Tohoku Univ., Sci. Rep., 2nd ser. (Geol.), Special Volume, no. 6 (Hatai Memorial Volume), p. 179–204, 10 figs., 4 tables, pls. 16–17, February 25, 1973

Molluscan Assemblages of the Basal Part of the Zushi Formation in the Miura Peninsula

Tokio Shikama*

INTRODUCTION

The Zushi Formation composing the lower part of the Miura Group consists of thick siltstone beds intercalating many tuff beds. It carries almost no distinct molluscan fossils except at its basal part, although *Nucula* sp., *Nuculana* (*Thestyleda*) sp., *Yoldia thraciaeformis* Storer and *Acila divaricata* (Hinds) have been occasionally reported**. In 1920 M. Yokoyama described *Pecten miurensis* Yok. and *Lima zushiensis* Yok. from Zushi and Harashita, Shimomiyata in his "Fossils from the Miura Peninsula and Its Immediate North". He placed both localities in his Yokosuka and Miyata zones, and mentioned 80 species from the former zone including the Ôtsu shell bed. Probably large parts of the fossils of the zone were from the Pleistocene Ôtsu shell bed, but the two species mentioned above were from the famous fossil locality of the sea coast of Abuzuri – Tagoe, south of the Tagoe River, Zushi City.***

The name of Miura Formation was proposed by H. Yabe in 1921. K. Watanabe, 1925, established the Zushi shale bed as the basement of the Musashino Group which corresponds to Yabe's Miura Formation. The Zushi shale bed overlies the Hayama shale bed with clino-unconformity that can be observed at Tagoe.*** This unconformity is significant in the Cenozoic tectonic history of Japan. F. Ueda's Taura bed (1930) or Y. Otuka's (1930) Daibutsu shale bed corresponds in part to the Zushi shale bed. H. Akamine *et al.* (1950) proposed the Tagoe shell fossil bed as the basal conglomeratic bed exposed at the Sakurayama sea coast, Zushi, but in 1956 they used the name Tagoegawa sandy conglomerate bed. K. Koike's (1951) Tagoegawa conglomeratic bed, K. Suzuki & U. Kitazaki's (1951) Tagoegawa tuffaceous sandy conglomerate bed, and S. Ogose's (1967) Tagoegawa bed are synonyms of the same bed. H. Aramaki (1955) studied the geology of the Hayama Group but his work was not published. Akamine *et al.* (1956) proposed the Shimoyamaguchi sandy conglomerate bed as a stratigraphic unit at the basal part of the Zushi Formation distributed from Uchisaba, Hayama to Kumura, and to Kurihama in Yokosuka City. T. Mitsunashi and K. Yazaki (1958) in their geological map of the Miura Peninsula in the scale of 1/25000 divided the Zushi Formation (their Zushi mudstone and Misaki alternation of sandstone and mudstone) into 11 members based upon lithology (degree of sand content in the layers, and many tephrozones). They also separated the basal member under the name of Tagoegawa and Shimoyamaguchi conglomerates. Subsequently, Y. Kanie (1967) mentioned the occurrence of *Amussiopecten iitomiensis*, *Lima*, *Glycymeris*, *Natica*, *Neverita*, Brachiopoda and corals, etc. from the basal part of the Miura Group. K. Kurihara's (1971) geological map of the area east of Hayama shows that the limestone and conglomerate beds at the basal part of the Zushi Formation are separated laterally and thus the distribution of those beds is different from that of Mitsunashi and Yazaki.

* Yokohama National University

** Recently *Cavolina* was found from a siltstone bed at Yamanome, north of Zushi railway station

*** The precise locality is now named Sakurayama

In spite of the geological researches concerning the Tagoegawa-Zushi beds, no paleontological work on the molluscan assemblages have been published since Yokoyama's work. In 1932, K. Suzuki recorded from the Zushi Formation, *Chlamys miurensis* (Yok.), *Glycymeris* cf. *nipponica* (Yok.), *Lima zushiensis* Yok., *Trochus* spp., *Serripes pauperculus* (?) Yok., *Mytilus giganteus* Holmberg, *Cardium* sp., *Pseudogrammatodon dalli obliquata* (Yok.), *Glycymeris* cfr. *vestita* (Dkr.), *Paphia* sp., *Lemintiana* sp., *Fulgoraria prevostiana* (Crosse), *Flabellum* sp., and Madreporarian corals. Ogose (1962) mentioned the occurrence of *Amussiopecten planicostulatum* (Nomura & Niino), *Umbonium yabei* Sugiyama and *Glycymeris* sp. nov. from the same unit as Suzuki. Ogose *et al.* (1949) regarded the Tagoegawa bed as Lower Pliocene (HIb), and correlated it to the Dainichi sand bed of the Kakegawa Formation based upon the mutual occurrence of *Umbonium yabei.* His view was not supported and the Zushi Formation was correlated to the Late Miocene Sagara Formation from the existence of *Sagarites*, etc. K. Asano *et al.* (Boso Research Group, 1958) reported *Globorotalia fohsi* Cushm. & Ellisor, *G.* cf. *fohsi barisanensis* Leroy, *G. menardi* (d'Orb.) and *Globigerinoides hotaensis* Asano, etc. from the Tagoegawa bed. The recent studies of the Japanese Neogene based upon planktonic foraminifera (N. Ikebe *et al.*, 1972) indicate that the Sagara Group corresponds with Blow's N 15–N 18 (Late Miocene) and that the *G. fohsi* datum corresponds to Blow's N 10 (basal Middle Miocene). K. Masuda (1962) put *planicostulatum* into *Patinopecten* and proposed a new species *akiyamae* for the specimens from the Zushi and Inakozawa formations (Middle Miocene); according to him *akiyamae* is distinct from *iitomiensis* Otuka from the Shizukawa Formation of Yamanashi Prefecture and the Tsuma Formation of Miyazaki Prefecture (Late Miocene). K. Oyama (1952) noted that the Tagoegawa molluscan assemblage with *Chlamys* and *Lima* might not have been deposited in a tidal to euneritic sea (his N_{0-1}) but in a mesoneritic to subneritic sea (his N_{2-3}). T. Hamada (1956) made a paleogeographical study of the Tagoegawa fauna and correlated it to the Kanaya and Naarai faunas in Chiba Prefecture; he mentioned 5 faunae, namely shell sand, Bryozoa, *Pecten miurensis*, *Lima goliath* and *Pleurotomaria* – Brachiopoda; the shell sand fauna is represented by that at Kumura; *Pecten miurensis* fauna by that at Abuzuri and Sakurayama; *Lima goliath* fauna by the one at Futagoyama. He regarded the Tagoegawa, Senbata and Naarai conglomerate beds to be synchronous sediments and suggested the existence of the Paleo-Tama River which transported exotic pebbles of Paleozoic rocks to the eastern area of the Miura Peninsula and northern area of the Boso Peninsula.

Since 1952 the writer and other members of the Geological Institute, Yokohama National University have been engaged in research of the geology and paleontology of the basal part of the Zushi Formation. In 1958 and 1959, S. Takahashi, M. Horikoshi, S. Oda, H. Takase, B. Takanashi, S. Takenaga, H. Takeuchi and S. Hiroishi, etc., together with the writer surveyed the distribution of the Tagoegawa bed and collected many fossil shells. Recently H. Ozaki, T. Eto, S. Yui and K. Murayama, etc. in collaboration with the writer continued the work mentioned above. Abundant fossil shells of the Tagoegawa bed are preserved in the Yokosuka City Museum; they were collected by N. Akaboshi (from Abuzuri), T. Shibata (from Sakamoto) and by K. Hirayama (from Syoei-danchi, Kinugasa). The writer studied those materials through the courtesy of Dr. Y. Haneda and Mr. Y. Kanie. In 1958 he obtained many facilities from Dr. Y. Ikebe and others of the Petroleum Exploring Co. Ltd., Tokyo. The writer here expresses his cordial thanks to those persons for their help and kind offers of many valuable materials. Thanks are also due to Prof. T. Takahashi, Messrs. H. Ozaki, T. Eto, S. Yui and K. Murayama for their kind assistance rendered to the writer in laboratory work.

STRATIGRAPHICAL OUTLINE

The basal part of the Zushi Formation (or Zushi Siltstone), composed of coarse or non-silty sediments, is called the Tagoegawa bed. It overlies with unconformity the Hayama Group or is in contact with faults. The Tagoegawa bed is distributed with a general trend of E-W in belt form from Sakurayama — Tagoe, Zushi (Loc. 1) to Osakuyato, Yokosuka (Loc. 6). The belt turns to NNW-SSE in the area of Yokosuka City (Locs. 7–11), then to N-S in the neighbourhood of Ôyabe (Loc. 12), then again to EW in the Iwado — Kumura area (Locs. 13, 14). There are two zones of the bed in the area south of zone I; zone II is distributed from Uchisaba, Hayama (Loc. 15) to Hôkinzan (Loc. 16), running generally from east to west; zone III extends from Akiya to Syogyoin with a trend of E-W and further in ESE direction. The basement composed of the Hayama Group occupying the areas of Morito, Futagoyama and Kinugasa is surrounded by zones I and II; this area was named by K. Watanabe Hayama island from the paleogeographical point of view. The Tagoegawa bed of zone I dips from 25° to 70° N or NE. That of zone II, from 20° to 50° N or NE and is disturbed by many faults. That of zone III, from 20° to 40° N or NE. There is a small area exposing the bed at the east of Sajima (Loc. 17). The Hayama basement is also distributed in the area between zone III and Sajima and extends eastward to the Takeyama — Fujisan area. The area of the Zushi Formation between Hayama island of Watanabe and the Hayama basement of the Takeyama-Fujisan area was named by Hamada the Ôkusuyama passage. The western half of zone I is composed of dark green to dark gray colored conglomerate or conglomeratic sandstone of less than 30 m thick. Type locality is the sea coast of Sakurayama, Zushi City (Loc. 1) and the name of Tagoegawa conglomerate bed was given to this facies. The pebbles here consist of angular to subangular sandstone or hard siltstone derived from the Hayama Group. Sometimes serpentine or round pebbles of Paleozoic rock are seen. Shell aggregation represented by *Chlamys miurensis* occurs in zone I but not in zone III. Zone II and the eastern half of zone I are composed of bluish pyroclastic coarse grained sandstone, calcareous sandstone, coquina, limestone, tuff, etc. In the neighbourhood of Hôkinzan (Loc. 16) and Daimyoji, Kinugasa (Loc. 11) the sandstone bed overlies the calcareous sandstone or limestone bed with conformity. The sandstone sometimes carries cobbles of quartz porphyry, peridotite and the other kinds of volcanic rocks. In some localities of the Yokosuka area (between Loc. 8 and Loc. 9) sandstone becomes very scoriaceous and even disappears; in such a case the Zushi Siltstone directly overlies the Hayama Group. At the eastern end of zone I (Locs. 13, 14) thick tuff or a tuffaceous sandstone bed underlies a limestone bed. The sandstone often carries shell aggregations of *Glycymeris*. Coquina or limestone is mainly composed of *Balanus* and shell fragments, and various kinds of marine animals are included. After Eto's determination, it is known that there are *Textularia*, *Bolivina*, *Ammonia*, *Amphistegina*, *Gypsina* (?), *Globigerina* and *Globorotalia*, etc. in a limestone of Kumura (Loc. 14). Planktonic foraminifera also occur found from that limestone at Hôkinzan. The type locality of the sandstone is Hôkinzan (Loc. 16) and the name of Shimoyamaguchi sandy conglomerate bed is given to the two facies mentioned above. At the eastern end of zone I (Locs. 13, 14) the non-silty sediments become very thick, attaining 50 m or more and are distinctly pyroclastic or tuffaceous; here the limestone occupies the upper horizon of the non-silty bed.

