

A Study on the Miocene Molluscan Faunas of the Kitatsugaru and Nishitsugaru Districts, North Honshu

by
Atsuyuki Mizuno

Abstract

This paper deals with the problem of the Miocene molluscan faunal sequences in the Kitatsugaru and Nishitsugaru districts of north Honshu, and the special references are given to the chronologic situations of the Isomatsu formation of Kitatsugaru and the "Fukaura-" and "Kuroasaki formations" from the viewpoints of molluscan fossil faunas. The Isomatsu fauna largely consists of the Miocene species of inner bay or shallow sea bottom dwellers under warm climate, and its specific constituent suggests, together with the stratigraphic evidence, the attribution of the Isomatsu formation to the lower part of the so-called Daishima stage of the "Green tuff region" of Northeast Japan. The Fukaura fauna is considered to be synchronous with the Tanosawa fauna that is widely distributed in the so-called Nishikurosawa stage of the Nishitsugaru district. Lastly, the Kuroasaki fauna consists of rather cold type molluscan faunas: it is probably the representative of the fauna of the upper Miocene "Funakawa stage" in the Nishitsugaru district.

Introduction

The purpose of this paper is to clarify the faunal aspect of the Neogene Tertiary of Kitatsugaru, northern extremity of Honshu, Japan, particularly discussing the characters and chronologic situation of the so-called Isomatsu fauna comprised in the Tertiary, and also supplementarily discuss the chronologic

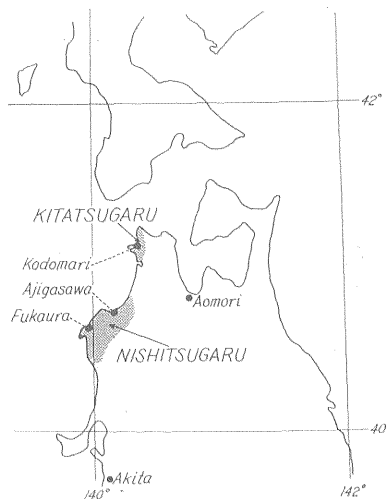


Fig. 1 Location map of the Kitatsugaru and Nishitsugaru districts

situation of the so-called Fukaura and Kurosaki faunas of Nishitsugaru.

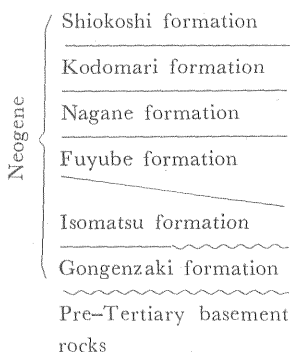
In the environs of Kodomari, facing to the Sea of Japan on the Tsugaru peninsula, the Tertiary deposits comprising thick Miocene altered pyroclastics are well developed as well as in other many areas of Northeast Honshu. The stratigraphy of them has been hitherto studied by many workers, but there yet remain some problems often discussed, particularly concerning the stratigraphic situation of the Isomatsu formation, a part of sequence. The Isomatsu formation yields some molluscan fossils. They were studied by NOMURA and HATAI (1936) and KOTAKA (1955) and were considered to be of upper Oligocene by them. While, IWASA (1962)'s recent study assigned the formation as the basal facies of the middle Miocene rocks, based upon his stratigraphic study on the Tsugaru Tertiary.

On the other hand, the geologic studies on the areas over the Tsugaru peninsula were performed about seven-eight years ago by many geologists of the Geological Survey of Japan. In that time, many fossil specimens from the Kitatsugaru Tertiary collected by them were awarded to the writer to be identified, when the materials led the writer to the view that the Isomatsu fauna is of Miocene, as shown in his preceding paper (MIZUNO, 1956).

Fortunately, the writer had a chance to visit the area for the field observation of those fossils, and also to visit the Nishitsugaru district, to study the so-called Fukaura fauna, which is yet unsettled in its chronologic situation whether it is of Miocene or of Pliocene. Some results of his studies on the faunas and related problems are presented here.

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Table 1 Stratigraphic sequence of the Kitatsugaru district (after TSUSHIMA and UEMURA, 1959 and OTA *et al.*, 1957)



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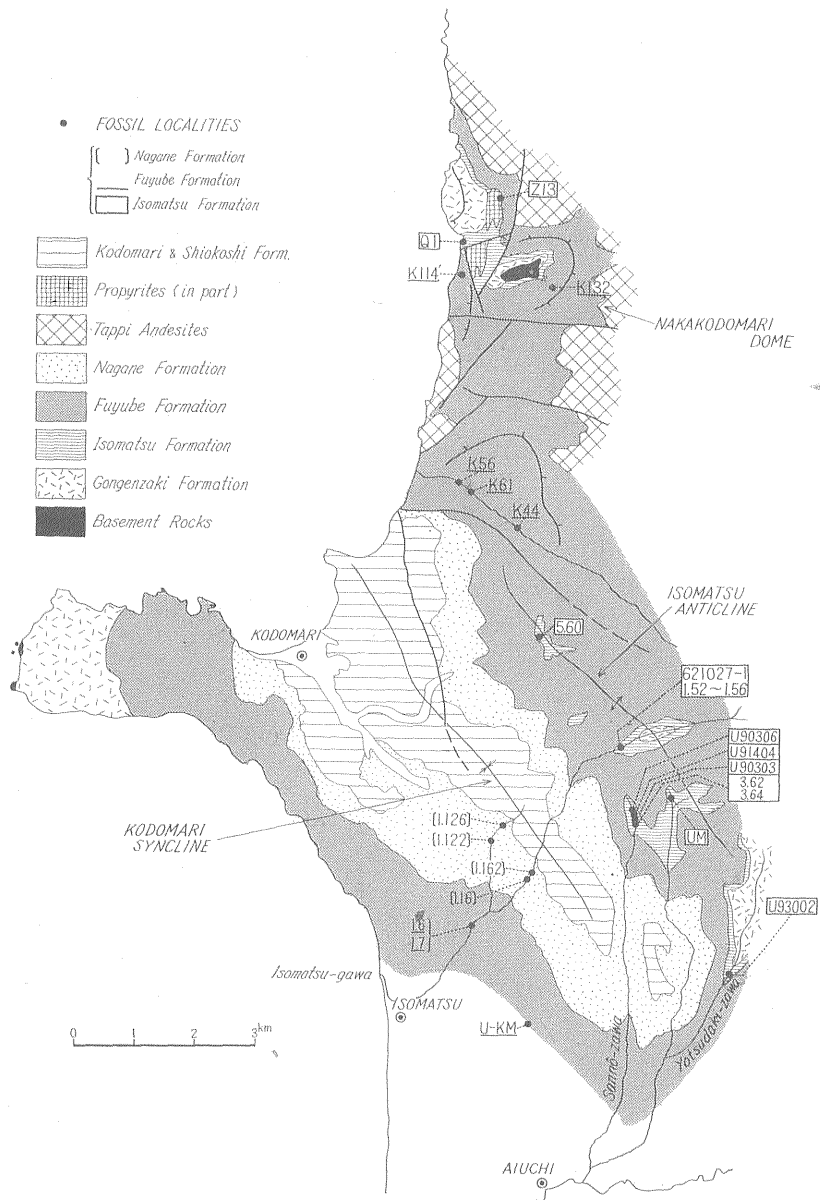


Fig. 2 Geological map of the Kitatsugaru district, showing the fossil localities (Geology: after TSUSHIMA and UEMURA, 1959 and OTA, *et al.*, 1957)

who permitted the writer to examine his materials from Kurosaki, Nishitsugaru district and also to publish its result.

Stratigraphy of the Kitatsugaru Tertiary

The distribution of Tertiary rocks which exhibit the sequence as shown in Tab. 1 is controlled mainly by the folding structure of Kodomari syncline, Isomatsu anticline and Nakakodomari dome, in the Kitatsugaru district (see Fig. 2).

In the western wing of the Kodomari syncline there is cropped out the Gongenzaki formation, the lowest division of the Kitatsugaru Tertiary, overlying the pre-Tertiary basement complex. It is superposed by the Fuyube, Nagane and Kodomari formations successively, and the Isomatsu formation is not recognizable there. On the other hand, at the axial part of the Isomatsu anticline running in parallel to the former syncline, the Isomatsu formation is discriminated between

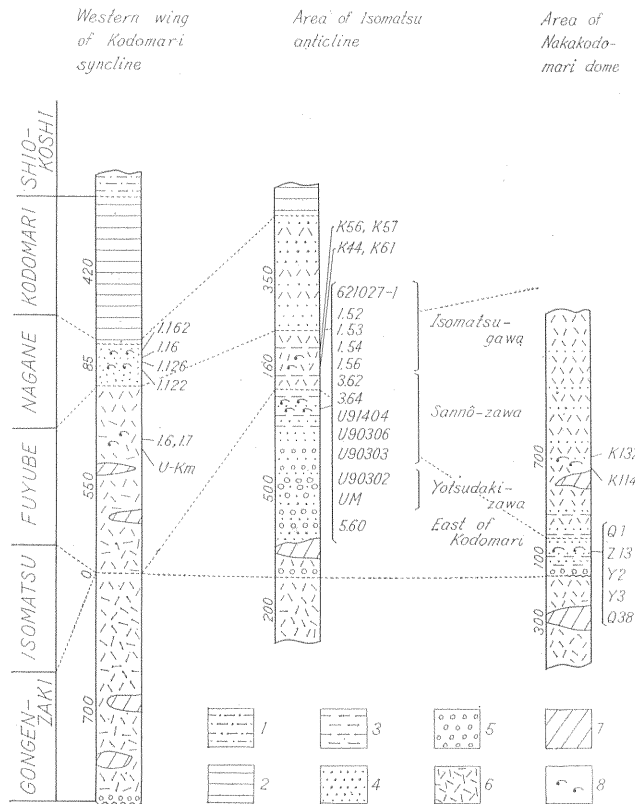


Fig. 3 Idealized columnar sections showing fossil occurrences

1. mainly diatomaceous mudstone
2. mainly hard shale
3. mudstone and shale
4. sandstone
5. conglomerate
6. pyroclastics
7. lava flow
8. fossil occurrences

the Gongenzaki and Fuyube formations, as well as at the Nakakodomari dome area.

The lithology of the Tertiary rocks is summarized as follows, according to TSUSHIMA and UEMURA (1959) and OTA *et al.* (1957), although each formation exhibits a considerable variation in litho-facies and thickness in a different column as shown in Fig. 3.

The *Gongenzaki formation* is composed mainly of purplish green coloured tuffaceous rocks, and besides, of propylite, and yields rarely the plant fossils such as *Fagus* sp. and *Quercus* sp.

