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On Some Molluscan Fossils from the Vicinity of Lake Jinzai, Izumo District

— Molluscan Fossils from Various Localities in Shimane Prefecture, Part 3 —

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Introduction

The molluscan fossils of the Miocene Fujina Formation was described by YOKOYAMA (1913, 1923), NOMURA and HATAI (1939), SUEHIRO (1979) and OGASAWARA and NOMURA (1980). They studied specimens obtained from the hilly area of the southern border of Lake Shinji, where the Fujina Formation is typically distributed.

The fossil localities reported in this paper are situated about 30 km west of Fujina, Tamayu Town, the type locality of the Formation, and the fossil bearing beds have been regarded as the equivalent of the Formation. However, some molluscan fossils newly collected from these localities are ones that have not ever been reported from the Fujina Formation. Then, their occurrence is an interesting problem from the view point of Neogene stratigraphy of the Izumo district, and is described in the paper in addition to fossil description.

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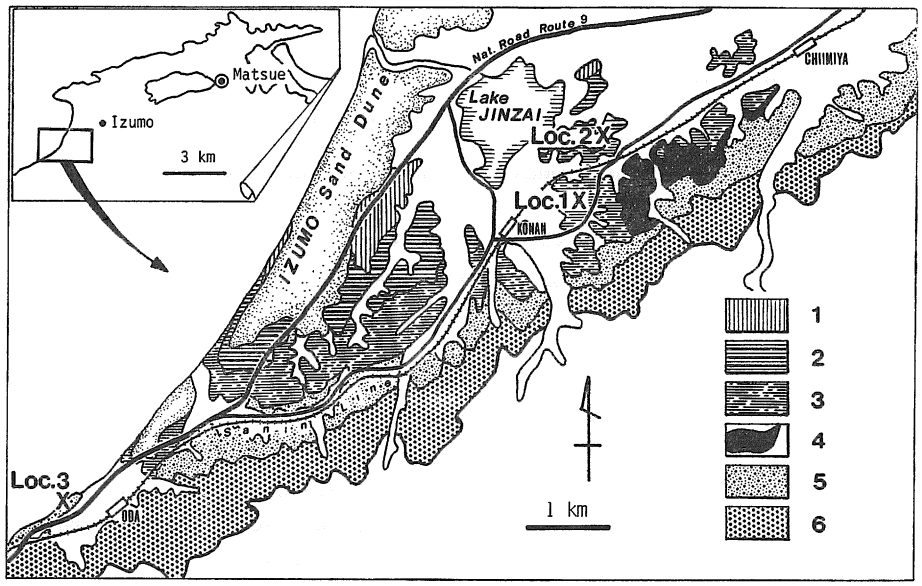
Geologic Setting and Fossil Localities

The fossil localities are shown in Textfig. 1, and the formation is divided lithologically into following six units in descending order.

Upper siltstone member: pale greenish massive siltstone; frequent intercalations of fine sandstone in the lower part. 50 m+ thick.

Alternation member : alternating beds of medium sandstone and siltstone. 50–100 m thick.

Lower siltstone member: greyish siltstone and fine sandstone with intercalations of medium sandstone; calcareous concretions in the middle part. 50–100 m thick.



Textfig. 1. Geological Sketch Map showing the Fossil Localities.

1; Upper siltstone member, 2; Alternation member, 3; Lower siltstone member, 4; Basaltic pyroclastics, 5; Sandstone member, 6; Conglomerate member

(Compiled by Shinji-ko Research Group, including the data by TAKANO, NODA and YAMADA, 1968 MS)

Basaltic pyroclastics : sandy tuff and scoria tuff; lava in part; being distributed only in the eastern area. 0–50 m thick.

Sandstone member : yellowish medium sandstone with intercalations of pebbly conglomerate and dacitic fine tuff in the lower part; calcareous concretions in the upper part. 50–100 m thick.

Conglomerate member : boulder conglomerate in the lower part; coarse sandstone with frequent intercalations of pebbly or cobbly conglomerate in the upper part; thicker in the western area. 30–150 m thick.

The formation covers unconformably the andesitic pyroclastic rocks and lavas of the Omori Formation (Middle Miocene in age), and dips gently northwestward.

Loc. 1 is in the middle horizon of the lower siltstone member, and the fossiliferous zone including a row of calcareous concretions is about 2 meters thick. Loc. 2 is in the lower horizon of the alternation member. At this locality, the fossils are assembled in paticular zones in medium- to fine-grained sandstone beds. The thickness of each zone is about 0.5 meters. At Loc. 3, fossils are obtained from beach gravels of calcareous medium-grained sandstone. They are inferred to have been derived from upper part of the sandstone member, which is exposed near Loc. 3.

