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Miocene Molluscs from Sai, Shinji-cho, Shimane Prefecture

—Molluscan Fossils from Various Localities in Shimane Prefecture, Part 4—

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Introduction

The Miocene deposits distributed in the San-in district of west Japan are called the Iwami and the Izumo Groups in ascending order. From oldest to youngest the Iwami Group is subdivided into the Hata, Kawai, Kuri and Omori Formations. The Izumo Group is also subdivided into three units, the Kimachi, Fujina and Matsue Formations in ascending order.

In this sequence, there are two horizons which contain abundant marine molluscan fossils. The lower horizon is in the Kawai and Kuri Formations and their correlatives, which yield molluscs of a warm sea type correlated with the Kadonosawa Fauna of late Early Miocene to early Middle Miocene of northeast Japan. The upper horizon is in the Fujina and Matsue Formations and their correlatives, which yield cool water molluscs and relics of warm current species, correlative with the Shiobara-type Fauna of Middle to Late Miocene of northeast Japan.

As volcanic rocks dominate the remaining formations, marine mollusca in other horizons are rare.

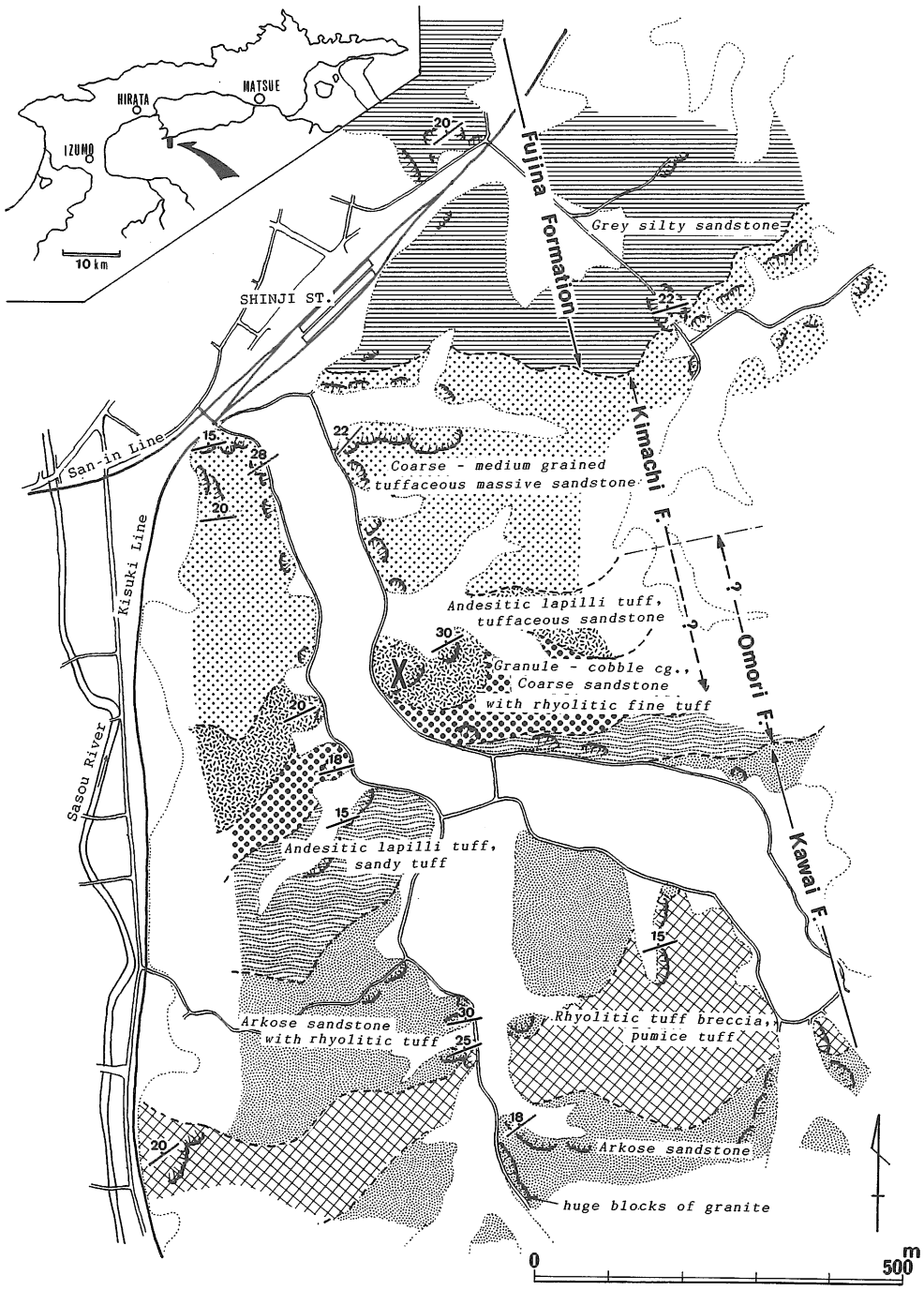
The fossil locality reported in this paper is situated stratigraphically between the Kuri and the Fujina Formations, thus providing information on the change of marine molluscan faunas in this district.

