617. OMMA-MANGANJIAN MOLLUSCAN FAUNA IN THE FUTATSIU AREA OF NORTHERN AKITA, JAPAN*

KIYOTAKA CHINZEI

Geological Institute, University of Tokyo, Hongo, Tokyo 113

Introduction

The molluscan fauna in the marine Pliocene of the Japan Sea coast of Honshu has been generally called the Omma-Manganjian fauna. The name was proposed by OTUKA (1939a) who described the fauna as “a fauna of the Japan Sea during the Pliocene”. It has been thought to be composed of cold deep water inhabitants (OTUKA, 1939b; HATAI and NISIYAMA, 1939 etc.). CHINZEI (1963) noted that species characteristic to the fauna are mostly dwellers of off-shore muddy or fine sandy bottoms with elements intermingled from gravelly facies.

* Received Nov. 17, 1972; read Jan. 16, 1973 at Sendai.

He regarded the fauna as representative of the off-shore assemblages of the Pliocene in Northeast Japan, and compared it with the shallow sea assemblages of the Tatsunokuchian fauna.

In detail, however, the composition of the fauna varies remarkably in different areas and at different localities, even in areas typical of the Omma-Manganjian fauna such as Kanazawa (HATAI and NISIYAMA, 1939; KASENO and MATSUURA, 1965) and Manganji in southern Akita (OTUKA, 1936). This suggests that the fauna includes assemblages representing various types of environments, and that the fauna does not always represent an off-shore community. Detailed analysis has only been done by KASENO and
MATSUURA (1965) on the fauna in the Kanazawa area. KASENO and MATSUURA concluded that the molluscan fauna of the Omma formation is composed mainly of upper sublittoral species, although the shells are mostly transported and mixed with those of different habitats.

In this paper, the writer will present a brief description of the molluscan assemblages in the Pliocene deposits of the Futatsui area, northern Akita Prefecture. This area is known as one where molluscan fossils belonging to the Omma-Manganjian fauna are found abundantly.

Analysis is made of the modes of fossil occurrence and the type of sediments that contain the fossils. Five types of molluscan assemblages can be distinguished when discussion is confined to the autochthonous individuals or individuals transported only a short distance. Each type of assemblage is characterized by two or three predominant or common species, and is in a particular sedimentary facies. In this respect, an assemblage may be regarded as a unit whose constituents have a close ecological relationship to each other.

The combined occurrence of these assemblages including the species composition of each assemblage is considered to be typical of the Omma-Manganjian type molluscan fauna.

Acknowledgements: Professor Tetsuro HANAI and the writer’s colleagues at the Geological Institute, University of Tokyo made valuable suggestions during the course of the study. Comments on stratigraphical problems were made by Dr. Jiro HIRAYAMA of the Geological Survey of Japan. The manuscript was read by Professor T. HANAI, and Mr. John GRIMMER of the University of California, Los Angeles. The writer wishes to express his deep thanks to these persons.

Outline of stratigraphy and description of sedimentary facies

The Futatsui area is situated at the northeastern corner of the Akita oilfield. The upper part of the marine Neogene is exposed in this area forming gentle folds with a NNE-SSW trend. The stratigraphy of the Neogene deposits in this area is similar to that in the type-section of the oil-field in the Akita area. In the study area the formations are dominated by marine clastic deposits, while the Neogene deposits exposed to the immediate east and the north of the study area are rich in altered volcanic materials known as the Green-Tuff.

The lowest horizon exposed in the area is the Upper Nanakura tuff member of the Fujikotogawa formation (HIRAYAMA and SUMI, 1963). It is composed of fine acidic pumices containing large numbers of pumice blocks and other lithic fragments. The tuff is correlated with the top of the upper Miocene Funakawa formation of the Akita area.

