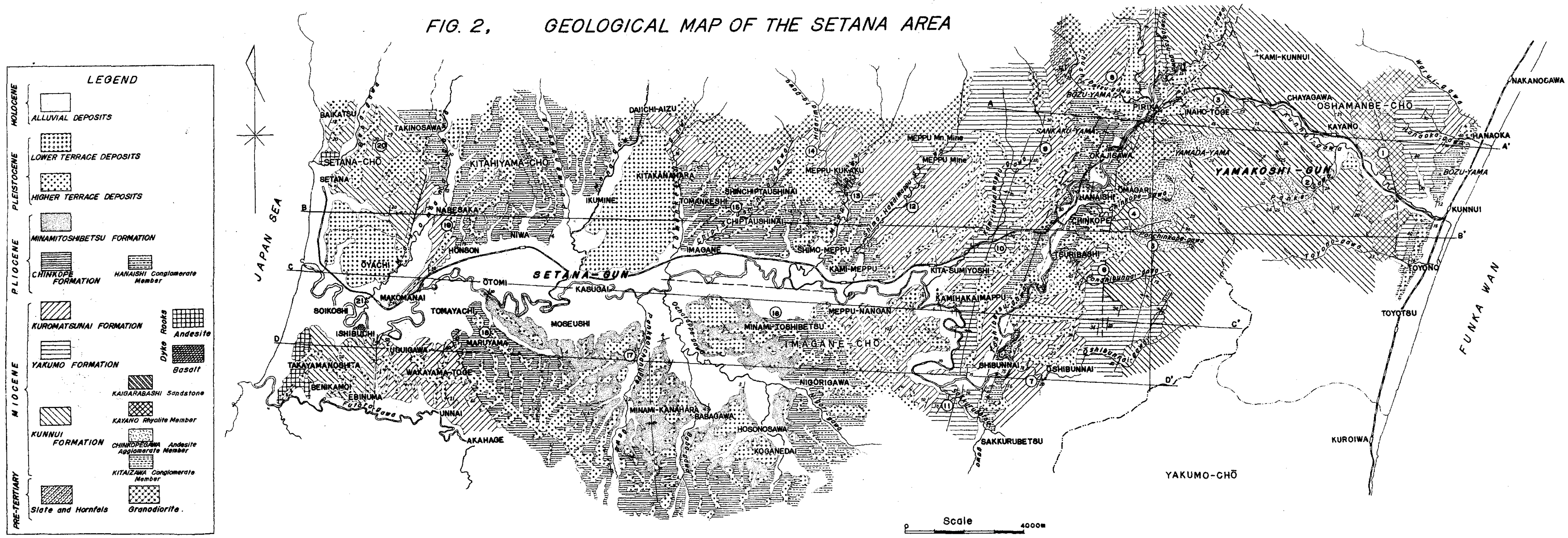


FIG. 3, CROSS-SECTIONS OF THE SETANA AREA

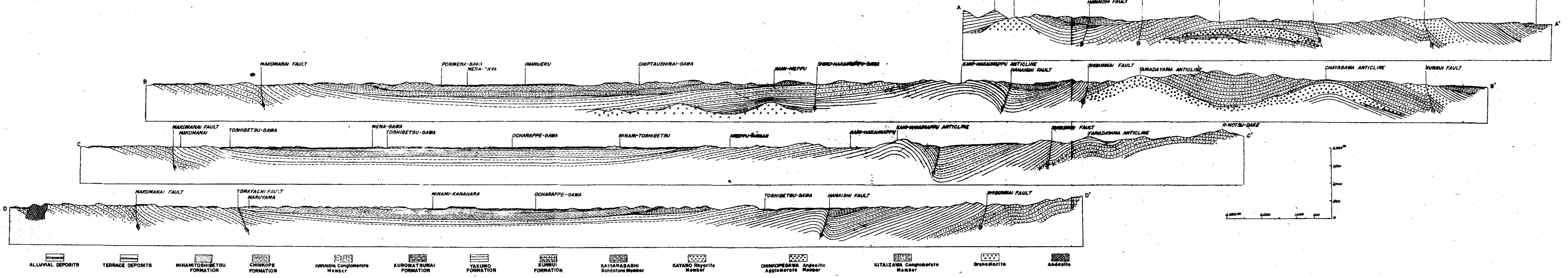


FIG. 5. STRATIGRAPHIC SECTIONS OF THE SETANA AREA

Numerals encircled refer to locality of section in the geological map

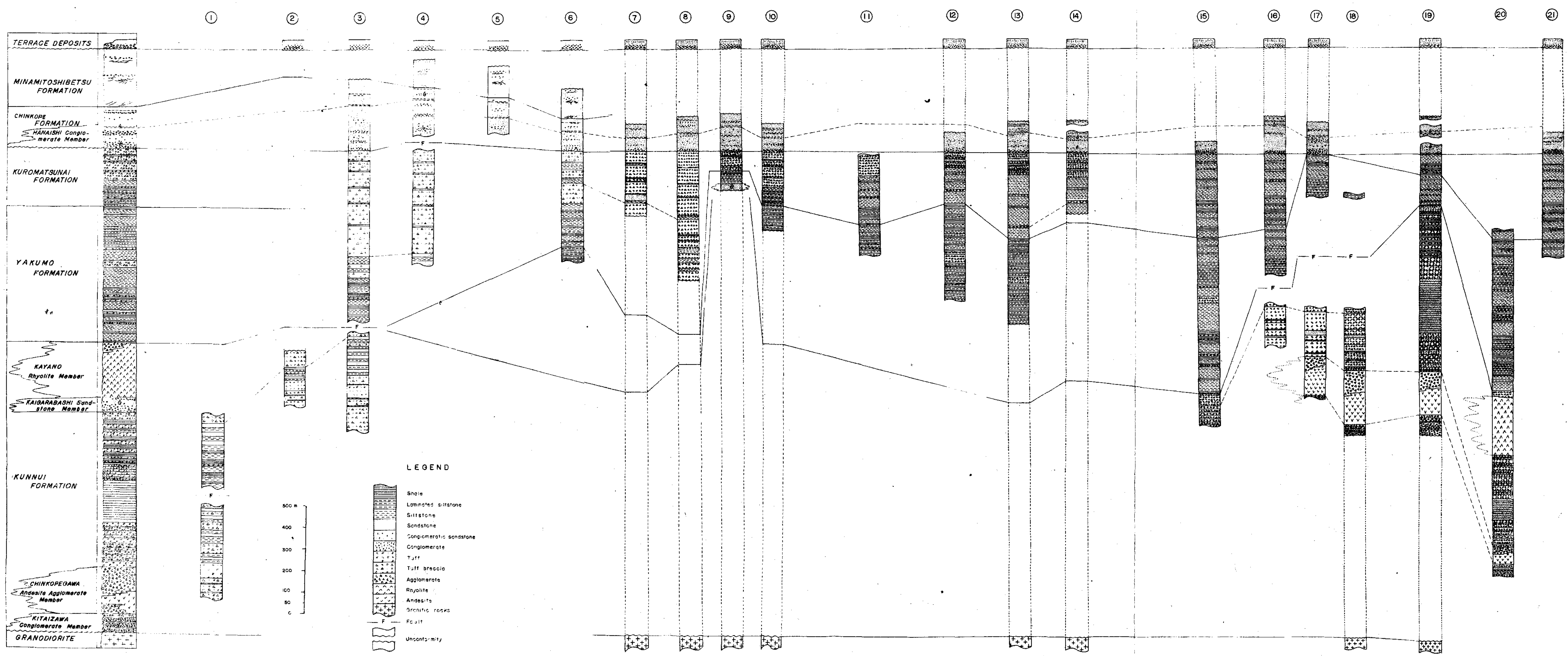
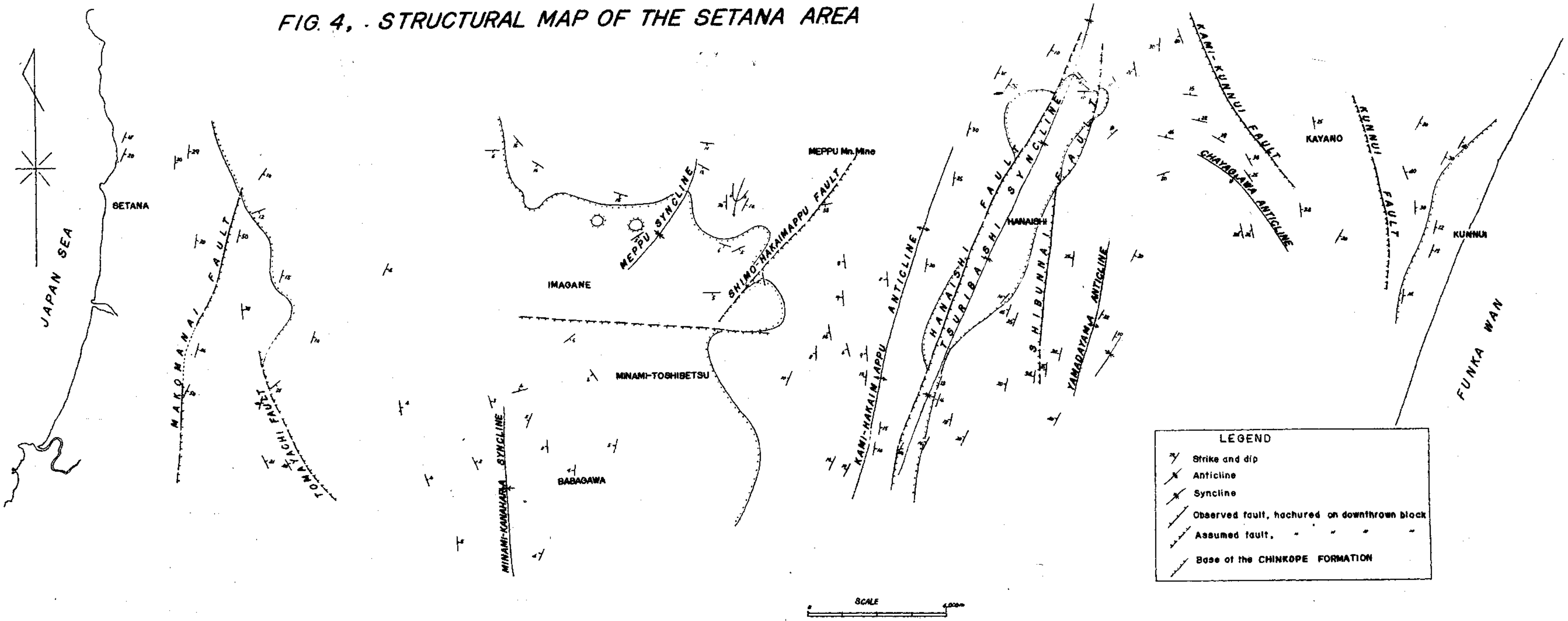