Before entering into the discussion, the writer wishes to thank Dr. Paul Morris of Sydny University for improving the English.

Outline of Geology

The fossil locality is a cutting at Sai, Shinji-cho, Yatsuka-gun, Shimane Prefecture, about 580 meters south of the National Railway's Shinji Station. The outline of the local geology is shown in Textfigure 1.

Exposed in the cutting is dark greenish andesitic lapilli tuff containing many patches of tuffaceous siltstone and carbonized chips of wood. About 25 meters above this horizon is a massive tuffaceous sandstone, a typical facies of the Kimachi Formation. Granule to cobble conglomerates are exposed just below the fossil locality.



Textfig. 1. Outline of the local geology
×: fossil locality

These conglomerate beds and its correlative sandstone rest upon andesitic tuffaceous sandstones which are correlated with the Omori Formation, on the basis of similar lithofacies. Furthermore, arkosic sandstones and rhyolitic pyroclastics of the Kuri or the Kawai Formations exist below the tuffaceous sandstones.

OGASAWARA and NOMURA (1980) listed five fossil localities in the Omori Formation. Their OM–4 occurrence is adjacent to the present locality, both are considered to be stratigraphically equivalent. Their OM–2 and OM–3 localities (located at Sasou, Shinji-cho, about 1 km west of the present locality) are also regarded as equivalent horizons to the present locality because of the similarity of lithofacies.

On the other hand, in a discussion of the Izumo Group, TAKAYASU and NAKAMURA (1984) maintained that the tuffs, tuffaceous sandstones and conglomerates previously regarded as the upper part of the Omori Formation should be included in the Kimachi Formation. Accordingly, the present locality belongs to the lower part of the Kimachi Formation.

Although the question of whether the locality belongs to the Kimachi Formation or the Omori Formation should be further studied, it can be concluded that the stratigraphical position of the present locality is between the lower and upper fossil horizons of the Miocene in this district.

Characteristics of the Molluscan Assemblage

The molluscan species collected from the present locality are as follows:

Neverita kiritaniana (YOKOYAMA)
Acila (*Acila*) *submirabilis* MAKIYAMA
Saccella confusa toyomaensis KAMADA
Glycymeris sp.
Modiolus difficilis KURODA and HABE
Crassostrea gigas (THUNBERG)
Kotorapecten kagamianus moniwaensis (MASUDA)
Cyclocardia fujinaensis OGASAWARA and NOMURA
Mercenaria yokoyamai (MAKIYAMA)
Teredo sp.
Fissidentalium yokoyamai (MAKIYAMA)

In addition, there are several specimens which cannot be precicely identified because of their poor preservation. They are *Olivella*? sp., *Alvenius*? sp., *Macoma*? sp. and *Panope*? sp.

None of these species are abundant, but such species as *Kotorapecten kagamianus moniwaensis*, *Mercenaria yokoyamai*, *Fissidentalium yokoyamai*, *Neverita kiritaniana* and *Crassostrea gigas* are comparatively common.