The Upper Nanakura tuff is overlain conformably by a grey massive siltstone more than 450 m thick. This siltstone is a part of the Kobinaizawa formation (HIRAYAMA and SUMI, 1963). The main part of the siltstone is correlated with the Tentokuji formation as judged from the stratigraphic position and lithology. It is a coarse-grained homogeneous siltstone, and is tuffaceous, containing small fragments of volcanic glass, plagioclase, hornblende and other crystals. Thin layers of pumice-tuff and tuffaceous fine-grained sandstone are found rarely. The upper part of the siltstone becomes sandy, and is intercalated by very fine-grained silty sandstone. Mol-
Text-fig. 1. Geologic map and fossil localities of the Futatsui area.
1-63: fossil localities; A-M: the locations where the columnar sections (Text-fig. 2) are measured. Symbols for geologic map; 1: sands and gravels, 2: bedded pumice tuff, 3: fine- and medium-grained sandstone, 4: siltstone, 5: the Upper Nanakura tuff.
luscan remains are found sporadically in the upper horizon of the siltstone. They are the assemblage of muddy facies referred to in the following sections. Foraminifera are also found in the siltstone.

Near the northeastern corner of the area, between Locs. 49 and 51, a conglomerate lens 50 cm to 2 m thick is intercalated between the siltstone and an overlying fine-grained sandstone. It is composed of andesitic granules and pebbles, and contains abundant water-worn fragments of shells.

The siltstone is overlain conformably by fine-grained sandstone. The sandstone probably corresponds to the Sasaoka formation of the Akita area although the stratigraphic relationship between the two is not possible to ascertain directly because the sandstone is separated from other areas of the oil-field by anticlinal highs of the underlying formations. The lithology of the sandstone resembles the Tofuiwa facies (Takayasu, 1861) of the upper Sasaoka formation at the type locality. The sandstone is massive or very weakly bedded with interbedded layers of pumice-tuff. It is mainly composed of well-sorted grains of volcanic rocks, crystals and pumices. The sand fraction is 75 to 85 percent in general, and the modes of the frequency distributions of the grains average approximately 3.5φ. Medium- to coarse-grained strata are exceptionally seen in the lower part of the sandstone in the southeastern corner of the area (columns L and M in Text-fig. 2). Thin layers of siltstone are also seen in the southwest. The sandstone contains rich molluscan fauna. They are grouped in

Text-fig. 2. Columnar sections of the upper Neogene deposits in the Futatsui area, indicating the stratigraphic horizon of fossil localities.

this paper as the assemblages of the fine-grained sand facies.

As shown in Text-fig. 2, the boundary between the sandstone and the underlying siltstone obliquely crosses the interbedded pumice-tuff layers which are probably isochronous horizons. The sandstone occurs at the lowest horizon in the northeastern part of the area while the uppermost horizon of the siltstone is seen in the western part of the area. The sandstone is thickest in the northeast where it is approximately 400 m thick. It is 250 to 300 m thick in the west.

The upper part of the sandstone grades upward into a medium-grained loose sandstone mineralogically similar to the fine-grained part. This medium-grained sandstone is poorly stratified and rich in pumice grains. A cluster of molluscan shells was found in a lower horizon of the medium-grained sandstone in the western part of the area (Loc. 63 of Text-fig. 1). Median diameter of the grains of the sandstone at Loc. 63 is 2.1 φ and the sand content is approximately 65%.

The sandstone is overlain by well bedded light grey pumice tuff beds. The tuff beds are covered by thick alternating sands and gravels which form the plateau of Oonotai. Judging from their sedimentary features these tuff and gravel beds were considered by Hirayama and Sumi (1963) to be of fresh water origin. As they are nearly horizontal, they probably cover the underlying slightly inclined sandstone unconformably.

**Modes of fossil occurrence**

The sediments in which fossil molluscs are found can be divided into four types, mud, fine-grained sand, medium-grained sand, and gravels. The modes of fossil occurrence can be closely correlated with these sediment types.

1. Muddy facies. The muddy facies fauna is most common in the siltstone beds which correspond to the Tentokuji formation. The fauna also occurs sporadically in silty layers interbedded in the lower part of the fine-grained sandstone.

Molluscs are scattered in the siltstone with a frequency, in general, of 1 to 5 per square-meter of the outcrop. The individuals usually do not have a particular orientation. At Locs. 14 and 40, such flat shells as Nuculana and Pandora, are found lying parallel to the bedding planes of thin patches of very fine-grained sandstone. Most of the bivalves occur with conjoined valves except for some specimens of Serripes groenlandica. Minute sculpture of the shell-surface and even fragile protoconchs of some gastropods are well preserved. There is no indication of transportation.