FIG. 4. STRUCTURAL MAP OF THE SETANA AREA



List of the fossil localities

I. Kuromatsunai area

A. Horizon III, *Soibetsungawa formation. Late Pliocene.*

Loc. no. 1 : River cliff of the Soibetsu-gawa, 900 m SW of Nakanokawa railway station, Kuromatsunai-cho, Suttu-gun. Lat. 42° 42′ 50″ N., Long. 140° 17′ 08″ E.

B. Horizon II, *Nakanokawa formation. Early Pliocene.*

Loc. no. 2 : Stream cliff of the Yunosawa, 1,900 m SW of Nakanokawa railway station, Kuromatsunai-cho, Suttu-gun. Lat. 42° 41′ 30″ N., Long. 140° 16′ 10″ E.

Loc. no. 3 : River cliff of the Soibetsu-gawa, 2,700 m SW of Nakanokawa railway station, Kuromatsunai-cho, Suttu-gun. Lat. 42° 40′ 55″ N., Long. 140° 16′ 50″ E.

Loc. no. 4 : Stream cliff of the Kaigarazwa, 3,000 m SWW of Kuromatsunai raiway station, Kuromatsunai-cho, Suttu-gun. Lat. 42° 39′ 30″ N., Long. 140° 16′ 25″ E.

Loc. no. 5 : Stream cliff of the Nakanokawa, 3,000 m SW of Kuromatsunai raiway station, Kuromatsunai-cho, Suttu-gun. Lat. 42° 38′ 55″ N., Long. 140° 16′ 30″ E.

Loc. no. 6 : Railway-cutting, 1,000 m S of the Kuromatsunai railway station, Kuromatsunai-cho, Suttu-gun. Lat. 42° 39′ 25″ N., Long. 140° 18′ 10″ E.

Loc. no. 7 : River cliff of the Byakutan-gawa, 1,500 m E of Byakutan, Kuromatsunai-cho, Suttu-gun. Lat. 42° 42′ 25″ N., Long. 140° 18′ 55″ E.

Loc. no. 8 : River cliff of the tributary of Yunosawa, 3,200 m SWW of Nakanokawa railway station, Kuromatsunai-cho, Suttu-gun. Lat. 42° 41′ 15″ N., Long. 140° 15′ 20″ E.

C. Horizon I, *Kaigarabuchi conglomerate member of the Nakanokawa formation. Early pliocene.*

Loc. no. 9 : Road side cliff, 300 m N of Neppu, Kuromatsunai-cho, Suttu-gun. Lat. 42° 41′ 20″ N., Long. 140° 18′ 10″ E.

Loc. no. 10 : River cliff of the Neppu-gawa, 1,250 m NEE of Kuromatsunai railway station, Kuromatsunai-cho, Suttu-gun. Lat. 42° 40′ 20″ N., Long. 140° 19′ 20″ E.

Loc. no. 11 : River side cliff of the Shubuto-gawa, 1,900 m SEE of Nakanokawa railway station, Kuromatsunai-cho, Suttu-gun. Lat. 42° 39′ 40″ N., Long. 140° 19′ 35″ E.

Loc. no. 12 : River cliff of the Shubuto-gawa, 250 m W of Nakazato, Kuromatsunai-cho, Suttu-gun. Lat. 42° 39′ 10″ N., Long. 140° 19′ 55″ E.

Loc. no. 13 : River cliff of the Shubuto-gawa, 750 m S of Nakazato, Kuromatsunai-cho, Suttu-gun. Lat. 42° 38′ 45″ N., Long. 140° 19′ 55″ E.

Loc. no. 14 : River cliff of the Shubuto-gawa, 200 m W of Kaigarabuchi, Kuromatsunai-cho, Suttu-gun. Lat. 42° 38′ 15″ N., 140° 20′ 15″ E.

Loc. no. 15 : River side cliff of the Utasai-gawa, 1,100 m E of Warabitai railway station, Kuromatsunai-cho, Suttu-gun. Lat. 42° 37′ 55″ N., Long. 140° 19′ 35″ E.

Loc. no. 16 : Stream cliff of the Kaigarazawa, 3,000 m W of Kaigara, Rankoshi-mura, Isoya-gun. Lat. 42° 44′ 45″ N., Long. 140° 24′ 10″ E.

II. Setana area

A. Horizon II, *Chinkope formation. Early Pliocene.*

Loc. no. 17 : River cliff of the Toshibetsu-gawa, 750 m SW of Pirika railway station, Imagane-cho, Setana-gun. Lat. 42° 27′ 55″ N., Long. 140° 11′ 45″ E.

Loc. no. 18 : River cliff of the Toshibetsu-gawa, 2,000 m SW of Pirika railway station, Imagane-cho, Setana-gun. Lat. 42° 27′ 25″ N., Long. 140° 11′ 00″ E.

Loc. no. 19 : River cliff of the Toshibetsu-gawa, 1,300 m NE of Hanaishi railway station, Imagane-cho, Setana-gun. Lat. 42° 27′ 25″ N., Long. 140° 10′ 45″ E.

Loc. no. 20 : River cliff of the Pon-Shibunnai-gawa, 500 m SE of Tsuribashi, Imagane-cho, Setana-gun. Lat. 42° 25′ 20″ N., Long. 140° 09′ 40″ E.

Loc. no. 21 : Road side cliff, 500 m N of Maruyama, Kitahiyama-cho, Setana-gun. Lat. 42° 24′ 25″ N., Long. 139° 55′ 0″ E.

Loc. no. 22 : Road side cliff, 250 m N of Maruyama, Kitahiyama-cho, Setana-gun. Lat. 42° 24′ 05″ N., Long. 139° 55′ 00″ E.

Loc. no. 23 : Road side cliff, 150 m N of Maruyama, Kitahiyama-cho, Setana-gun. Lat. 42° 23′ 50″ N., Long. 139° 54′ 55″ E.

Loc. no. 24 : Road side cliff, 750 m S of Maruyama, Kitahiyama-cho, Setana-gun. Lat. 42° 23′ 30″ N., Long. 139° 54′ 50″ E.

Loc. no. 25 : Road side cliff, 1,000 m SE of Maruyama, Kitahiyama-cho, Setana-gun. Lat. 42° 24′ 00″ N., Long. 139° 54′ 50″ E.