Molluscan Assemblages

The list of molluscan fossils from three localities is given in Table 1. The assemblages of three localities are considerably different each other. In Loc. 1, the representative species, such as *Ennucula praenipponica*, *Serripes fujinensis*, *Macoma optiva* and *Cultellus izumoensis*, are common to the characteristic species of the Fujina molluscan fauna in the type area. *Anadara tazawensis* and *Glycymeris cisshuensis* are the species which have not been reported from the Fujina Formation, and *Kaneharaia kaneharai fujinaensis* has been found rarely from the Formation of the type area. *Mercenaria yokoyamai* and *Turritella tanaguraensis* are regarded as synonymous with *M. chitaniana* of SUEHIRO (1979), and *T.* cf. *saishuensis* / *T. saishuensis motidukii* of the same author, respectively. Though they are slightly different in the morphological characters from the specimens reported from the type area, the differences can be seemed to be within the range of specific variations. In Loc. 2 and 3, the characteristic species of the Fujina molluscan fauna are almost absent. *Phacosoma hataii* which is synonymous with *Dosinia nomurai* of SUEHIRO (1979), is a rare species in the type area,

Table 1. Molluscan fossils from the Vicinity of Lake Jinzai.

Species	Loc. 1	Loc. 2	Loc. 3	Type area of Fujina F.*
Ennucula praenipponica KAMADA	A	—	—	F
Anadara tazawensis TANAKA	A	F	—	—
Glycymeris cisshuensis MAKIYAMA	R	—	F	—
Crassostrea cf. *gigas* (THUNBERG)	R	—	—	+
Serripes fujinensis (YOKOYAMA)	C	—	—	R
Macoma optiva (YOKOYAMA)	C	—	—	A
Cultellus izumoensis YOKOYAMA	C	—	—	C
Laevicardium shiobarense (YOKOYAMA)	—	—	C	—
Mercenaria yokoyamai (MAKIYAMA)	R	F	—	A
Phacosoma hataii (MASUDA)	—	A	A	+
Kaneharaia kaneharai fujinaensis (MASUDA)	F	—	—	+
Panopea nomurae KAMADA	C	—	—	+
Fissidentalium yokoyamai (MAKIYAMA)	R	—	—	F
Turritella tanaguraensis KOTAKA	F	—	—	F
Cryptonatica janthostomoides (KURODA and HABE)	F	—	—	F
Phos iwakianus fujinaensis OGASAWARA and NOMURA	R	—	—	+
Ancistrolepis cf. *fujitai* KURODA	R	—	—	+

A; abundant, C; common, F; few, R; rare, *; represented by national route 9 side cliff at Kagami, Shinji Town, and + means the occurrence from other localities in the type area of the Fujina Formation.

and *Laevicardium shiobarense* is reported from the Fujina Formation for the first time.

As pointed out by some authors (CHINZEI and IWASAKI, 1967; IWASAKI, 1970, 1981; OGASAWARA and NOMURA, 1989), the representative species of the Fujina Formation are common to those of the Shiobara-type molluscan fauna. This fauna has been assigned to represent the Middle to Late Miocene cold water and nearshore fauna in Northeast Japan and the Japan Sea coast area (CHINZEI, 1963). According to OGASAWARA and NOMURA (1980), most species of the Fujina Formation are well comparable with the Shiobara-type mollusca, but some other species of it are characteristic species of so-called Yama molluscan fauna, which is the deeper water fauna of the same age as the Shiobara-type fauna. Therefore, it is inferred that the Fujina molluscan fauna may have been flourished in fine sandy bottom shallow (20 to 50–60 m depth) to more or less deeper off-shore environment.

In the present area, the predominant species of Loc. 1 are common to the representative species of the Fujina molluscan fauna, and most of them are also comparable with the Shiobara-type fauna. For example, *Macoma optive*, *Turritella tanaguraensis* and *Cultellus izumoensis* are characteristic species of *Lucinoma-Turritella* assemblage of the Shiobara-type fauna (IWASAKI, 1970), being inferred to be muddy bottom of shallow sea. Moreover, some mollusca, such as *Anadara*, *Glycymeris*, *Kaneharaia* and *Mercenaria*, are the constituents of *Anadara-Dosinia* assemblage, representing sandy bottom of shallow sea. In addition to these species, *Ennucula praenipponica* indicates exceptionally the deeper sea of muddy bottom as an element of the Yama fauna. Therefore, the paleoenvironment suggested from the assemblage of Loc. 1 is fine sandy bottom, shallower than the type area of the Fujina Formation.

In the case of Loc. 2 and 3, the mollusca are restricted to the representatives of *Anadara-Dosinia* assemblage of the Shiobara-type molluscan fauna, and the paleoenvironment is considered to have been coarser and shallower bottom than Loc. 1. These characteristics are more conspicuous in Loc. 3 than Loc. 2.

Some Geological Remarks

Although stratigraphic correlation between the present area and the type area of the Fujina Formation remains insufficient, the main part of the latter characterized by bluish grey, massive sandy siltstone may be compared with the members underlying the basaltic pyroclastics in the former. The lithological differences between them may be due to the differences of sedimentary environment.