The assemblage is characterized by the mixture of sandy bottom suspension

feeders (such as *Kotorapecten*, *Mercenaria*, *Modiolus* and *Glycymeris*, and muddy bottom deposit feeders (such as *Succella*, *Acila* and *Fissidentalium*). As the lithofacies of the present locality does not seem a desirable environment for the life of molluscs, all fossils are considered to be allopatric. This observation is further supported by the fact that no fossils are preserved in life position and most of the shells are worn to some degree.

All of the identified genera collected from the present locality have been reported from the Fujina Formation (YOKOYAMA, 1923; NOMURA and HATAI, 1939; SUEHIRO, 1979; OGASAWARA and NOMURA, 1980; TAKAYASU, 1982) and most of the present species are common to the species from this Formation. Furthermore, those species listed by OGASAWARA and NOMURA (1980) from their fossil localities OM–2, OM–3 and OM–4 (such as *Anadara* sp., *Conchocele* sp., *Vasticardium* sp., *Clinocardium* sp., *Mercenaria* sp., *Clementia papyracea*, *Macoma* sp., *Calliostoma simane*, *Euspira* sp., *Sinum yabei* and *Fissidentalium yokoyamai*) are mostly common in genus level to those of the Fujina Formation, although *Conchocele* and *Clementia* have not previously been reported from the Fujina Formation.

However, in making a more detailed comparison between the present assemblage and that of the Fujina molluscan fauna, some differences are recognized. *Kotorapecten* from the Fujina Formation is identified as *kagamianus* (s. s.), but the species from the present locality is *kagamianus moniwaensis*. In the case of *Acila* and *Cyclocardia*, although both of them are conspecific with those from the Fujina Formation, the present specimens are generally smaller in size then those from the Formation, because the former is immature in most cases. Moreover, *Macoma optiva* and *Cultellus izumoensis*, which are the representative species of the Fujina molluscan fauna, have not been recorded from the present locality.

On the other hand, with a few exceptions such as *Acila submirabilis* and *Fissidentalium yokoyamai*, most of the species from the present locality have not been reported from the Kawai and the Kuri Formations, and their correlatives of this district. Therefore, the characteristics of the present assemblage can be said to resemble those of the Fujina Formation rather than the Kawai and the Kuri Formations.

Systematic Remarks on Some Species

Family NATICIDAE

Genus *Neverita* RISSO, 1826

Neverita kiritaniana (YOKOYAMA, 1931)

Pl. I, Figs. 1a, b

Polinices (Neverita) ampla, YOKOYAMA, 1926, p. 131.
Natica kiritaniana YOKOYAMA, 1931, p. 201–202, pl. 12, fig. 2.

Polinices (*Neverita*) *kiritaniana*, NOMURA and ZINBO, 1935, p. 190, pl. 15, fig. 31.
Polinices (*Neverita*) *didymus*, NOMURA and HATAI, 1936, p. 146–147, pl. 17, figs. 3, 4.
Polinices (*Neverita*) *kiritaniana*, NOMURA and HATAI, 1936, p. 147.
Polinices kiritaniana, NOMURA and ONISI, 1940, p. 185, pl. 18, figs. 3a, b.
Polinices (*Neverita*) *kiritaniana*, FUJIE and UOZUMI, 1957, p. 36, pl. 24, figs. 9a, b.
Neverita kiritaniana, IWASAKI, 1970, p. 416–418, pl. 2, figs. 10–12, textfig. 19.
Neverita kiritaniana, OGASAWARA, 1976, p. 63–64, pl. 5, fig. 10.
Neverita sp., SUEHIRO, 1979, p. 89–90, pl. 16, figs. 1a, b.
Neverita kiritaniana, OGASAWARA and NOMURA, 1980, pl. 12, figs. 3a–c.

Dimensions:—

DGSU coll. cat. no.	Hight (mm)	Diameter (mm)	Apical angle
T.2255	(24.0)	(24.5)	115°
T.2256	27.8	(25.5)	118°
T.2257	(28.1)	(24.0+)	113°

Remarks — There are three individuals belonging to the named species in the collection from the present locality. All of them are somewhat deformed and broken.