B-1. Horizon I, *Hanaishi conglomerate member of the Chinkope formation. Early Pliocene.*

Loc. no. 26 : River cliff of the Toshibetsu-gawa, 100 m N of Pirikabashi, Pirika, Imagane-cho, Setana-gun. Lat. 42° 28′ 35″ N., Long. 140° 11′ 40″ E.

Loc. no. 27 : River cliff of the Toshibetsu-gawa, 750 m SW of Pirika railway station, Imagane-cho, Setana-gun. Lat. 42° 27′ 55″ N., Long. 140° 11′ 55″ E.

Loc. no. 28 : River cliff of the Toshibetau-gawa, 1,100 m SE of Pirika railway station, Imagane-cho, Setana-gun. Lat. 42° 27′ 45″ N., Long. 140° 11′ 35″ E.

Loc. no. 29 : River cliff of the Toshibetsu-gawa, 1,800 m SW of Pirika railway station, Imagane-cho, Setana-gun. Lat. 42° 27′ 25″ N., Long. 140° 11′ 15″ E.

Loc. no. 30 : River cliff of the Toshibetsu-gawa, 1,000 m NEE of Hanaishi railway station, Imagane-cho, Setana-gun. Lat. 42° 26′ 40″ N., Long. 140° 10′ 15″ E.

Loc. no. 31 : River cliff of the Toshibetsu-gawa, 500 m W of Hanaishi railway station, Imagane-cho, Setana-gun. Lat. 42° 26′ 35″ N., Long. 140° 09′ 50″ E.

Loc. no 32 : River cliff of the Toshibetsu-gawa, 550 m SW of Hanaishi railway station, Imagane-cho, Setana-gun. Lat. 42° 26′ 25″ N., Long. 140° 09′ 45″ E.

Loc. no. 33 : River cliff at Hanaishi railway-bridge, Imagane-cho, Setana-gun. Lat. 42° 26′ 05″ N., Long. 140° 09′ 40″ E.

Loc. no. 34 : Eastern Entrance of the Hanaishi-tunnel, 1,800 m Sw of Hanaishi railway station, Imagane-cho, Setana-gun. Lat. 42° 25′ 50″ N., Long. 140° 09′ 05″ E.

Loc. no. 35 : River cliff of the Toshibetsu-gawa, 750 m S of Tsuribashi, Imagane-cho, Setana-gun. Lat. 42° 24′ 05″ N., Long. 140° 09′ 15″ E.

Loc. no. 36 : River cliff of the Toshibetsu-gawa, 1,200 m SSE of Tsuribashi, Imagane-cho, Setana-gun. Lat. 42° 24′ 55″ N., Long. 140° 09′ 10″ E.

Loc. no. 37 : River cliff of the Toshibetsu-gawa, 1,500 m S of Tsuribashi, Imagane-cho, Setana-gun. Lat. 42° 24′ 45″ N., Long. 140° 09′ 15″ E.

Loc. no. 38 : River Cliff of the Toshibetsu-gawa, 2,00 m S of Tsuribashi, Imagane-cho, Setana-gun. Lat. 42° 24′ 40″ N., Long. 140° 08′ 45″ E.

Loc. no. 39 : Road side cliff, 1,200 m NNW of Kitatoyotsu railway station, Oshamanbe-cho, Yamakoshi-gun. Lat. 42° 25′ 30″ N., Long. 140° 18′ 23″ E.

B–2. Horizon M, *Kaigarabashi sandstone member of the Kunnui formation. Early Miocene.*

Loc. no. 40 : Road side cliff, 150 m N of Kaigarabashi, Imagane-cho, Setana-gun. Lat. 42° 26′ 55″ N., Long. 140° 10′ 20″ E.

Loc. no. 41 : River cliff of the Hidarimata-gawa, 400 m SSW of kaigarabashi, Imagane-cho, Setana-gun. Lat. 42° 35′ 00″ N., Long. 140° 04′ 15″ E.

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Explanation of Plates

Plate 1

Fig. 1. *Chlamys daishakaensis* Masuda and Sawada × 1/2. right valve Loc. no. 16, Kaigarabuchi conglomerate member of the Nakanokawa formation, Pliocene.

Fig. 2. *Chlamys tamurae* Masuda and Sawada × 1. right valve. Loc. no. 23. Chinkope formation, Pliocene.

Fig. 3. *Swiftopecten swiftii* (Bernardi) × 1.5 right valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 4. *Chlamys osugii* Kubota × 1. right valve. Loc. no. 16. Kaigarabuchi conglomerate member of the Nakanokawa formation, Pliocene.

Fig. 5. *Chlamys otukae* Masuda and Sawada × 1. right valve. Loc. no. 41. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Figs. 6–7. *Chlamys otukae* Masuda and Sawada × 1. right valve. Loc. no. 41. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Figs. 8–9. *Chlamys nipponensis* Kuroda × 1. right valve. Loc. no. 1. Soibetsugawa formation, Pliocene.

Fig. 10. *Placopecten wakuyaensis* Masuda × 1. left valve. Loc. no. 40. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Fig. 11. *Patinopecten yessoensis* (Jay) × 1. left valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 12. *Chlamys kumanodoensis* Masuda × 1. right valve. cardinal area. Loc. no. 49. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Figs. 13–14. *Monia umbonata* (Gould) × 1. left valve. 13; external surface, 14; internal surface. Loc. no. 6. Nakanokawa formation, Pliocene.

Figs. 15–16. *Papyridea (Fulvia) kurodai* Hatai and Nisiyama × 1. right valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 17. *Mitrella (Mitrella) burchardi* (Dunker) × 3. apertural view. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 18. *Barbitonia arthritica* (Bernardi) × 1. juvenille form. apertural view. Loc. no. 3. Nakanokawa formation, Pliocene.

Figs. 19–20. *Scala (Boreoscala) yabei echigonum* (Kanehara) × 1. 19; apertural view, 20; dorsal view. Loc. no. 33. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Figs. 21–22. *Granotoma kotakae* Sawada, n. sp. × 2. 21; dorsal view, 22; apertural view. Loc. no. 39. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Fig. 23. *Hemithyris psitacea woodwardi* (A. Adams) × 1.5. ventral view. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 24. *Terebratalia coreanica* (Adams and Reeve) × 1.5. dorsal view. Loc. no. 6. Nakanokawa formation, Pliocene.

Figs. 25–26. *Placopecten setanaensis* (Kubota) × 1. 25; right valve, 26; left valve. Loc. no. 40. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Figs. 27–28. *Liocyma fluctuosa* (Gould) × 1. left valve. Loc. no. 4. Chinkope formation, Pliocene.

Plate 2

Fig. 1. *Buccinum leucostoma* Lischke × 1. dorsal view. Loc. no. 39. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Fig. 2. *Placopecten wakuyaensis* Masuda × 1. right valve. Loc. no. 40. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Fig. 3. *Swiftopecten swiftii* (Bernardi) × 1. left valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 4. *Chlamys kagamianus* (Yokoyama) × 1. left valve. Loc. no. 40. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Fig. 5. *Turritella (Neohaustator) fortilirata habei* Kotaka × 1. apertural view. Loc. no. 33. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Fig. 6. *Oenopota kagana toyotsuensis* Sawada, n. subsp. × 2. apertural view. Loc. no. 39. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Fig. 7. *Clinocardium californiense* (Deshayes) × 1. right valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Figs. 8–9. *Neptunea iwaii* Hatai, Masuda and Suzuki × 1. 8; apertural view, 9; dorsal view. Loc. no. 22. Chinkope formation, Pliocene.

Figs. 10–11. *Bittium yakoyamai* Otuka × 3. 10; dorsal view, 11; apertural view. Loc. no. 39. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Figs. 12–13. *Trophonopsis (Boreotrophon) sasae* Sawada, n. sp. × 1.5. 12; dorsal view, 13; apertural view. Loc. no. 39. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Figs. 14–15. *Antiplanes contraria* (Yokoyama) × 1. 14; apertural view, 15; dorsal view. Loc. no. 20. Chinkope formation, Pliocene.

Fig. 16. *Cerithium kochi* Philippi × 2. apertural view. Loc. no. 4. Nakanokawa formation, Pliocene.

Fig. 17. *Cerithium kochi* Philippi × 1.5. apertural view. Loc. no. 3. Nakanokawa formation, Pliocene.

Figs. 18–19. *Volutomitra hataii* Sawada, n. sp. × 5. 18; apertural view, 19; dorsal view. Loc. no. 39. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Figs. 20–21. *Plicifusus yanamii* (Yokoyama) × 1.5. 20; apertural view, 21; dorsal view. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 22. *Mytilus grayanus* Dunker × 1/2. left valve. Loc. no. 1. Soibeltsugawa formation, Pliocene.