Based on the studies of benthic and planktonic foraminifers and mollusca, the geologic age of the Fujina Formation has been considered to be Late Miocene (TAI, 1955; OKAMOTO, 1959, 1981; TAI *et al.*, 1979; OGASAWARA and NOMURA, 1980). However, the fact that the Fujina Formation has some representative species, such as *Patinopecten* (*Kotorapecten*) *kagamianus*, *Cultellus izumoensis*, *Macoma optiva* and *Desmostylus japonicus* of Japanese Middle Miocene, rather contradicts the above view.

Furthermore, the Kubota Formation of Higashi-Tanakura district, Fukushima Prefecture, type locality of the Shiobara-type molluscan fauna, was recently reported to be Middle Miocene in age (from N. 11 to N. 13 of BLOW's zone) based on the planktonic foraminiferal and radiolarian biostratigraphies (CHINZEI *et al.*, 1981). In this connection, the occurrence of *Anadara tazawensis* associated with *Turritella tanaguraensis* in Loc. 1 is of paticular interest. These species has been regarded as the important species for the molluscan biostratigraphy in Japan, indicating the Middle Miocene age (KOTAKA, 1959; NODA, 1966). Therefore, the Fujina Formation in the type area, which is inferred to be older than the beds at Loc. 1, is not so different in geologic age from the other formations yielding the Shiobara-type fauna. In other words, so far as molluscan fossils are concerned, it is concluded that the Fujina Formation is hardly correlatable with the Upper Miocene.

Description of Species

Family TURRITELLIDAE

Genus *Turritella* LAMARCK, 1799

Subgenus *Idaella* KOTAKA, 1959

Turritella (*Idaella*) *tanaguraensis* KOTAKA, 1951
(Pl. I, figs. 1, 2)

1926. *Turritella saishuensis*, YOKOYAMA, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec.* 2, vol. 1, pt. 4, p. 131.
1931. *Turritella* sp., YOKOYAMA, *Ibid.*, Vol. 3, p. 201, pl. 12, fig. 4.
1936. *Turritella kadonosawaensis*, NOMURA and HATAI, *Saito Ho-on Kai Mus. Res. Bull.*, no. 10, p. 143, pl. 16, figs. 1, 2.
1951. *Turritella tanaguraensis* KOTAKA, *Ibid.*, no. 21, p. 10, pl. 1, figs. 16, 17.
1952. *Turritella tanagutaensis*, IDA, *Rep. Geol. Surv. Japan*, vol. 150, p. 59, pl. 2, figs. 4, 5, pl. 5, fig. 4.
1959. *Turritella* (*Idaella*) *tanaguraensis*, KOTAKA, *Sci. Rep., Tohoku Univ., 2nd Ser.*, vol. 31, no. 2, pp. 97–98, pl. 8, figs. 1–9.
1970. *Turritella tanaguraensis*, IWASAKI, *Jour. Fac. Sci., Univ. Tokyo, Sec.* 2, vol. 17, no. 3, p. 413, pl. 5, figs. 7, 8.
1979. *Turritella* (*Neohaustator*) cfr. *saishuensis*, SUEHIRO, *Bull. Mizunami Fossil Mus.*, no. 6, pp. 86–87, pl. 15, figs. 7, 8.
1979. *Turritella* (*Neohaustator*) *saishuensis motizukii*, SUEHIRO, *Ibid.*, p. 87. pl. 15, fig. 6.
1980. *Turritella* (*Idaella*) *tanaguraensis*, OGASAWARA and NOMURA, *Prof. S. Kanno Mem. Vol.*, pp. 91–92, pl. 12, figs. 7a–11.
1980. *Turritella* (*Idaella*) *tanaguraensis*, TAKAYASU, *Mem. Fac. Sci., Shimane Univ.*, no. 14, pp. 135–136, pl. 1, figs. 1, 2.

All specimens at hand were collected from Loc. 1.

Description: — Shell moderate in size, spire conical, whorl profile slightly convex. Surface sculptured with two distinct flat topped primary spiral cords B_1 and C_2, and a

fairly weak primary cord A, and faint secondary cords s and t. Growth-line with moderately deep lateral sinus, its maximum falls on spiral cord B. In weathered specimen secondary spirals indistinct.

Dimensions: —

DGSU* coll. cat. no.	Max. diameter (mm)	Height (mm)	Preserv. whorls	Pleural angle
T. 1735	14.0	58.4+	13	15.5°
T. 1736	17.3	56.8+	9	15.0°
T. 1737	17.5	—	2.5	—
T. 1738	14.5	46.4+	8.5	15.5°

* Abbreviation for Department of Geology, Faculty of Sciense, Shimane University, Matsue.

Remarks: — SUEHIRO (1979) reported *Turritella* (*Neohaustator*) cf. *saishuensis* and *Turritella* (*Neohaustator*) *saishuensis motidukii* from the Fujina Formation of the type area. However, the specimens illustrated by him are ill preserved ones. On the other hand, OGASAWARA and NOMURA (1980) examined a few well preserved specimens of *Turritella* from the Fujina Formation, and identified them *T.* (*Idaella*) *tanaguraensis* KOTAKA which was first reported from the Miocene Kubota Formation, Fukushima Prefecture. According to them, "in some weathered specimens, spiral cords are formulated as (A s B C) which is somewhat similar to that of *Turritella saishuensis*, however," *T. tanaguraensis* "can be distinguished from *T. saishuensis* in having very strong primary spirals B and C and weak narrowly developed spiral A." The re-examination by the present writer revealed that both species reported by SUEHIRO have characters supporting the view of OGASAWARA and NOMURA.