Mitsunashi and Yazaki divided the Zushi mudstone formation of 1600±m thick into more than 7 members, as, Ts, Cm, Fs, Md, Am_5, Am_4, Am_3, etc. according to the degree of sand layer content, of which Ts and Cm may correspond to the pyroclastic sandstone facies. According to them, there are about 24 tephrozones in the Zushi Formation north of Hayama island, and the zone I in the lower tephrozone tends to occupy lower horizons in eastward direction as shown in Table 1. Transgression proceeded from east to west along the

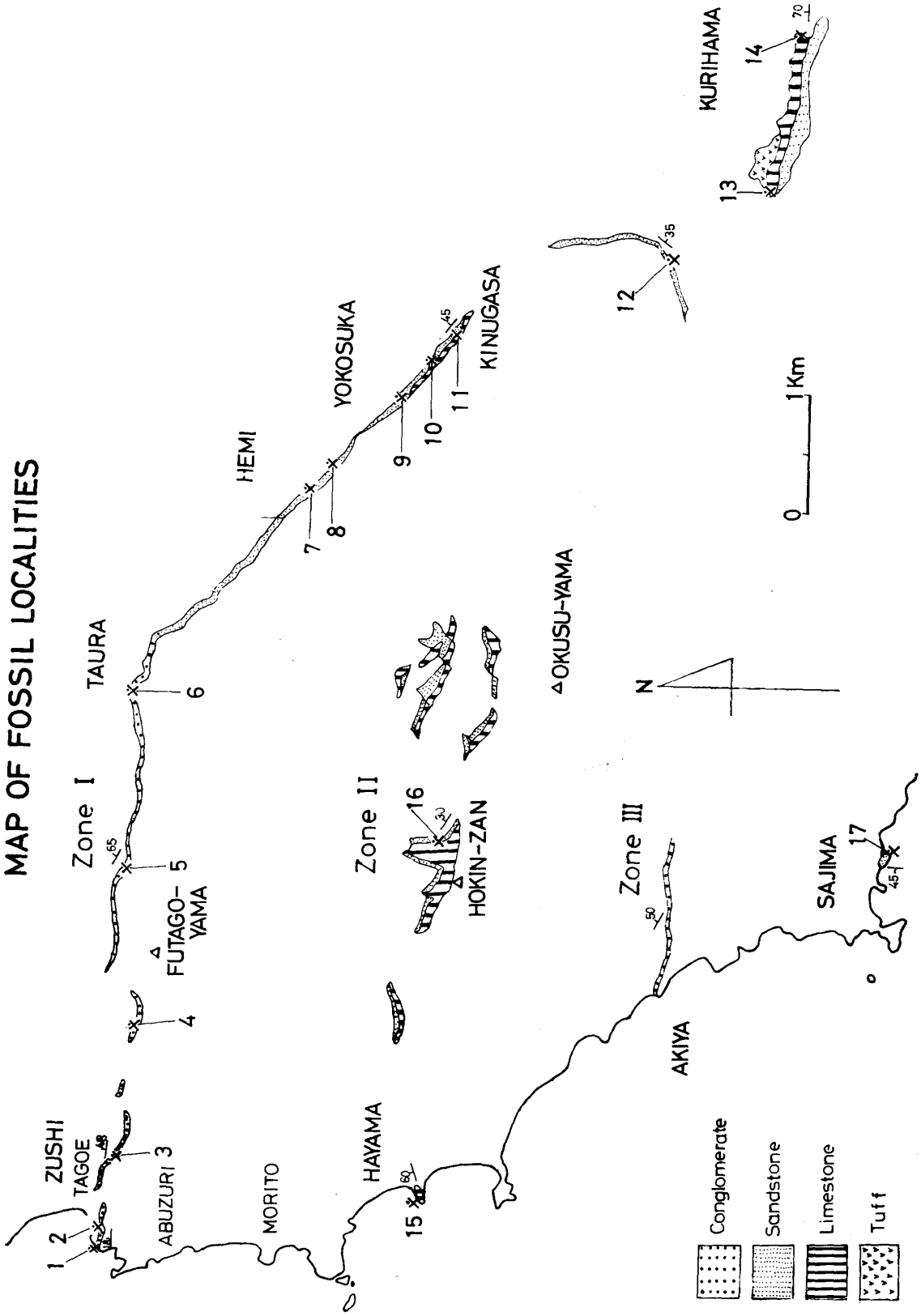


Fig. 1. Distribution map of the Tagoegawa bed showing fossil localities.

Table 1. Relationship between tephrozones and fossil localities of zone I (ascending order).

Tephrozones (Mitsunashi & Yazaki)			Fossil localities
1 .... Ok		.....	..... 12, 13, 14
2 .... Mo			
3 .... Mk			
4 .... In	4′	Bw	..... 9, 10, 11
5 .... Ms	5′	Cr	..... 7, 8
6 .... Sn			
7 .... An			
8 .... Sk			
9 .... Ty		..... ?	6
10 .... Dk			
11 .... Ss			
12 .... Js		.....	1, 2, 3, 4, 5

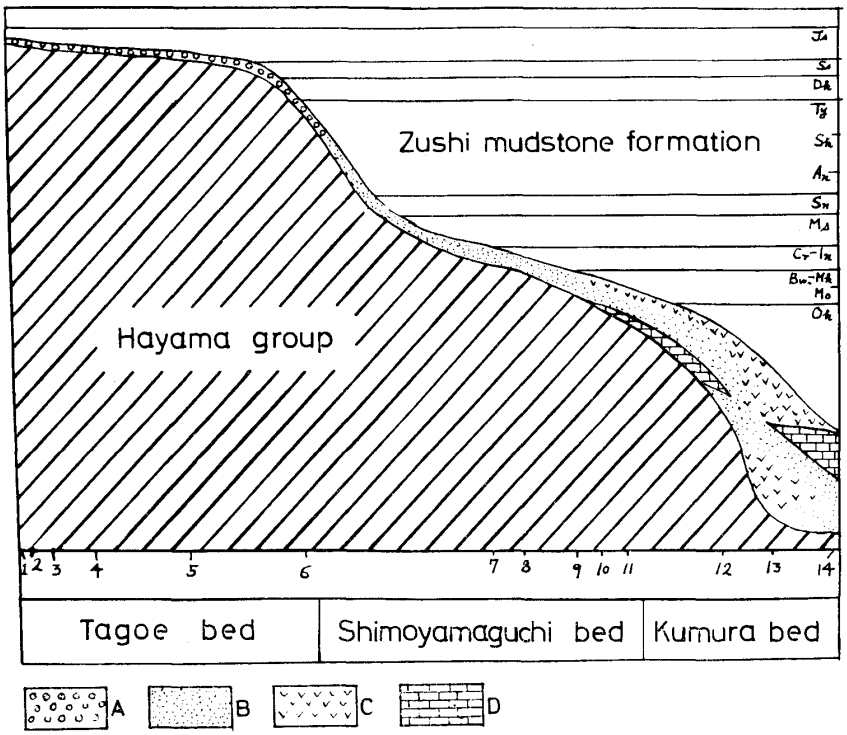


Fig. 2. Diagramatic section of the basal part of the Zushi Formation. A: conglomerate, B: sandstone, C: tuff, D: limestone.

northern coast of Hayama island, hence the Shimoyamaguchi facies is older than the Tagoe facies. The limestone or coquina facies with tuff or tuffaceous sandstone is older than the sandstone facies. At some localities (Locs. 7, 12) the sandstone facies carries a Brachiopoda assemblage. These three lithofacies are here called the Tagoe-, Shimoyamaguchi- and Kumura beds respectively. They are not synchronous with each other and a part of them (Kumura or Shimoyamaguchi) belongs to Blow's N 10 (basal Middle Miocene).

GENERAL ASPECT OF FOSSIL LOCALITIES

Loc. 1. Sea coast of Sakurayama*, Zushi City; Lat. 35°16′55″N, Long. 139°34′15″E.

* Generally known as Abuzuri.

The conglomerate, about 1 m thick, exposed at the sea coast of Sakurayama, south of the mouth of Tagoe River, Zushi City, is known for its abundant molluscan fossils. It strikes E-W and dips 18°N, and overlies with rather irregular unconformity the Hayama Group (Morito Shale). The matrix of the conglomerate is of dark blue or dark green pyroclastic sands. The pebbles are 2–5 cm and up to 10 cm in diameter, angular or subangular composed of sandstone or shale of the Hayama Group. The fossil site is now in a pool in the Zushi sewerage treatment house.

Loc. 2. Roadside cliff, 150 m east of Loc. 1; Sakurayama 9–1, Zushi City; Lat. 35°16′55″N, Long. 139°34′23″E.

The conglomerate exposed in a roadside cliff at Sakurayama 9–1 is about 0.5–2 m thick, strikes E-W and dips 15°N, and is composed of 1–3 cm and partially 10 cm size angular or subangular pebbles of sandstone and shale of the Hayama Group. Some trace fossils occur. This site is known for the Abuzuri unconformity, which is also visible in a cliff of Loc. 1.

Loc. 3. Southern entrance of Sakurayama tunnel between Sakurayama, Zushi and Hayama-cho; Lat. 35°16′50″N, Long. 139°37′50″E.

A cliff just above the tunnel entrance exposes a conglomerate bed with strike of N 86°W, dip of 48°N and is cut by a reverse fault. The bed is about 1–2.5 m thick and its lithic character is rather allied to that of Loc. 2.

Loc. 4. Riverside cliff of Ôyama, Nagae, Hayama-cho; Lat. 35°16′40″N, Long. 139°35′30″E.

A conglomerate with some fossils is exposed in a small cliff of the Morito River. Its lithology is similar to that of Loc. 3.

Loc. 5. Ravine head of the Morito River, northeast of Futago Mountain, Nagae, Hayama-cho; Lat. 35°16′50″N, Long. 139°36′30″E.

The conglomerate bed exposed in a ravine wall and floor of this locality is about 5 m thick. It has strike of N 60°W and dip of 65°NE. It is coloured gray or brownish gray with subround or subangular pebbles of sandstone or hard shale of the Hayama Group, and gradually changes into scoriaceous coarse grained sandstone.

Loc. 6. Valley bottom of Ôsakuyato, Taura, Yokosuka City; Lat. 35°16′40″N, Long. 139°37′30″E.

The conglomeratic sandstone or fine grained conglomerate exposed in the valley bottom of this locality resembles that of Loc. 5.

Loc. 7. Ravine wall of Higashihemi 4, Yokosuka City; Lat. 35°16′10″N, Long. 139°38′50″E.

Dark gray or dark blue coarse grained sandstone that yielded *Thracidora gigantea* Shikama* is exposed in the ravine wall 1500 m north of the northern entrance of the tunnel between Hemi* and Ikegami. The bed is about 10 m thick and overlies the Hayama Group with unconformity. The pebbles mainly 1 cm in size are subround shale and sandstone of the Hayama Group. Coral and shell fragments are aggregated.

Loc. 8. Ravine wall of the precincts of an old crematorium, Sakamoto-cho, Yokosuka City; Lat. 35°16′5″N, Long. 139°38′57″E.

This locality is situated 3 km southeast of Loc. 7. A gray or brown conglomerate of angular pebbles, 4–7 cm in size of dark gray sandstone of the Hayama Group 1 m thick overlies the Hayama Group with unconformity. Angular granules of hard shale are dominant. Shells are aggregated in part of the bed which often becomes hard and calcareous.

Loc. 9. Small cliff of the ground of an asylum for the aged, Kinugasa, Yokosuka City; Lat. 35°15′40″N, Long. 139°39′30″E.

* The locality name of Hayami in the writer's paper of 1968 is erraneous. Hemi is correct.

The dark gray or dark green pyroclastic coarse grained sandstone bed with many pebbles of 5–9 mm in size, composed of sandstone of the Hayama Group and of chert or green rock of Paleozoic formations, several meters thick is exposed at this locality. Shell fragments, *Balanus* and echinoids are aggregated in part and shows a coquina like aspect.

Loc. 10. Housing area of Daimyoji — Syoei-danchi, Kinugasa, Yokosuka City; Lat. 35°15′37″N, Long. 139°39′40″E.

A layer of gray hard limestone or coquina like calcareous sandstone (calcarenite), 7 m thick, lies with unconformity on the Hayama Group and below a dark gray to greenish brown coarse grained sandstone bed of about 18 m thick. The sandstone bears subangular to subround pebbles, 5–10 mm in diameter, of hard shale of the Hayama Group, quartzite and green rock of the Paleozoic formations. Also subangular pebbles, 10 cm in diameter, of quartz porphyry also occur. The sandstone bed strikes N 30°–60°W, and dips 40°–65°NE with abundant fossil aggregations. The upper part of the bed is scoriaceous and intercalates 4 tuff beds and 2 pumice beds.

Loc. 11. Cliff of the neighbourhood of Kôshinji temple, Kinugasa, Yokosuka City; Lat. 35°15′19″N, Long. 139°39′59″E.

A brown calcareous sandstone bed, 6 m thick, underlies a 24 m thick brown or grayish brown pyroclastic sandstone which intercalates 6 beds of tuff. The sandstone bed strikes N 50°–60°W, dips 75°–80°NE and its basal part carries subangular pebbles of gray siltstone (40–60%) in a matrix of sandy silt. Its middle part is of fine to medium grained tuffaceous sandstone with angular scoriae, 1–4 mm in diameter (30–40%). The calcareous sandstone (calcarenite) carries shells of *Glycymeris*, *Balanus* and echinoid spines, etc.

Loc. 12. Ravine wall of a valley between Ôyabe and Kazahaya, Kurihama, Yokosuka City; Lat. 35°14′40″N, Long. 139°40′40″E.

A dark green to dark gray colored conglomerate and a siltstone, 50–70 cm thick are exposed in the ravine wall. The bed strikes N 40°E, dips 35°SE and overlies with unconformity the Hayama Group. The conglomerate grades upwards into gray tuffaceous sandstone with several meters thick pumice patches. Aramaki collected many Brachiopoda and Foraminifera besides Mollusca from the facies. Probably the foraminiferal assemblage of *Globorotalia fohsi* and others may have occurred from this sandstone.

Loc. 13. Roadside cliff east of Iwado, Kurihama, Yokosuka City; Lat. 35°13′47″N, Long. 139°40′54″E.

A dark gray colored tuff and tuffaceous sandstone bed, 35 m thick, overlies the Hayama Group, and is succeeded upwards by an about 3 m thick conglomerate bed and a tuff bed of 14 m thick. Pebbles of the conglomerate are subangular or subround, 1–2 cm in diameter, and composed of sandstone of the Hayama Group or Paleozoic rocks. The lapilli of the tuff is less than 1 cm in diameter. The conglomerate becomes partially calcareous and changes to limestone (biosparite) with echinoid spines.

Loc. 14. Neighbourhood of Syogyoji temple, Kumura, Kurihama, Yokosuka City; Lat. 35°5′35″N, Long. 139°41′59″E.

An about 20 m thick brown tuffaceous sandstone bed overlies the Hayama Group and its basal part, 0.7 m thick, carries many pyroxene crystals and flat pebbles, 2×3 cm in diameter, of siliceous mudstone and hard sandstone of the Hayama Group. The sandstone bed is overlain by 12 m thick calcareous sandstone (calcarenite) and 6.3 m thick conglomeratic sandstone. The calcareous sandstone becomes change into limestone (biosparite) and has many fragments of coral and *Balanus*. It strikes E-W and dip 70°N.