Fig. 23. *Yoldia (Cnesterium) johanni* Dall × 1.5. left valve. Loc. no. 7. Nakanokawa formation, Pliocene.

Fig. 24. *Scala (Boreoscala) aomoriensis* (Iwai) × 1. apertural view. Loc. no. 16. Kaigarabuchi conglomerate member of the Nakanokawa formation. Pliocene.

Fig. 25. *Barbitonia arthritica* (Bernardi) × 1.5. juvenille form. dorsal view. Loc. no. Nakanokawa formation, Pliocene.

Fig. 26. *Monia macroschisma ezoana* (Kanehara) × 1. left valve. Loc. no. 1. Soibetsugawa formation, Pliocene.

Fig. 27. *Venericardia (Cyclocardia) crebricostata* (Krause) × 1. right valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Plate 3

Fig. 1. *Nanaochlamys notoensis* (Yokoyama) × 1. left valve. Loc. no. 40. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Figs. 2–3. *Astarte* (*Tridonta*) *borealis* (Schumacher) × 1. right valve. Loc. no. 1. Soibetsugawa formation, Pliocene.

Fig. 4. *Swiftopecten swiftii* (Bernardi) × 1.5. right valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 5. *Patinopecten yessoensis* (Jay) × 2/3. left valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 6. *Chlamys osugii* Kubota × 1. left valve. Loc. no. 16. Kaigarabuchi conglomerate member of the Nakanokawa formation, Pliocene.

Fig. 7. *Oenopota kuromatsunaiensis* Sawada, n. sp. × 2. Paratype. dorsal view. Loc. no. 7. Nakanokawa formation, Pliocene.

Fig. 8. *Turritella* (*Neohaustator*) *fortilirata habei* Kotaka × 1. dorsal view. Loc. no. 3. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Figs. 9–10. *Turritella* (*Neohaustator*) *nipponica* Yokoyama × 2. 9; apertural view 10; dorsal view, Loc. no. 7. Nakanokawa formation, Pliocene.

Figs. 11–12. *Hemithyris psitacea woodwardi* (A. Adams) × 1. 11; lateral view, 12; ventral view. Loc. no. 6. Nakanokawa formation, Pliocene.

Fig. 13. *Patinopecten kagamianus* (Yokoyama) × 1/2. right valve. Loc. no. 40. Kaigarabashi conglomerate member of the Kunnui formation, Miocene.

Figs. 14–15. *Crepidula grandis* Middendorff × 1. 14; dorsal view. 15; apertural view. Loc. no. 3. Nakanokawa formation, Pliocene.

Plate 4

Figs. 1–2. *Nucella* cfr. *freycinetti* (Deshayes) × 2. juvenille form. 1; dorsal view, 2; apertural view. Loc. no. 3. Nakanokawa formation, Pliocene.

Figs. 3–4. *Chlamys chinkopensis* Masuda and Sawada, × 1. 3; right valve, 4; left valve. Loc. no. 32. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Figs. 5–6. *Venericardia* (*Cyclocardia*) *crebricostata* (Krause) × 2. right valve. Loc. no. 4. Chinkope formation, Pliocene.

Fig. 7. *Chlamys islandica erythrocomata* (Dall) × 1. left valve. Loc. no. 38. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Fig. 8. Ditto. × 1. right valve.

Fig. 9. *Latirus* (?) sp. × 2. apertural view. Loc. no. 4. Nakanokawa formation, Pliocene.

Fig. 10. *Antiplanes* (*Rectiplanes*) *sanctaiioannis* (Smith) × 1. apertural view. Loc. no. 31. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Fig. 11. *Chlamys daishakaensis* Masuda and Sawada × 1/2. left valve. Loc. no. 14. Kaigarabuchi conglomerate member of the Nakanokawa formation, Pliocene.

Figs. 12–13. *Glycymeris* (*Glycymeris*) *yessoensis* (Sowerby) × 1. left valve, 12; external surface, 13; internal surface. Loc. no. 1. Soibetsugawa formation, Pliocene.

Fig. 14. *Patinopecten yessoensis* (Jay) × 1. right valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Figs. 15–16. *Homalopoma amusitatum* (Gould) × 2. 16; apertural view, 15; dorsal view. Loc. no. 6. Nakanokawa formation, Pliocene.

Fig. 17. *Turritella* (*Neohaustator*) *fortilirata habei* Kotaka × 1. Loc. no. 33. Hanaishi con-

glomerate member of the Chinkope formation, Pliocene.

Fig. 18. *Chlamys tamurae* Masuda and Sawada × 1. left valve. Loc. no. 23. Chinkope formation, Pliocene.

Figs. 19–20. *Oenopota kuromatsunaiensis* Sawada. n. sp. × 2. Holotype, 19; dorsal view, 20; apertural view. Loc. no. 7. Nakanokawa formation, Pliocene.

Fig. 21. *Oenopota kuromatsunaiensis* Sawada, n. sp. × 2. Paratype, apertural view. Loc. no. 7. Nakanokawa formation, Pliocene.

Plate 5

Figs. 1–2. *Callithaca (Protocallithaca) adamsi* (Reeve) × 1. left valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 3. *Hemithyris psitacea woodwardi* (A. Adams) × 1. dorsal view. Loc. no 6. Nakanokawa formation, Pliocene.

Fig. 4. *Latirus* (?) sp. × 2. dorsal view. Loc. no. 4. Nakanokawa formation, Pliocene.

Fig. 5. *Coptothyris grayi* (Davidson) × 1. ventral view. Loc. no. 40. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Figs. 6–7. *Amathina nobilis* (A. Adams) × 1.5. 6; apertural view, 7; dorsal view. Loc. no. 4. Nakanokawa formation, Pliocene.

Figs. 8–9. *Ezocallista brevisiphonata* (Carpenter) × 2/3. left valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Figs. 10–11. *Spisula (Spisula) sachalinensis* (Schrenck) × 2/3. left valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 12. *Scala (Boreoscala) yabei echigonum* (Kanehara) × 1.5. apertural view. Loc. no. 3. Nakanokawa formation, Pliocene.

Figs. 13–14. *Tectonatica janthostoma* (Deshayes) ×2. 13; apertural view, 14; dorsal view. Loc. no. 7. Nakanokawa formation, Pliocene.

Figs. 15–16. *Littorina (Littorivaga) brevicula* (Philippi) × 3. 15; dorsal view, 16; apertural view. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 17. *Antiplanes (Rectiplanes) sanctaiioannis* (Smith) × 1. dorsal view. Loc. no. 31. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Figs. 18–19. *Hinia (Tritonella) japonica* (A. Adams) × 3. 18; apertural view, 20; dorsal view. Loc. no. 4. Nakanokawa formation, Pliocene.

Fig. 20. *Ezocallista brevisiphonata* (Carpenter) × 2/3. right valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Plate 6

Figs. 1–2. *Monia macroschisma* (Deshayes) × 1. 1; left valve, 2; right valve. Loc. no. 1. Soibetsugawa formation, Pliocene.

Figs. 3–4. *Arca boucardi* Jousseaum × 1.5. right valve. 3; external surface 4; internal surface. Loc. no. 4. Nakanokawa formation, Pliocene.

Figs. 5–6. *Plectodon (Plectodon) ligula* (Yokoyama) × 3. left valve. 5; external surface, 6; internal surface. Loc. no. 1. Soibetsugawa formation, Pliocene.

Figs. 7–8. *Limopsis tokaiensis* Yokoyama × 1.5. left valve 7; external surface, 8; internal surface, Loc. no. 20. Chinkope formation, Pliocene.

Figs. 9–10. *Venericardia (Cyclocardia) paucicostata* (Krause) × 1.5. right valve. 9; external surface, 10; internal surface. Loc. no. 39. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Figs. 11–12. *Venericaldia (Cyclocardia) paucicostata* (Krause) × 1.5. left valve. 11; external surface, 12; internal surface. Loc. no. 39. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Fig. 13. *Venericardia (Cyclocardia) crebricostata* (Krause) × 1. right valve. Loc. no. 4. Nakanokawa formation, Pliocene.

Figs. 14–15. *Venericardia (Cyclocardia) crebricostata* (Krause) × 1. left valve. Loc. no. 4. Nakanokawa formation, Pliocene.

Figs. 16–17. *Lucinoma annulatum* (Reeve) × 1.5. 16; right valve. 17; left valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 18. *Astarte (Tridonta) alaskensis* Dall × 1.5. right valve. Loc. no. 22. Chinkope formation, Pliocene.