The *Isomatsu formation* only distributed in the areas of Isomatsu anticline and Nakakodomari dome, is mainly composed of various clastic sediments of conglomerate, sandstone and mudstone, partly yielding many molluscan fossils largely of shallow marine, which are described in this report. The formation bears also some beds of tuff and propylite.

The *Fuyube formation* largely consists of green coloured various pyroclastic sediments of andesite origin, and partly occupied by small amounts of sandstone and mudstone beds. It rarely yields molluscan fossils. According to the previous works, the Fuyube is regarded to be partly interfingered with the Isomatsu.

The *Nagane formation* is mainly composed of green coloured marine sandstone constituted by various volcanic fine-grained materials, and yields many marine molluscan fossils here and there.

The *Kodomari* and *Shiokoshi formations*, occupying the upper part of the Tertiary sequence are composed of the so-called hard shale and diatomaceous shale respectively, and those yield hardly mega-fossil.

Molluscan Faunas

In the present article, the molluscan faunas of the Isomatsu, Fuyube and Nagane formations are described and discussed. Their localities of occurrence and stratigraphic situation are given in Figs. 2 and 3.

Isomatsu fauna The materials from eighteen stations were available to the writer. The stations agree with some of NOMURA & HATAI (1936) and KOTAKA (1955)'s in part. The total species from them number forty-four, as shown in Tab.2, and among those species five have been already described from the Isomatsu formation by the previous authors.

The fossils are crowded generally in massive fine- to very fine-grained sandstone or medium-grained sandstone in the upper part of the Isomatsu columns at the areas of Isomatsu anticline and Nakakodomari dome areas. The most widely distributed form is occupied by *Littorinopsis*, *Crassostrea* and *Nipponomarcia* which are richly yielded at more than five stations, and among them the latter

Table 2 Molluscan fossils from the Isomatsu formation

Station and litho-facies																			
	fss	fss	fss	vfss	fss	fss	vfss	mss	fss	mss	mss	fss	fss	sdv tf	mss	cgl	f-mss	f-mss	
Specific name	27-1	L. 52	L. 53	L. 54	L. 56	5. 60	Q. 1	1. 66	Y. 2	Y. 3	Q38	Z13	UM	U04	U02	U03	3. 64	3. 63	3. 62
GASTROPODA																			
<i>Littorinopsis</i> sp. nov.	●	×					●			×			×						
" <i>Turritella</i> " sp.				×	×		×							×					
<i>Cerithidea kanpokuensis</i> MAKIYAMA	×																		
<i>Batillaria tateiwai</i> MAKIYAMA	×																		
<i>B. yamanarii</i> MAKIYAMA	●	×	●		×														
<i>Vicaryella tyosenica otukai</i> (NOMURA)	●	×					○												
<i>V. ancisa</i> (YOKOYAMA)							×						×						
<i>Crepidula isimotoi</i> OTUKA	×													×	×				
<i>C. jimboana</i> YOKOYAMA														×	×				
<i>Sinum yabei</i> OTUKA							×												
<i>Searlesya kurodai</i> MAKIYAMA							×												
<i>Truncaria nakamurai</i> OTUKA		×																	
<i>Rhizophorimurex tiganouranus</i> (NOMURA)													×						
<i>Nassarius</i> sp.							×												
<i>N. simizui</i> OTUKA	×																		
<i>Fulgoraria</i> sp.															×				
SCAPHOPODA																			
<i>Dentalium</i> sp.																			×
PELECYPODA																			
<i>Acila</i> sp.	×																		
<i>Yoldia</i> sp.																			×
<i>Mytilus k-sakurai</i> NOMURA et HATAI																			×
<i>Modiolus tugaruana</i> NOMURA et HATAI																		×	×
<i>Patinopecten kobiyamai</i> KAMADA																		×	●
<i>Nanaochlamys notoensis</i> (YOKOYAMA)						×												×	●
<i>N. Kitamurai</i> (KOTAKA)							○								×				
<i>Crassostrea takiana</i> (YOKOYAMA)	×	●	×	*			●		×	●	●					×	×		×
<i>Trapezium isomatsuense</i> KOTAKA	×	○	×	*															
<i>Venericardia siogamensis</i> NOMURA	×																		
<i>V. cf. orbica</i> YOKOYAMA																			×
<i>Diplodonta ferruginata</i> MAKIYAMA							×						×						
<i>Lucinoma otukai</i> HATAI et NISIYAMA							×												×
<i>Clinocardium</i> sp.	×						×							×	×				
<i>Callista</i> sp.	×																		
<i>Protothaca tateiwai</i> MAKIYAMA	●	×																	
<i>Saxidomus</i> ? sp.									×					×					
<i>Dosinia nomurai</i> OTUKA								×		×									
<i>Cyclina lunulata</i> MAKIYAMA		○	×	*				×		×									
<i>Pitar aiutiensis</i> (NOMURA et HATAI)		○	○	*															
<i>Nipponomarsia nakamurai</i> (IKEBE)							×	●	○				●						×
<i>Tapes siratoriensis</i> OTUKA	○	×												×					
<i>Soletellina minoensis</i> YOKOYAMA	○	×				×								×					
<i>Nuttalia</i> ? sp.	×													×	×				
<i>Macoma</i> cf. <i>incongrua</i> (v. MARTENS)	×													×	×				
<i>Arcopagia</i> ? sp.	○	×																	
<i>Solen</i> sp.	○		×																

Abbreviations :

Station numbers

- 27.1. 621027-1
- U 04 U91404
- U 02 U93002
- U 03 U90303

Litho-facies

- fss fine-grained sandstone
- vfss very fine-grained sandstone
- mss medium-grained sandstone
- cgl conglomeratic
- sdv sandy

* conjoined valves

● abundant

○ common

×

rare

Table 3 Molluscan fossils reported by the previous authors from
the Isomatsu formation

Molluscan fossils reported by NOMURA and HATAI
(1936) from the middle course of Komata-zawa

- Turritella* sp.
* *Mytilus k-sakurai* NOMURA et HATAI
M. sp.
* *Volsella tugaruana* NOMURA et HATAI
* *Cardium (Clinocardium) mutuense* NOMURA et HATAI
* *Liocyma aomori* NOMURA et HATAI
* *Clementia aiutiensis* NOMURA et HATAI
* *Macoma* sp.
Venericardia subnipponica NAGAO

Molluscan fossils reported by KOTAKA (1955)
from the upper course of Komata-zawa, upper course of
Isomatsu-gawa, vicinity of Osore-zawa and northern
coast of Yokodomari, shown by symbols 1, 2, 3 and 4
in this table respectively.

<i>Turritella</i> cfr. <i>Karatsuensis</i> NAGAO	1		
* <i>Cerithium hanzawai</i> KOTAKA			3
<i>Trochocerithium</i> sp.			3
* <i>Crepidula hataiana</i> KOTAKA	1	2	
<i>Volsella tugaruana</i> NOMURA et HATAI	1		
* <i>Chlamys kitamurai</i> KOTAKA			3
* <i>Lima</i> cfr. <i>oakvillensis</i> CLARK			4
<i>Ostrea</i> sp.		2	3
* <i>Trapezium isomatsuense</i> KOTAKA		2	
* <i>Cardium</i> sp.	1	2	
<i>Pitar aiutiensis</i> (NOMURA et HATAI)	1		3
<i>Dosinia</i> sp.	1		
Cfr. <i>Siratoria</i> sp.		2	
<i>Fabulina</i> sp.		2	
<i>Macoma twinensis</i> CLARK		2	
* <i>Caryocorbula saikawai</i> KOTAKA	1	2	3

* Shows the figured species in the respective papers.

two are often found as many conjoined valves, probably showing their autochthonous occurrences. Followed to the three forms, such species as *Soletellina*, *Trapezium*, *Clinocardium*, *Cyclina*, *Batillaria*, *Vicaryella* and "*Turritella*" are rather abundantly yielded in three or four stations. *Protothaca*, *Pitar* and *Patinopecten* are found only in one or two stations though rather richly. From the viewpoint of the constituent of faunule, an assemblage is, in most cases, composed of the genera as cited above, while those of some stations (Sts. 3.63 and 3.62) is represented by *Yoldia*, *Mytilus*, *Modiolus*, *Venericardia* cfr. *orbica*, *Lucinoma* etc.

Table 4 Molluscan fossils from the Fuyube formation

	1.6	U-km	1.7	K61	K57	K44	K56	K114'	K132
GASTROPODA									
<i>Ampullina</i> ? sp.					×				
<i>Sinum hataiana</i> (KOTAKA)							×?		
<i>Crepidula jimboana</i> YOKOYAMA							○		
<i>Ancistrolepis</i> sp.				×					
PELECYPODA									
<i>Acila</i> cfr. <i>eximia</i> (YOKOYAMA)							×*		
<i>Nuculana pennula</i> (YOKOYAMA)							×*		
<i>Mytilus</i> sp.		×							
<i>Modiolus</i> cfr. <i>tugaruana</i> NOMURA et HATAI							×		
<i>Brachidontes</i> sp.								×	
<i>Lima</i> cfr. <i>smithi</i> SOWERBY								×	
<i>Chlamys</i> sp.									×
<i>C.</i> cfr. <i>arakawai</i> NOMURA				×					
<i>Patinopecten yamasakii iwasakiensis</i> (NOMURA)			●						
<i>Ostrea</i> "rosacea" DESHAYES			×						
<i>Venericardia siogamensis</i> NOMURA		×							
<i>V.</i> sp.						×			
<i>Dosinia nomurai</i> OTUKA			×						
<i>Pitar itoi</i> MAKIYAMA		×							
<i>P.</i> sp.		×							
<i>Nipponomarcia nakamurai</i> (IKEBE)			●						
<i>Macoma calcarea</i> (GMELIN)	○*			×					
<i>Macoma</i> cfr. <i>tokyoensis</i> MAKIYAMA		×							
<i>Solen</i> sp.		×							

Remarks: * Conjoined valves. ● abundant. ○ common. × rare
Lithofacies:

- 1.6 : tuffaceous sandy siltstone
- U-km : green-coloured tuffaceous fine-grained sandstone
- 1.7 : green-coloured conglomeratic very coarse-grained sandstone
- K61 : sandy siltstone
- K57 : tuffaceous silty very fine-grained sandstone
- K44 : Ditto
- K56 : Ditto
- K114' : sandy siltstone
- K132 : tuffaceous very coarse-grained sandstone

Fuyube fauna From the Fuyube formation, the twenty-three species shown in Tab. 4 were discriminated in the materials from nine stations. The faunule of fine-grained clastic-facies is represented by *Ampullina*, *Crepidula*, *Acila*, *Nuculana*, *Modiolus*, *Lima*, *Macoma calcarea* etc., thus more or less resembling to that of a part of the Isomatsu. That of coarse-grained clastic facies is, however, composed of *Patinopecten*, *chlamys* etc. (St. 1.7), which is commonly yielded in the Nagane fauna. Another association is found in fine-grained sandstone facies of the Fuyube: it is represented by the faunule predominant in *Nipponomarcia*, accompanied by *Pitar*, *Crepidula* etc., thus showing some similarities to the Isomatsu fauna.