Loc. 15. Small rock cape of Uchisaba, Hayama-cho; Lat. 35°15′26″N, Long. 139°34′33″E.

At a rock beach of this cape, 2 m thick hard grayish white limestone (sorted biosparite) overlies the Hayama Group with unconformity. The rock bears numerous

fragments of *Balanus* and shells, the former of which occupies almost 80 percent of the fossils in quantity. There are included subangular pebbles of 5×10, or 10×15 cm in size composed of rocks of the Hayama Group. The limestone* strikes N 70°E, and dips 60° NW.

Loc. 16. Golf link of Hayama Country Club, east of Hôkinzan, Hayama-cho; Lat. 35°15′22″N, Long. 139°36′44″E.

A layer of brown pyroclastic coarse grained sandstone of over 30 m thick lies on the Hayama Group. It intercalates granules or small pebbles, 3–4 mm in diameter composed of rocks of the Hayama Group. Shells of *Glycymeris* and *Astriclypeus* are aggregated partially. The basal part of the bed changes into an about 10 m thick gray hard coarse grained limestone (biosparite or calcarenite) composed of *Balanus* and shell fragments. The sandstone bed strikes N 60°W and dips 30°NE.

Loc. 17. Sea coast of Sajima, Yokosuka City; Lat. 35°1′24″N, Long. 139°36′21″E.

A 1.5 m thick brown conglomeratic sandstone bed overlies the Hayama Group, and has N-S strike and 45°W dip. The conglomerate pebbles are of serpentine and rocks of the Hayama Group. Shells, *Balanus*, coral and Bryozoa are mostly eroded and broken. *Amussiopecten* is aggregated in the conglomeratic sandstone at Yaguramae, northeast of Sajima.

ASSEMBLAGES

The quantitative occurrence of megafossils of the Tagoe, Shimoyamaguchi and Kumura beds is shown in Table 2 and their geological, geographical and bathymetric distributions in Table 3. The Shimoyamaguchi bed yielded most of the species (53 species), followed by the Tagoe (45 species) and the Kumura bed (22 species). The specific distribution in the three beds is shown in Table 4. Pelecypoda and Gastropoda are the important components of the assemblages and quantitatively the dominant elements of the three beds are as follows:

Tagoe bed (conglomeratic facies), *Chlamys* (s.s.) *miurensis*, *Lima zushiensis*, *Lima goliath*, *Glycymeris* aff. *pilsbryi*, *Ginebis argenteonitens*, *Crassatellites uchidanus*, *Flabellum* aff. *transversale*, *Venus* (*Ventricola*) aff. *foveolata*, *Nemocardium* (*Keenaea*) *samarangae* — *Chlamys-Lima* assemblage.

Shimoyamaguchi bed (sandstone facies), *Glycymeris* cf. *cisshuensis***, *Leukoma* aff. *marica*, *Suchium* (s.s.) *koyuense*, *Controchus parahispidus*, *Chlamys* (s.s.) *miurensis*, *Terebratulina peculiaris***, *Glycymeris* aff. *pilsbryi*, *Tegulorhynchia döderleini***, *Dentalium vernedi*, *Lucinoma annulata***, *Nemocardium* (*Keenaea*) *samarangae* — *Glycymeris-Leukoma* assemblage.

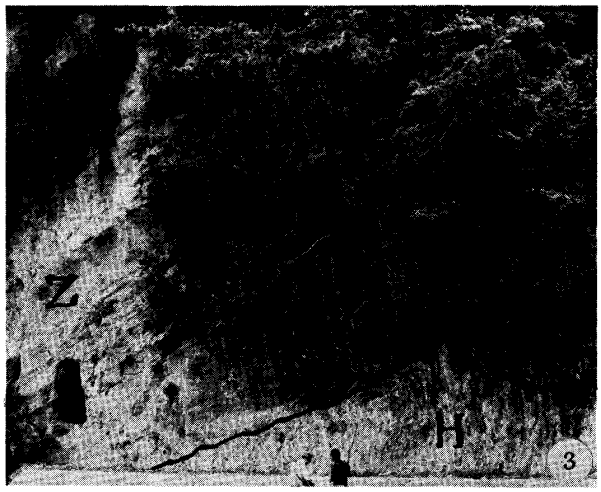
Kumura bed (limestone-coquina facies), *Flabellum* aff. *transversale*, *Balanus* aff. *amphicostatus*, echinoid, *Ctena* aff. *divergens*, *Premocyathus compressus* — Coral-*Balanus* assemblage.

It is clear that each assemblage is controlled by the bottom sediments as seen in the *Chlamys-Lima* assemblage of conglomerate or conglomeratic sandstone, the *Glycymeris-Leukoma* assemblage of sandstone, the Coral-*Balanus* assemblage of limestone, coquina or calcareous sandstone. *Chlamys miurensis* is the most dominant and representative species

* The limestone of Uchisaba, Iwado and Kumura contains $CaCO_3$ and $MgCO_3$ as follows:

	Uchisaba	Iwado	Kumura
$CaCO_3$	78.4	31.0	71.1%
$MgCO_3$	0.15	0.11	1.26

** Both valves are not detached from each other, showing autochthonous occurrences.



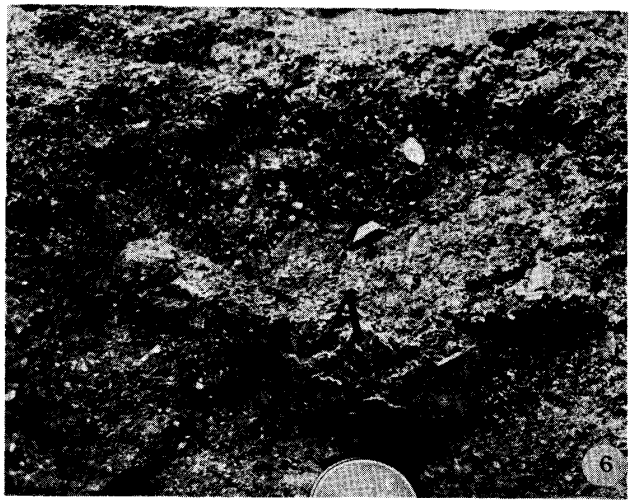


Fig. 3. Abuzuri unconformity exposed at Loc. 1. H; Hayama Group. Z; Zushi mudstone formation.
Fig. 4. Fine conglomerate of Tagoe bed at Loc. 1. T; Tagoe bed.
Fig. 5. Conglomerate with shell aggregation of Tagoe bed at Loc. 1.
Fig. 6. Coarse grained sandstone with shells at Loc. 16. A; *Astriclypeus*.
Fig. 7. Unconformity between Hayama Group (H) and Kumura bed consisted of coquina (K) at Loc. 15.
Fig. 8. Limestone of Kumura bed at Loc. 10.

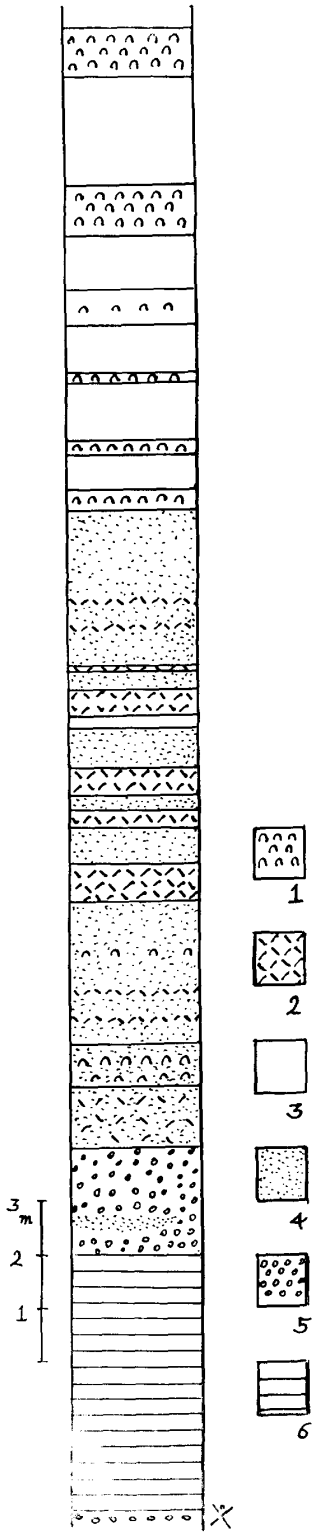


Fig. 9. Columnar section of Shimoyamaguchi- and Kumura beds at Loc. 11. 1; pumice, 2; tuff, 3; silt, 4; sandstone, 5; conglomerate, 6; calcareous sandstone or limestone.

of the Tagoe bed and is common in the sandy sediments of the Shimoyamaguchi bed. In the former bed it occupies almost 90–95 percent of all megafossils but occurs as an aggregation of detached valves. The valves are not broken but well preserved just as in the case of *Lima zushiensis* and *L. goliath*. *Glycymeris* cf. *cisshuensis* may also be a representative species of the Shimoyamaguchi bed. It is autochthonous at Loc. 16. The autochthonous condition of fossil Mollusca is often seen in the Shimoyamaguchi bed, suggesting deposition in a calm physiographical condition of water. *Leucoma* aff. *marica* and *Ctena* aff. *divergens* are dominant members of the fossil assemblage and the latter with *Balanus* sometimes becomes a component of the coquina.

The bathymetric range of living species is shown by nomination based on Oyama's method (N_0-B) in Table 3. Histograms of the bathymetric range of the fossil assemblages of each bed are shown in Fig. 10, where four lines indicate only living species with and without quantitative frequency, and the living and fossil species with and without it. The bathymetric range of the fossil species is shown by parenthesis in Table 3 because it is not known so precisely as the living species. In the case of the Tagoe histogram without frequency, the peak lies in N_3 of both living and the living+fossil lines. When frequency is added, the peak is shifted to N_4-B or N_3-B. Thus, it is probable that the assemblage of the Tagoe bed lived at a depth of N_3-B; this points to the lower part of the upper shelf to archibenthal environments. In the Shimoyamaguchi histogram without frequency, the peak lies in N_1 and N_3 of the living line and in N_3 of the living +fossil line. When frequency is added, the peak is shifted to N_0 and N_3; meaning that the tidal and the lower part of the upper shelf environments are mixed, that is to say, the tidal elements were transported to the upper shelf environment. In the Kumura histogram without frequency, the peak lies in N_3 of the living line and in N_1 and N_4 of the living+fossil line. When frequency is added the peak is not shifted; this means that the elements of the upper part of the upper shelf were transported to the lower part of the upper shelf or to the lower shelf environment. This kind of transportation might be caused by undercurrent. *Turbo* aff. *cornutus* may be a typical element of the tidal zone of the rock floor, while *Perotrochus* and *Mikadotrochus* are typical of the lower shelf or the archibenthal zone. Many of the simple corals and brachiopods indicate the lower shelf or archibenthal zone. The bottom condition of the Tagoe bed may be noteworthy as it

is conglomeratic or of very coarse grained sediments of N_3-B zone. According to Horikoshi, in Sagami Bay the hard bottom facies with archibenthal fauna is represented by *Mikadotrochus*, *Fulgoraria smithi* and *Lima goliath*, etc. as seen in the rocky slopes around the bank of Okino-sé.*. The *Chlamys-Lima* assemblage of the Tagoe bed must have lived in an environment like that of the Okinosé bank. It may be said that as far as living species with frequency is concerned the Shimoyamaguchi bed (N_0-N_3) was deposited in a sea shallower than the other two beds and the Tagoe bed (N_4-B) was in a deeper sea than the Kumura bed (N_3).

The assemblages of the three beds belong to the warm water fauna of the paleo-Kuroshio water region. *Perotrochus*, *Mikadotrochus*, *Charonia* and *Conus* are its characteristic elements. The deep sea benthonic fauna of the paleo-Kuroshio water region during the Late Miocene (Blow's N 10–N 18) is represented by the Tagoegawa fauna (assemblages of Tagoe, Shimoyamaguchi and Kumura beds). The deep sea hard bottom fauna of the Naarai conglomerate bed has 10 species in common with the Tagoe assemblage (22%) and 10 species with the Shimoyamaguchi assemblage (19%). The fauna of the Ochiai Formation, the upper Susugaya Group in Tanzawa has 5 species in common with the Tagoe assemblage (11%) and 10 species with the Shimoyamaguchi assemblage (19%). The fauna of the middle part of the Isshi Group in Mie Prefecture and the Syukunohora bed of the Mizunami Group in Gifu Prefecture have few species in common with the Tagoegawa fauna, because they are a shallow sea fauna of inland sea type. The fauna of the Tsuma Group in Miyazaki Prefecture has some characteristic species in common as *Suchium koyuense*, *Glycymeris* cf. *cisshuensis* and *Amussiopecten* aff. *iitomiensis* (Shuto's *hyugaensis*) but it is questionable whether the both faunae are coeval with each other. The Miocene Oyashio faunae as seen in the Chichibumachi Group of the Chichibu basin, the Yunagaya Group of the Joban coalfield or the Tanagura Formation in Fukushima Prefecture have very few common species. The biostratigraphical correlation of the Tagoegawa fauna with those of the other regions, from the standpoint of fossil Mollusca, is not easy to determine and depends on further studies.

DESCRIPTION OF SOME NOTABLE SPECIES

Perotrochus(?) *aosimai* Ozaki
Pl. 16, figs. 1, 2

1958 *Perotrochus aosimai* Ozaki, Nat. Sci. Mus., Bull., no. 42, p. 137–138, pl. 9, figs. 1–4.

Type specimen: – NSMT-P-4403.