2. Fine-grained sand facies. Fossils can be seen at most of the exposures of the fine-grained sandstone, and they are especially abundant in the western area. In the usual case, they are scattered very densely, and do not form particular fossil beds. Exceptions are found at Locs. 22, 31, 36, 38, 39 and 43, where the shells are clustered in beds. The number of individuals varies from 6 (Loc. 62) to more than 400 (Loc. 45) per square-meter of exposure surface.

Bivalves are mostly conjoined even when occurring in clusters. They are randomly oriented in the sandstone except for Mya cuneiformis which is nearly vertical with the posterior upwards. Gastropods, represented abundantly by Turritella saishuensis, do not show any marked orientation. The majority of bivalves and gastropods do not show evidence of transportation by water.
3. Medium-grained sand facies. A bed of shells was found at Loc. 63 in the medium-grained sandstone. It is a lens 20 cm in maximum thickness and more than 6 m in length. Bivalves are invariably represented by odd valves which are arranged parallel to the bedding plane. Broken and fragmental shells are abundant. Although the surface sculpture of the shells is well preserved, they were undoubtedly transported and accumulated by water. Tests of the flat echinoid, *Echinarchnium* cf. *humilis* Nisiyama, are found in the lower part of the shell bed.

4. Gravel facies. The gravel facies fauna is found in the lenticular conglomerate at the base of the fine-grained sandstone. Molluscs are all worn and broken. They are mixed with the gravels. The shells were probably transported by water from remote places.

### Molluscan assemblages

Judging from the modes of occurrence described above, the molluscs found in the muddy and the fine sand facies can be regarded as autochthonous, preserved at or near the place of their origin. The species observed at an outcrop are considered to have some ecological rela-

<table>
<thead>
<tr>
<th>Species</th>
<th>Assemblage</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turritella nipponica YOKOYAMA</td>
<td>Nuclana - Turritella nipponica</td>
<td>12 13 14 17 18 23 24 27 40 48 49 50 51 52 53 56 57</td>
</tr>
<tr>
<td>Pulgoraria prevostiiana (CROSSE)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buconium tobi KURODA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neptunia sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Testudinaria tugarana (NOMURA &amp; HATAI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pustritton oregonensis (REDFIELD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propatella sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admone tabatia (YOKOYAMA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nostreas saeberiae (YOKOYAMA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turritula kaderiei (LISCHKE)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclana robai KURODA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mucosa caloarea (OMELIN)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serripes groenlandica BRUGUIERE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pandora pulchella (YOKOYAMA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Astarte cf. insignia (GOULD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limopsis tokalensis YOKOYAMA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limatula kurodai OYAMA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panaema borengiana DALL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panaema atrometane OTUKA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinocardium sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portlandia japonica (ADAMS et REEVE)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclana sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seminula tenella (MONTAGU)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclana yokoyamai KURODA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zonaria angulata (CONRAD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Venericardia ferruginea (CLESSIN)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peleponassa sp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pallioloma praeclara (GABB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actitrite borealio (BOURJACH)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thyasira bisecta (CONRAD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siphonodentalium sp.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Individual number / m² of outcrop; ○ 10 - 6, ◆ 5 - 3, ● < 2
tionship to each other.

Molluscs found in the medium-grained sand facies were apparently transported as noted above. They are, however, treated here tentatively as an assemblage of the medium-grained sand facies since they are thought to have lived not far from the place of deposition judging from the state of preservation. The assemblage contained in the gravel facies is a mixture of species from more than one habitat.

1. Muddy facies

Molluscs found in the muddy facies are listed in Table 1. The difference in species composition by locality is noticeable. This may result partly from the chance of observation because the density of individuals in the sediment is extremely low.

The muddy facies fauna is characterized by a richness of gastropod species compared with the assemblages in the fine-grained sand facies. The fauna may be called the Nuculana—Turritella nipponica* assemblage since Nuculana robai and Turritella nipponica are the species most commonly seen in the muddy facies. Other characteristic species of the assemblage are Rectiplanes sadoensis, Fulgoraria prevostiana, Buccinum tsubai, Neptunea sp., Admete tabatai, Macoma calcarea, Pandora pulchella, Panomya beringiana, Thyasira bisecta,Portlandia japonica, etc. The assemblage is typically seen at Loc. 24.