Table 5 Molluscan fossils from the Nagane formation

	1. 29	1. 162	1. 16	1. 126	1. 222	1. 128
GASTROPODA						
<i>Calyptraea</i> sp.		×		×		
<i>Euspira meisensis</i> (MAKIYAMA)					○	
<i>Shichiheia yabei</i> (NOMURA et HATAI)						×
PELECYPODA						
<i>Glycymeris vestitoides</i> NOMURA		×				
<i>G. cisshuensis</i> MAKIYAMA				×	○	
<i>Arca</i> sp.					×	
<i>Pinna</i> ? sp.				×		
<i>Anomia</i> ? sp.			×			
<i>Chlamys</i> cfr. <i>kaneharai</i> (YOKOYAMA)	×					
<i>C.</i> cfr. <i>arakawai</i> (NOMURA)				×		
<i>Patinopecten yamasakii iwasakiensis</i> (NOMURA) ..			○	○	×	
<i>Ostrea</i> "rosacea" DESHAYES"			×			
<i>Lucinoma otukai</i> HATAI et NISIYAMA						×
<i>Pitar itoi</i> (MAKIYAMA)				○		
<i>Dosinia nomurai</i> OTUKA		×	×	×	×	
<i>Cyclina lunulata</i> MAKIYAMA		×		×		
<i>C.</i> ? sp.					×	
<i>Clementia</i> ? sp.		×				
<i>Tapes siratoriensis</i> OTUKA		×		×	×	
<i>Soletellina minoensis</i> YOKOYAMA				×	×	
<i>Spisula</i> sp.			×	×	×	
<i>Thracia</i> sp.			×			
<i>Macoma</i> sp.						×

○ common, × rare

Remarks: A litho-facies at each station is shown by green-coloured conglomeratic very coarse-grained sandstone including more or less molluscan fossils among which pelecypod valves are ajoined, except St. 1. 128 where conjoined valves of *Lucinoma* are yielded tuffaceous whitish gray medium-grained sandstone.

Nagane fauna Twenty-three species presented in Tab. 5 were found in the materials mostly of green-coloured very coarse-grained sandstone from six stations. Except that *Lucinoma*, *Shichiheia* etc. are yielded in medium-grained sandstone (St. 1.128), *Glycymeris*, *Patinopecten* and *Dosinia* are abundantly crowded in the very coarse-grained sandstone.

Remarks on Some Species

The brief notes are given here on some interesting species of the Isomatsu, and Fuyube faunas.

Iittorinopsis sp. nov. pl. 1, figs. 4, 5.

Many specimens were collected from five stations in the Isomatsu formation: they are very ill-preserved as moulds and casts in most cases. This form probably

represents the new species of the genus *Littorinopsis*, but its formal description will be given in future after obtaining well-preserved specimens.

This new species is characterized by small, conic shell with about five whorls. Body whorl is very large, much inflated than the other whorls, and somewhat shouldered; it is sculptured by many spiral cords, regularly arranged on the surface. The other whorls are ornamented with about seven-eight spiral cords, few of which are remarkable on the middle portion of more or less convex each whorl. These features that characterize the species are well shown in the specimen figured in fig. 5 of pl. 1, and they distinguish it from the known species of Japanese Miocene *Littorinopsis*; that is, *L. miodelicatula* OYAMA (OYAMA, 1950, p. 8, pl. 1, figs. 2, 3) has less convex whorls and more slender shape than the present species.

Dimensions : The specimen figured in fig. 5 of pl. 1 attains about 16.0mm+ in height and about 14mm in width of body whorl.

Occurrences : Only Isomatsu formation. St. 621027-1 (abundant), St. Q1 (abundant), St. 1.52 (rare), St. Y3 (rare), St. UM (rare).

Vicaryella tyosenica otukai (NOMURA) pl. 1, figs. 8-10; (?) pl. 4, fig. 5.

The potamidid species first cited as "*Proclava*" aff. *ishiihana* (YOKOYAMA) by OTUKA (1934, p.624, pl. 49, figs. 72, 73) was named *Cerithium (Proclava) otukai* by NOMURA (1935, p. 227), based on OTUKA's Nisatai specimen. KAMADA's recent study clarified the attribution of the Nisatai specimen to *Vicaryella*, and he cited it as *Vicaryella tyosenica otukai* (NOMURA) (KAMADA, 1960, p. 281, pl. 31, figs. 3a, b).

Some of the Isomatsu specimens are clearly identified to the above-said Nisatai specimen from the characteristics of shell, and the representative of them is figured in pl. 1, fig. 8 of this paper. As shown there, it is characterized in having ornamentation of each whorl, which is shown by three spiral cords and four-six spiral striae generally arranged in alternation, all of them being finely granulated : moreover some whorls of adult stage have distinct one row of sub-sutural tubercles; these tubercles can not be found in younger whorls and in some other specimens even in the adult whorls any distinct tubercles are invisible. The figs. 9, 10 of pl. 1 show rather small specimens of no distinct tubercle on the whole whorls, probably in order that their growth was not enough to attain any tubercles.

In relation to the matters mentioned above, a problem is given on the validity of *Cerithium hanzawai* KOTAKA. It was established by KOTAKA (1955, p. 28, pl. 2, fig. 3) with the following description, based upon the single specimen from the Isomatsu formation in the vicinity of Osoreishi, Kodomari-mura.

"Shell moderate in size, turreted, more than ten whorls preserved, whorls more or less flattened, and separated by sharp defined sutures without sutural bands. Surface sculpture consists of three prominent spiral beaded cords, which

are much broader than narrow interspaces, and two or three (on body-whorl) weakly beaded interstitial striae, younger whorl with only prominent beaded cords, while on adult- and body-whorl beaded striae developed in interspaces between prominent beaded cords. Base of body-whorl rather flat, covered with four spiral striae, aperture uncertain. Columella rather long with two columellar folds". And moreover, he stated "The sculpture of the whorls strongly recalls the genus *Cerithiopsis* but the columella with two folds does not permit its inclusion in that genus. In the shape of the columella the present specimens resemble the named genus, but the two strong folds reserve doubt. This may represent a new genus standing between *Cerithium* and *Cerithiopsis*."

However, as shown in fig. 5 of pl. 4 of the present paper, its holotype specimen closely resembles those of no tubercle before mentioned in spiral ornamentation, although the granules on the spiral cords and striae seem to be somewhat coarser than the writer's most specimens. This fact, together with that there are found somewhat coarsely granulated specimens in the writer's hand too, leads the writer to his tentative conclusion that *Cerithium hanzawai* is not valid, and is probably conspecific with *Vicaryella tyosenica otukai* in question, though the final conclusion should be given after the careful studies on many specimens of "*Cerithium hanzawai*."

Dimensions : The specimens figured in pl. 1, figs. 8, 9 and 10 roughly exhibit the height of 42mm, 26mm and 26.5mm+ respectively.

Occurrences : Only Isomatsu formation; St. 621027-1 (abundant), St. Q1 (common), St. 1. 52 (rare).

Nipponomarcia nakamurai (IKEBE) pl. 3, figs. 2-6.

The most parts of tapetinid fossils from Isomatsu and Fuyube, excluding those surely identified *Tapes sicatoriensis* OTUKA (pl. 3, fig. 1 in this paper) from its characteristics of peculiar surface ornamentation, probably belong to *Nipponomarcia nakamurai* (IKEBE) (IKEBE, 1941, p. 1, pl. 2, figs. 1-8) originally attributed to *Katelysia*, in their characteristics of outline of shell, hinge and pallial sinus.

A somewhat similar form was formerly reported by NOMURA and HATAI (1936, p. 280, pl. 33, fig. 7) as *Liocyma aomori* n. sp. from the middle course of Komatazawa, and it may be possibly conspecific with the present species of *Nipponomarcia*, although the ill-preservation of type specimen of the former refuse the final conclusion.

Nipponomarcia nakamurai has been hitherto known only from the Miocene of Setouchi province, Southwestern Japan. But recently KAMADA (1962, p. 118, pl. 13, figs. 10-12) clarified its new occurrence from the basal part of Miocene in the Joban coal field. It is interesting for its geographic distribution that the species is also found in the Kitatsugaru district far north of the coal field.

Occurrences: Very abundant from six stations in Isomatsu formation, often much crowded, and also partly abundant in one station in the Fuyube.

Discussion on Faunas

On the molluscan faunas of the Kitatsugaru Tertiary, the three types of assemblages are recognizable from the viewpoint of their occurrences, as shown

Table 6 Three types of assemblage

I	{	<p>* <i>Littorinopsis</i>, <i>Batillaria</i>, <i>Vicaryella</i>, <i>Crassostrea</i>, <i>Clinocardium</i>, <i>Nipponomarcia</i>, <i>Soletellina</i></p> <p>** "Turritella", <i>Crepidula</i>, <i>Rhizophorimurex</i>, <i>Nanaochlamys</i>, <i>Trapezium</i>, <i>Venericardia</i>, <i>Diplodonta</i>, Pitarinae, Dosiniinae</p>
II	{	<p><i>Crepidula</i>, <i>Ancistrolepis</i>, <i>Acila</i>, <i>Nuculana</i>, <i>Mytilidae</i>, <i>Lima</i>, <i>Venericardia</i>, <i>Macoma</i>, <i>Lucinoma</i></p>
III	{	<p><i>Glycymeris</i>, <i>Patinopecten</i>, <i>Dosinia</i>, <i>Tapes</i>, <i>Spisula</i>, <i>Euspira</i>, <i>Chlamys</i>, <i>Pitar</i>, <i>Cyclina</i>, <i>Soletellina</i></p>

In the assemblage type I * shows the prevailing genera, and
** shows the associated genera.

in Tab. 6, though they may be possibly a mixed assemblage of allochthonous occurrence in most cases as a result that an original assemblage was destroyed by works of sorting and transportation in the time of sedimentation.