Specimen described: – A shell from Loc. 3 is moderate in size, depressed trochiform, much wider than high, with 5 volutions. Suture shallow, lateral margin of spire rather straight. Base not convex but flat, periphery of last whorl sharply angulated. Slit not preserved, seems to be shallow, slit band narrow. Spiral striations on surface moderate, with weak nodules, about 8 above slit band and 3–4 below also occur on basal surface. Umbo apparently unperforated. Aperture rhombic, wider than high, with strong inner lip. Shell rather thin, 99.5 mm in maximum diameter and 50.5±mm high.

Remarks: – In general shell outline the specimen described closely resembles the type specimen of *aosimai* Ozaki, which probably belongs to *Perotrochus* Fischer. Besides the type species, *quoyana* Fischer & Bernardi, 1856, many living species have been recorded from the West Indies. Compared with these species, *aosimai* may be characterized by its

* It is about 200–1000 m deep. Challenger St. 236 and 236a: Lat. 34°58′N. Long. 139°29′E: 1410 and 764 m.

Table 2. Quantitative

A: Total specimen numbers. B: Total locality numbers. ··: Occurrence uncalculated.	Tagoe facies			
	1	2	3	4
GASTROPODA				
1. *Perotrochus* (?) *aosimai* Ozaki	-	-	1	-
2. *Mikadotrochus yosiwarai* (Ozaki)	1	-	-	-
3. *Diodora yokoyamai* Otuka	-	-	-	-
4. *Calliostoma* (?) *sp.*	-	-	-	-
5. *Machaeroplax* (?) *hayamensis*, n. sp.	-	-	-	1
6. *Suchium* (s.s.) *koyuense* Shuto	-	-	-	-
7. *Gaza* (?) sp.	-	-	-	-
8. *Ginebis argenteonitens* (Lischke)	-	-	-	-
9. *Homalopoma* (*Phanerolepida*) *pseudotransena* Ozaki	-	-	-	-
10. *Turbo* (*Batillus*) aff. *cornutus* Gmelin	-	-	-	-
11. *Pachypoma* aff. *takitai* Ozaki	-	-	-	-
12. *Astraea* (*Incilaster*) *virgata* Ozaki	1	-	-	-
13. *Calyptraea aramakii*, n. sp.	-	-	-	2
14. *Neverita* aff. *hosoyai* Kuroda	-	-	-	-
15. *Doliocassis* aff. *japonica* (Yokoyama)	-	-	1	-
16. *Charonia sauliae* (Reeve)	-	-	-	-
17. *Cymatium* sp.	-	-	-	-
18. *Nassarius* sp.	-	-	-	-
19. *Buccinum* (?) sp.	-	-	-	-
20. *Olivella* sp.	-	-	1	-
21. *Conus* sp.	-	-	-	-
SCAPHOPODA				
22. *Dentalium vernedi* Sowerby	-	-	-	-
23. *D.* aff. *rhabdatum* Pilsbry	-	-	-	-
24. *D.* sp.	-	-	-	-
PELECYPODA				
25. *Yoldia* sp.	-	-	-	-
26. *Nuculana* sp.	-	-	-	-
27. *Barbatia obliquata* (Yokoyama)	1	-	-	-
28. *Glycymeris* aff. *pilsbryi* (Yokoyama)	-	-	-	-
29. *G. vestita* Dunker	-	-	-	-
30. *G.* cf. *cisshuensis* Makiyama	-	-	-	-
31. *G. matsumoriensis* Nomura & Hatai	-	-	-	-
32. *G.* sp.	1	-	-	-
33. *Limopsis* (*Nipponolimopsis*) *ozawana* Yokoyama	-	-	-	-
34. *L.* sp.	-	-	-	-
35. *Mytilus coroscus* Gould	-	-	-	-
36. *Chlamys* (s.s.) *miurensis* (Yokoyama)	50+	5+	5+	-
37. *C.* (*Mimachlamys*) *kaneharai* (Yokoyama)	-	-	-	-
38. *Amussiopecten iitomiensis* (Otuka)	1	-	-	-
39. *Aequipecten* (*Cryptopecten*) *yanagawaensis* (Nomura & Zinbo)	-	-	-	-
40. *Dimya* sp.	1	-	-	-
41. *Lima* (s.s.) *zushiensis* Yokoyama	5+	1	1?	1
42. *L.* (s.s.) *quantoensis* Yokoyama	-	-	-	-
43. *L.* (*Acesta*) *goliath* Sowerby	-	-	-	-
44. *Ostrea* aff. *circumpicta* Pilsbry	-	-	-	-
45. *O.* sp.	-	-	-	-
46. *Anomia* sp.	-	-	-	-
47. *Crassatellites uchidanus* (Yokoyama)	-	-	-	-
48. *Cardita hataii*, n. sp.	1	-	-	-
49. *Lucinoma annulata* (Reeve)	-	-	-	-
50. *Ctena* aff. *minoensis* Itoigawa	-	-	-	-
51. *Thyasira* (?) sp.	-	-	-	-
52. *Nemocardium* (*Keenaea*) *samarangae* (Makiyama)	-	-	-	-
53. *Pitar kaniei*, n. sp.	-	-	-	-
54. *Venus* (*Chione*) *chitaniana* (Yokoyama)	-	-	-	-

occurrence of megafossils.

		Shimoyamaguchi fac.						Kumura fac.			Shimoy.		A	B
5	6	7	8	9	10	11	12	13	14	15	16	17		
-	-	-	1	-	-	-	-	-	-	-	-	-	2	2
-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
-	-	-	-	-	-	-	1	-	-	-	-	-	1	1
1	-	-	-	-	-	-	-	-	-	-	-	-	1	1
2	-	-	-	-	-	-	-	-	-	-	-	-	3	2
-	-	-	-	16	6	-	-	-	-	-	-	-	22	2
-	1	-	-	-	-	-	-	-	-	-	-	-	1	1
9	1	-	-	-	1	-	-	-	-	-	-	-	11	3
-	1	-	-	-	-	-	-	-	-	-	-	-	1	1
-	-	-	-	-	2	-	-	-	-	-	-	-	2	1
2	-	1	-	-	2	-	-	-	-	-	-	-	5	3
-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
-	1	-	-	-	-	-	-	-	-	-	-	-	3	2
-	-	-	-	-	1	-	-	-	-	-	-	..	1	1
2	1	-	-	-	-	-	-	-	-	-	-	-	4	3
-	-	-	-	-	1	-	-	-	-	-	-	-	1	1
-	-	-	-	1	-	-	-	-	-	-	-	-	1	1
-	-	-	-	-	-	-	-	-	1	-	-	-	1	1
-	-	-	1	-	3	-	-	-	-	-	-	-	4	2
-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
-	-	-	1	-	3	-	-	-	-	-	-	-	4	2
-	-	-	-	-	7	-	-	-	-	-	-	-	7	1
-	1	-	-	-	-	-	-	-	-	-	-	-	1	1
-	-	-	-	1	-	-	-	-	-	-	-	1	2	2
-	-	-	-	-	-	-	-	-	1	-	-	-	1	1
-	-	-	-	-	-	-	-	-	1	-	-	-	1	1
-	-	1	-	-	-	-	-	-	-	-	-	-	2	2
4	7	1	-	-	-	-	6	-	-	2	-	-	20	5
-	-	-	-	2	21	-	-	-	-	-	-	-	23+	2
-	-	-	2+	-	20+	-	-	-	-	1	21+	..	44+	4
-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
-	-	-	-	-	-	-	7	-	-	-	-	-	8	2
-	-	2	-	-	-	-	-	-	-	-	-	-	2	1
-	-	-	-	-	1	-	-	-	-	-	-	-	1	1
-	-	-	-	-	5	-	-	-	-	-	-	-	5	1
1	1	1	-	-	4	7	1	-	1	1	1	-	78+	12
-	-	-	-	-	2	-	-	-	-	-	-	-	2	1
-	-	-	-	-	-	-	-	-	-	-	1	11	13	3
-	1	-	-	-	-	-	-	-	5	2	-	-	8	3
-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
11	4	-	2	-	-	-	1	-	1	1+	-	1	29+	11
1	-	-	-	-	-	-	-	-	-	-	-	-	1	1
6+	3+	-	-	-	2	-	-	-	-	-	-	-	11+	3
1	-	-	-	-	-	-	-	-	-	-	-	-	1	1
1	-	-	-	-	1	-	-	-	-	1	-	-	3	3
2	-	-	-	-	-	-	-	-	-	-	1	-	3	2
1	8	-	-	-	-	-	-	-	3	-	-	-	12	3
-	-	-+	-	-	1	-	-	-	-	1	-	-	3	3
-	-	6	-	-	-	-	-	-	-	-	-	-	6	1
-	-	-	-	1	-	-	-	-	3	4+	-	-	8+	3
-	1	-	-	-	-	-	-	-	-	-	-	-	1	1
3	-	3	-	-	-	-	-	-	-	-	-	2	8	3
-	-	-	-	-	3	-	-	-	-	-	-	-	3	1
-	-	-	-	-	2	-	-	-	-	-	-	-	2	1

Table 2.

A: Total specimen numbers. B: Total locality numbers. ··: Occurrence uncalculated.	Tagoe facies			
	1	2	3	4
55. *V.* (*Chione*) *miurensis*, n. sp.	-	-	-	-
56. *V.* (*Ventricola*) aff. *foveolata* Sowerby	-	1	-	-
57. *Dosinia* (*Phacosoma*) aff. *pubescens* (Philippi)	-	2	-	-
58. *D.* (?) sp.	-	-	-	-
59. *Protothaca tateiwai* Makiyama (?)	2	-	-	-
60. *P.* sp.	-	-	1	-
61. *Leukoma* aff. *marica* (Linné)	-	-	-	-
62. *Paphia* sp.	-	-	-	-
63. *Solen* sp.	-	-	-	-
64. *Halicardia* (?) sp.	-	-	-	1
65. Bivalvia g. & sp. indet. A	-	-	-	-
66. 〃 B	-	-	-	-
67. 〃 C	-	-	-	-
68. 〃 D	-	-	-	-
BRACHIOPODA				
69. *Tegulorhynchia döderleini* (Davidson)	-	-	-	-
70. *Terebratulina peculiaris* Hatai	-	-	-	-
71. *T. crossei* Davidson	-	-	-	-
BRYOZOA				
72. G. & sp. indet.	1	-	-	-
CORAL				
73. *Euphyllia* cf. *fimbriata* (Spengler)	-	-	-	-
74. *Enallopsamia* (*Anissopsamia*) *amhelioides* (Alcock)	-	-	-	-
75. *Premocyathus compressus* Yabe & Eguchi	-	-	-	-
76. *Conotrochus parahispidus* Yabe & Eguchi	-	-	-	-
77. *Fragilocyathus conotrochoides* Yabe & Eguchi	-	-	-	-
78. *Paradeltocyathus* aff. *orientalis* (Duncan)	-	-	-	-
79. *Carophyllia* aff. *japonica* Marenzeller	-	-	-	-
80. *Flabellum* aff. *transversale* Moseley	3	-	-	-
CIRRIPEDIA				
81. *Balanus* aff. *amphicostatus* Pilsbry	-	-	-	-
82. *B.* sp.	-	-	-	-
ECHINOIDEA				
83. *Astriclypeus manni integer* Yoshiwara	-	-	-	-
84. Echinoid g. & sp. indet.	-	-	-	-
VERTEBRATA				
85. *Carcharodon megalodon* (Charlesworth)	-	-	-	-
86. *Oxyrhina hastalis* (Agassiz)	-	-	-	-
87. Cetacea g. & sp. indet.	1	-	?	-
Total specific numbers	13	4	6+	4

distinctly depressed spire.

Localities: Loc. 3 (Sakurayama); very rare (collected by Ishizuka). Loc. 8 (Sakamoto); very rare (collected by Shibata).

Mikadotrochus yosiwarai (Ozaki)

Pl. 16, figs. 3, 4

1954 *Pleurotomaria yosiwarai* Ozaki, Nat. Sci. Mus., Bull., N.S., v. 1, no. 1, p. 9, 10, pls. 1, 2.

Type specimen: – NSMT-P-4258.