The present specimens are about a half as large as *T. tanaguraensis* from the Fujina Formation of the type area. Moreover, weathered specimen bears closely resemblance to *T. saishuensis motidukii*, a Pliocene *Turritella*, in the size and surface sculptures. However, the specimen reported by YOKOYAMA (1926) from the Kanomatazawa Formation in Shiobara region, Tochigi Prefecture, is as large as the present specimens in size, and IWASAKI (1970) regarded it as the same species with *T. tanaguraensis* with some characteristics still remained questionably.

Though the same problem still remains in the case of the Fujina specimens, they can be identified as that species by the characteristics of surface sculptures.

Family ARCIDAE

Genus *Anadara* GRAY, 1847

Subgenus *Anadara* s. s.

Anadara (*Anadara*) *tazawensis* TANAKA, 1960
(Pl. I, figs. 3a–4b)

1960. *Anadara amicula tazawensis* TANAKA, *Bull. Fac. Educ., Shinshu Univ.*, no. 11, pp. 182–183, pl. 1, figs. 9–10.
1966. *Anadara* (*Anadara*) *tazawaensis*, NODA, *Sci. Rep., Tohoku Univ., 2nd Ser.*, vol. 38, no. 1, pp. 102–103, pl. 11, figs. 5.
?1979. *Anadara* sp., SUEHIRO, *Bull. Mizunami Fossil Mus.*, no. 6, p. 74, pl. 11, figs. 4a, b.
1980. *Anadara* (*Anadara*) *ogawai*, TAKAYASU, *Mem Fac. Sci., Shimane Univ.*, pp. 136–137, pl. 1, figs. 9a–10.

More than 90 specimens from Loc. 1 and a few specimens from Loc. 2 were examined. They were obtained as isolated valves and have a wide variation in morphological characters.

Description: — Shell moderate in size, ovately to squarish rounded in outline, rather flat to well inflated valve. Height against Length about 0.74–0.93, and depth against length about 0.24–0.41. Radial ribs 24 to 29 in number, most frequently 27. Ornamentation on radial ribs dichotomous in about two third of examined specimens, nondichotomous in about a third of them and double dichotomous in a few specimens. In some specimens, granulated structure on radial ribs. Interspace, in general, wider than radial rib in right valve and narrower than it in left valve. Umbonal area moderately inflated, beak small, prominent, curved anteriorly, situated 0.32–0.43 from anterior end. Ligamental area somewhat asymmetrical triangular with chevron shaped grooves of 1.5 to 6 in number, most frequently 4. Hinge plate straight, teeth numerous, ventrally convergent at both extremities. Muscular scars well depressed, anterior one ovately rounded, posterior one squarish rounded larger than anterior one.

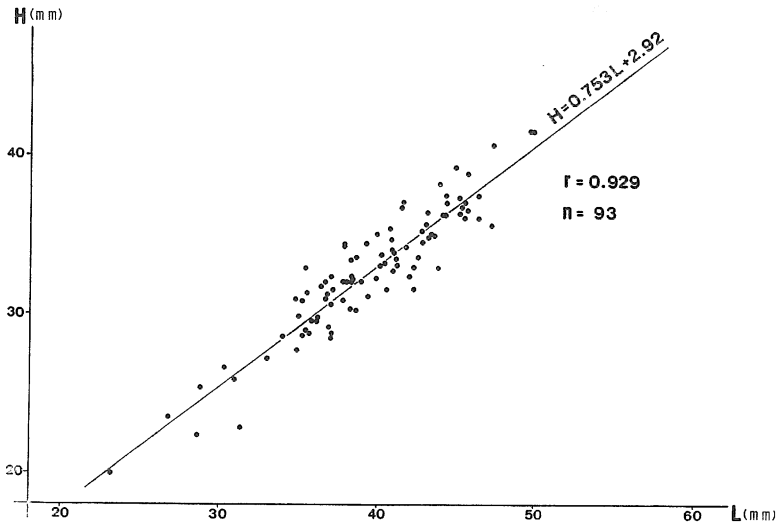
Dimensions: —

DGSU coll. cat. no.	Length (mm)	Height (mm)	Depth (mm)	Length of ligament (mm)	Apical angle	Number of radial ribs
T. 1739 (R)	43.3	ca. 34.8	14.8	23.3	99°	28
T. 1740 (R)	43.5	39.2	15.5	29.4	94°	25
T. 1741 (R)	45.0	39.2	15.1	30.9	84°	28
T. 1742 (L)	47.3	35.5	14.7	29.9	95°	25
T. 1743 (R)	46.5	37.4	16.8	29.2	93°	27
T. 1744 (L)	35.0	29.9	13.5	22.0	98°	27
T. 1745 (R)	46.5	36.0	16.5	29.1	97°	27
T. 1746 (R)	49.8	41.5	19.1	31.9	95°	28
T. 1747 (R)	41.6	36.7	16.8	29.5	91°	26
T. 1748 (L)	38.3	32.3	13.8	23.4	95°	25