Assemblage type I. This type is represented by a large part of faunules of the Isomatsu formation, and also by a part of those of the Fuyube formation. It is abundantly shown by the genera, *Littorinopsis*, *Batillaria*, *Vicaryella*, *Crassostrea*, *Clinocardium*, *Nipponomarcia* and *Soletellina*, and is associated with "Turritella", *Crepidula*, *Trapezium* and others. Such an assemblage seems to be of littoral zone in the estuary or lagoon and upper neritic zone, and roughly agrees in the constituent with the *Cyclina japonica* - *Soletellina minoensis* assemblage and *Dosinia nomurai* - *Diplodonta ferruginata* - *Siratoria siratoriensis* assemblage of the lower Shiratorigawan stage by AOKI (1960). The particular resemblance is found between the present assemblage and the faunas of the Yotsuyaku formation and the lower part of Kadonosawa formation, both in the Kitakami district, North Honshu. According to CHINZEI (1958), the Yotsuyaku formation, the basal part of the Miocene sequence of the district, partly yields such a fauna represented by *Katylisia* sp., *Vicaryella tyosenica otukai*, *Crepidula* cfr. *jimboana*, *Batillaria yamanarii*, *Dosinia* cfr. *japonica*, *Clinocardium shinjiense* etc. Thus, this assemblage is closely similar to a part of that of type I here designated. Moreover, the fauna of the Tate member of the Kadonosawa formation, reported by him, lying conformably the preceding formation, is more or less similar to the type I. Also,

a part of the so-called Kurosedani fauna of the Hokuriku Miocene (TSUDA, 1960) seems to be represented in the assemblage type I. There are found many common species between this assemblage and particularly "assemblage I" of Kurosedani which is considered to be the fauna strongly influenced by a brackish water.

Assemblage type II. The present type is mainly found in the rather fine-grained clastic facies of Fuyube formation, but this is also represented by some faunules of Isomatsu (Sts. 3.62 and 3.63) and Nagane (St. 1.128). It characterizes the faunules of very fine-grained sandstone to sandy siltstone throughout the three formations, and consists of rather deep water and cold water type of open sea.

Assemblage type III. This type is nearly exclusively found in the rather coarse-grained clastic facies of Nagane formation, but is also rarely comprised in the similar facies of Fuyube (St. 1.7). It is characterized by the pectinid fossils particularly abundantly represented by *Patinopecten yamasakii iwasakiensis*. Besides it, *Glycymeris*, *Dosinia*, *Tapes* and *Spisula* are also rather richly represented there. The fauna of this type, which is considered to be of shallow neritic bottom influenced by a warm current, is commonly known from the so-called Nishikurosawa stage in the "Green tuff region". Roughly it agrees with the Tanosawa fauna of the Nishitsugaru district that will be later accounted in the present article.

The stratigraphic distributions of the above-mentioned three assemblages are summarized as shown in Tab. 7. The table suggests that a prevailing assemblage was successively changed from the Isomatsu to Nagane time, though two or three assemblage types coexisted in each time. This was probably caused by the more or less progressive changes of prevailing sedimentary environment through the time from Inner bay near a mouth of river at Isomatsu time to open sea at Nagane.

Next, the chronological correlation of the faunal sequence in the Kitatsugaru district and others is discussed.

Throughout the so-called Green tuff region of Northeast Honshu, there are found a rather regular stratigraphic, lithologic or paleontologic sequence in the Neogene rocks, although it considerably varies locally. Based upon this fact, the

Table 7 Stratigraphic occurrences of three assemblages

Formation	Assemblage		
	I	II	III
Nagane formation		○	●
Fuyube formation	○	●	○
Isomatsu formation	●	○	

●.....Representative assemblage type in the respective formation

Tertiary sequence is usually divided into the following stages, in ascending order : Monzen, Daishima, Nishikurosawa, Onnagawa, Funakawa, Kitaura, Wakimoto etc. Among them, the sequence from Monzen to Onnagawa is generally assigned to lower - middle Miocene, that of Funakawa - Kitaura is to upper Miocene and the Wakimoto is to Pliocene. In the columns of the Kitatsugaru Tertiary, the stratigraphic and lithologic characteristics of each formation enable us the rough correlations of the Shiokoshi - Kitaura, both of which mainly consist of diatomaceous shale, the Kodomari - Onnagawa and Funakawa, both being prevailed by hard shale and black shale, and the Nagane - Nishikurosawa; the last two are characterized by rather coarse-grained sediments, conformably lying below the fine-grained clastic sediments mentioned above.

The molluscan fossils of Nagane seem to support these correlative relationships, particularly on the Nagane - Nishikurosawa correlation. The Fuyube formation of Kitatsugaru is roughly correlated with the Daishima stage in the respect that the both are almost occupied by pyroclastics often intercalating fossiliferous clastic sediments, below the nearly synchronous formerly cited two. And its molluscan fauna never deny the relationship, too. Concerning the

Table 8 Representative molluscan fossils from the Isomatsu, Fuyube and Nagane formations

	I	F	N
GASTROPODA			
<i>Littorinopsis</i> sp. nov.	●		
" <i>Turritella</i> " sp.	○		
<i>Cerithidea kanpokuensis</i> MAKIYAMA	×		
<i>Batillaria tateiwai</i> MAKIYAMA	×		
<i>B. yamanarii</i> MAKIYAMA	●		
<i>Vicaryella tyosenica otukai</i> (NOMURA)	●		
<i>V. ancisa</i> (YOKOYAMA)	×		
<i>Crepidula isimotoi</i> OTUKA	×		
<i>C. jimboana</i> YOKOYAMA	×	×	
<i>Sinum hataiana</i> (KOTAKA)	×	×	
<i>Euspira meisensis</i> (MAKIYAMA)			×
<i>Shichiheia yabei</i> (NOMURA et HATAI)			×
<i>Searlesya kurodai</i> MAKIYAMA	×		
<i>Truncaria nakamurai</i> OTUKA	×		
<i>Rhizophorimurex tiganouranus</i> (NOMURA) ..	×		
<i>Nassarius simizui</i> OTUKA	×		
PELECYPODA			
<i>Acila</i> cf. <i>eximia</i> (YOKOYAMA)		×	
<i>Nuculana pennula</i> YOKOYAMA		×	
<i>Glycymeris vestitoides</i> NOMURA			×
<i>G. cisshuensis</i> MAKIYAMA			×

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(continued)

<i>Mytilus k-sakurai</i> NOMURA et HATAI	×		
<i>Modiolus tugaruana</i> NOMURA et HATAI	×	×	
<i>Chlamys arakawai</i> (NOMURA)		×	×
<i>C. cfr. kaneharai</i> (YOKOYAMA)			×
<i>Nanaochlamys notoensis</i> (YOKOYAMA)	×		
<i>N. kitamurai</i> (KOTAKA)	×		
<i>Patinopecten kobiyamai</i> KAMADA	●		
<i>P. yamasakii iwasakiensis</i> (NOMURA)		×	○
<i>Crassostrea takiana</i> (YOKOYAMA)	●		
<i>Trapezium isomatsuensis</i> KOTAKA	×		
<i>Venericardia siogamensis</i> NOMURA	×	×	
<i>V. cfr. orbica</i> YOKOYAMA	×		
<i>Diplodonta ferruginata</i> MAKIYAMA	×		
<i>Lucinoma otukai</i> HATAI et NISIYAMA	×		×
<i>Pitar itoi</i> MAKIYAMA		×	×
<i>Protothaca tateiwai</i> MAKIYAMA	×		
<i>Dosinia nomurai</i> OTUKA	×	×	○
<i>Cyclina lunulata</i> MAKIYAMA	×		×
<i>Tapes siratoriensis</i> OTUKA	×		×
<i>Pitar aiutiensis</i> (NOMURA et HATAI)	×		
<i>Nipponomarcia nakamurai</i> (IKEBE)	●	×	
<i>Soletellina minoensis</i> YOKOYAMA	○		×
<i>Macoma calcarea</i> (GMELIN)		×	
<i>Arcopagia</i> ? sp.	×		

I, Isomatsu; F, Fuyube; N, Nagane formations.

●.....abundant at rather many stations, ○.....common at rather many stations.

●.....abundant at few stations, ×.....rather rare, through each formation.

Isomatsu formation, in spite of NOMURA and HATAI (1936)'s and KOTAKA (1955)'s statements, its fauna includes no Oligocene species, but consists only of Miocene elements, partly similar to that of Fuyube, according to the writer's study. The lower - middle Miocene age of Isomatsu from the paleontologic evidence is also assured by the stratigraphy that the Isomatsu lies between the upper, Fuyube (partly interfingered) and lower, Gongenzaki, the latter of which is probably the correlative of the Monzen stage in consisting only of volcanic materials. Thus, it seems to be appropriate to consider the Isomatsu formation as the representative of a part of the lower part of Daishima stage in the Kitatsugaru district.

On the So-called Fukaura Fauna and Some Related
Problems to the Nishitsugaru Miocene Faunas

General stratigraphy of the Nishitsugaru Tertiary The Tertiary stratigraphy of the Nishitsugaru district is somewhat similar to that of the Kitatsugaru district in the respect that there are found thick pyroclastic sediments in the lower horizon

and normal clastic sediments in the upper horizon. But the considerable differences of litho-facies and detailed stratigraphy furnish another stratigraphic discrimination of rocks as shown in Tab. 9. Each formation exhibits more or less

Table 9 Stratigraphic sequence of the Nishitsugaru district
(after MORITANI and UEMURA, 1964)