This species was originally described by YOKOYAMA (1931) from the Tanagura Miocene in Fukushima Prefecture. The shell outline of the species closely resembles very much *Neverita coticazae* (MAKIYAMA, 1926) from the Miocene deposits of North Korea. NOMURA and HATAI (1936) and IWASAKI (1970) pointed out that in both species the ranges of variation in shell characters are very wide, so discrimination of these two species is difficult. KAMADA (1962) regarded YOKOYAMA's *kiritaniana* as synonymous with MAKIYAMA's *coticazae*, and dropped the specific name *kiritaniana*.

The present species is, however, slightly different from *N. coticazae* in having a rather prominent shoulder on each spires. This species is also allied to *N. didyma* (BOLTON), a living species in Japan, but the latter has an appressed and inconspicuous suture like *coticazae*.

Family NUCULIDAE

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

Subgenus *Acila* s.s.

Acila (*Acila*) *submirabilis* MAKIYAMA, 1926

Pl. II, fig. 2

Nucula milabilis, YOKOYAMA, 1925, p. 21, pl. 3, fig. 6.
Acila submirabilis MAKIYAMA, 1926, p. 151–152, pl. 12, fig. 9.
Acila (*Acila*) *submirabilis*, KANNO, 1960, p. 190, pl. 31, figs. 3–4.
Acila (*Acila*) *divaricata submirabilis*, KAMADA, 1962, p. 45–46, pl. 1, figs. 15–22.
Acila submirabilis, HAYASHI and MIURA, 1973, pl. 1, fig. 2.
Acila submirabilis, HAYASHI, 1973, pl. 5, fig. 4.

Acila (Acila) submirabilis, OKAMOTO, TAKAHASHI and TERACHI, 1973, pl. 14, figs. 1a, b.
Acila submirabilis, ITOIGAWA, SHIBATA and NISHIMOTO, 1974, p. 46, pl. 1, figs. 9a–14b.
Acila submirabilis, TAGUCHI, ONO and OKAMOTO, 1979, pl. 1, figs. 1–4.
Acila sp., SUEHIRO, 1979, p. pl. 10 figs. 2a–d, 3a–d.
Acila divaricata submirabilis, OGASAWARA and NOMURA, 1980, p. 88, pl. 9, figs. 3a, b, 4, 5, 18.
Acila submirabilis, ITOIGAWA, SHIBATA and OKUMURA, 1981, pl. 1, figs. 3a–4b.
Acila (Acila) submirabilis, TAKAYASU, 1981, p. 97, pl. 2, fig. 6.

Dimensions:—

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)
T.2244 (left valve)	9.3	13.2	3.2
T.2245 (conjoined)	6.9	8.4	4.0/2
T.2246 (conjoined)	5.0	6.8	3.2/2

Remarks: — Several immature, well preserved specimens were collected.

Although the posterior rostlum, which is distinct in matured specimens of this species, is not so well developed in the present specimens, it may due to the fact that they are young. This species is closely allied to *Acila divaricata* (HINDS) (syn. *Nucula mirabilis* A. ADAMS and REEVE), but the former is distinguished by the characteristic features of the sculpture on the lunule and escutcheon as originally recognized by MAKIYAMA (1926).

Family NUCULANIDAE

Genus *Saccella* WOODRING, 1925

Saccella confusa toyomaensis KAMADA, 1962

Pl. I, Fig. 1

Saccella canfusa toyomaensis KAMADA, 1962, p. 50–52, pl. 2, figs. 1–5.
Scaccella sp., SUEHIRO, p. 73, pl. 10, figs. 4a–c, 5a, b.
Saccella confusa toyomaensis, OGASAWARA and NOMURA, 1980, pl. 9, fig. 2.

Dimensions:—

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)	H/L
T.2236 (conjoined)	11.5	21.0	8.0/2	.55
T.2237 (conjoined)	8.7	15.8	5.3/2	.55

Remarks — Two well preserved specimens were examined.