Turritella nipponica is relatively common in the upper part of the siliciclast and in the silty layers interbedded in the fine-grained sandstone. In these

lithologies the species associated with T. nipponica are more or less different from those found in the typical assemblage. Nuculana robai and gastropods are generally absent. In some localities, e.g., Locs. 17 and 18, T. nipponica is associated with Limopsis tokaiensis and no other molluscan species. Limopsis tokaiensis is commonly found in the Turritella—Limopsis—Acila assemblage of the fine-grained sand facies. These facts suggest that the variety of assemblage characterized by T. nipponica and Limopsis tokaiensis is the transitional between the typical muddy facies assemblage and the fine-grained sand facies assemblage.

2. Fine-grained sand facies

The molluscan fauna contained in the fine-grained sand facies is characterized by the predominant occurrence of Turritella saishuensis motidukii, Mya cuneiformis and Macoma tokyoensis, except in the northeastern part of the area where the former two species are rare. The fauna can be divided into two major assemblages on the basis of the difference in species associated with the dominant three forms. The assemblages are Turritella saishuensis—Limopsis—Acila nakazimai, and Turritella saishuensis—Macoma tokyoensis—Mercenaria. Although no appreciable difference can be detected between the sediments containing the two assemblages, the stratigraphic distribution of the faunas is different. The Turritella—Limopsis—Acila assemblage is concentrated in the lower part of the fine-grained sandstone, whereas the Turritella—Macoma—Mercenaria assemblage is characteristic of the middle part.

In addition to the two assemblages above, an assemblage dominated by Felaniella ustia and Thracia kakumana
is found in the middle horizon of the fine-grained sandstone.

a) *Turritella saishuensis—Limopsis—Acila nakazimai* assemblage

This assemblage is characterized by the abundant occurrence of *Limopsis tokaiensis* and *Acila nakazimai* associated with *Turritella saishuensis motitukii*. In general, *Mya cuneiformis*, *Venericardia ferruginea* and *Macoma tokyoensis* are also found commonly. Other subordinate species and individuals are few in number. The associations simply composed of *Turritella* or *Turritella* and *Mya* are included in this assemblage. This assemblage is concentrated in the lower part of the fine-grained sandstone and in the west.

Detailed study reveals that the association of species found on the same bedding plane or within a single layer is simple in composition, but varies with locality or horizon. The following associations of species can be recognized; species are arranged in the order of abundance of individuals.

<table>
<thead>
<tr>
<th>Turritella (monospecific)</th>
<th>Loc. 20</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Turritella</em>—<em>Mya</em></td>
<td>Locs. 26, 34</td>
</tr>
<tr>
<td><em>Turritella</em>—<em>Mya—Limopsis</em></td>
<td>Loc. 33</td>
</tr>
<tr>
<td><em>Turritella</em>—<em>Mya—Acila</em></td>
<td>Loc. 28</td>
</tr>
<tr>
<td><em>Turritella</em>—<em>Limopsis</em></td>
<td>Locs. 26, 29, 31</td>
</tr>
<tr>
<td><em>Turritella</em>—<em>Limopsis—Venericardia</em></td>
<td>Locs. 30, 45</td>
</tr>
<tr>
<td><em>Turritella—Acila—Limopsis</em></td>
<td>Loc. 42</td>
</tr>
<tr>
<td><em>Limopsis—Acila—Turritella</em></td>
<td>Loc. 26</td>
</tr>
<tr>
<td><em>Limopsis—Acila—Mya</em></td>
<td>Loc. 26</td>
</tr>
</tbody>
</table>
617. Omma-Manganjian fauna

sand facies in the Futatsui area.