Neogene	Narusawa formation	sandstone
	Maido formation	siltstone
	Akaishi formation.....	black mudstone, siltstone etc. 20-250m thick, partly with basal conglomerate and sandstone
	Odoji formation.....	mainly hard shale, partly with rhyolitic tuff, 40-150m thick
	Tanosawa formation	sandstone and mudstone, 30-150m thick
	Odose formation.....	andesitic and rhyolitic tuff and lava, partly with coal-bearing sandstone and shale, 1, 100m thick
	Fujikuragawa formation	altered andesite lava and pyroclastics, 500m thick
	~~~~~	Pre-Tertiary basement rocks

horizontal changes of litho-facies and thickness, and the changes are particularly presented in the environs of Fukaura here in question. There, the fossil-bearing sandstone beds rest upon the Odose formation. The beds have been called the Fukaura formation, Nakayama-toge sandstone or Fukaura sandstone, and the faunal aspect as shown in Tab. 10 made diversify the opinions on the horizon of the sandstone; according to YABE and HATAI (1941) it belongs to the horizon upper than the Kitaura (Maido horizon in the present district); IWASA (1962) agreed with the preceding authors, but MORITANI (1963) tentatively considered it to be of Akaishi horizon and KITAMURA and IWAI (1963) considered the sandstone as of the Tanosawa horizon; on the other hand, IWAI (1960) who reported some fossils suggesting the Miocene age considered them as derived fossils.

**Fukaura sandstone and its fauna**      The Fukaura sandstone is, according to

Table 10 Molluscan fossils previously reported from Fukaura formation  
By YABE and HATAI (1941)

<i>Ostrea gigas</i> THUNBERG	
<i>Pecten (Chlamys) ingeniosa</i> YOKOYAMA	
By IWAI (1960a)	
<i>Glycymeris</i> cfr. <i>cisshuensis</i> MAKIYAMA	frequent
<i>Chlamys</i> cfr. <i>arakawai</i> NOMURA	abundant
<i>Patinopecten</i> cfr. <i>paraplebejus</i> NOMURA	frequent



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(continued)

*Anomia* cfr. *cytaeum* GRAY frequent

By IWASA (1962) (identified by T. Takayasu)

*Acmaea* sp.

*Chlamys ingeniosa* (YOKOYAMA)

*C. heteroglyptus* (YOKOYAMA)

*C.* cfr. *islandicus* (MÜLL.)

*Ostrea gigas* THUMBERG

*Venericardia* (*Cyclocardia*) *ferruginea* CLESSIN

*Glycymeris* sp.

MORITANI and UEMURA (1964), unconformably underlain by the Odose formation, and consists of rather soft and loose massive sandstone rarely with thin beds of tuff besides its basal part represented by somewhat calcareous coarse-grained sandstone. The writer could find fortunately the molluscan fossils of seven species as shown in Tab. 11 and partly figs 14-17 of pl. 1 in massive silty very fine-grained sandstone bed at the road-side exposure about 500 m north of Nakayama-toge. The pelecypod fossils, occupying the most parts of them, are preserved in the sandstone as casts and moulds of ajoined shells, showing their allochthonous occurrences. It never brings out the conclusion of "derived fossils" suggested by

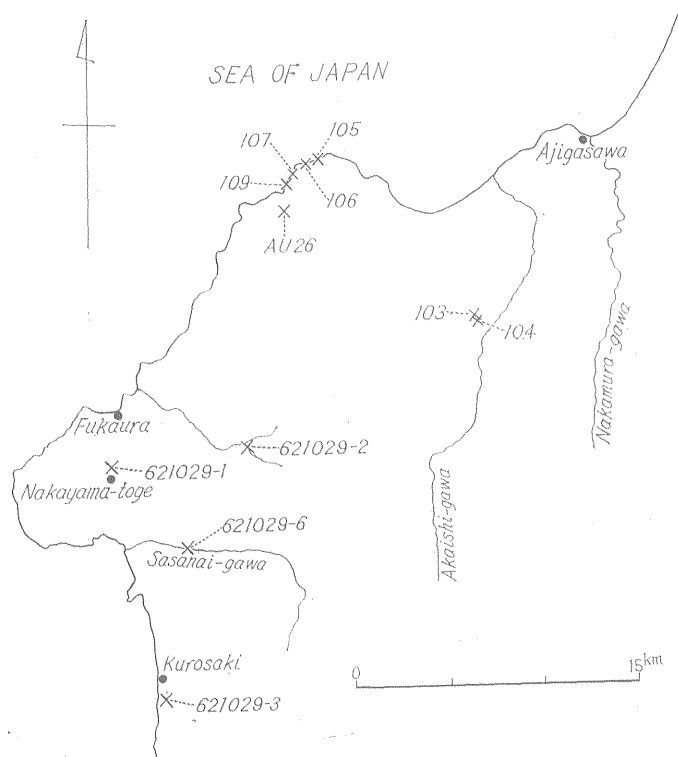


Fig. 4 Main fossil localities of the Nishitsugaru district

Table 11 Molluscan fossils from the so-called Fukaura formation, obtained by the writer at St. 621029-1.

Litho-facies: massive silty very fine-grained

sandstone, whitish gray coloured in weathered surface.

*Dentalium* sp.

*Limopsis* sp.

*Placopecten protomollitus* (NOMURA) abundant, pl. 1, figs. 16, 17

*P. nomurai* MASUDA pl. 1, fig. 15

*Patinopecten* cf. *kimurai* (YOKOYAMA)

*Venericardia siogamensis* NOMURA common, pl. 1, fig. 14

*Clinocardium* ? sp.

IWAI (1960), however, that there are abundantly found the nearly perfect shells of *Placopecten* which are able to be easily broken in the course of transportation to settling owing to its own very thin tests.

*Placopecten protomollitus* (NOMURA) (pl. 1, figs. 16, 17)—The characteristics of this species, established by NOMURA (1935a, p. 41, pl. 6, fig. 3) based upon somewhat ill-preserved specimen, was clarified by MASUDA (1962). The large parts of fossils belonging to the genus *Placopecten* from the exposure almost agree with MASUDA's figures (MASUDA, 1962, pl. 22, fig. 16) in being ornamented with many round-topped radial ribs which are separated by wider interspaces providing one or two radial riblets, as shown in the figures of this paper. They are abundantly found in the very fine-grained sandstone at the exposure in nearly perfect preservation, but a sampling procedure often breaks them in fragments, owing to the weak lithification of the rock they are comprised in. Many well-preserved specimens of this species were also found in the Tanosawa formation at the lower course of Sasanaigawa (St. 621029-6; see Tab. 12).

*Placopecten nomurai* MASUDA (pl. 1, fig. 15)—One specimen found in the exposure shows the characteristics of *Placopecten nomurai* MASUDA (MASUDA, 1953, p. 83, pl. 8, figs. 1-7) which was named to NOMURA (1940)'s *P. protomollitus* from the environs of Sendai. The writer's specimen is very imperfect, but its fine, often bifurcated, flat-topped radial ribs suggest that it is identified to the present species. *P. nomurai* is crowded in some part of Tanosawa formation, according to the writer's observation (St. 104; see Tab. 12).

*Venericardia siogamensis* NOMURA (pl. 1, fig. 14)—Two specimens which belong to *Venericardia* were obtained. They are rather small and considerably broken, but somewhat narrow and faintly granulated ribs and inflation of shell suggest their attribution to *V. siogamensis* NOMURA (NOMURA, 1935b, p. 212, pl. 17, figs. 8-11), of which abundant occurrence was also reported by KAMADA (1962) from the middle Miocene rocks of Joban coal field.

On the Nishitsugaru Miocene faunas, with a special reference to the horizons of Fukaura and Kurosaki faunas. What fauna is most similar to the Fukaura fauna ?

For solving this problem, the Neogene faunas on the coastal areas of Nishitsugaru district were examined widely. In his course of study, the writer also attained to certain conclusion on the so-called Kurosaki fauna. It will be presented here, too.

Among seven divisions of the Nishitsugaru Tertiary shown in Tab. 9, molluscan fossils are more or less comprised in the Odose, Tanosawa, Akaishi and Narusawa formations.

Table 12 Molluscan fossils of the Tanosawa formation

St. 103. Litho-facies: greenish coloured fine-grained sandstone,  
just below the base of hard shale of the Odoji formation

<i>Turritella tanaguraensis</i> NOMURA	
<i>Cerithidea</i> sp.	common
<i>Sinum yabei</i> OTUKA	
<i>Euspira meisensis</i> (MAKIYAMA)	
<i>Cancellaria</i> "spengleriana" DESH."	
<i>Acila yanagawaensis</i> NOMURA et ZIMBO	
<i>Yoldia</i> ( <i>Cnesterium</i> ) sp.	
<i>Patinopecten kimurai murayamai</i> (YOKOYAMA)	
<i>Lucinoma acutilineatum</i> (CONRAD)	abundant, cj.
<i>Serripes</i> cfr. <i>shiobaraensis</i> NODA	
<i>Macoma amoriensis</i> NOMURA	abundant, cj.
<i>Mya cuneiformis</i> (BÖHM) subsp.	