This species is closely allied to the Recent *S. confusa* (s. s.) and *S. confusa kongiensis* from the "Lower Kadonosawa series", Iwate Prefecture, but the latter two forms differ from the present subspecies in having a larger height to length ratio. The

unnamed *Saccella* from the Fujina Formation described and illustrated by SUEHIRO (1979) appears to be slightly different from the present subspecies in having two blunt radial ridges from beak to anterior and posterior ventral margins. However, the specimens from the Fujina Formation show a variation with regard to the ridges. Judging by the degree of variation, they appear to grade into *Saccela confusa toyomaensis*. Therefore, SUEHIRO's species is identical with the present subspecies.

Family GLYCYMERIDAE

Genus *Glycymeris* Da COSTA, 1778

Glycymeris sp.

Pl. II, Fig. 3

Dimensions:—

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)
T.2243 (left valve)	10.7	12.3	(2.5)

Remarks — Only a single ill preserved speciemn is at hand.

The present species can be referred to the genus *Glycymeris* in having an ovately rounded shell, whose surface is sculptured with faint radiating ribs and taxodont teeth on both sides of beak, but it is left unnamed until additional well-preserved material is obtained.

Family PECTINIDAE

Genus *Kotorapecten* MASUDA, 1962

Kotorapecten kagamianus moniwaensis (MASUDA, 1958)

Pl. I, Figs. 3, 4

Pecten (*Patinopecten*?) *kagamianus*, YOKOYAMA, 1929, p. 2, pl. 1, fig. 1.
Pecten (*Vola*) *kagamianus*, NOMURA and ZINBO, 1936, pl. 20, fig. 3.
Patinopecten kagamianus moniwaensis MASUDA, 1958, p. 276–277, pl. 41, figs. 3–5.
Patinopecten kagamianus moniwaensis, MASUDA, 1962, p. 217–218.

Dimensions:—

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)	Apical angle	No. rad. ribs
T.2216 (right valve)	102.2	109.3	13.0	108°	10
T.2217 (conjoined)	—	(115.0)	—	—	9
T.2218 (left valve)	102.8	—	13.0	105°	10

Remarks: — *Kotorapecten kagamianus* was first described by YOKOYAMA (1923) from the Fujina Formation at Kagami, Shinji-cho, about 4 km ENE of the present locality.

Subsequently, many specimens have been reported under this specific name from the Miocene formations of Japan. MASUDA (1958) examined them and concluded that the *kagamianus* groups can be classified into the following subspecies: *kagamianus* (s. s.), *kagamianus permirus*, *kagamianus moniwaensis* and *kagamianus nimaensis*.

According to him, the present subspecies "is characterized by its large, rather thin shell, 9 to 13, low, round-topped radial ribs which are much broader than their interspaces and divided into numerous fine riblets by shallow longitudinal furrows, very slender and low radial ribs at the lateral portions of disc in the right valve, and by the left valve in having elevated radial ribs which are much narrower than their interspaces and divided into a few fine riblets by shallow longitudinal furrows, and a few fine radial threads on the surface of auricles".

Although the specimens at hand are somewhat water-worn and fluctuated, they are clearly identical with *K. kagamianus moniwaensis* in the number and characteristics of radial ribs. *K. kagamianus* (s. s.) which is often found in the Fujina Formation resembles this subspecies in its outline, but the former can be distinguished by having 15 to 18 radial ribs.

Family OSTREIDAE

Genus *Crassostrea* SACCO, 1897

Crassostrea gigas (THUNBERG, 1793)

Pl. II, Figs. 11, 12a, b

Ostrea (*Crassotrea*) *gigas*, NOMURA and HATAI, 1937, p. 126, pl. 18, fig. 3.
Ostrea gigas, OTUKA, 1938, pl. 12, fig. 2.
Ostrea (*Crassostrea*) *gigas*, KASENO and MATSUURA, 1965, pl. 12, fig. 2.
Ostrea (*Crassostrea*) *gigas*, NODA, 1973, pl. 5, fig. 6.

Dimensions:—

DGSU coll. cat. no.	Height (mm)	Length (mm)
T.2251 (Colonial specimen)	47.9	31.0
	56.6	(26.5)
	45.3+	32.2
T.2252 (right valve)	71.5+	48.5+
T.2253 (right valve)	41.1	25.2

Remarks: — Several, rather well preserved specimens are at hand.