Fig. 19. *Macoma (Macoma) incongrua* (v. Martens) × 1. left valve. Loc. no. 33. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Fig. 20. *Chlamys arakawai* (Nomura) × 1. left valve. Loc. no. 40. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Fig. 21. *Chlamys kumanodoensis* Masuda × 1. right valve. external surface, Loc. no. 40. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Fig. 22. *Chlamys kumanodoensis* Masuda × 1. right valve. Loc. no. 40. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Fig. 23. *Chlamys kumanodoensis* Masuda × 1. left valve. external surface. Loc. no. 40. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Fig. 24. *Chlamys cosibensis* (Yokoyama) × 1. right valve. Loc. no. 40. Kaigarabashi sandstone member of the Kunnui formation, Miocene.

Figs. 25–26. *Felaniella usta* (Gould) × 2. left valve, 25; internal surface, 26; external surface. Loc. no. 6. Nakanokawa formation, Pliocene.

Fig. 27. *Patinopecten tokyoensis* (Tokunaga) ×1.5. left valve. Loc. no. 1. Soibetsugawa formation, Pliocene.

Fig. 28. *Admete japonica lischkei* (Yokoyama) × 2. apertural view. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 29. *Astarte (Tridonta) borealis* (Schumacher) × 1. right valve. Loc. no. 4. Nakanokawa formation, Pliocene.

Figs. 30–31. *Acila (Truncacila) insignis* (Gould) × 2. right valve. 30; external surface, 31; internal surface. Loc. no. 6. Nakanokawa formation, Pliocene.

Fig. 32. *Eocylichna musashiensis* (Tokunaga) × 3. apertural view. Loc. no. 3. Nakanokawa formation, Pliocene.

Plate 7

Fig. 1. *Patinopecten tokunagai* (Yokoyama) × 2/3. left value. Loc. no. 27. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Fig. 2. *Amathina nobilis* (A. Adams) × 1.5. lateral view. Loc. no. 4. Nakanokawa formation, Pliocene.

Fig. 3. *Buccinum leucostoma* Lischke × 1. apertural view. Loc. no. 39. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Figs. 4–5. *Trophonopsis (Austrotrophon) candelabrum* Reeve × 1. 4; apertural view, 5; dorsal view. Loc. no. 39. Hanaishi conglomerate member of the Chinkope formation, Pliocene.

Fig. 6. *Saxidomus purpuratus* (Sowerby) × 1. left valve. Loc. no. 4. Chinkope formation, Pliocene.

Fig. 7. *Terebratalia gouldii* (Dall) × 2. dorsal view. Loc. no. 6. Nakanokawa formation, Pliocene.

Figs. 8–9. *Astarte (Tridonta) borealis* (Schumacher) × 1. left valve. Loc. no. 1. Soibetsugawa formation, Pliocene.

Fig. 10. *Patinopecten yessoensis* (Jay) × 2/3. right valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Figs. 11–12. *Liocyma fluctuosa* (Gould) × 1. right valve. Loc. no. 4. Chinkope formation, Pliocene.

Figs. 13–14. *Myadora proxima* (Smith) × 1.5. right valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 15. *Soletellina (Nuttallia) petri* (Bartsch) × 1. right valve. Loc. no. 3. Nakanokawa formation, Pliocene.

Figs. 16–17. *Turbo* sp. × 1. 16; apertural view, 17; dorsal view. Loc. no. 22. Chinkope formation, Pliocene.

Fig. 18. *Patinopecten tokyoensis* (Tokunaga) × 1.5. right valve. Loc. no. 1. Soibetsugawa formation, Pliocene.

Figs. 19–20. *Amathina nobilis* A. Adams × 3. 19; dorsal view, 20; lateral view. Loc. no. 3. Nakanokawa formation, Pliocene.

Fig. 21. *Patinopecten tokyoensis* (Tokunaga) × 1/2. right valve. Loc. no. 1. Soibetsugawa formation, Pliocene.

Figs. 22–23. *Macoma (Macoma) tokyoensis* Makiyama × 1. left valve. Loc. no. 4. Chinkope formation, Pliocene.

Plate 8

Fig. 1. Showing the alternation of the green tuff and the small scale alternation of gray coloured sandstone and gray coloured siltstone of the Kunnui formation, along the railway side cutting of the Setana line, about 4 km W of Kayano, Yamakoshigun.

Fig. 2. The crushed zone of the Shimo-Hakaimappu fault (the left side) cutting the Kuromatsunai formation, about 200 m NE of the Meppu Mine, Imagane-cho, Setana-gun.

Fig. 3. The cross-bedded coarse grained sandstone of the Kaigarabuchi conglomerate member of the Nakanokawa formation and the gravel bed of the lower terrace deposits (the uppermost part of the cliff) exposed along the Shubuto-gawa, 200 m W of Nakazato, Kuromatsunai-cho, Suttsu-gun.

Fig. 4. The clino-unconformity between the Kaigarabuchi conglomerate member of the Nakanokawa formation and the Garogawa andesitic agglomerate member of the Kuromatsunai formation observed at the cliff along the Warabitai-zawa, a small tributary of the Shamanbe-gawa, 500 m SW of the Warabitai railway station of the Hakodate main line, Kuromatsunai-cho, Suttsu-gun.

Fig. 5. The cliff showing the upper of the Yakumo formation. The alternation of gray coloured siltstone and small scale alternation of gray coloured siltstone and dark gray coloured shale. The cliff facing the Kami-Hakaimappu-gawa, about 1 km NNE of the Kita-Sumiyoshi railway station of the Setana line, Imagane-cho, Suttsu-gun.

Fig. 6. The cliff of the siltstone intercalating the thin layer of the coarse to medium grained sandstone of the Kuromatsunai formation, along the side of the Pirika-gawa 500 m SW of the Pirika railway station of the Setana line, Imagane-cho, Setana-gun.

Fig. 7. The Garogawa andesitic agglomerate member of the Kuromatsunai formation exposed along the road side about 4.5 km W of the Kuromatsunai railway station of the Hakodate

main line, Kuromatsunai-cho, Suttsu-gun.

Fig. 8. The Kaigarabuchi conglomerate member of the Nakanokawa formation exposed along the road side cliff, 600 m N of Neppu, Kuromatsunai-cho, Suttsu-gun.

Fig. 9. The Soibetsugawa formation exposed along the cliff of the Soibetsu-gawa, 600 m SW of the Nakanokawa railway station of the Suttsu line, Kuromatsunai-cho, Suttsu-gun.

Fig. 10. *Chlamys daishakaensis* Masuda and Sawada in the Kaigarabuchi conglomerate member of the Nakanokawa formation exposed along the river side cliff of the Soibetsu-gawa, 100 m SW of Kaigarabuchi, Kuromatsunai-cho, Suttsu-gun.

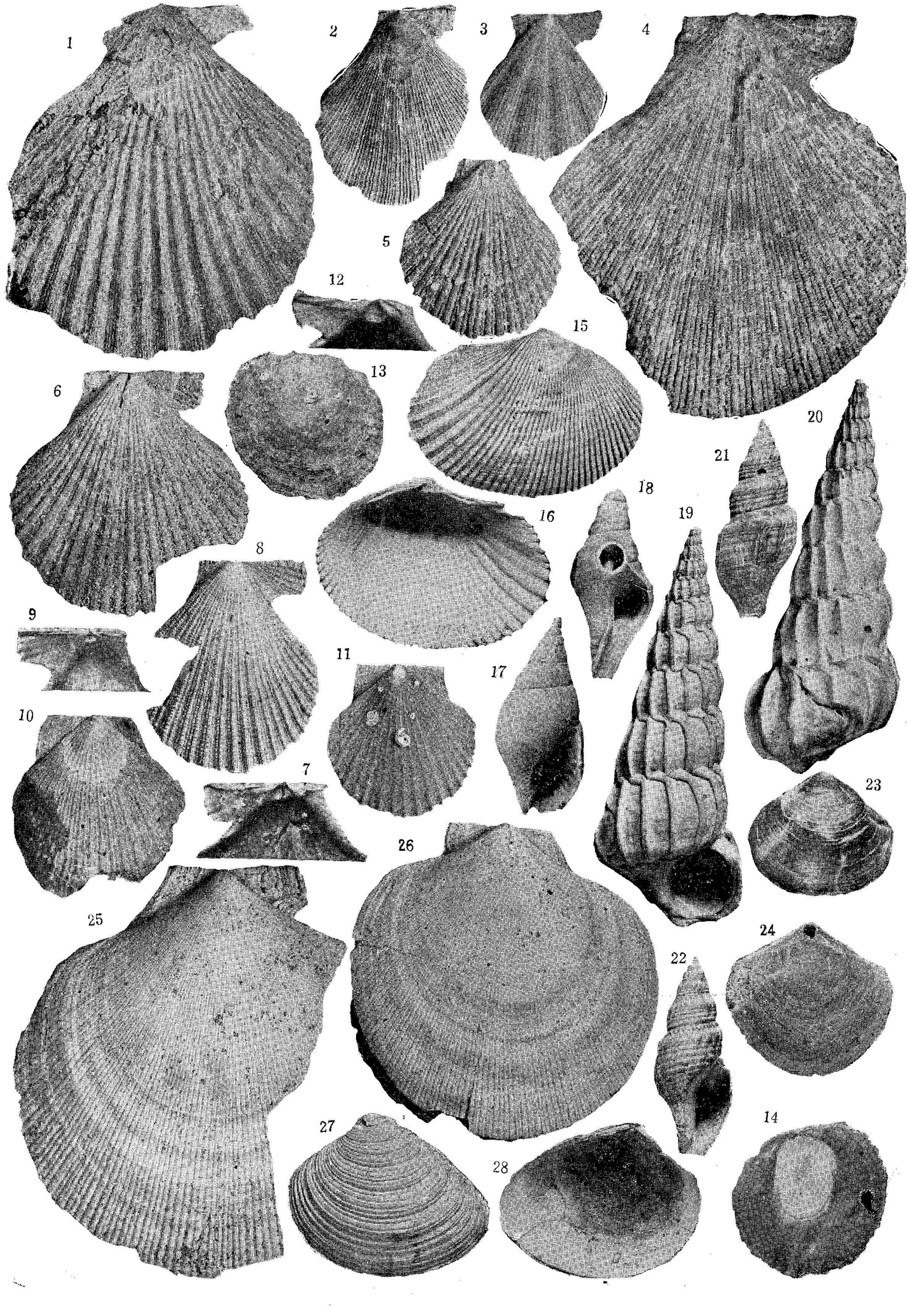
Fig. 11. The squeezed out structure preserved in the Kaigarabuchi conglomerate member of the Nakanokawa formation, exposed in the cliff of the Soibetsu-gawa, about 3.5 km SE of the Nakanokawa railway station of the Suttsu line, Kuromatsunai-cho, Suttsu-gun.