<i>Panope japonica</i> REEVE	

St. 104. Litho-facies: greenish conglomeratic coarse-grained  
sandstone including abundant ajoined pelecypod shells, some-  
what below St. 103 in horizon

<i>Chlamys hataii</i> MASUDA et AKUTSU	abundant
<i>C. nisataiensis</i> OTUKA	abundant
<i>Placopecten nomurai</i> MASUDA	abundant
<i>Ostrea</i> sp.	
<i>Cardita</i> sp.	
<i>Serripes</i> cfr. <i>shiobaraensis</i> NODA	
<i>Dosinia nomurai</i> OTUKA	abundant
<i>Tapes siratoriensis</i> OTUKA	
<i>Panomya simotomensis</i> OTUKA	

St. 105. Litho-facies: dolomite including some large  
pelecypod shells (the lower part of the formation)

<i>Lima</i> sp.	
<i>Chlamys kaneharai</i> (YOKOYAMA)	
<i>C. arakawai</i> (NOMURA)	
<i>Patinopecten kimurai murayamai</i> (YOKOYAMA)	

St. 106. Litho-facies: tuffaceous fine-grained sandstone  
(the lower part of the formation)

<i>Sacella kongiensis</i> (OTUKA)	cj.
<i>Anadara ogawai</i> (MAKIYAMA)	
<i>Glycymeris vestitoides</i> NOMURA	

(continued)

*Placopecten protomollitus* (NOMURA)  
*Mercenaria* ? sp.  
*Dosinia nomurai* OTUKA abundant, cj.  
*Tapes siratoriensis* OTUKA cj.  
*Solen* sp.

St. 107. Litho-facies: very fine-grained sandstone,  
 somewhat muddy (the middle part of the formation)

*Thyasira bisecta* CONRAD  
*Patinopecten kimurai* (YOKOYAMA)  
*Dosinia nomurai* OTUKA  
*Clementia* cfr. *iizukai* (YOKOYAMA)

St. 109. Litho-facies: very fine-grained sandstone (the  
 middle part of the formation)

*Euspira meisensis* (MAKIYAMA)  
*Dentalium* sp.  
*Glycymeris vestitoides* NOMURA cj.  
*Chlamys* sp.  
*Patinopecten kimurai* YOKOYAMA  
 "Ostrea rosacea DESHAYES"  
*Lucinoma acutilineatum* (CONRAD) common, cj.  
*Dosinia nomurai* OTUKA common  
*Thracia pertrapezoides* NOMURA

St. AU26. Litho-facies: dark bluish coloured muddy  
 very fine-grained sandstone (the lower part of the  
 formation)

*Nassarius kometubus* OTUKA  
*Dentalium yokoyamai* MAKIYAMA common  
*Neilonella* ? sp.  
*Saccella kongiensis* (OTUKA)  
*Anadara* sp.  
*Patinopecten kimurai* YOKOYAMA  
*Lucinoma* sp. common  
*Venericardia siogamensis* NOMURA  
*Thracia* sp.

St. 621029-6. Litho-facies: calcareous medium — coarse-grained  
 sandstone crowded by pelecypod shells, just below the glauconite-  
 bearing hard shale

*Patinopecten kimurai* (YOKOYAMA)  
*P. yamasakii iwasakiensis* (NOMURA) abundant  
*P.* cfr. *imamurai* MASUDA  
*Placopecten protomollitus* (NOMURA) abundant  
 Brachiopoda two species (undetermined)

Of the four, the faunal aspect of the *Tanosawa formation* has been already clarified by NOMURA (1935a), and an additional detailed information upon it was obtained by the writer's materials that are listed in Tab. 12. The *Tanosawa formation* is underlain by the *Odose formation* with a slight unconformity and upwards passes conformably to the *Odoji formation* which is mostly occupied by hard shale. It is characterized as a whole by fossiliferous clastic sediments mostly of sandstone yielding *Miogyopsina* and *Operculina* in some places. In detailed

feature, however, the litho-facies and thickness are considerably diversified in different places. For example, according to MORITANI and UEMURA (1964), the present formation is composed of limestone, mudstone and muddy sandstone, and alternation of granule conglomerate, coarse-grained sandstone and tuff, in ascending order, in the vicinity of Tanosawa where this formation is most thickly developed, but in the other most areas muddy sediments are scarcely comprised in the sequence, and instead, sandstone and conglomerate are predominant there.

The Tanosawa fauna numbers about forty molluscan species, but it is very noticeable that there can be found only some species common to the faunules of different localities throughout those of eight presented in Tab. 12. And, the specific constituents at the localities suggest the discrimination of some types of assemblage probably controlled by the environmental factors mainly represented by bottom character at the depositional time. Largely, the assemblages seem to be represented by those of coarse-grained rocks (St. 104, St. 621029-6), which are prevailed by pectinids, and another is suggested by those of rather fine-grained rocks (St. 103, St. 106, St. 109 and others), which are characterized by rather many species of pelecypod fossils.

Below the Tanosawa formation, there is developed the *Odose formation* widely. This covers the Fujikuragawa formation, the lowest division of the Nishitsugaru Tertiary that is exclusively represented by the volcanic materials of altered andesite lava and tuff, and it mainly consists of andesitic volcanic materials together with various clastic sediments. The molluscan fossils are rarely yielded in tuffaceous sandstone of its upper part. They are presented in Tab. 13. The fauna is similar to those of Tanosawa as a whole in constituent, though

Table 13 Molluscan fossils of the Odose formation at St. 621029-2

Litho-facies : laminated coarse-grained sandstone, greenish gray coloured, bearing crowded shells : pelecypod valves are all ajoined.

<i>Glycymeris vestitoides</i> NOMURA	abundant
<i>Monia</i> sp.	
<i>Chlamys</i> cfr. <i>kaneharai</i> (YOKOYAMA)	abundant
<i>Ostrea</i> sp.	
<i>Crassatellites</i> sp.	abundant
<i>Venericardia siogamensis</i> (NOMURA)	abundant
<i>V.</i> cfr. <i>osawanoensis</i> TSUDA	common
<i>Lucinoma</i> cfr. <i>otukai</i> HATAI et NISIYAMA	
<i>Callista</i> ? sp.	
<i>Dasinia nomurai</i> OTUKA	
<i>Cyclina</i> sp.	
<i>Phaxas</i> sp.	

there are found some forms as *Crassatellites* and *Venericardia* cfr. *osawanoensis* peculiar to it and the meaning of this peculiarity is quite obscure now.

The Fukaura fauna here in question is characterized by the two species of *Placopecten*, namely, *P. protomollitus* and *P. nomurai*. Such an assemblage is found in some of faunules of the Tanosawa. Moreover, the other species, *Venericardia siogamensis* and *Patinopecten* cfr. *kimurai* are also comprised in the Tanosawa fauna.

These species are never found in the Pliocene faunas of Japan, a part of which is represented by the Narusawa fauna in Nishitsugaru, and moreover they are not included in the Kurosaki fauna later cited in detail, which is situated at the upper Miocene Akaishi horizon in this district. Although there are some possibilities that it belongs to the Odoji horizon or those of Odoose and Fujikuragawa, it is highly probable that the Fukaura fauna is of the Tanosawa horizon, from the reason that it is very similar to the Tanosawa fauna as a whole and above all *Placopecten protomollitus* is abundantly yielded in that at the lower course of Sasanaigawa which is situated very near to the Nakayama-toge station.

In comparison of both the Nishitsugaru and Kitatsugaru Tertiary faunas, the Tanosawa fauna thus including the Fukaura fauna is very similar to that of Nagane in Kitatsugaru, and less similar to those of Isomatsu and Fuyube, as a whole.