The present species is somewhat allied to *Crassostrea sunakozakaensis* from the Miocene Sunakozaka Formation, Ishikawa Prefecture (originally described by OGASAWARA, 1976), but the latter differs in having distinct radial ribs on the shell surface of the left valve. *Crassostrea mundana* from the Miocene Iwaki Formation in the Joban Coal-field, (originally described YOKOYAMA, 1924), is also allied to the present

species, but the former is distinguishable in having a pointed and curved beak on the right valve, and radial striations on the surface of the right valve.

Family CARDITIDAE

Genus *Cyclocardia* CONRAD, 1867

Cyclocardia fujinaensis OGASAWARA and NOMURA, 1980

Pl. II, Figs. 5, 6

Cyclocardia onukii, SUEHIRO, 1979, p. 77, pl. 12, figs. 2a, b, 3a, b, 4a, b.
Cyclocardia fujinaensis OGASAWARA and NOMURA, 1980, p. 90–91, pl. 9, figs. 11a–17.

Dimensions:—

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)	No. rad. rib.
T.2239 (right valve)	(12.8)	(11.5+)	4.7	31
T.2241 (right int. mould)	(10.6)	(10.1)	(2.5)	20

Remarks: — Several imperfect specimens have been collected from the present locality.

According to the original description by OGASAWARA and NOMURA (1980), the present species is characterised by a thick, well inflated shell, which is a little higher shell than its length and small for the genus. Although each of the present specimens is imperfect, such specific characteristics as described by OGASAWARA and NOMURA (1980) are fully recognized.

Family KELLIELLIDAE

Genus *Alvenius* CONRAD, 1865

Alvenius? sp.

Pl. II, Fig. 4

Dimensions:—

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)
T.2235 (right valve)	9.7	(10.1)	3.5

Remarks:— Only one imperfect specimen is at hand.

The present unnamed specimen is diagnosed as follows; "Shell small in size, roundly trigonal, rather inflated. Surface smooth, but sculptured with faint concentric growth lines. Rather strong, only one cardinal tooth remaining but others unknown. Inner margin smooth. Pallial line indistinct". The present specimen is referrable to the genus "*Alvelius*" on the basis of having a round trigonal inflated shell, but differs from this genus in having much larger shell and rather strong teeth. Therefore,

generic allocation of the present specimen to *Alvenius* is questionable.