R; right valve, L; left valve

Remarks: — This species was originally reported by TANAKA (1960b) from the Miocene Aoki Formation, Nagano Prefecture, and from the external sculpture this species has been presumed to be the ancestor of *Anadara amicula* (s.l.). The general characters of the present species are common to those of *Anad. amicula* (s. l.), but the number of radial ribs of the former is smaller than those of the latter. According to NODA (1966), it is 30 in *Anad. amicula amicula*, 31 in *Anad. amicula elongata* and 32 in *Anad. amicula rotunda* in the most frequent number.

The present specimens are somewhat allied in outline to *Anad. amicula elongata*, which was originally named for the specimen from the Pliocene Omma Formation, Ishikawa Prefecture. The relationship of shell length (L) to height (H) of the specimens at hand is shown in Textfig. 2. In the case, the line of regression of H on L is formularized as $H=0.753L+2.92$ ($r=0.929$, $n=93$). For *Anad. amicula elongata* from the Omma Formation, after the data of NODA (1966), the formula is $H=0.766L+3.04$ ($r=0.952$, $n=63$), and for *Anad. amicula amicula* from the Ogawa Formation, the Upper Miocene or Pliocene of Nagano Prefecture, after the data of TANAKA (1960a), it is $H=0.721L+2.00$ ($r=0.850$, $n=22$).



Textfig. 2. Relationship of Length to Height of *Anadara tazawensis* from Loc. 1.

Anadara ninohensis, one of the representative species of the Kubota Formation, Fukushima Prefecture, is also allied to the present specimens in having dichotomous or double dichotomous radial ribs and in the number of ribs. According to IWASAKI (1970), the morphological variation of the former species is, as well as the present psecimens, an outstanding characteristic among the fauna, and some specimens illustrated by him are very similar to the present ones in outline. KOBAYASHI and KAMIYA (1968) and KOBAYASHI (1976) confirmed on the internal shell structure that

the outer shell layer of *Anad. ninohensis* has the composite prismatic structure, but in the case of *Anad. amicula* the structure is not developed. According to KOBAYASHI (personal com.), the composite prizmatic structure is not observed in the specimen from Loc. 1.

Anad. ogawai, originally described by MAKIYAMA (1926) from the Miocene Bankodo Formation, North Korea, resembles the present specimens in having dichotomous radial ribs, but differes in its more swollen and somewhat stout shell. A few Anadarid shells obtained from the Matsue Formation at Nange, Matsue City, which were identified with *Anad. ogawai* by the present writer (TAKAYASU, 1980), are included within the variations of the present species.

Family GLYCYMERIDAE

Genus *Glycymeris* da COSTA, 1778

Glycymeris cisshuensis MAKIYAMA, 1926
(Pl. I, figs. 5a, b)

1926. *Glycymeris cisshuensis* MAKIYAMA, *Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B*, vol. 2, no. 3, p. 155, pl. 13, figs. 2, 3.
1928. *Glycymeris cisshuensis*, NAGAO, *Sci. Rep. Tohoku Imp. Univ., 2nd Ser.*, vol. 12, no. 1, p. 29, pl. 2, figs. 1–13, pl. 3, figs. 1–3, pl. 4, figs. 22–25.
1937. *Glycymeris cisshuensis*, NOMURA and HATAI, *Saito Ho-on Kai Mus. Res. Bull.* no. 13, p. 125, pl. 17, fig. 7.
1956. *Glycymeris cisshuensis*, HIRAYAMA, *Sci. Rep. Tokyo Univ. Ed., Sec. C*, vol. 5, no. 45, p. 103.
1960. *Glycymeris cisshuensis*, KANNO, *Japan Soc. Prom. Sci.*, pp. 207–208, pl. 31, figs. 34, 35.
1960. *Glycymeris cisshuensis*, ARAKI, *Bull. Lib. Arts Dep., Mie Univ., Spec.* vol., no. 1, p. 79, pl. 5, figs. 7a–8.
1962. *Glycymeris cisshuensis*, KAMADA, *Spec. Pap., Palaeont. Soc. Japan, no.* 8, pl. 3, figs. 1–3.
1963. *Glycymeris cisshuensis*, OKAMOTO and NAKANO, *Geol. Rep., Hiroshima Univ.*, no. 12, p. 538, pl. 57, figs. 1a–3.
1970. *Glycymeris cisshuensis*, IWASAKI, *Jour. Fac. Sci., Univ. Tokyo, Sec.* 2, vol. 17, pt. 3, p. 393, pl. 4, figs. 6, 7.
1974. *Glycymeris cisshuensis*, ITOIGAWA in ITOIGAWA, SHIBATA and NISHIMOTO, *Bull. Mizunami Fossil Mus.*, no. 1, pp. 57–58, pl. 5, figs. 1–5.
1981. *Glycymeris cisshuensis*, TAKAYASU, *Mem. Fac. Sci., Shimane Univ.*, no. 14, pp. 137–138, pl. 2, figs. 2–4b.