In a joint consideration with the Ainaigawa fauna reported from the Minami-sugaru district, immediately east of the Nishitsugaru, by IWAI (1961) and also with the vicaryan fauna from the south of Ajigasawa by IWAI (1960a), it is probable that the fauna as represented by the assemblage type I of Kitatsugaru is rather prevailing in rather lower horizon and those, rich in open-sea elements, which is shown in the assemblage type III of Kitatsugaru and also in the Tanosawa and Ainaigawa, are rather prevailing in rather upper horizon in the sequence of Daishima-Nishikurosawa stages of the districts. But its final conclusion should be given after more detailed studies through the districts in future. Also, another problem to be solved hereafter, concerning the districts, is shown by the probability of subdivision of the faunas into minor paleo-ecological units: it was briefly suggested in this paper, and was also shown by IWAI (1961) on the Ainaigawa fauna.

What another attention should be given in the Nishitsugaru district is the *Kurosaki fauna*. The fauna is found in the so-called Kurosaki formation which is composed of pumiceous sandstone on the coastal area of Kurosaki about 17km south of Nakayama-toge. The formation was once attributed to the Tanosawa horizon by IWASA (1962) who cited about thirty molluscan species of T. TAKAYASU's collection, but the writer's visit to Kurosaki and his reexamination of T. TAKAYASU's materials bring out another conclusion on the subject. The assemblage of the Kurosaki fauna, shown in Tabs. 14 and 15, is characterized by the abundant occurrences of pectinid, cardiid and buccinid species. And, particularly the latter two forms suggest, as well as *Monia*, *Astarte*, *Callista brevisiphonata*,

that this fauna was more or less influenced by a cold current. Taking into a

Table 14 Molluscan fossils of the "Kurosaki formation" collected from the lower stream of Shiragami-gawa (St. 621029-3)

Litho-facies : pumiceous volcanic conglomerate

- Neptunea modesta* (KURODA)  
 Buccinidae, gen. et sp. indet. (*Ancistrolepis* ? sp.)  
*Nuculana nidatoriensis* OTUKA  
*Chlamys nisataiensis* OTUKA  
*C. swiftii* BERNARDI  
*C. cfr. kaneharai* (YOKOYAMA)  
*Patinopecten* sp.  
*Ostrea* sp.

joint consideration of the above-said peculiarity of the assemblage and the occurrences of *Nuculana nidatoriensis*, *Portlandia aokii*, *Glycymeris* cfr. *matsumoriensis*, *Neptunea modesta* etc., which are all restricted to certain horizon in the Japanese Miocene, it seems to be no doubt that the fauna is very similar to AOKI (1960)'s "Mabechigawan fauna", KOTAKA (1958)'s "Mixed Buccinidae- Cardiidae-

Table 15 Molluscan fossils of the "Kurosaki formation" (based upon T. TAKAYASU's materials kept in the Geological Institute of Akita University)

- Nuculana* cfr. *pernula* (MÜLLER)  
*N. nidatoriensis* OTUKA  
*Portlandia aokii* (NOMURA et ZIMBO)  
*P. cfr. iwatensis* (HATAI)  
*Acila* (*Truncacila*) sp.  
*Arca* sp.  
*Glycymeris* cfr. *matsumoriensis* NOMURA et HATAI  
*Mytilus grayanus* (SCHRENCK)  
*Chlamys* cfr. *kaneharai* (YOKOYAMA)  
*C. cfr. arakawai* (NOMURA)  
*C. swiftii* (BERNARDI)  
*C. cosibensis* (YOKOYAMA)  
*C. cosibensis hanzawai* MASUDA  
*Patinopecten* sp.  
*Ostrea* sp.  
*Monia macrochisma* (DESHAVES)  
*Astarte* sp.  
*Venericardia* sp.  
*Lucinoma acutilineatum* (CONRAD)  
*Clinocardium shinjiense* (YOKOYAMA)  
*C. cfr. ciliatum* (FABRICIUS)  
*Serripes notabilis* (SOWERBY)  
*Macoma* sp.  
*Callista brevisiphonata* CARPENTER  
*Haliotis* sp.  
*Neptunea modesta* (KURODA)  
*Ancistrolepis* sp.

*Pecten* assemblage" of Funakawa fauna, or certain author's, "Yama fauna" represented by the Kurosawa fauna (OTUKA, 1941; HAYASAKA, 1957). In addition to this faunal resemblance, that the Kurosaki fauna characterized by the cold water type species hardly allows paleogeographically the estimation of simultaneous co-existence of it and Tanosawa fauna leads the writer to the following conclusion on the horizon of the Kurosaki fauna, that is, the Kurosaki fauna is not of the Tanosawa horizon, but is probably of the Akaishi horizon, which has been not nearly characterized by molluscan fossils but has been generally considered to be of the upper Miocene Funakawa stage from the stratigraphic and lithologic characteristics. This supports MORITANI and UEMURA (1964)'s view on the matter from the stratigraphic and tectonic standpoint. Moreover, if this view is acceptable, the Kurosaki fauna is very interesting in the respect, that it is the upper Miocene rich fauna first recognized in the Nishitsugaru district.

The molluscan fauna of the *Narusawa formation* which occupies the uppermost part of the Nishitsugaru Tertiary was investigated by IWAI (1960) in detail. According to his study, it is definitely composed of Pliocene type generic and specific assemblage of shallow sea and cold water inhabitants, and it can be doubtlessly distinguished from the faunas discussed in the preceding lines.

**Conclusive remarks** The Miocene molluscan faunas of Nishitsugaru can be discriminated at least two groups which have limited chronologic ranges respectively. One is represented by those of the Tanosawa and upper Odose horizons, and another, which was first established in this paper, is shown by that of the Akaishi ("Kurosaki formation"). The Fukaura fauna is clearly simultaneous with the former from the viewpoint of its specific constituent. The Tanosawa fauna is similar to that of Nagane in the Kitatsugaru district, and is less similar

Table 16 Correlative relationships of the Miocene rocks and faunas in the "Green tuff region" of Northeast Honshu

	Standard stages	Nishitsugaru district	Kitatsugaru district
Upper Miocene	Kitaura	× Maido	Shiokoshi
	Funakawa	× Akaishi ← <i>Kurosaki fauna</i>	Kodomari
Lower-middle Miocene	Onnagawa	Odoji	
	Nishikurosawa	× Tanosawa ← <i>Fukaura fauna</i>	× Nagane
	Daishima	× Odose	× Fuyube × Isomatsu
	Monzen	Fujikuragawa	Gongenzaki

× ..... Horizons of molluscan faunas



to those Fuyube and Isomatsu of the district. The Akaishi fauna is not represented in the cited district. The correlative relationships of the Miocene rocks and faunas of both the Nishitsugaru and Kitatsugaru and the standard divisions of the "Green tuff region" are summarized in Tab. 16.

### Summary

In concern to the Kitatsugaru Tertiary, the writer's comparative study of the Isomatsu fauna which has been hitherto considered to be of Oligocene and both the Fuyube and Nagane faunas brings out the following conclusion.

1) The three faunas exhibit some similarity to each other in constituent, although a considerable differentiation is found in the generic and specific assemblages of them.