<table>
<thead>
<tr>
<th>Turritella saishuensis - Macoma tokyoensis - Mercenaria</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 3 4 5 6 7 8 9 10 11 21 22 23 24 39 43 46 47 54 55 58 59 60 61 62</td>
</tr>
</tbody>
</table>

Limopsis—Venericardia Loc. 26
Limopsis—Mya Loc. 19

The greatest number of associations are found at Loc. 26, where five different associations are observed repeatedly within a 30 m sequence. The differences in species associations probably indicate minor environmental differences. *Acila* and *Venericardia* do not occur together. This may suggest that the two species were in competition for the same ecological niche, as the modes of life of these genera are quite similar to each other.

b) *Turritella saishuensis—Macoma tokyoensis—Mercenaria assemblage*

This assemblage is characterized by the common occurrence of *Macoma tokyoensis* and *Mercenaria stimpsoni* associated with *Protothaca adamsii*, *Anadara amicula*, *Clinocardium* sp., *Dosinia japonica*, and some other bivalves. *Turritella saishuensis motidukii* is abundant at most of the localities, and *Mya cuneiformis* is also commonly found. Other noteworthy species in this assemblage are *Tellina protovenulosa*, *Spisula voyi*, *Mactra kurikoma*, and *Patiopecten kurosawensis* although they are rare. These species have been reported from several areas of the Omma-Manganjian faunal distribution as the important constituents of the fauna. A large and well preserved shell of *Patiopecten kurosawensis* was collected at Loc. 44. Shells of *Serripes groenlandica* and *Glycymeris yessoensis* were recognized at several
localities. They are rare, ordinarily occurring as single valves, some of which are broken. These species are probably not indigenous to the assemblage.

The relative abundance of some of the associated species is somewhat variable. The assemblages of Locs. 2 and 21 are dominated by *Aciia insignis*, and those of Locs. 22 and 38 by *Anadara amicula*. In general, *Anadara amicula* becomes dominant toward the upper horizon of the fine-grained sandstone. At Locs. 22 and 38, shells of *Anadara amicula* are mostly conjoined valves which are found in shell beds 5 to 10 cm thick. *Macoma tokyoensis*, *Clinocardium* sp., etc., are found in the immediate upper and lower horizons of the *Anadara* beds, but are not seen within the beds.

At Loc. 43, the shells of *Turritella saishuensis*, *Protothaca adamsi*, and *Macoma tokyoensis* form an indistinct zone of shell cluster, while *Mya cuneiformis* specimens are found about 25 to 30 cm below the *Turritella* zone in their living position. These modes of occurrence seem to compare closely with the life habits of Recent allied forms. These *Mya* probably lived at the same time as *Turritella* and other molluscs, and the shell bed seems to have preserved this part of the benthic community at the time of deposition.

c) *Felaniella—Thracia* assemblage

This assemblage is found only at Locs. 35 and 36, both in the middle horizon of the fine-grained sandstone in the western part of the area. Loc. 35 is situated at a horizon about 3 m lower than that of Loc. 36. The shells form a loosely clustered shell bed at each locality.

*Felaniella usta* and *Thracia kakumana* are dominant at both localities. The former species is extremely abundant. *Macoma tokyoensis*, *Mercenaria stimpsoni*, and *Tellina protovenulosa* are species commonly associated with the dominant forms. *Turritella saishuensis* and *Mya cuneiformis* which are abundant in other assemblages of the fine-grained sand facies are absent in the shell beds and the surrounding sediments. A shell bed composed exclusively of conjoined shells of *Felaniella usta* occurs along with the *Felaniella—Thracia* bed at Loc. 36.

3. Medium-grained sand facies

As mentioned, molluscs were found in the medium-grained sand facies only at Loc. 63 where they form a thin lenticular shell bed. The most abundant species in the bed is *Umbonium akitanum*. It is associated with *Glycymeris yessoensis* and *Dosinia japonica*. Small individuals of *Mercenaria stimpsoni* and *Clinocardium* sp. are also found in the shell bed. The bivalves are all disassociated. *Dosinia*, *Mercenaria*, and *Clinocardium* are common in the *Turritella—Macoma—Mercenaria* assemblage of the fine-grained sand facies. The assemblage of the medium-grained sand facies is named the *Umbonium—Glycymeris* assemblage, and tentatively regarded as typical of the molluscan fauna in the medium-grained sand facies.