Fig. 12. The Hanaishi conglomerate member of the Chinkope formation exposed along the cliff of the Toshibetsu-gawa, 1 km SW of the Pirika railway station of the Setana line, Imagane-cho, Setana-gun.

Fig. 13. The same locality as shown in Fig. 9.

Fig. 14. The pectinid fossils in the Kaigarabashi sandstone member of the Kunnui formation exposed along the road side cutting, about 3.5 km upperstream of the junction of the Meppu-gawa, a tributary of the Toshibetsu-gawa, Meppu-kukaku, Imagane-cho, Setana-gun.

Fig. 15. The Kaigarabuchi conglomerate member of the Nakanokawa formation exposed along the cliff of the Shubuto-gawa, 500 m S of Nakazato, Kuromatsunai-cho, Suttsu-gun.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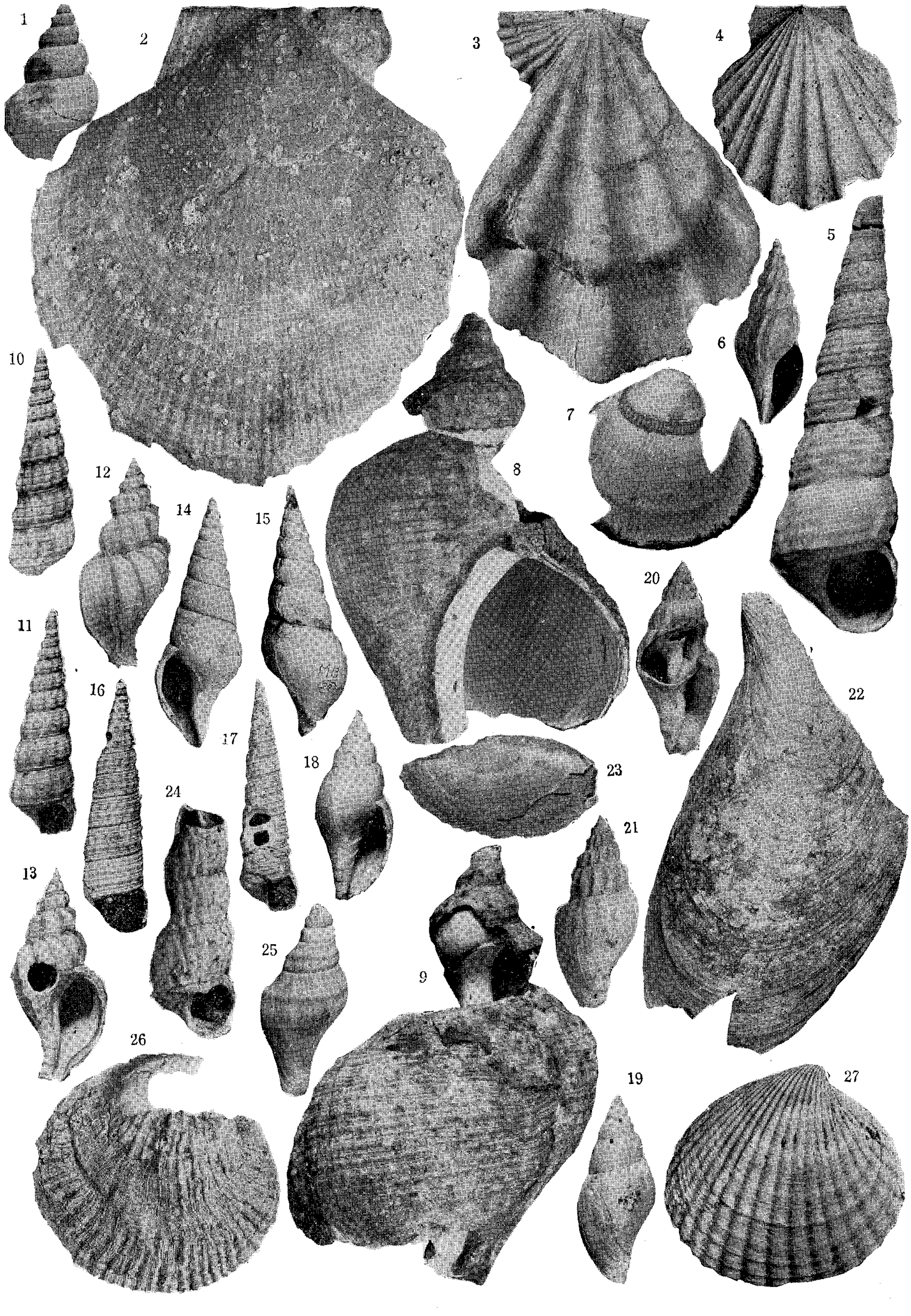
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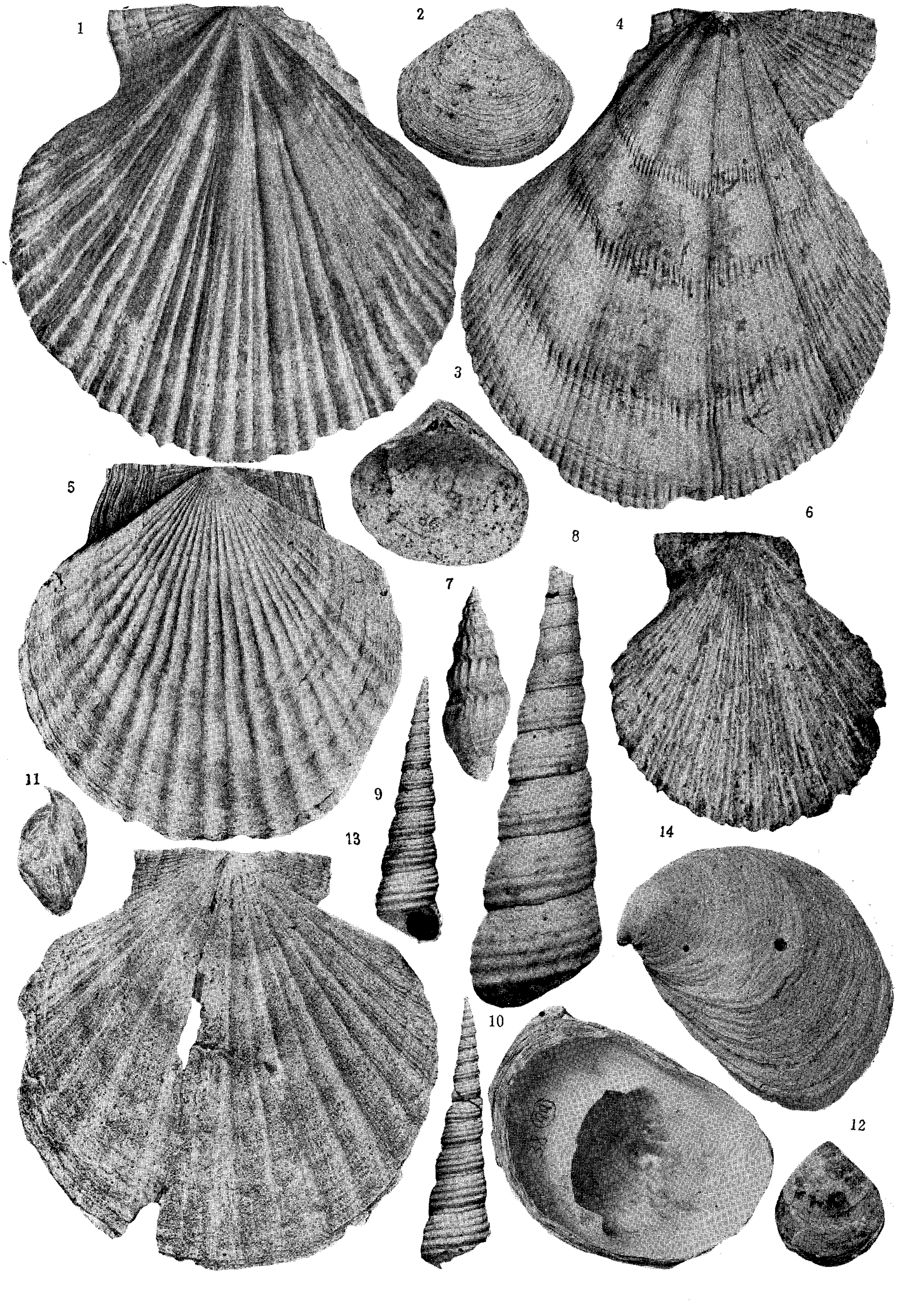
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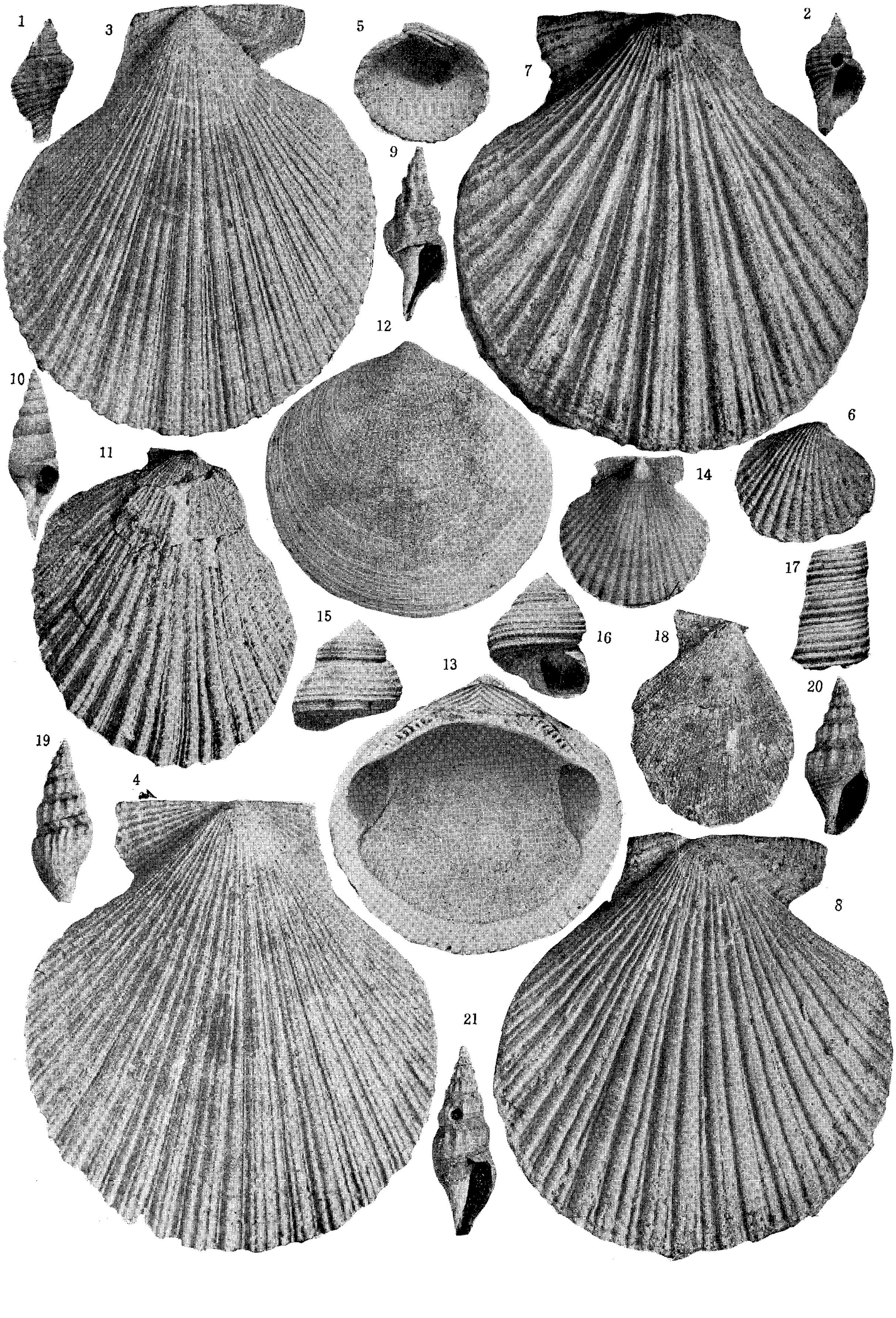