Continued

		Shimoyamaguchi fac.						Kumura fac.			Shimoy.		A	B
5	6	7	8	9	10	11	12	13	14	15	16	17		
-	-	-	-	-	2	-	-	-	-	-	-	-	2	1
6	-	-	-	-	-	-	-	-	-	-	-	-	7	2
-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
-	1	-	-	-	-	-	-	-	-	-	-	-	3	2
-	-	-	-	-	-	1	-	-	-	-	-	-	2	2
-	-	-	-	2	15+	-	-	-	-	-	-	1	18	3
-	-	-	-	-	-	-	-	-	1	-	-	-	1	1
-	-	-	-	2	6	-	-	-	-	-	-	-	8	2
-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
-	-	1	-	-	-	-	-	-	-	-	-	-	1	1
-	-	1	-	-	-	-	-	-	-	-	-	-	1	1
-	-	-	-	-	-	-	-	-	2	-	-	-	2	1
-	-	-	-	-	-	-	-	-	2	-	-	-	2	1
1	-	-	-	-	-	-	8+	-	-	-	-	-	9+	2
-	-	8+	-	-	-	-	-	-	-	-	-	2	10	2
-	-	-	-	-	-	-	1	-	-	-	-	-	1	1
-	-	-	-	-	-	-	-	-	-	-	-	1	2	2
-	-	-	-	-	-	-	2	-	-	-	-	-	2	1
-	3	-	-	-	-	-	2	-	-	3	-	-	8	3
-	-	-	-	-	-	-	-	5	-	-	-	-	5	1
-	-	-	-	-	-	-	-	-	-	-	-	13+	13+	1
-	-	-	-	-	-	-	-	-	-	-	-	2	2	1
3	3	-	-	-	-	-	-	-	-	-	-	-	6	2
-	3	-	-	-	-	-	-	-	-	-	-	-	3	1
4	-	?	-	-	-	-	2	-	9	-	-	-	18	4
1	-	-	-	..	..	..	-	-	-	-	-	-	4+	4
1	-	-	-	-	-	-	-	-	-	-	-	1+	2+	2
-	-	-	-	-	1	-	-	-	-	-	6	-	7	2
-	-	-	-	..	..	..	-	5+	-	-	-	-	8+	4
-	-	-	-	-	1	-	-	-	-	-	-	-	1	1
1	-	-	-	-	-	-	-	1	-	-	-	-	2	2
1	-	-	-	-	-	-	-	-	-	-	-	-	2	2
23	17	10+	5	9+	28+	4+	10	3	12	9	5	11+		

Specimen described: – Shell of moderately size, 94.5 mm wide and 65.9 mm high, trochiform, wider than high, with more than 5 volutions. Suture very shallow, lateral margin of spire nearly straight. Slit very shallow, narrow, slit band situated a little below middle height of volution. Weak spiral striations present, about 8 above slit band and about 4 below; striation is like that of *hirasei*. Base moderately convex with obsolete spiral striations. Umbilicus apparently closed. Aperture quadrate with strong inner lip. Fasciole rather broad. Shell very thick.

Remarks: – This species is rather allied to *schmalzi* Shikama in possessing a thick shell, convex base with obsolete striation, high spire and shallow slit, etc. Shikama's

Table 3. Megafossil distribution of Tagoe, Shimoyamaguchi and Kumura beds.

	Tagoe bed	Shimoyamaguchi b.	Kumura bed	Bathymetric range	Geographical distribution		Naarai bed	Ochiai Formation
					Pacific	Japan Sea		
1. *Perotrochus* (?) *aosimai* Ozaki	—	—		N_4-B			0	?
2. *Mikadotrochus yosiwarai* (Ozaki)	—			N_4-B			0	
3. *Diodora yokoyamai* Otuka		—		N_4	33-34		0	
4. *Calliostoma* (?) sp.	—							
5. *Machaeroplax* (?) *hayamensis*, n. sp.	—							
6. *Suchium* (s.s.) *koyuense* Shuto		=		(N_0)				
7. *Gaza* (?) sp.	—							
8. *Ginebis argenteonitens* (Lischke)	=	—		N_3-B	33-35		0?	
9. *Homalopoma* (*Phanerolepida*) *pseudotransena* Ozaki	—			(N_4-B)				
10. *Turbo* (*Batillus*) aff. *cornutus* Gmelin		—		(N_0)				?
11. *Pachypoma* aff. *takitai* Ozaki	—	—		(N_4-B)			0	
12. *Astraea* (*Incilaster*) *virgata* Ozaki	—			(N_4-B)			0	
13. *Calyptraea aramakii*, n. sp.	—							
14. *Neverita* aff. *hosoyai* Kuroda		—		N_0	33-35			
15. *Doliocasis* aff. *japonica* (Yokoyama)	—							
16. *Charonia sauliae* (Reeve)		—		N_1	14?-36	-36		
17. *Cymatium* sp.		—						
18. *Nassarius* sp.			—					
19. *Buccinum* (?) sp.		—		(N_{1-3})				
20. *Olivella* sp.	—							
21. *Conus* sp.		—						0
22. *Dentalium vernedi* Sowerby		=		N_{1-3}	23-34			
23. *D.* aff. *rhabdatum* Pilsbry	—			N_{3-4}	33-39	-41		
24. *D.* sp.		—						
25. *Yoldia* sp.			—					
26. *Nuculana* sp.			—					
27. *Barbatia obliquata* (Yokoyama)	—	—	—	N_{1-3}	34-41	-43	0	
28. *Glycymeris* aff. *pilsbryi* (Yokoyama)	=	=	—	N_{2-3}	31-41	32-41		
29. *G. vestita* Dunker		—					0	0
30. *G.* cf. *cisshuensis* Makiyama		—	—					0?
31. *G. matsumoriensis* Nomura & Hatai		—						
32. *G.* sp.	—	—						
33. *Limopsis* (*Nipponolimopsis*) *ozawana* Yokoyama		—						
34. *L.* sp.		—						
35. *Mytilus coroscus* Gould		—		N_1	38-51	-46	0	
36. *Chlamys* (s.s.) *miurensis* (Yokoyama)	=	=	—				0	0
37. *C.* (*Mimachlamys*) *kaneharai* (Yokoyama)		—						0
38. *Amussiopecten iitomiensis* (Otuka)		—						
39. *Aequipecten* (*Cryptopecten*) *yanagawaensis* (Nomura & Zinbo)	—		—					
40. *Dimya* sp.	—							
41. *Lima* (s.s.) *zushiensis* Yokoyama	=	—	—	N_{0-1}	33-35	-37	0	0
42. *L.* (s.s.) *quantoensis* Yokoyama	—	—		N_2	33-35	32-38		
43. *L.* (*Acesta*) *goliath* Sowerby	—	—		N_4-B	35-40	-42	0	
44. *Ostrea* aff. *circumpicta* Pilsbry	—	—		N_0	31-39	-40		0
45. *Ostrea* sp.		—	—					
46. *Anomia* sp.	—	—						
47. *Crassatellites uchidanus* (Yokoyama)	=	—	—					
48. *Cardita hataii*, n. sp.	—	—	—					
49. *Lucinoma annulata* (Reeve)		=		N_{0-2}	33-41	-41		
50. *Ctena* aff. *minoensis* Itoigawa		—	=	(N_0)				

Table 3. Continued.

	Tagoe bed	Shimoyamaguchi b.	Kumura bed	Bathymetric range	Geographical distribution: Pacific	Geographical distribution: Japan Sea	Naarai bed	Ochiai Formation
51. *Thyasira* (?) sp.								
52. *Nemocardium* (*Keenaea*) *samarangae* (Mak.)				N_{2-3}	32-36	32-41		0
53. *Pitar. kaniei*, n. sp.				(N_{0-1})				
54. *Venus* (*Chione*) *chitaniana* (Yokoyama)				(N_{0-1})				
55. *V.* (*Chione*) *miurensis*, n. sp.				(N_{0-1})				
56. *V.* (*Ventricola*) aff. *foveolata* Sowerby				N_3	31-36	-40	0	
57. *Dosinia* (*Phacosoma*) aff. *pubescens*(Philippi)				N_0	10-?			
58. *D.* (?) sp.						34-36		
59. *Protothaca tateiwai* Makiyama (?)				(N_{0-1})				
60. *P.* sp.								
61. *Leukoma* aff. *marica* (Linné)				N_0	-0-28			
62. *Paphia* sp.						-37		
63. *Solen* sp.								
64. *Halicardia* (?) sp.				(B)				
65. Bivalvia g. & sp. indet. A								
66. 〃 B								
67. 〃 C								
68. 〃 D								
69. *Tegulorhynchia döderleini* (Davidson)				530m(B)				
70. *Terebratulina peculiaris* Hatai								
71. *T. crossei* Davidson								
72. Bryozoa g. & sp. indet.								
73. *Euphyllia* cf. *fimbriata* (Spengler)								
74. *Enallopsamia* (*Anissopsamia*) *amhelioides* (Alcock)				100-200m(N_{3-4})				
75. *Premocyathus compressus* Yabe & Eguchi				180-190m(N_4)				
76. *Conotrochus parahispidus* Yabe & Eguchi				88-600m(N_0-B)				
77. *Fragilocyathus conotrochoides* Yabe & Eguchi				188m(N_4)				
78. *Paradeltocyathus* aff. *orientalis* (Duncan)				59-550m(N_2-B)				
79. *Carophyllia* aff. *japonica* Marenzeller				50m(N_2)				
80. *Flabellum* aff. *transversale* Moseley				17-300m(N_1-B)				
81. *Balanus* aff. *amphicostatus* Pilsbry								
82. *B.* sp.								
83. *Astriclypeus manni integer* Yoshiwara								
84. Echinoid g. & sp. indet.								
85. *Carcharodon megalodon* (Charlesworth)								
86. *Oxyrhina hastalis* (Agassiz)								
87. Cetacea g. & sp.								
Total specific numbers	45	53	20					

species was proposed for the living species from off Tosa which was hitherto known under the name of *salmiana* Rolle.

Locality: – Loc. Sakurayama coast; very rare (collected by Tanabe).

Machaeroplax (?) *hayamensis* Shikama, n. sp.
Pl. 16, figs. 7, 8

Type specimen: – Two shells from Loc. 5; GIYU-M-4.

Table 4. Specific distribution of benthonic animals.

	Tagoe bed	Shimoyamaguchi bed	Kumura bed
Gastropoda	12	11	1
Scaphoda	1	2	0
Pelecypoda	22	27	14
Brachiopoda	1	3	1
Bryozoa	1	1	0
Coral	4	5	3
Cirripedia	2	0	1
Echinodermata	0	1	1
Total	43	50	21

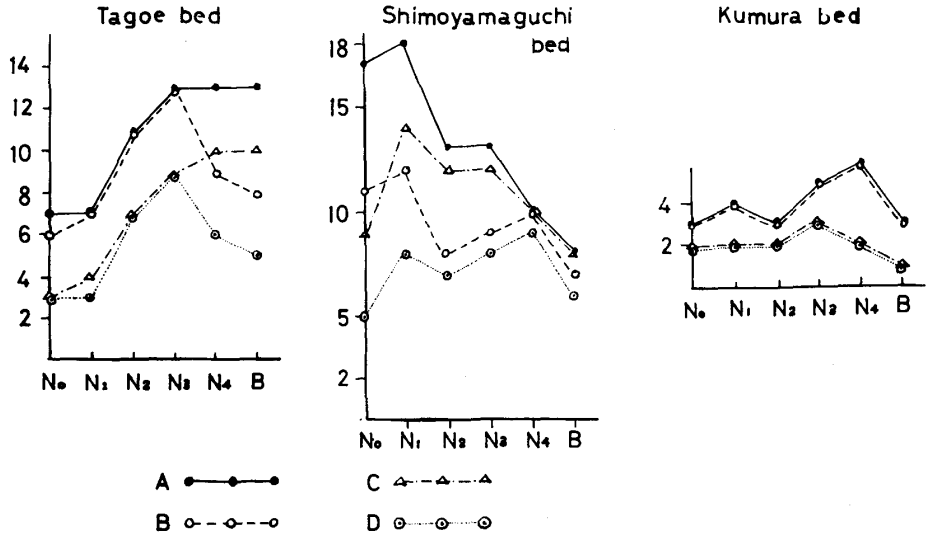


Fig. 10. Histograms of bathymetric ranges of fossil assemblages of the Tagoe, Shimoyamaguchi and Kumura beds.

Description: – Shell small, depressed trochiform, much wider than high, with 3 volutions and very small protoconch. Suture rather deep and sharp. Shoulder round. Umbilicus opened, apparently rather deep. Shell very thin and nacreous. Larger one 16.0 mm wide and 8.5±mm high, smaller one 11.8 mm wide and 4.1 mm high.

Remarks: – Owing to the poor preservation, the radial striation or keeled margin of the umbilicus is not clear. *M. varicosa koreanica* (Dall) resembles this species in outline and shell character but differs by its higher spire.

Locality: – Loc. 5 (Futagoyama); rare (collected by Aramaki).

Ginebis argenteonitens (Lischke)
Pl. 16, figs. 5, 6

1872 *Trochus argenteonitens* Lischke, Malk. Blatt., 19, p. 104.
1943 *Turcicula argenteonitens*, Is. Taki & Otuka, Conch. Asiatica, 1, p. 105, pl. 1, fig. 3.
1962 *Bathybembix (Ginebis) argenteonitens*, Kira, Shells West Pacific Col., 1, p. 9, fig. 6.
1969 *Turcicula crumpii yokoyamai* Otuka, Shikama & Masujima, Yok. Nat. Univ., Sci. Rep., sec. 2, no. 15, pl. 5, fig. 10.
1971 *Ginebis argenteonitens*, Kuroda, Habe & Oyama, Sea Shells Sagami Bay, p. 30, pl. 9, figs. 7, 8.

Localities: – Loc. 5 (Futagoyama); common, Loc. 6 (Taura); rare, Loc. 10 (Daimyoji-danchi); rare.

Suchium (s.s.) *koyuense* Shuto
Pl. 16, figs. 9, 10

1956 *Schium koyuense* Shuto, Japan. Jour. Geol. Geogl., v. 27, no. 1, p. 49–51, pl. 4. figs. 1, 2.

Holotype: – GH-L 15011; gained from the lower Tsuma group at Yamaji, Minomura, Koyu-gun, Miyazaki Prefecture.

Specimens described: – More than 14 shells were collected. Shell small trochiform, wider than high, with about 4 volutions and small protoconch. Suture sharp, moderately depressed. Some tubercles on subsutural band; tubercles relatively small obtuse, about 7 in one volution. Periphery not angulated. Shell surface very smooth. Base convex, umbilicus covered by relatively large callus pad. Largest one 14.5 mm wide and 10.7 mm high.