2) The three assemblage types, I, II and III are recognized in the faunas. The first type is mainly represented in the Isomatsu fauna, and it is characterized by the abundant occurrences of *Littorinopsis*, *Batillaria*, *Vicaryella*, *Crassostrea*, *Clinocardium*, *Nipponomarcia* and *Soletellina*. This assemblage suggests littoral or upper neritic environments under warm climate. The type II is more or less represented in the three faunas, but is particularly rich in the Fuyube. It is characterized by rather sporadic occurrences of *Crepidula*, *Ancistrolepis*, *Acila*, *Nuculana*, Mytilidae, *Lima*, *Lucinoma* etc., and this assemblage probably shows rather cold environments off shore. Lastly, the type III is mainly represented in the Nagane fauna, and it is characterized by the so-called "Pectinid fauna". The faunal lists are presented in the Tabs. 2, 4, 5 and 8 in this paper.

3) In the sequence of Isomatsu, Fuyube and Nagane formations the above-cited three assemblages are distributed rather regularly as shown in the Tab. 7, probably as a result of chronologically successive change of environments through the times of sedimentations of the three formations.

4) The Isomatsu fauna never suggests its Paleogene age in its generic and specific constituent and it is evidently of Miocene together with the other two faunas of Kitatsugaru.

Another conclusion is given on the chronologic situation of the so-called Fukaura fauna and the other Tertiary faunas, particularly of the "Kurosaki formation" on the Nishitsugaru Tertiary.

Through the present study, the seven molluscan species including *Placopecten protomollitus*, *P. nomurai*, *Patinopecten* cfr. *kimurai* and *Venericardia siogamensis* were found in silty very fine-grained sandstone of a part of the Fukaura sandstone which was unsettled in a chronologic situation by the previous authors. Comparing them with the faunas of Odose, Tanosawa, Akaishi and Narusawa formations of the Nishitsugaru Tertiary, the fauna is most similar to a part of the Tanosawa fauna, and it is surely concluded that the Fukaura sandstone belongs to the

Tanosawa horizon. Moreover, the Kurosaki fauna once assigned to be of the Tanosawa horizon is considerably different from that of Tanosawa in comprising rather many cold water type species; it belongs to the Akaishi horizon of the Nishitsugaru district, and it is a representative of the fauna of upper Miocene Funakawa stage in Nishitsugaru.

So far as the Miocene faunal sequences of both the districts are concerned, it is obvious that there are two major groups of fauna, chronologically differentiated, namely, the lower - middle Miocene and that of upper Miocene. They may correspond almost with a part of those of AOKI's Shiratorigawan and Mabechigawan respectively. It is, however, the problem to be solved by future detailed studies to clarify the paleo-ecological and biostratigraphical meanings of some assemblages recognized in the cited lower - middle Miocene fauna in a joint consideration with the faunas of the other many districts.

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## 北津軽・西津軽地域の中新世 貝類群の研究

水野 篤行

この論文では、青森県の北津軽・西津軽両地域の中新世貝類群についてのいくつかの問題をあつかった。とくに、前者での磯松層、後者でのいわゆる深浦層および黒崎層の古生物学的立場からの時代的位置づけの問題に中心がおかれている。

磯松層は、以前、貝類化石群の立場から、上部漸新統とされていたが、筆者の研究結果ではその証拠は何もなく、貝類化石群はその上位の冬部・長根両層と共通した様子をしめすことから、明らかに中新統(下部~中部)に属すると考えられる。3層を通じて、3つの assemblage がみとめられ、これらが下位から上位にむかつて、重複しながら、漸移出現する。

いわゆる深浦層の層準については、従来さまざまな見解がのべられてきたが、今回筆者が得た貝類化石は、明らかに、同層が、西津軽地域の田ノ沢層(中部中新統)の層準に属することをしめしている。

一方、いわゆる黒崎層は田ノ沢層の層準と考えられたことがあるが、その貝類化石群はより若い時代をしめし、赤石層(上部中新統)の層準と考えるのが妥当である。

これらの問題に関連して、北津軽・西津軽地域での中新世貝類群の時代的変遷についてもべられている。最後に、磯松・冬部・長根・深浦諸層の貝類化石のうち、代表的なものを図版によつてしめた。

PLATES  
AND  
EXPLANATIONS

(With 4 Plates)

Plate 1

- Figs. 1~3. *Batillaria yamanarii* MAKIYAMA  
× ca. 1; loc. 621027-1. Isomatsu formation.
- Figs. 4, 5. *Littorinopsis* sp. nov.  
4. × ca. 1; loc. Y 3. Isomatsu formation.  
5. × ca. 1; loc. 621027-1. Isomatsu formation.
- Figs. 6, 7. "*Turritella*" sp.  
6. × ca. 1; loc. Q 1. Isomatsu formation.  
7. × ca. 1; loc. U 91404. Isomatsu formation.
- Figs. 8~10. *Vicaryella tyosenica otukai* (NOMURA)  
8. × 1.66; loc. Q 1. Isomatsu formation.  
9, 10. × ca. 1; loc. 621027-1. Isomatsu formation.
- Figs. 11, 12. *Crepidula jimboana* YOKOYAMA  
11. × 1.5; modified; loc. U 91404. Isomatsu formation.  
12. × 1.64; loc. U 91404. Isomatsu formation.
- Fig. 13. *Pitar itoi* MAKIYAMA  
× 1.6; loc. I, 126. Nagane formation.
- Fig. 14. *Venericardia siogamensis* NOMURA  
× 2.75; loc. 621029-1. "Fukaura formation".
- Fig. 15. *Placopecten nomurai* MASUDA  
× 1.91; loc. 621029-1. "Fukaura formation".
- Figs. 16, 17. *Placopecten protomollitus* (NOMURA)  
16. × 1.9; 17. × 2; loc. 621029-1. "Fukaura formation".

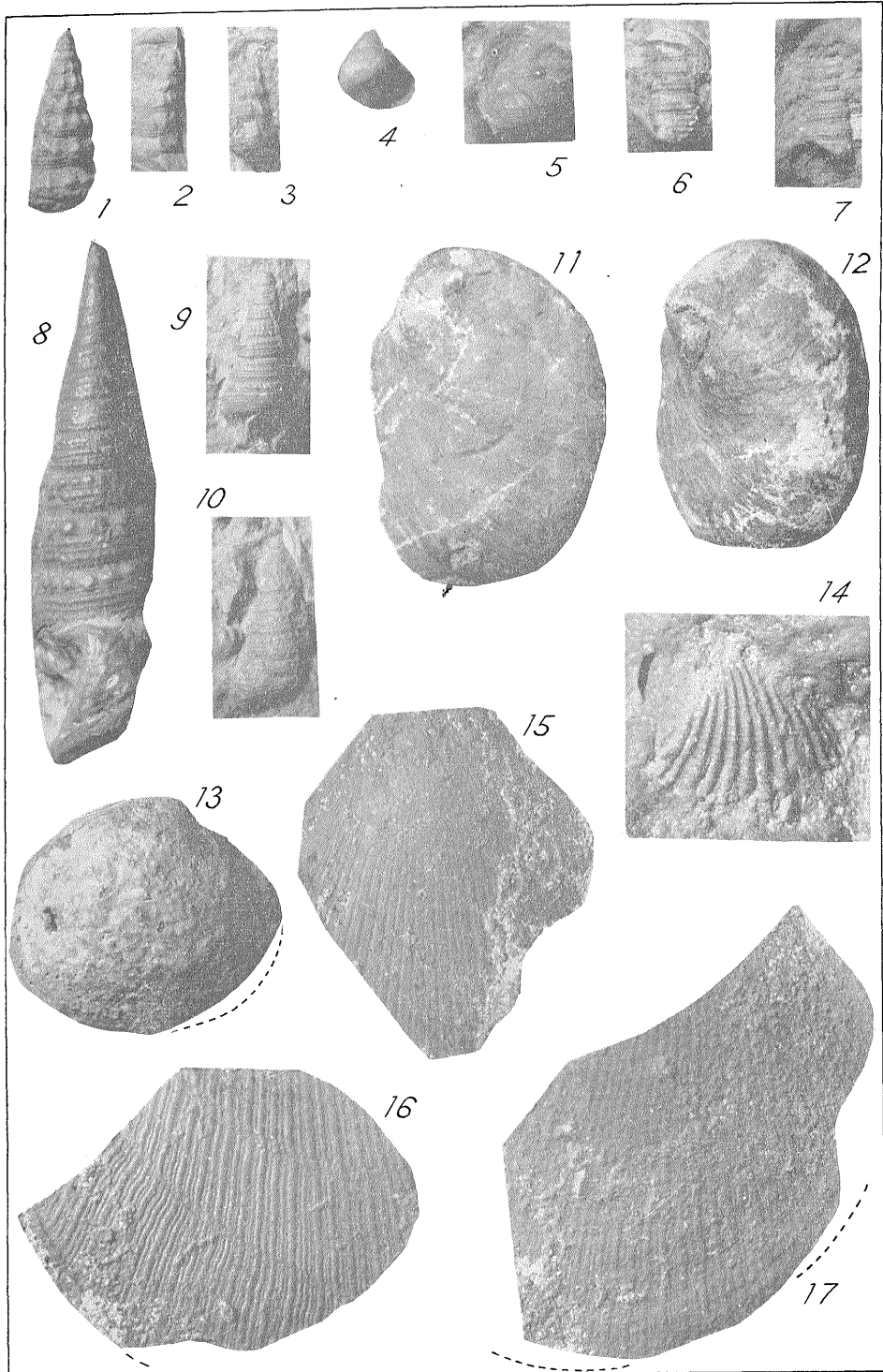


Plate 2

- Figs. 1a~c, 2. *Crassostrea takiana* (YOKOYAMA)  
1a.  $\times 1.12$ ; 1b.  $\times 1.16$ ; 1c.  $\times 1.07$ ; loc. 1.52. Isomatsu formation.  
2.  $\times 1.07$ ; loc. 1.53. Isomatsu formation.
- Figs. 3~5. *Patinopecten kobyamai* KAMADA  
3.  $\times 1$ ; loc. 3.63; 4, 5.  $\times 1$ ; loc. 3.62. Isomatsu formation.
- Fig. 6. *Diplodonta ferruginata* MAKIYAMA  
 $\times 1$ ; loc. Z 13. Isomatsu formation.
- Figs. 7a, b. *Trapezium isomatsuense* KOTAKA  
 $\times 1.11$ ; loc. 1.52. Isomatsu formation.



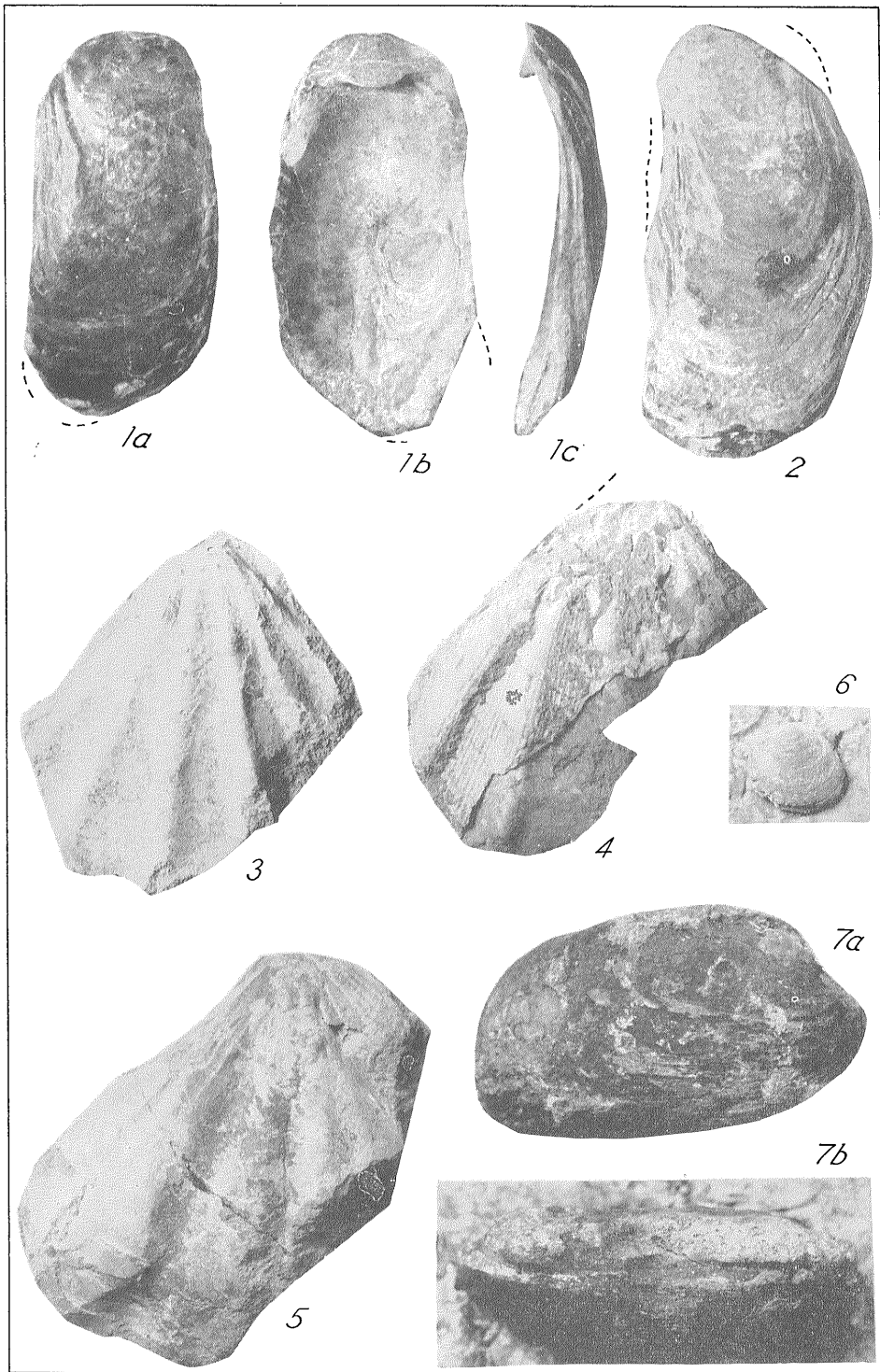


Plate 3

- Fig. 1. *Tapes siratoriensis* OTUKA  
× 0.92; loc. 621027-1. Isomatsu formation.
- Figs. 2~6. *Nipponomarcia nakamurai* (IKEBE)  
2, 3. × 1; loc. Z 13. Isomatsu formation.  
4. × 2.2; loc. U-km. Fuyube formation.  
5. × 1; loc. Z 13. Isomatsu formation.  
6. × 1.62; loc. 1.52. Isomatsu formation.
- Fig. 7. "*Cardium*" sp.  
× 1.5; loc. UM. Isomatsu formation.
- Figs. 8, 9. *Pitar aiutiensis* (NOMURA et HATAI)  
8. × 1.57; loc. Q 1. Isomatsu formation.  
9. × 1.60; loc. 1.52. Isomatsu formation.
- Fig. 10. *Macoma calcarea* (GMELIN)  
× 1.2; loc. K 61. Fuyube formation.
- Fig. 11. *Arcopagia* ? sp.  
× 1.61; loc. 621027-1 Isomatsu formation.
- Fig. 12. *Glycymeris vestitoides* NOMURA  
× 1.54; loc. 1.162. Nagane formation.
- Fig. 13. *Cyclina lunulata* MAKIYAMA  
× 1; loc. 1.52. Isomatsu formation.

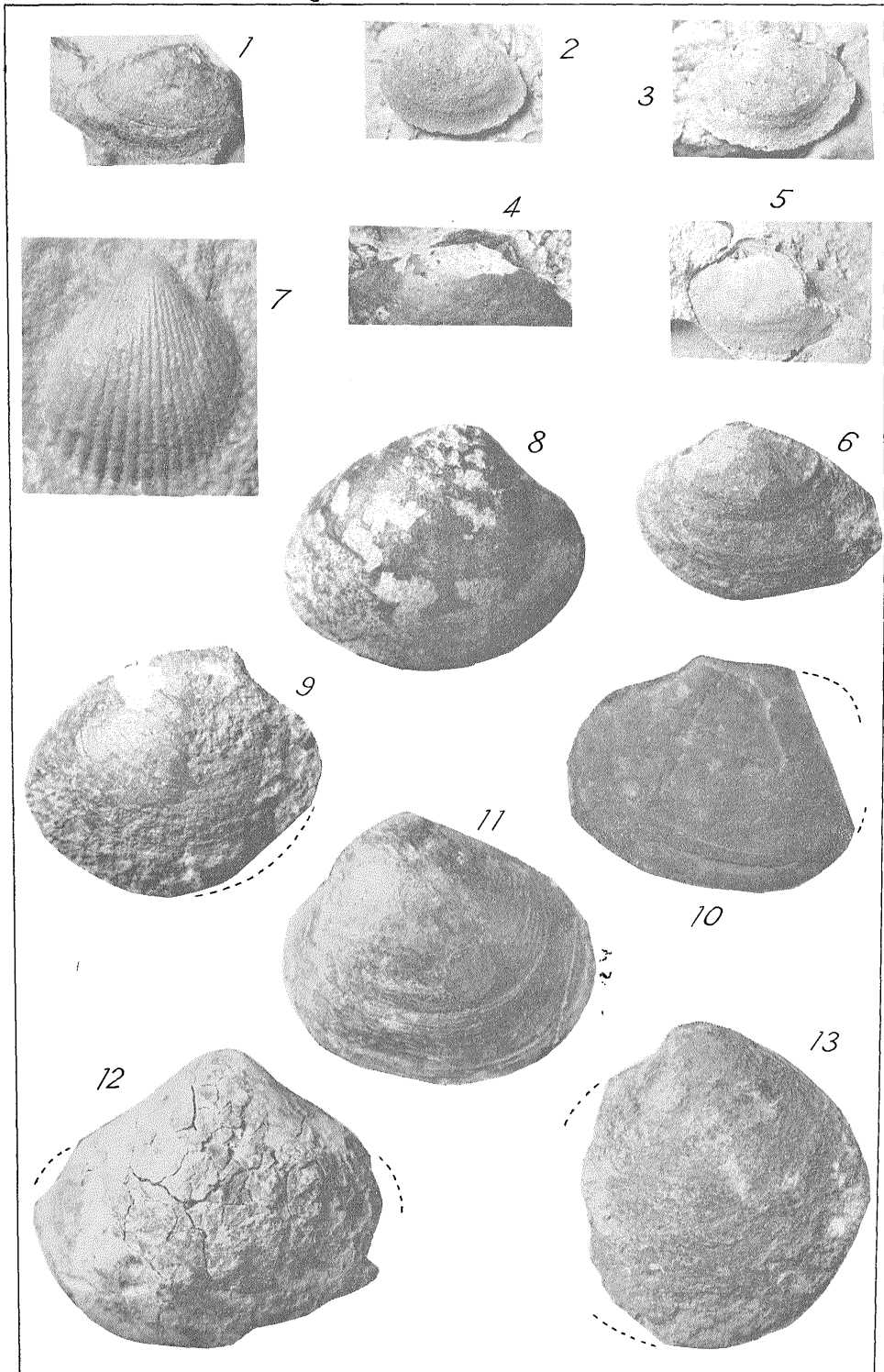


Plate 4

- Fig. 1. *Protothaca tateiwai* MAKIYAMA  
× 1.5 ; loc. 621027-1. Isomatsu formation.
- Fig. 2. *Nuculana pennula* (YOKOYAMA)  
× 1.1 ; loc. KO 56. Fuyube formation.
- Figs. 3, 4. *Soletellina minoensis* YOKOYAMA  
× 1.5 ; loc. 621027-1. Isomatsu formation. The specimen shown in Figs. 4a,  
b is slightly deformed.
- Fig. 5. ? *Vicaryella tyosenica otukai* (NOMURA) Holotype specimen of "*Cerithium han-  
zawai* KOTAKA" kept in the Geological and Paleontological Institute, Tohoku  
University, IGPS coll. cat. no. 74008  
× 1.56
- Fig. 6. *Brachidontes* sp.  
× 1.2 ; loc. K 114'. Fuyube formation.
- Figs. 7, 8. *Mytilus k-sakurai* NOMURA et HATAI  
× 1.52 ; loc. 3.62. Isomatsu formation.