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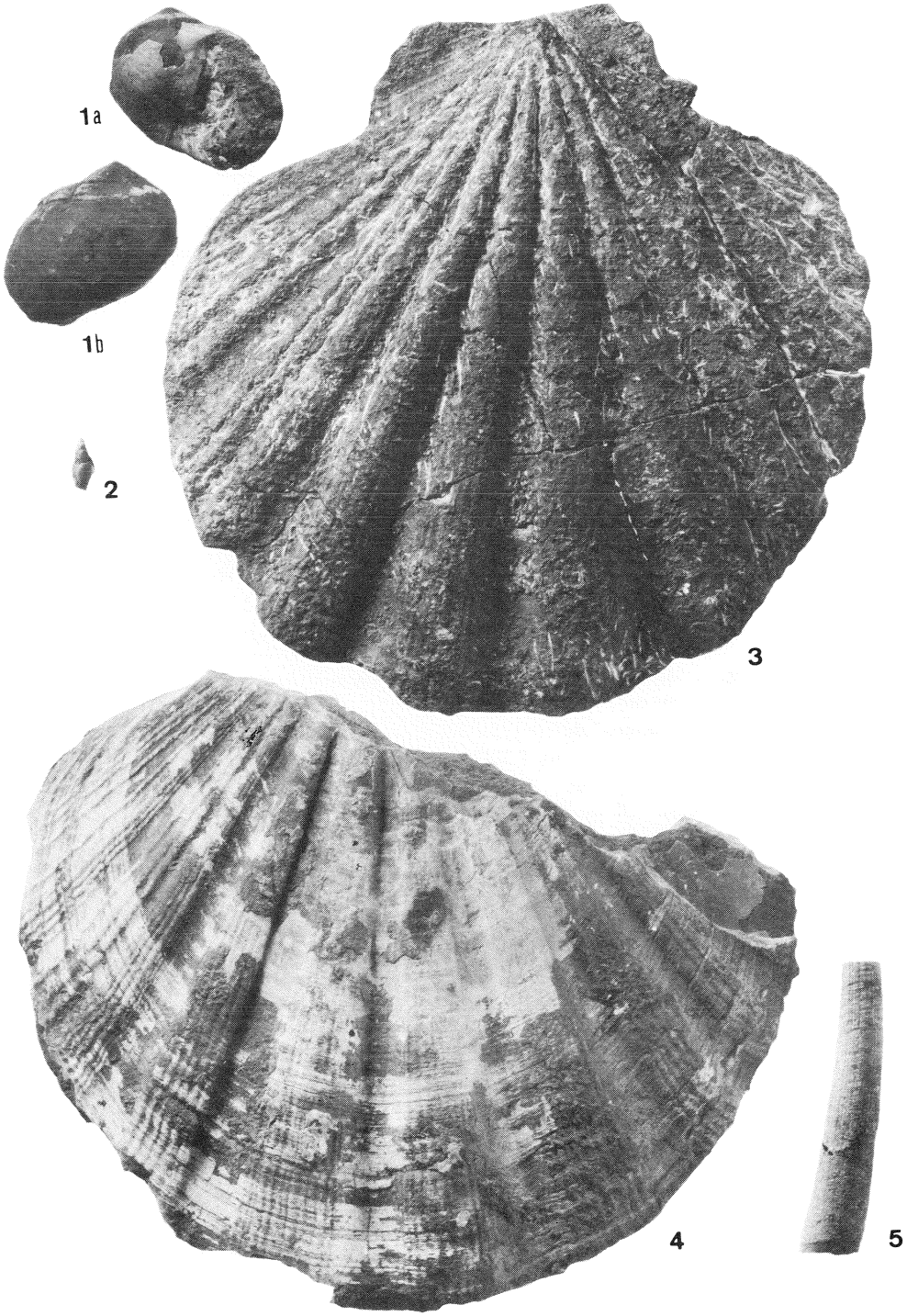
Explanation of Plate I
(All figures in natural size)

Figs. 1a–b. *Neverita kiritaniana* (YOKOYAMA)
DGSU coll. cat. no. T.2255.
Fig. 2. *Olivella*? sp.
Inner mould, GDSU coll. cat. no. T.2254.
Figs. 3, 4. *Kotorapecten kagamianus moniwaensis* (MASUDA)
Fig. 3, right valve, DGSU coll. cat. no. T.2216;
fig. 4, right valve, DGSU coll. cat. no. T.2217.
Fig. 5. *Fissidentalium yokoyamai* (MAKIYAMA)
DGSU coll. cat. no. T.2259.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Explanation of Plate II

(All figures in natural size)

Fig. 1. *Saccella confusa toyomaensis* KAMADA
DGSU coll. cat. no. T.2236.

Fig. 2. *Acila* (*Acila*) *submirabilis* MAKIYAMA
DGSU coll. cat. no. T.2249.

Fig. 3. *Glycymeris* sp.
DGSU coll. cat. no. T.2243.

Fig. 4. *Alvenius*? sp.
DGSU coll. no. T.2235.

Figs. 5, 6. *Cyclocardia fujinaensis* OGASAWARA and NOMURA
Fig. 5, interior mould of right valve, DGSU coll. cat. no. T.2241;
fig. 6, right valve, DGSU coll. cat. no. T.2239.

Fig. 7. *Teredo* sp.
DGSU coll. cat. no. T.2250.