Remarks: – This species was described by Shuto in detail. He observed the shell structure by an axial section and described the umbilicated protoconch and its succeeding 4 volutions. He regarded this species as transitional one between *Protorotella* and *Suchium*. It may be one of the oldest records of *Suchium* (s.s.) and the direct ancestor of *Suchium yabei* Sugiyama. Sugiyama once regarded *yabei* as predecessor of *giganteum yamamotoi-g. naganumanum* lineage, while Shuto considered *yabei* as the direct ancestor of *subsuchiense*. Some authors (*e.g.* Ogose, 1962) determined the umbonid shell of the Miura Group to be *yabei*. The latter is clearly distinguished from *koyuense* by the many spiral striations and it occurs in the Dainichi sand of the Kakegawa Group.

Localities: – Loc. 9 (Kinugasa Asylum); much, Loc. 10 (Daimyoji-danchi); few (collected by Hiroishi and Oda).

Turbo (*Batillus*) aff. *cornutus* Gmelin
Pl. 16, figs. 11–13

Specimen described: – Shell moderate in size, trochiform, only 2 volutions preserved; protoconch and its basal portion are largely broken. Whorl high, angulated, carries many distinct spines which are also largely broken. Two rows of spines on larger volution as preserved, those of upper row larger than those of lower; 6 spines of upper row and about 5 of lower preserved; distal end of spine not acutely pointed but rather truncated as in *cornutus*. Suture seems to be rather deep and sharp. Shell surface apparently rather smooth and without spiral grooves or striations. Shell 77.8 mm in maximum width of last whorl and 16.2 mm in height of penultimate whorl.

Remarks: – The shell in question is like that of *cornutus* in general outline, aspect of spines and shell size, etc. but may be separated from it by the smooth shell surface. Missing of the fasciole and operculum is fatal for determination of its true taxonomic position.

Locality: – Loc. 10 (Daimyoji-danchi); few (collected by Ozaki and Yui).

Pachypoma aff. *takitai* Ozaki
Pl. 16, figs. 16, 17

Compared with:
1954 *Pachypoma takitai* Ozaki, Nat. Sci. Mus., Bull., N.S., v. 1, no. 1, p. 12, 13, figs. 1, 2.

Holotype: – NSMT-P-4301.

Specimen described: – Five specimens, all broken but one from Loc. 7 retains 2 volutions. A part of shell surface carries about 7 tuberculated spiral ridges, of which about 3 are stronger than others. Original surface of last whorl probably had over 5 main spiral ridges and about 8 accessory ones. In this character this species is distinguished

from *takitai* Ozaki which has 5 spiral ridges and numerous axial striations. The largest, about 59.6 mm in maximum diameter and 32.0 mm high as preserved.

Remarks: – Ozaki put *takitai* in the genus *Pachypoma* J.E. Gray, the type species of which *inaequalis* Martyn is now living in the Californian sea. The shell of *inaequalis* has no radial foliated spines at the margin of last whorl. In this point *takitai* may belong to *Pachypoma*.

Localities: – Loc. 5 (Futagoyama), few; Loc. 7 (Higashihemi), rare; Loc. 10 (Daimyoji-danchi), rare (collected by Aramaki and Hirayama).

Calyptraea (*Calyptraea* ?) *aramakii* Shikama, n. sp.
Pl. 16, figs. 19, 20

Type specimen: – One shell from Loc. 6 (Taura); GIYU-M-5.

Description: – Shell like *Calyptraea* of medium size 14.8 mm in maximum diameter and 3.9 mm high, suboval in dorsal view and depressed conical in lateral view. Both lateral margins distinctly convex. Suture very distinct and depressed especially between last and penultimate whorls. Shell with about 3 volutions, and very small protoconch. Shell surface smooth without striations or rugosity.

Remarks: – *Calyptraea yokoyamai* Kuroda living in Sagami Bay to off the coast of Tosa has its protoconch situated nearer to shell margin than this species. The last whorl of *yokoyamai* is more distinctly convex dorsalward than that of *aramakii*. In the position of protoconch, this species is near to *C. sinensis* Linné of the Atlantic Ocean or *C.* sp. reported by Yokoyama from the Asagai Formation in the Joban coalfield under the name of *C. mamillaris* (Broderip). *C. sinensis* is distinct from this species by its tuberculated or rugose shell surface. The Asagaian *Calyptraea* is also distinguished from this species by its more acutely projected whorl. *C. mamillaris* (Broderip) of the Pacific coast of Mexico and *C. morbidum* Reeve of the South China Sea are the same. *Calyptraea yokoyamai tubura* Otuka from the Miocene Shikonai bed of the Kadonosawa Group has more depressed shell though its protoconch lies rather in the center of shell.

Locality: – Loc. 6 (Taura); rare (collected by Takeuchi).

Charonia sauliae (Reeve)
Pl. 16, fig. 21

1844 *Triton sauliae* Reeve, Conch. Icon., *Triton* sp. 17.
1962 *Charonia sauliae*, Kira, Shell West Pacific Col., v. 1, p. 56, pl. 22, fig. 11.

Specimen described: – A shell from Loc. 10 (YCM-GP-523-3) preserves its last whorl and preceeding 3 volutions. Apex of whorl and columella broken, shell unpreserved. Last whorl as preserved retains two rows of tubercles, upper one with over 7 obtuse and tolerably large tubercles. Many spiral striations present. Varices preserved on last and penultimate whorls not continuous to each other. Suture very sharp. Shell 99.9 mm high and 63.6 mm in maximum width.

Remarks: – Owing to deformation of the specimen precise determination depends on future researches.

Locality: – Loc. 10 (Syoei-danchi); rare (collected by Hirayama).

Glycymeris cf. *cisshuensis* Makiyama
Pl. 17, figs. 1, 2

1926 *Glycymeris cisshuensis* Makiyama, Kyoto Imp. Univ., Coll. Sci. Mem., ser. B, v. 2, no. 3, p. 155–156, pl. 13, figs. 2, 3.
1928 *Glycymeris cisshuensis*, Nagao, Tohoku Imp. Univ., Sci. Rep., ser. 2, v. 12, no. 1, p. 29, 30,

pl. 2, figs. 1–13, pl. 3, figs. 1–3, pl. 4, figs. 22–25.
1962 *Glycymeris cisshuensis*, Kamada, Pal. Soc. Japan., Spec. Pap., no. 8, p. 62–63, pl. 3, figs. 1–3.

Type locality: – Kinsei, Meisen district, North Korea. Miocene Banko sandstone, Meisen group. Type was stored in the Geological Survey of Seoul.

Specimen described: – Shells from Loc. 10 (Daimyoji-danchi) and Loc. 16 (Hôkinzan) are included in this species. Shell large, thick, solid, suborbicular, rather longer than high, and a little unequilateral. Beak prominent and rounded. Shell surface with many radial lines. Ligamental area long, relatively large, broadly triangular and with chevroned grooves. Teeth strong, dinstinctly pectinate, hooked, about 12 in number. Basal margin of inner surface has eminent crenulation. A shell from Loc. 16 is 64.5 mm long and 63.5 mm high.

Remarks: – As Makiyama stated, this species may be separated from *vestita* by its better developed hinge plate, thicker shell and more prominent beak, etc. The occurrence of this species from the Ashiya Group (Nagao, 1928), Ushikubitôge Formation, Chichibu (Kanno, 1960) and Honya Formation, Jôban coalfield (Kamada, 1962) may be significant.

Localities: – Loc. 8 (Sakamoto); common (collected by Shibata), Loc. 10 (Daimyoji-danchi); abundant (collected by Ozaki, Yui and Hirayama, etc.), Loc. 16 (Hokinzan); abundant (collected by Ozaki and Yui), Loc. 15 (Uchisaba); rare (collected by Aramaki).

Mytilus coruscus Gould
Pl. 17, fig. 3

1861 *Mytilus coruscus* Gould, Proc. Boston Soc. Nat. Hist., 8, p. 38.
1868 *Mytilus crassitesta* Lischke, Malak. Blatt., 15, p. 221.
1971 *Mytilus coruscus*, Kuroda, Habe & Oyama, Sea Shell Sagami Bay, p. 343, pl. 72, figs. 3, 4.

Specimen described: – A well preserved shell from Loc. 10 (YCM-GP-95) retains only part of shell. Shell elongate subtrigonal with eminently projected beak and relatively sharp longitudinal ridge. Median portion of dorsal margin moderately angulated. Shell expands posteriorly, 118.1 mm long as preserved and 64.6 mm high.

Remarks: – This species is very much like *M. grayanus* Dunker but is distinguished by the more elongate and narrower muscle scar. As the right side of the core retains a narrow scar, this shell belongs to *coruscus*.

Chlamys (s.s.) *miurensis* (Yokoyama)
Pl. 17, fig. 4

1920 *Pecten miurensis* Yokoyama, Tokyo Imp. Univ., Jour. Coll. Sci., v. 39, art. 6, pp. 157, 158, pl. 12, figs. 2–6.
1954 *Chlamys miurensis*, Ozaki, Nat. Sci. Mus., Bull., N.S., v. 1, no. 1, pp. 15, 16, pl. 9, figs. 1, 2.
1962 *Chlamys miurensis*, Masuda, Tohoku Univ., Sci. Rep., ser. 2, v. 33, no. 2, pp. 177, 178, pl. 23, fig. 1.

Holotype: – GT-Reg. no. CM 20562.

Specimen illustrated: – A well preserved left valve from Loc. 1, is a little higher than long, with about 25 radial ribs. There are 2–3 accessory ribs in interspaces, of which median one is widest. Radial rib almost smooth and flat but divided into 3 riblets distally. Anterior 7 ribs finely scaled and anterior ear with 10 scaled ribs. Shell 123.2 mm long and 130.0 mm high.

Remarks: – This species has been regarded as an index fossil of the basal part of the Miura Group. It is known to occur from: Ochiai Formation in Tanzawa, Kanagawa Pref.; Naarai, Kurotaki and Inakozawa formations in Chiba Pref.; Shirahama Formation

in Shizuoka Pref.; Futaba and Tomioka formations in Fukushima Pref.; middle horizon of the Isshi Group in Mie Pref.

Localities: – Loc. 1 (Sakurayama coast); abundant, the other 11 localities.

Chlamys (*Mimachlamys*) *kaneharai* (Yokoyama)
Pl. 17, fig. 5

1926 *Pecten* (*Chlamys*) *kaneharai* Yokoyama, Imp. Univ. Tokyo, Jour. Fac. Sci., sec. 2, v. 1, no. 4, p. 135, 136, pl. 18, fig. 1, pl. 19, figs. 1, 2, 5–7.
1962 *Chlamys kaneharai*, Masuda, Tohoku Univ., Sci. Rep., ser. 2, v. 33, no. 2, p. 187, pl. 20, fig. 7, pl. 22, figs. 8–10, pl. 26, figs. 11, 12.

Holotype: – GT Reg. no. KF 2631 from Kanomatazawa Formation in Shiobara, Tochigi Prefecture.

Specimen illustrated: – A large right valve from Loc. 10 (YCM-GP-100), 129.5 mm long and 134.5 mm high, with about 28 radial ribs which are divided into 2–4 riblets distally. About 3 radial accessory ribs in each interspace. Rib and accessory rib finely scaled. Anterior sinus not deep.

Remarks: – This species is known to be widely distributed in the Early-Middle Miocene in Aomori, Miyagi, Yamagata, Fukushima, Gunma and Yamanashi prefectures. The Ochiai Formation in Kanagawa Pref. also yielded this species.

Localety: – Loc. 10 (Daimyoji- and Syoei-danchi); rare (collected by Hirayama and Ozaki).

Cardita hataii Shikama, n. sp.
Pl. 17, fig. 10

Type specimen: – Right valve from Loc. 10 (Daimyoji-danchi); GIYU-M-6.

Description: – Shell small, 21.7 mm long and 15.7 mm high, quadrate in outline, posterior ventral margin distinctly angulated. Shell carries about 10, not scaled but smooth radial ribs; median 3 ribs eminent and thick. Beak not projected.

Remarks: – *Cardita leana* Dunker and *C. laticosta* Sowerby are distinguished by having more than 15 scaled ribs. Japanese fossil species such as *C. katsumatai* Nagao, *C. kondoi* Nagao and *C. mandaica* Yokoyama, etc. are all distinguished by their larger number of radial ribs.

Locality: – Loc. 10 (Daimyoji-danchi); rare (collected by Aramaki).

Venus (*Chione*) *miurensis* Shikama, n. sp.
Pl. 17, fig. 17

Type specimen: – A right valve from Loc. 10 (Syoei-danchi); YCM-GP-525-17.

Description: – Shell large, thick, heavy, subtrigonal in outline, unequilateral. Beak not raised, incurved, much turned forward. Anterior margin distinctly concave in middle portion, where lunule is situated. Dorsal margin curved gently, ventral margin moderately. Lunule short, deep, small. Median portion of shell eminently vaulted. Shell surface with numerous fine radial ridges; also with many thin and low concentric lamellae. Cancellation visible at ventral area. Shell 91.3 mm long and 67.0 mm high.

Remarks: – In shell structure and ornamentation, *V.* (*Chione*) *cancellata* Linné is rather similar to this species but distinguished by its smaller size and stronger radial ridges and concentric lamellae, etc. *Mercenaria mercenaria* (Linné), *M, campechiensis* (Gmelin) and *M. stimpsoni* (Gould), etc., are all distinguished by the absence of radial ridges. *Pseudamiantis tauyensis* (Yokoyama) differs by its obsolete lunule and more convex posterior margin.

Venus (*Chione*) *chitaniana* (Yokoyama) and *V.* (*Chione*) *tateiwai* Makiyama are distinguished by its shorter shell, more conspicuous radial ridge and more convex shell, etc. *V.* (*Chione*) *trigona* (Kanno) is separated by its smaller shell and longer and straight posterior margin.