4. Gravel facies

The assemblage found in the conglomerate is identified as a mixture derived from two or more different habitats. *Mercenaria stimpsoni*, *Felaniella usta*, etc. are found commonly in the fine-grained sand facies, while the rest of the species, *Glycymeris* sp., *Patinpecten* sp., *Swiftpecten* sp., are not found from the other facies in the study area.
Discussion

The molluscan assemblages seen in the upper Neogene deposits of the Futatsui area are summarized as follows:

Muddy facies
*Nuculana—Turritella nipponica* assemblage

Fine-grained sand facies
*Turritella saishuensis—Limopsis—Acila nakazimai* ass.
*Turritella saishuensis—Macoma tokyensis—Mercenaria* ass.
*Felaniella—Thracia* ass.

Medium-grained sand facies
*Umbonium—Glycymeris* ass.

The order of the assemblages corresponds in general to their stratigraphic distribution as shown in Text-fig. 3.

The distribution of assemblages coincides well with the distribution of the sedimentary facies. The boundary between the muddy facies assemblage and the fine-grained sand facies assemblage coincides with the sedimentary boundary which crosses the isochronous tuff beds obliquely. Moreover, the muddy facies mollusc *Turritella nipponica* and its associates, appear repeatedly in the silty layers in the lower part of the fine-grained sandstone. Accordingly the distribution of molluscs is seemingly controlled by the distribution of sedi-

![Text-fig. 3. Schematic stratigraphic section of the Futatsui area and the distribution of the assemblages.](image)

mentary facies and not by the time-
stratigraphic horizon.

The sediments become generally
coarser in the upper horizons, and are
finally covered by fresh water deposits.
The distribution of formations in the
area surrounding Futatsui also indicates
the withdrawal of the marine environ-
ment towards the west and southwest
during the Pliocene as discussed and
illustrated by UEDA (1965).

Thus the vertical changes in the mol-
luscan assemblages are controlled fun-
damentally by the regressive change of
environment, and the limit of the dis-
tribution is defined by that of the sedi-
mentary facies. The vertical succession
of molluscan assemblages may also be
indicative of the horizontal or geogra-
phical relation of the assemblages. The
muddy facies assemblage probably rep-
resents an off-shore, deep water fauna,
while the Turritella—Macoma—Mer-
cenaria or the Umbonium—Glycymeris
assemblages are the near shore and
shallow water faunas. The ecological
relationship in terms of depth between
the latter two assemblages is not clear;
there is, of course, a difference in sedi-
mentary facies.

This conclusion agrees well with
previous conclusion of the writer (CHI-
NZEI, 1961) regarding the Pliocene mol-
luscan fauna of the Sannohe group in
eastern Aomori. In the middle and
upper parts of the Sannohe group, the
assemblages dominated by Turritella
nipponica, Rectiplanes sadoensis, Venerei-
cardia ferruginea and other species com-
mon to the muddy facies assemblage of
the Futatsui area are found in the cen-
tral and deeper part of the sedimentary
basin. The assemblages characterized
by Mercenaria, Peronidia, Anadara, For-
tipecten and other bivalved species are
in the marginal and shallow facies of
the basin. Genera of the molluscan
fauna seen in the marginal facies of the
Sannohe group, the Togawa faunule, are
allied with the genera of the Turritella—
Macoma—Mercenaria assemblage. Ana-
dara, Dosinia, and some important con-
stituents of the Togawa assemblages
are represented by different species than
those of the Futatsui assemblages. They
are the same as the shallow embayment
assemblages of the Tatsunokuchian
fauna (CHINZEI and IWASAKI, 1967). Con-
sequently, the shallow sea assemblages
seen in the Futatsui area are considered
to be ecologically parallel (THORSON,
1957) to those of the Sannohe area and
the Tatsunokuchian fauna.

Molluscan assemblages composed of
the species found in the Futatsui area
occur commonly in Pliocene deposits
along the Japan Sea coast of Japan. The
assemblages described by IWAI (1961)
from the Narusawa formation in the
Nishi-Tsugaru District, Aomori, are cha-
racterized by species common to the
Nuculana—Turritella nipponica assem-
blage and also contain species which
occur in the coarse-grained sand or grav-
elly facies which have not been recog-
nized in the Futatsui area. The species,
found in the Nuculana—Turritella assem-
blage are the main constituents of the
mudstone fauna of the Pliocene Nishiyama and Haizume formations in the
Niigata oil-field (ITOIGAWA, 1958).