Description: — Shell mediun in size, well inflated. Umbonal area well swollen, beak rather small, bluntly pointed. Ligamental area low triangular, equilateral, flattened without grooves. Hinge plate rather large, teeth strong, almost hooked.
Dimensions: —

DGSU coll. cat. no.	Length (mm)	Height (mm)	Depth (mm)
T. 1753 (L)	54.5	47.4	15.3

Remarks: — The examined specimen was collected from Loc. 1. The present specimen looks small and somewhat fragile as compared with those from the Matsue Formation at Nange, Matsue City. However, The characteristics described above are well identical with those of MAKIYAMA's type specimen.

Family CARDIIDAE

Genus *Laevicardium* SWAINSON, 1936

Laevicardium shiobarense (YOKOYAMA, 1926)

(Pl. II, figs. 4a–5)

1926. *Cardium shiobarense* YOKOYAMA, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec.* 2, vol. 1, Pt. 4, p. 134, p. 134, pl. 20, figs. 2–5.
1931. *Cardium shiobarense*, YOKOYAMA, *Ibid.*, vol. 3, Pt. 4, p. 202, pl. 12, fig. 1.
1935. *Cardium* (*Trachycardium*) *shiobarense*, NOMURA, *Saito Ho-on Kai Mus., Res. Bull.*, no. 5, pp. 80–81, pl. 4, figs. 1–3.
1936. *Cardium* (*Trachycardium*) *shiobarense*, NOMURA and HATAI, *Ibid.*, no. 10, p. 125, pl. 15, figs. 4.
1970. *Laevicardium shiobarense*, IWASAKI, *Jour. Fac. Sci., Univ. Tokyo, Sec.* 2, vol. 17, Pt. 3, p. 402, pl. 1, figs. 1, 2.

Many specimens were collected from Loc. 3, but the shell materials had been more or less dissolved out.

Description: — Shell medium to rather large, well inflated, obliquely ovate in outline, higher than long. Umbonal area well swollen, but in young individuals not so inflated. Surface sculptured with radial ribs. Ribs 34 to 40 in number, squarish round in cross-section. Interspaces very narrow. Beak pointed and incurved.

Dimensions: —

DGSU coll. cat. no.		Length (mm)	Height (mm)	Depth (mm)	Number of ribs
T. 1759	(R)	45.8	48.2	19.6	40
T. 1760	(L)	38.9	41.5	15.6	34
T. 1761	(R)	37.0	39.4	14.5	37
T. 1762	(R)	39.5	42.4	17.5	36
T. 1763	(L)	33.8	36.5	14.0	37
T. 1764	(R)	40.0	(41.8)	17.8	39

Remarks: — This species originally descrived by YOKOYAMA (1926) from the Kanomatazawa Formation, Tochigi Prefecture, and it is found commonly in fine sandstone of the Kubota formation, Fukushima Prefecture, associated with the *Anadara-Dosinia* assemblage (IWASAKI, 1970). The present specimen are obtained from somewhat coarser facies than the case of Tanagura specimens, and smaller in size than the latter. *Clinocardium shinjiense*, which is the characteristic species of the Fujina Formation,

is easily distinguished from the present species in having carinated radial ribs and small umbo. *Vasticardium* sp. of OGASAWARA and NOMURA (1970), also from the Fujina Formation, is somewhat allied to this species in its obliquely ovate outline, but the former differs from the latter in having small umbonal area.

Family VENERIDAE

Genus *Phacosoma* JUKES-BROWN, 1912

Phacosoma hataii (MASUDA, 1963)
(Pl. I, figs. 6, 7)

1936. *Dosinia odosensis*, NOMURA and HATAI, *Saito Ho-on Kai Mus., Res. Bull.*, no. 10, p. 128, pl. 14, fig. 1.
1963. *Dosinia (Phacosoma) hataii* MASUDA, *Trans. Proc. Palaeont. Soc. Japan, N.S.*, no. 49, pp. 34–35, pl. 6, figs. 1a–c, 2.
1970. *Dosinia (Phacosoma) japonica*, IWASAKI, *Jour. Fac. Sci., Univ. Tokyo, Sec.* 2, vol. 17, Pt. 3, pp. 407–408, pl. 4, figs. 3, 4.
1979. *Dosinia (Phacosoma) nomurai*, SUEHIRO, *Bull. Mizunami Fossil Mus.*, no. 6, p. 81, pl. 13, figs. 6a–c.
1980. *Phacosoma* cf. *japonica*, TAKAYASU, *Mem. Fac. Sci. Shimane Univ.*, no. 14, p. 144, pl. 5, figs. 1a–c.

Several well preserved specimen from Loc. 3 are examined. The specimens from Loc. 2 are all moulds.