Locality: – Loc. 10 (Syoei-danchi); rare (collected by Hirayama).

Pitar kaniei Shikama, n. sp.
Pl. 17, figs. 12, 13

Type specimens: – Two right and one left valves from Loc. 10; YCM-GP-525.

Description: – Shell small, not thick, subtrigonal, unequilateral. Beak large, incurved and turned forward. Ventral margin gently curved, posterior margin moderately angulated in middle portion. Shell much vaulted especially at posterior half. Lunule obsolete. Shell surface with many fine concentric striations.

Remarks: – The Japanese Paleogene *Pitar* like *kyushuensis* Nagao or *P. matsumotoi* Nagao are distinguished by the outline of their shells. *P. itoi* Makiyama is distinct by its larger and relatively higher shell with more distinctly curved ventral margin. *P. yabei* Otuka has a much higher shell. *P. affinis* (Gmelin) is distinguished by its beak which is not turned so much forward.

Locality: – Loc. 10 (Syoei-danchi); few (collected by Hirayama).

CONCLUSION

1. The Tagoegawa fauna is represented by the assemblages of the Tagoe, Shimoyamaguchi and Kumura beds, which compose the basal part of the Zushi Formation and consist of conglomerate or conglomeratic sandstone, sandstone and of limestone, coquina or calcareous sandstone facies respectively.

2. The Tagoe bed is the youngest and the Kumura bed is the oldest and at least the lower part of it belongs to Blow's N 10 (basal Middle Miocene). The Kumura bed is the thickest (about 50 m), but gradually becomes thinner toward the younger stage and the Tagoe bed is the thinnest (about 1 m) of all.

3. The Tagoe assemblage is represented by *Chlamys-Lima*, Shimoyamaguchi assemblage by *Glycymeris-Leukoma*, and Kumura assemblage by coral-*Balanus*. Their bathymetric range as seen from living species with frequency is N_4-B, N_0-N_3 and N_3 respectively. Transgression advanced from east to west; during the Shimoyamaguchi and Tagoe stages the sea became deeper, and shallower benthonic elements were transported to deeper parts.

4. The Tagoegawa fauna is born in the Paleo-Kuroshio water region of Japan and shows a Late Miocene (Blow's N 10–N 18) deep benthonic fauna.

REFERENCES

Akamine, H., and others, 1950, Geology of northern part of Miura Peninsula. *Geol. Soc. Jap., Jour.*, v. 55, no. 648–649, p. 189.

————, 1956, Geology of Miura Peninsula. *Earth Science*, no. 30, p. 1–8.

Akiyama, M., 1957, *Amussiopecten iitomiensis* (Otuka) and its allies from Japan. *Pal. Soc. Jap., Trans. Proc., N.S.*, no. 25, p. 31–39, pls. 6, 7.

Araki, Y., 1960, Geology, paleontology and sedimentary structures (including Problematica) of the Tertiary formations developed in the environs of Tsu City, Mie Prefecture, Japan. *Mie Univ., Lib. Arts Dep., Bull., Spec. Vol.*, no. 1, p. 1–118, pls. 1–11.

Aramaki, H., 1955, Geological studies of the Hayama Formation. *Yokohama Nat. Univ., Grad. Thesis, Geol.* no. 6. (MS).

Asano, K., and others (Boso-Miura Research Group), 1958, Correlation of Cainozoic formations between Boso and Miura peninsulae by planktonic foraminifera. "*Yukochu*" (*Foraminifera*), no. 9, p. 34–39.

Cross, E.R., 1971, The Pleurotomariidae — A survey of the known living species. *Haw. Shell News*, v. 19, no. 8, p. 3–14.

Hamada, T., 1956, Paleoecological considerations of the basal Miura Group. *Yokohama Chishitsu*, no. 1, p. 9–22.

Hatai, K., 1936, A note on a Brachiopod, *Tegulorhynchia döderleini* (Davidson). *Venus*, v. 6, no. 2, p. 96–104.

————, 1940, Cenozoic Brachiopoda from Japan. *Tohoku Imp. Univ., Sci. Rep., ser. 2*, v. 20, p. 1–413, pls. 1–12.

————, 1960, Japanese Miocene reconsidered. *Tohoku Unv., Sci. Rep., ser. 2, Spec. Vol.*, no. 4, p. 129–153.

Hatai, K., and S. Nisiyama, 1952, Check list of Japanese Tertiary Marine Mollusca. *Ibid.*, no. 3, p. 1–464.

Horikoshi, M., 1957, Note on the molluscan fauna of Sagami Bay and its adjacent water. *Yokohama Nat. Univ., Sci. Rep., ser. 2*, no. 6, p. 37–64, pl. 11.

Ikebe, N., Takayanagi, Y., Chiji, M., and Chinzei, K., 1972, Neogene biostratigraphy and radiometric time scale of Japan — An attempt at intercontinental correlation. *Pacific. Geol.*, no. 4, p. 39–78.

Ito, H., 1957, Geology of neighbourhood of Tanagura-cho, Higashi-Shirakawa-gun, Fukushima Prefecture. *Yokohama Nat. Univ., Grad. Thesis, Geol.*, no. 19 (MS.).

Itoigawa, J., 1960, Paleoecological studies of the Miocene Mizunami Group, central Japan. *Nagoya Univ., Earth Sci., Jour.*, v. 8, no. 2, p. 246–300, pls. 1–6.

Kamada, Y., 1962, Tertiary marine Mollusca from the Joban coal-field, Japan. *Pal. Soc. Jap., Spec. Pap.*, no. 8, p. 1–187, pls. 1–21.

Kanie, Y., 1967, Geology of the Sajima area, Yokosuka City, Miura Peninsula. *Yokosuka City Mus., Sci. Rep.*, no. 13, p. 38–44.

Kanno, S., 1956, On some new glycymerid Mollusca from Japan. *Pal. Soc. Jap., Trans. Proc., N.S.*, no. 24, p. 267–272, pl. 38.

————, 1960, The Tertiary systems of the Chichibu Basin, Saitama Prefecture, central Japan, pt. 11 Paleontology. *Jap. Soc. Prom. Sci. Tokyo*, p. 1–396, pls. 31–51.

Kira, T., 1960, Coloured illustration of the shells of Japan (I). *Hoikusha*, Tokyo.

Koike, K., 1951, Geological aspects of southern part of Miura Peninsula. *Geol. Soc. Jap., Jour.*, v. 57, no. 669, p. 225; no. 670, p. 237.

Kurihara, K., 1971, Foraminifera from the Hayama Group, Miura Peninsula, *Pal. Soc. Jap., Trans. Proc., N.S.*, no. 83, p. 131–142, pl. 15.

Kuroda, T., and T. Habe, 1952, Check list and bibliography of the Recent marine Mollusca of Japan, 210 p., *Hosokawa Print Co.*, Tokyo.

Kuroda, T., and Habe, T., and K. Oyama, 1971, The sea shells of Sagami Bay. *Biol. Lab. Imp. Houshold.*

Makiyama, J., 1926, Tertiary fossils from north Kankyo-do, Korea. *Kyoto Imp. Univ., Coll. Sci. Mem., ser. B*, v. 2, no. 3, p. 143–166, pls. 12, 13.

————, 1927, Molluscan fauna of the lower part of the Kakegawa series in the province of Totomi, Japan. *Ibid. ser. B*, v. 3, no. 1, art. 1, p. 1–149, pls. 1–6.

Masuda, K., 1962, Tertiary Pectinidae of Japan. *Tohoku Univ., Sci. Rep., ser. 2*, v. 33, no. 2, p. 117–238, pls. 18–27.

————, 1966, 67, Molluscan fauna of the Higashi-Innai Formation of Noto Peninsula, Japan. *Pal. Soc. Jap., Trans. Proc., N.S.*, no. 63, p. 261–293; no. 64, p. 317–337, pls. 35, 36; no. 65, p. 1–18, pls. 1, 2.

Mikami, K., and K. Okumura, 1971, Geological guidebook of Kanagawa Prefecture. *Morishige Pub. Co.*, Tokyo.

Mitsunashi, T., and K. Yazaki, 1968, Geological maps of the oil and gas field of Japan, 6 Miura Peninsula. *Geol. Surv. Jap.*

Nagao, T., 1928, Palaeogene fossils of the Island of Kyushu, Japan, pt. 2. *Tohoku Imp. Univ., Sci. Rep., ser. 2*, v. 12, no. 1, p. 11–140, pls. 1–17.

Nisiyama, S., 1966, The Echinoid fauna from Japan and adjacent regions pt. 1. *Pal. Soc. Jap., Spec. Pap.*, no. 11, p. 1–277, pls. 1–18.

Nomura, S., and K. Hatai, 1936, Fossils from the Tanagura beds in the vicinity of the town Tanagura, Hukushima-ken, Northeast Honsyu, Japan. *Saito Ho-on Kai Mus., Res. Bull.*, no. 10, p. 109–155, pls. 13–17.

————, 1936, A Note concerning data on the bathymetric range of certain marine animals and remarks on the geology of the Neogene Formation in Northeast Honsyu, Japan and their depth of sedimentation as indicated by the fossil fauna. *Ibid.*, no. 10, p. 231–334.

————, 1937, A List of the Miocene Mollusca and Brachiopoda collected from the region lying north of the Nanakita River in vicinity of Sendai, Rikuzen province, Japan. *Ibid.*, no. 13, p. 121–145, pls. 18–21.

Nomura, S., and N. Zinbo, 1936, Additional fossil Mollusca from the Yanagawa shell-beds in the Hukushima Basin, Northeast Honshu, Japan. *Ibid.*, no. 10, p. 335–345, pl. 20.

Ogose, S., 1959, Age and correlation of Miura Formation in Boso-Miura peninsulas from viewpoints of fossil Mollusca. *Jap. Assoc. Petr. Tech., Jour.*, v. 24, no. 3, p. 81–87.

Ogose, S. and others, 1949, Composite studies of middle-southern part of Miura Peninsula. *Geol. Soc. Jap., Jour.*, v. 54, no. 638, p. 148, 149.

————, 1962, Lexicon of stratigraphic names of Japan, Cenozoic erathem, pt. IV.

Okutani, T., 1967, Characteristics and origin of archibenthal Molluscan fauna on the Pacific coast of Honshu, Japan. *Jap. Jour. Mal.*, v. 25, no. 3–4, p. 136–146.

Otuka, Y., 1934, Tertiary structures of the northwestern end of the Kitakami Mountainland, Iwate Prefecture, Japan. *Tokyo Imp. Univ., Earthq. Res. Inst. Bull.*, v. 12, pt. 3, art 38, p. 566–638, pls. 44–51.

Oyama, K., 1943, Familia Limidae. *Conchologia Asiatica*, v. 1, pt. 1, p. 3–74, pls. 1–14.

————, 1952, Paleoecological studies on *Pecten*. *Misc. Rep., Res. Inst. Nat. Res.*, no. 25, p. 25–30.

————, 1952, On the vertical distribution of marine molluscas. *Jap. Jour. Mal.*, v. 17, no. 1, p. 27–35.

————, 1954, On the fossil communites of the coastal water (no. 2). *Misc. Rep., Res. Inst. Nat. Res.*, no. 33, p. 92–94.

Ozaki, H., 1954, On the paleontology of the basal conglomerate of Pliocene in Choshi City, Kanto region. *Nat. Sci. Mus. Tokyo, Bull., N.S.*, v. 1, no. 1, p. 9–20, pls. 1–10.

————, 1954, Stratigraphy of the basal conglomerate of the Pliocene Naarai Formation in the Choshi City. Kanto region, *Ibid.*, v. 1, no. 2, p. 46–61.

————, 1958, Stratigraphical and paleontological studies on the Neogene and Pleistocene Formations of the Choshi district. *Ibid.*, no. 42, p. 1–182, pls. 1–24.

Shibata, M., 1957, Some molluscan fossils from the eastern part of the Tanzawa Mountainland. *Pal. Soc. Jap., Trans. Proc., N.S.*, no. 25, p. 21–25, pl. 4.

Shikama, T., 1961, On *Mikadotrochus salmiana* found off Choshi, East Japan, *Venus*, v. 21, no. 4, p. 500–506, pls. 28, 29.

————, 1962, On some noteworthy shells from off Choshi, Chiba Prefecture. *Yokohama Nat. Univ., Sci. Rep., sec. 2*, no. 8, p. 29–56, pls. 1–3.

————, 1968, On a Giant *Thracidora* from the Hayama Group, Miura Peninsula, *Yokohama Nat. Univ, Sci. Rep., sec. 2*, no. 14, p. 13–16, pl. 2.

————, 1969, On the *Akebiconcha* assemblage. *Fossils*, no. 17, p. 16–21.

Shikama, T., and A. Masujima, 1969, Quantitative studies of the molluscan assemblages in the Ikego-Nojima formations. *Yokohama Nat. Univ., Sci. Rep., sec. 2*, no. 15, p. 61–94, pls. 5–7.

Shuto, T., 1956, Umboniinae from the Miyazaki Group (Palaeontological study of the Tertiary Miyazaki Group–1). *Jap. Jour. Geol. Geogr.*, v. 27, no. 1, p. 47–66, pl. 4.

Sugiyama, T., 1935, On the variation and evolution of the living and fossil *Umbonium* in Japan. *Geol. Soc. Tokyo, Jour.*, v. 42, no. 502, p. 403–430, pls. 11–13; no. 503, p. 449–482.

Suzuki, K., 1932, Pliocene formation north of Atsuki-machi, Kanagawa Prefecture (II). *Geol. Soc. Tokyo, Jour.*, v. 39, no. 462, p. 97–131.