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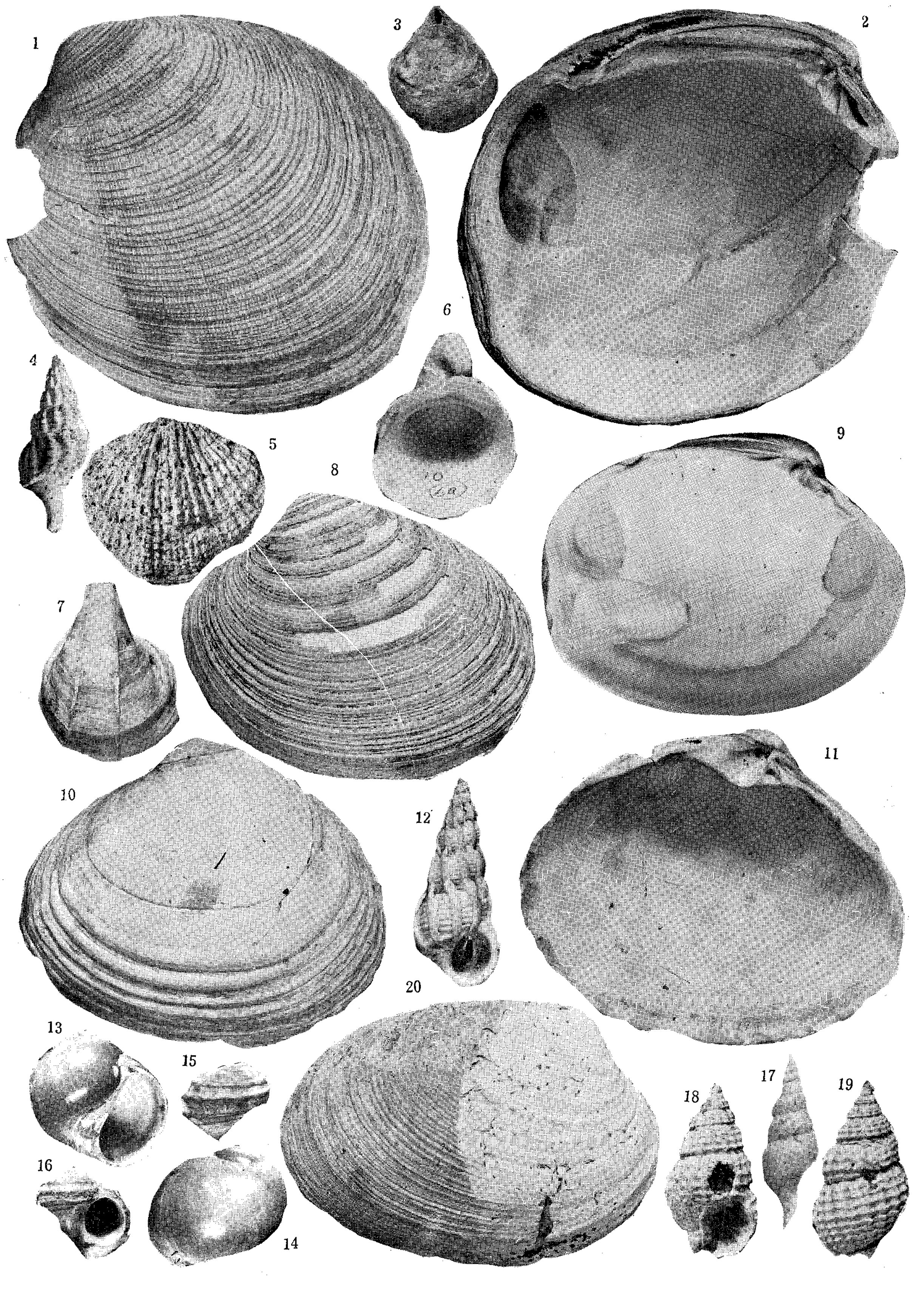
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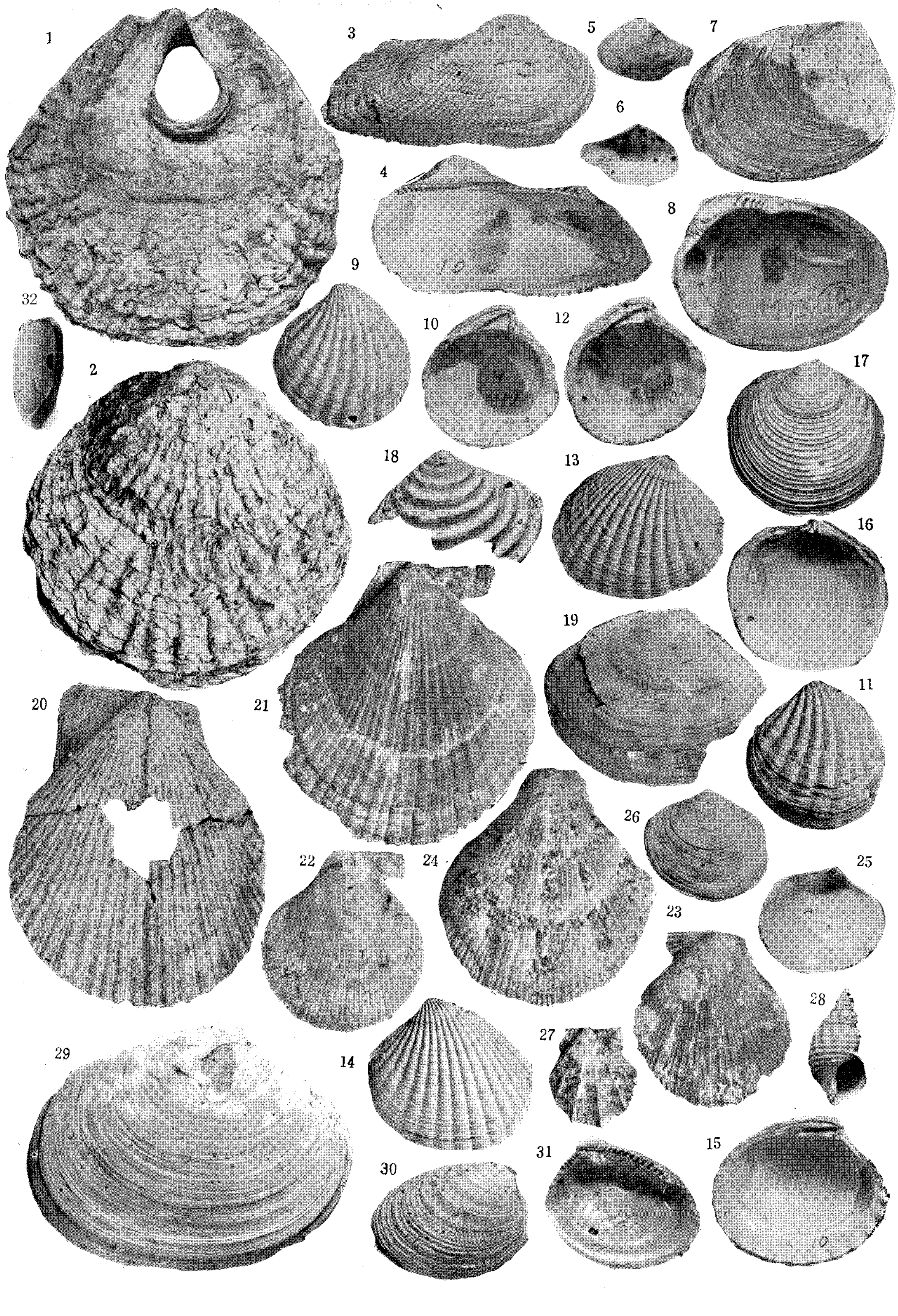
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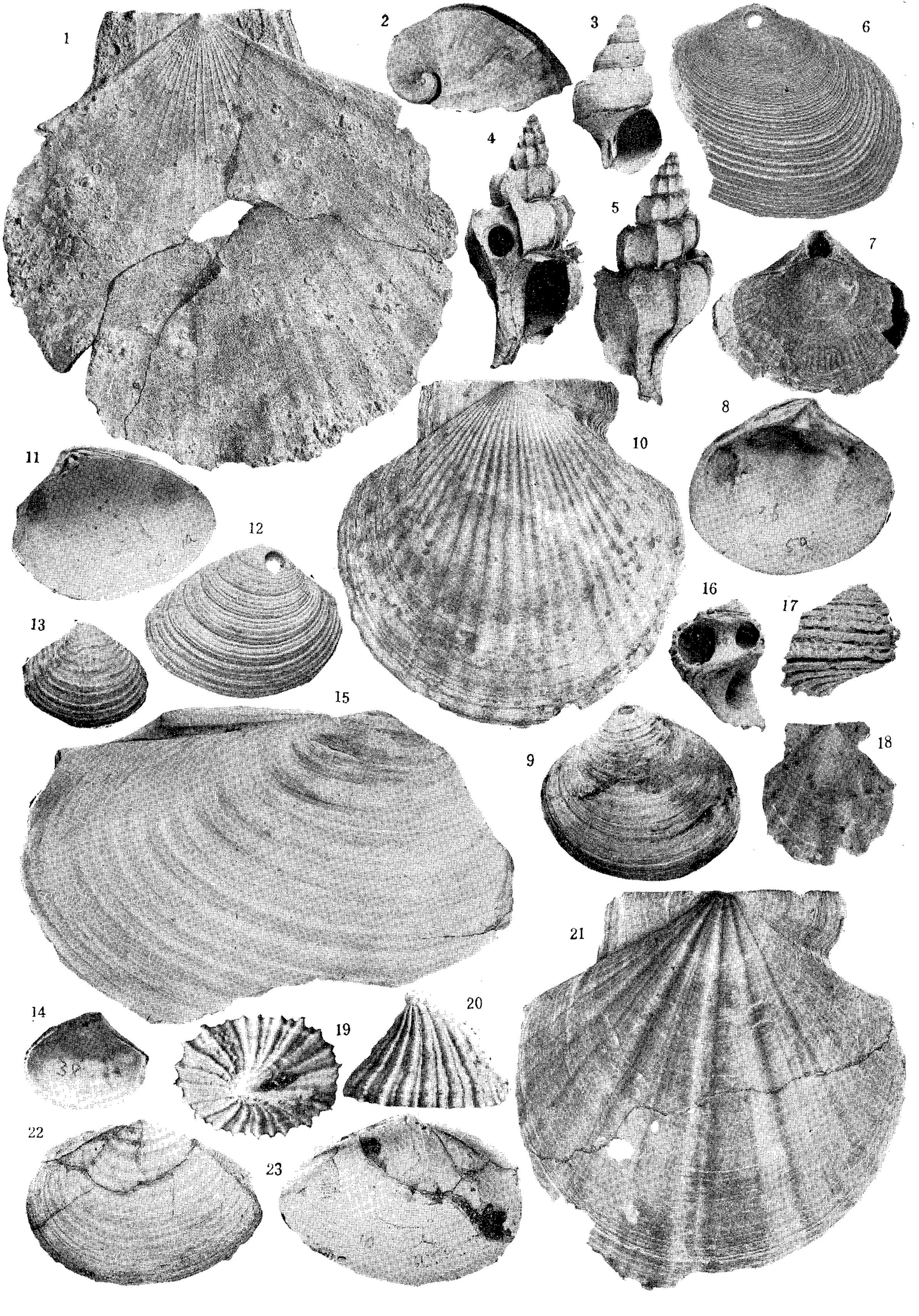
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