Description: — Shell moderate in size, moderately inflated, suborbicullar in outline; in the young stage having longar shell but tending to become orbicular with growth. Anterior side rounded, antero-dorsal margin short, broadly rounded, concave in front of beak; postero-dorsal margin long, broadly rounded, forming a blunt angle with postero-ventral margin. Beak small, pointed, somewhat curved forwards. Lunule distinctly impressed, rather large, cordate in shape; escutcheon long, narrow, bordered by a sharp edge. Surface sculptured with numerous, close-set, fine concentric lines. Pallial sinus slightly sloping upwards, rather narrow and small, somewhat pointed at end.

Dimensions: —

DGSU coll. cat. no.	Length (mm)	Height (mm)	Depth (mm)
T. 1749 (R)	54.2	51.5	12.3
T. 1750 (L)	63.3	61.3	16.1
T. 1751 (L)	51.7	49.6	11.0
T. 1752 (L)	44.4	42.0	ca. 9.0

Remarks: — This species was first proposed by MASUDA (1963) for the Kubota and Kanomatazawa specimens. According to him, it is "characterized by its large, orbi-

cular, thick shell, distinct large lunule and rather shallow, narrow pallial sinus being bluntly pointed at end." IWASAKI (1970), though he recognized the coincidence between his Tanagura specimens and MASUDA's *hataii*, identified them with *Dosinia* (*Phacosoma*) *japonica* (=*Phacosoma japonicum*) in broad sense, because his specimens have slender umbo and less inflated shell. The illustlations by him, however, are apparently different from the recent form of *Phacosoma japonicum* in having more orbicular shell and more broad anterior curvation.

The present specimens represent a quite resemblance with MASUDA's description excepting for their smaller and less inflated shell in the same way as the specimens from the Kubota Formation. Moreover, SUEHIRO's *Dosinia* (*Phacosoma*) *monurai* from the Fujina Formation can be regarded as the young form of the present species.

Genus *Kaneharaia* MAKIYAMA, 1936

Kaneharaia kaneharai fujinaensis (MASUDA, 1967)

(Pl. II, figs. 1a, b)

1967. *Dosinia* (*Kaneharaia*) *kaneharai fujinaensis* MASUDA, *Saito Ho-on Kai Mus., Res. Bull.*, no. 36, p. 24, 0l. 1, fig. 9, pl. 2, fig. 3.

cf. 1979. *Dosinia* (*Kaneharaia*) cfr. *kanehari*, SUEHIRO, *Bull. Mizunami Fossil Mus.*, no. 6, pp. 80–81, pl. 13, fig. 5.

1980. *Dosinia* (*Kaneharaia*) *kaneharai fujinaensis*, OGASAWA and NOMURA, *Prof. S. Kanno Mem. Vol.*, pl. 9, fig. 21.

Two imperfect specimens from Loc. 1 are at hand.

Dimensions: —

DGSU coll. cat. no.	Length (mm)	Height (mm)	Depth (mm)
T. 1757 (R)	74.8	ca. 73.0	22.4
T. 1758 (L)	—	—	ca. 19.0

Remarks: — The present subspecies was originally described by MASUDA (1967) from the Fujina Formation. It is characterized by its large, long shell and its surface sculpture with slightly lamellated concentric cords. The specimens at hand, though they had been broken and weathered, is identifiable with that subspecies by the very thick shell, having no marked escutcheon, characteristics of concentric cords, and so on.

Gemus *Mercenaria* SCHUMACHER, 1817

Mercenaria yokoyamai (MAKIYAMA, 1927)

(Pl. II, figs. 2–3b)

1923. *Venus* (*Mercenaria*) *stimpsoni*, YOKOYAMA, *Jap. Jour. Geol. Geogr.*, vol. 2, no. 1, p. 6,

pl. 1, fig. 5.

?1926. *Chione chitaniana* YOKOYAMA, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec.* 2, vol. 1, Pt. 9, pp. 352–353, pl. 39, fig. 13.

1927. *Venus yokoyamai* MAKIYAMA, *Mem Coll. Sci., Kyoto Imp. Univ., Ser. B,* vol. 3, no. 1, Art. 1, pp. 46–47, pl. 2, fig. 8.

1927. *Chione chitaniana,* YOKOYAMA, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec.* 2, vol. 2, Pt. 4, p. 201, pl. 51, figs. 3, 4.

1931. *Mercenaria stimpsoni*, YOKOYAMA, *Ibid.*, vol. 3, Pt. 4, p. 198.

1936. *Venus* (*Chione*) *yokoyamai*, NOMURA and HATAI, *Saito Ho-on Kai Mus., Res. Bull.*, no. 10, p. 126, pl. 14, figs. 3, 4.

1936. *Venus* (*Chione*) *yokoyamai*, NOMURA and ZINBO, *Ibid.*, pl. 20, fig. 12.

1936. *Mercenaria yokoyamai*, OTUKA, *Jour. Geol. Soc. Japan, vol.* 43, no. 516, 726–736, pls. 41–42.