Suzuki, K., and U. Kitazaki, 1951, Studies of Cenozoic Foraminifera fauna in Yokohama-Zushi-Katase area, Kanagawa Prefecture. *Geol. Soc. Japan., Jour.*, v. 57, no. 665, p. 65–78.

Takahashi, S., 1954, Note on a minor structure and a bone bed on the coast near Kanaya village, Boso Peninsula. *Yokohama Nat. Univ., Sci. Rep., sec. 2*, no. 3, p. 109–120.

Takeuchi, H., 1959, Geology of the southern part of Miura Peninsula. *Yokohama Nat. Univ., Grad. Thesis, Geol.* no. 30. (MS).

Taki, I., and Y. Otuka, 1942, Genus *Turicula* Dall. *Conchologia Asiatica*, v. 1, pt. 3, p. 93–108, pl. 1.

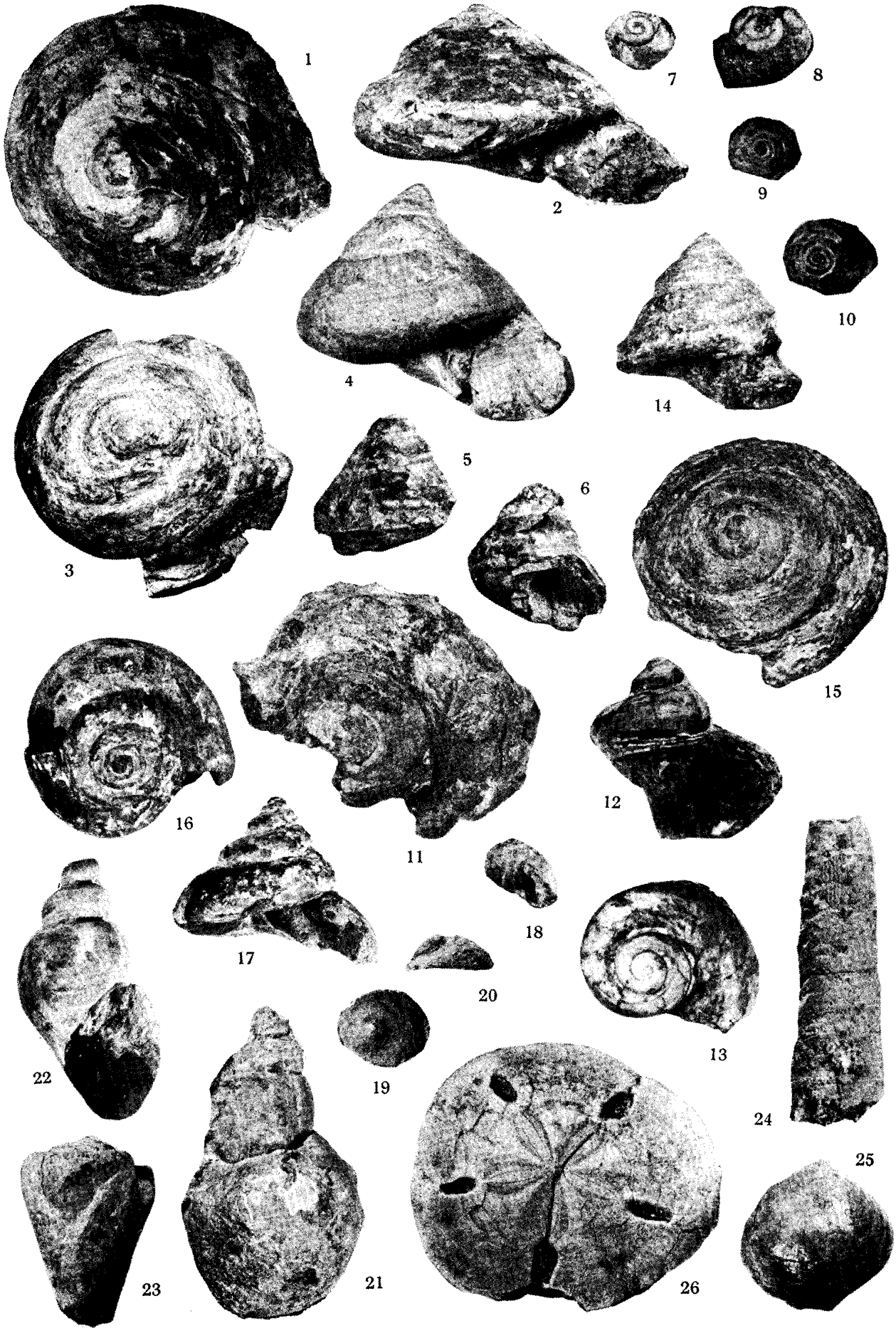
Watanabe, K., 1925, Base of Musashino Group. *Geogr. Tokyo, Jour.*, v. 38, no. 439, p. 495–501; no. 440, p. 584–595.

Yajima, A., 1972, Palaeontological studies of the Tanzawa Group. *Yokohama Nat. Univ., Grad. Thesis,*

Geol., no. 91. (MS).
Yamashita, S., 1965, Tertiary of Ichishi basin, Mie Prefecture. *Yokohama Nat. Univ., Grad. Thesis, Geol.*, no. 61. (MS).
Yokoyama, M., 1920, Fossils from the Miura Peninsula and its immediate north. *Tokyo Imp. Univ., Coll. Sci., Jour.*, v. 39, art. 6, p. 1–193, pls. 1–20.
————, 1925, Molluscan remains from the middle part of the Jo-Ban coal-field. *Ibid.*, v. 45, art. 7, p. 1–23, pls. 1–3.
————, 1926, Tertiary Mollusca from Shiobara in Shimotsuke. *Imp. Univ. Tokyo, Fac. Sci. Jour.*, sec. *2*, v. 1, pt. 4, p. 129–138, pls. 16–20.
————, 1928, Pliocene shells from Hyuga. *Ibid.*, Sec. *2*, v. 2, pt. 7, p. 331–350, pls. 46, 47.
————, 1931, Tertiary Mollusca from Iwaki. *Ibid.*, v. 3, pt. 4, p. 197–204, pls. 12, 13.

Plate 16

Figs. 1, 2. *Perotrochus* (?) *aosimai* Ozaki. ×0.5. Fig. 1; apical side, Fig. 2; lateral side. Loc. 3.
Figs. 3, 4. *Mikadotrochus yosiwarai* (Ozaki). ×0.5. Fig. 3; apical side, Fig. 4; lateral side. Loc. 1.
Figs. 5, 6. *Ginebis argenteonitens* (Lischke). ×1. Loc. 10.
Figs. 7, 8. *Machaeroplax* (?) *hayamensis*, n. sp. ×1. Apical side. Loc. 5.
Figs. 9, 10. *Suchium* (s.s.) *koyuense* Shuto. ×1. Apical side. Loc. 9.
Figs. 11–13. *Turbo* (*Batillus*) aff. *cornutus* Gmelin. Fig. 11 ×0.5. Figs. 12, 13 (YCM-GP-525-2) ×1. Loc. 10.
Figs. 14, 15. *Astraea* (*Incilaster*) *virgatus* Ozaki. YCM-GP-524. Fig. 14 ×0.5. Fig. 15×0.7. Loc. 1.
Figs. 16, 17. *Pachypoma* aff. *takitai* Ozaki. ×0.7. Fig. 16; apical side, Fig. 17; lateral side. YCM-GP-144. Loc. 10.
Fig. 18. *Neverita* aff. *hosoyai* Kuroda. ×1. Lateral side. Loc. 9.
Figs. 19, 20. *Calyptraea aramakii*, n. sp. ×1. Fig. 19; apical side, Fig. 20; lateral side. Loc. 4.
Fig. 21. *Charonia sauliae* (Reeve). ×0.5. YCM-GP-525-3. Loc. 10.
Fig. 22. *Buccinum* (?) sp. ×1. YCM-GP-525-7. Loc. 10.
Fig. 23. *Conus* sp. ×0.7. YCM-GP-525-4. Loc. 10.
Fig. 24. *Dentalium vernedi* Sowerby. ×1. YCM-GP-129. Loc. 10.
Fig. 25. *Tegulorhynchia döderleini* (Davidson). ×1. Loc. 12.
Fig. 26. *Astriclypeus manni integer* Yoshiwara. ×0.5. YCM-GP-96. Loc. 10.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26

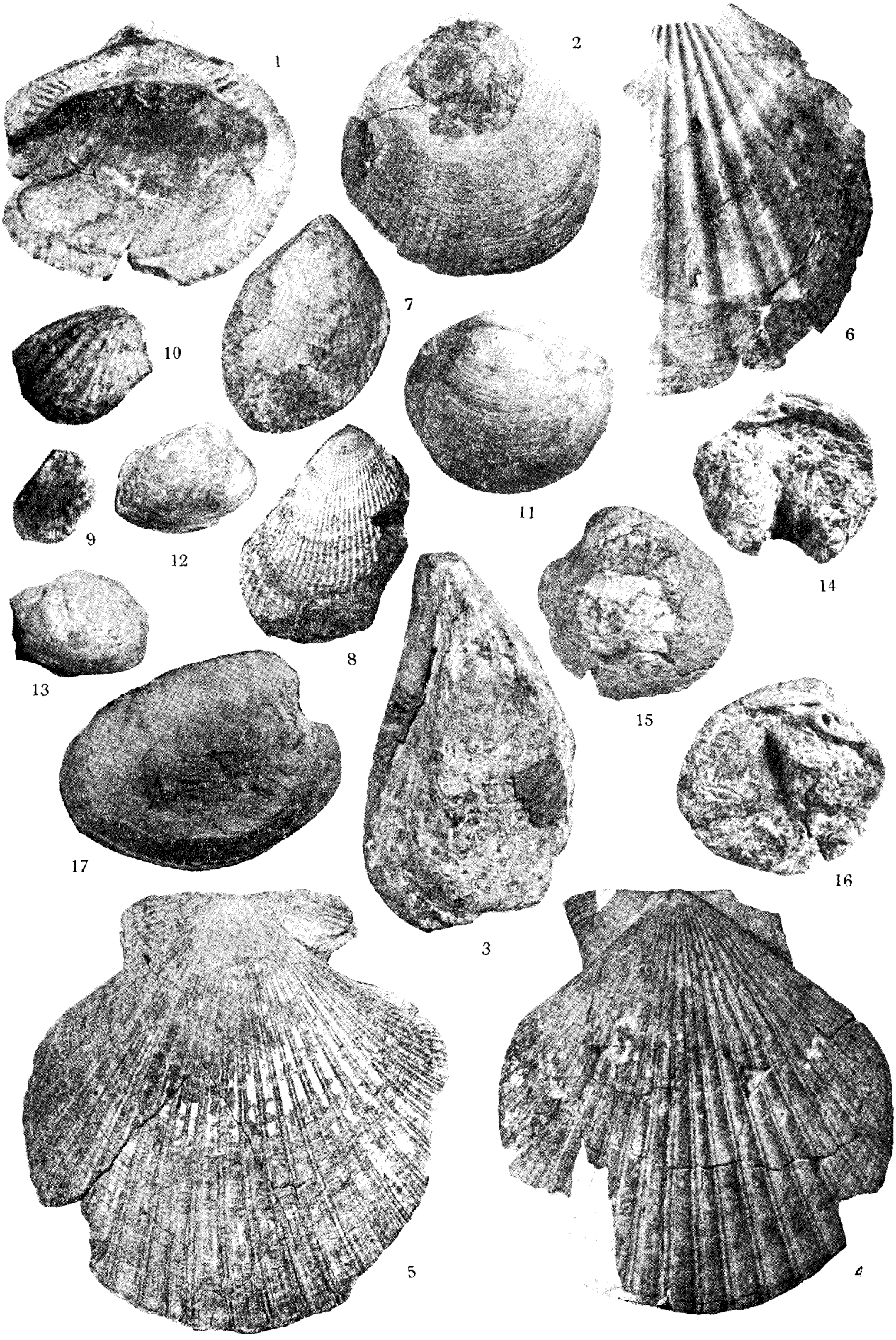

1
2
6
7
10
11
9
12
8
14
13
15
17
16
3
5
4

Plate 17

Figs. 1, 2. *Glycymeris* cf. *cisshuensis* Makiyama. ×0.7. Loc. 16.
Fig. 3. *Mytilus coruscus* Gould. ×0.5. YCM-GP-95. Loc. 10.
Fig. 4. *Chlamys* (s.s.) *miurensis* (Yokoyama). ×0.5. Loc. 1.
Fig. 5. *Chlamys* (*Mimachlamys*) *kaneharai* (Yokoyama). ×0.5. YCM-GP-100. Loc. 10.
Fig. 6. *Amussiopecten iitomiensis* (Otuka). ×0.7. Loc. 1.
Figs. 7, 8. *Lima* (s.s.) *zushiensis* Yokoyama. Fig. 7 ×1. Fig. 8 ×0.7. YCM-GP-527-2, 3. Loc. 8.
Fig. 9. *Lima* (s.s.) *quantoensis* Yokoyama. ×1. Loc. 5.
Fig. 10. *Cardita hataii*, n. sp. ×1. Loc. 10.
Fig. 11. *Lucinoma annulata* (Reeve). ×1. Loc. 7.
Figs. 12, 13. *Pitar kaniei*, n. sp. ×0.7. YCM-GP-525-18, 19. Loc. 10.
Figs. 14–16. *Venus* (*Ventricola*) aff. *foveolata* Sowerby. ×1. Loc. 5. Figs. 15, 16 show a same shell.
Fig. 17. *Venus* (*Chione*) *miurensis*, n. sp. ×0.5. YCM-GP-525-17. Loc. 10.