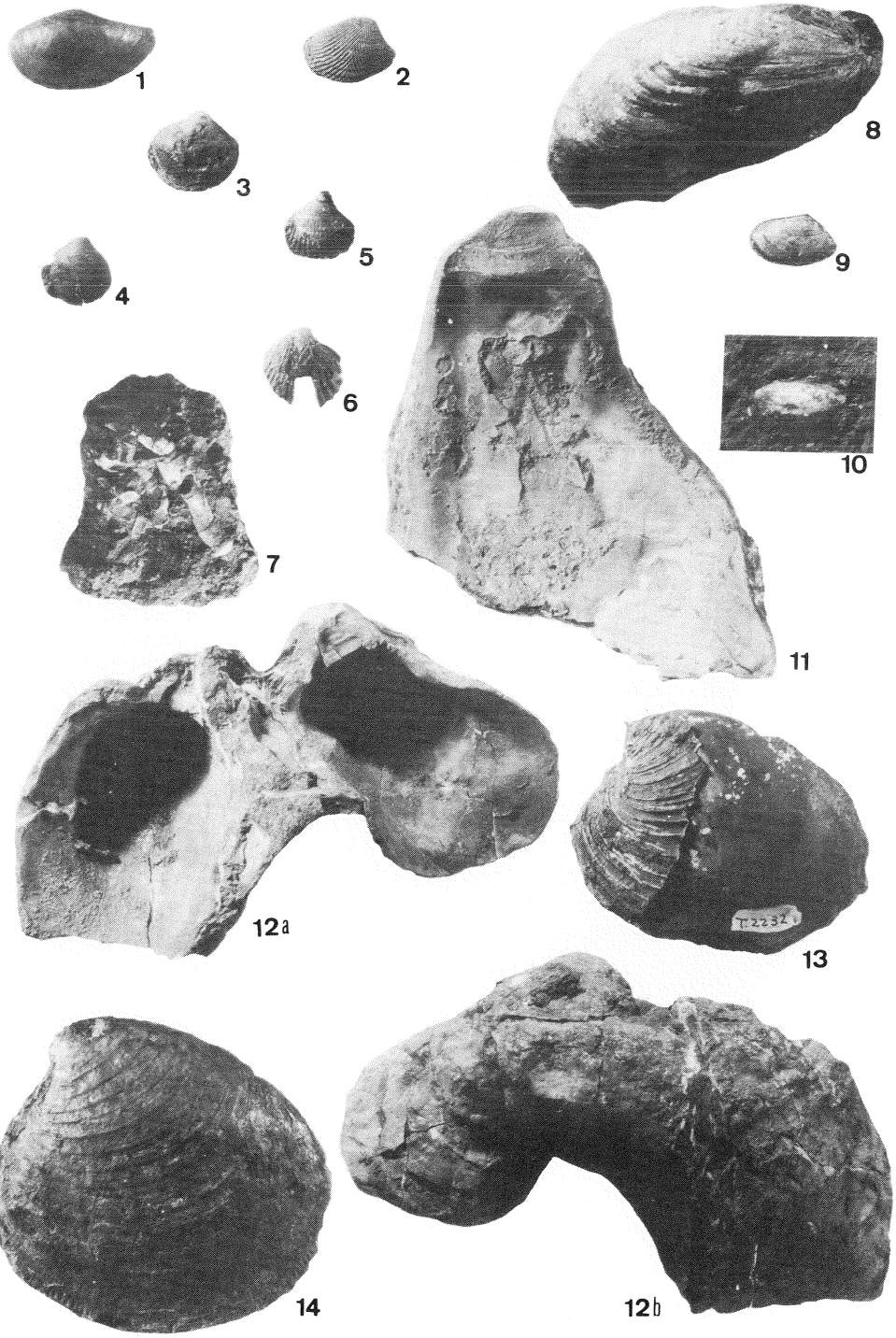
Fig. 8. *Modiolus difficilis* KURODA and HABE
DGSU coll. cat. no. T.2249.

Fig. 9. *Macoma*? sp.
DGSU coll. cat. no. T.2247.

Fig. 10. *Panope*? sp.
DGSU coll. cat. no. T.2248.

Figs. 11, 12a–b. *Crassostrea gigas* (THUNBERG)
Fig. 11, right valve, DGSU coll. cat. no. T.2252;
figs. 12a–b, left valves, DGSU coll. cat. no. T.2251.

Figs. 13, 14. *Mercenaria yokoyamai* (MAKIYAMA)
Fig. 13, left valve, DGSU coll. cat. no. T.2232;
fig. 14, left valve, DGSU coll. cat. no. T.2228.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12a
12b
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