Among the molluscan assemblages
reported by TAKAYASU (1961) from the
fine-grained sandstone of the Sasaoka
formation in the Akita oil-field, the as-
semblage of his Loc. 6 dominated by
Limopsis tokaiensis is identical with one
of the associations seen in the Tur-
ritella—Limopsis—Acila assemblage of
the Futatsui area. Other assemblages
of the Sasaoka formation are mixtures
of elements belonging to two or three
different assemblages in the Futatsui area. This conclusion is supported by the observation made by Takayasu (1961) that the shells of these assemblages are mostly odd valves and broken. The same is true for the assemblages contained in the Omma formation in Kanazawa.

Some of the species characteristic of the Omma-Manganjian fauna in other areas are absent or very rarely found in the Futatsui assemblages. They are such gastropod as Epitonium spp., Cerastoderma spp., Trophonopsis spp., and the bivalve Astarte borealis and allied species, Chlamys spp. and other pectinids, etc. They are most likely constituents of assemblage(s) whose habitats did not exist in the Futatsui area.

References


NII-Electronic Library Service
| Fujikotogawa | 藤琴川 | Nishitsugaru | 西津軽 |
| Funakawa    | 船川   | Nishiyama    | 西山   |
| Futatsui    | 二ツ井  | Omma         | 大桑   |
| Haizume     | 灰爪   | Sannohe      | 三戸   |
| Kanazawa    | 金沢   | Sasaoka      | 篠岡   |
| Kobinaizawa | 小比内沢 | Tatsunokuchi | 竜ノ口 |
| Manganji    | 万願寺 | Tentokuji    | 天徳寺 |
| Nanakura    | 七座   | Togawa       | 斗川   |
| Narusawa    | 鳴沢   | Tofuiwa      | 豆腐岩 |

**Explanation of Plate 14**

Fig. 1. *Anadara amicula* (YOKOYAMA) ×1, Loc. 43, Reg. No. CM 8080.
Figs. 2a, b. *Macoma calcarea* (GMELIN) ×1, Loc. 43, Reg. No. CM 8081.
Fig. 3. *Acila (Truncacita) nakazimai* OTUKA ×1.5, Loc. 28, Reg. No. CM 8082.
Fig. 4. *Felaniella usta* (GOULD) ×1.5, Loc. 36, Reg. No. CM 8083.
Fig. 5. *Mercenaria stimpsoni* (GOULD) ×1, Loc. 44, Reg. No. CM 8084.
Fig. 6. *Thracia kakumana* (YOKOYAMA) ×1, Loc. 35, Reg. No. CM 8085.
Fig. 7. *Rectiplanes sadoensis* (YOKOYAMA) ×1.5, Loc. 49, Reg. No. CM 8086.
Fig. 8. *Limopsis tokaiensis* YOKOYAMA ×1.5, Loc. 30, Reg. No. CM 8087.
Figs. 9a, b. *Tectonatica tugarana* NOMURA and HATAI ×1, Loc. 53, Reg. No. CM 8088.
Fig. 10. *Nuculana rabai* (KURODA) ×2, Loc. 24, Reg. No. CM 8089.
Fig. 11. *Umbonium (Suchium) akitanum* SUZUKI ×1.5, Loc. 63, Reg. No. CM 8090.
Fig. 12. *Turritella saishuensis motidukii* OTUKA ×1.5, Loc. 30, Reg. No. CM 8091.
Fig. 13. *Turricula kaderleyi* (LISCHKE) ×1.5, Loc. 24, Reg. No. CM 8092.
Fig. 14. *Turritella nipponica* YOKOYAMA ×1.5, Loc. 53, Reg. No. CM 8093.
Fig. 15. *Mya cuneiformis* (BOHMI) ×1, Loc. 25, Reg. No. CM 8094.

(All specimens are stored at the Department of Historical Geology and Palaeontology, University Museum, University of Tokyo)