1938. *Venus* (*Chione*) *chitaniana*, NOMURA, *Sci. Rep. Tohoku Imp. Univ., 2nd Ser.*, vol. 19, no. 2, pp. 260–261, pl. 33, fig. 17.

1954. *Mercenaria chitaniana*, HAYASAKA and UOZUMI, *Trans. Proc. Palaeont. Soc. Japan, N.S.*, no. 15, pp. 166–168, pl. 22, fig. 2.

1960. *Mercenaria chitaniana*, SHUTO, *Mem. Fac. Sci., Kyushu Univ., Ser. D,* vol. 9, no. 3, p. 145, pl. 13, fig. 7.

1970. *Mercenaria chitaniana*, IWASAKI, *Jour. Fac. Sci., Univ. Tokyo, Sec.* 2, vol. 17, Pt. 3, pl. 5, fig. 2, pl. 7, fig. 5–7.

1979. *Mercenaria chitaniana*, SUEHIRO, *Bull. Mizunami Fossil Mus.*, no. 6, pp. 79–80, pl. 13, figs. 1–4.

1980. *Mercenaria yokoyamai*, OGASAWARA and NOMURA, *Prof. S. Kanno Mem. Vol.*, pl. 9, figs. 19a, b.

Well preserved three specimens were examined. (T. 1754 from Loc. 1, T. 1755 and T. 1756 from Loc. 2)

Description: — Shell medium in size, moderately inflated. Surface sculptured with numerous concentric lamellae, but in case of the incompletely preserved specimens with numerous fine radial striations. Antero-dorsal margin short, moderately rounded, concave in front of beak; postero-dorsal margin long, broadly rounded forming a blunt angle with postero-ventral margin; ventral margin rather short, moderately rounded. Lunule and escutcheon distinct. Pallial sinus moderately deep, bluntly pointed at end. Inner margin crenulated.

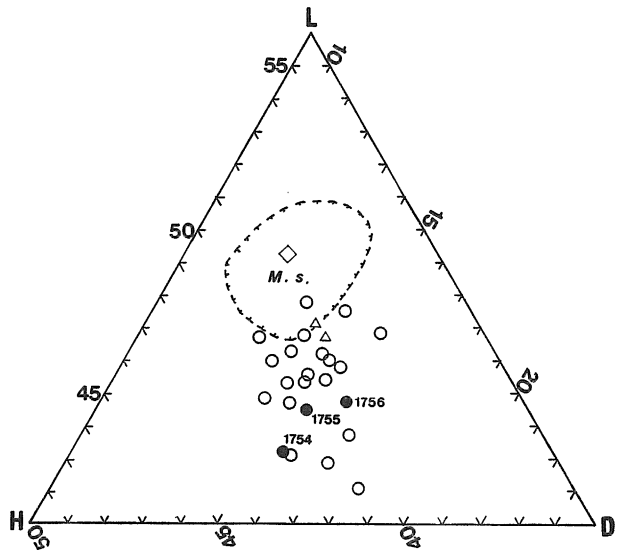
Dimensions: —

DGSU coll. cat. no.	Length (mm)	Height (mm)	Depth (mm)
T. 1754 (R)	52.2	50.8	17.8
T. 1755 (L)	48.2	44.2	15.8
T. 1756 (R)	56.2	49.9	19.6

Remarks: — This specific name was first proposed by MAKIYAMA (1927) for the specimens from the Pliocene Kakegawa Group, Shizuoka Prefecture. On that occation, he regarded the specimen from the Fujina Formation, originally described by YOKOYAMA (1923) as *Venus* (*Mercenaria*) *stimpsoni*, as a synonym of his new species.

On the other hand, YOKOYAMA (1926b) had also described a *Mercenaria* species from the Kakegawa Group, and named it *Chione chitaniana*. Though MAKIYAMA's *yokoyamai* is slightly different from YOKOYAMA's *chitaniana*, the former had been generally considered to be a synonym of the latter.

In 1960, CHINZEI discussed the morphological differences between *M. chitaniana* and *M. yokoyamai*, in the connection of *M. stimpsoni* from the Pliocene Sannohe Group of Aomori Prefecture. According to him, the YOKOYAMA's type specimen of *M. chitaniana* falls in the central area of *M. stimpsoni* field of the triangular diagram showing Length-Height-Depth ratio. Therefore, he regarded *M. chitaniana* as a synonym of *M. stimpsoni*, and proposed that *M. yokoyamai* is a valid name for "*M. chitaniana*" auct. nom. Since then, it seems that the nomenclature on these species has been gone upon the general conception that the form having higher, ovately trigonal shell outline is *M. yokoyamai* and the form having obliquely elongated outline is *M. chitaniana* or *M, stimpsoni*. For example, on the specimens from the Fujina Formation, SUEHIRO (1979) illustrated some obliquely elongated specimens and identified them with *M. chitaniana*, whereas OGASAWARA and NOMURA (1980) identified thier ovately



Textfig. 3. Length-Height-Depth Ratio of *Mercenaria yokoyamai* from the Fujina Formation.

L; Length, H; Height, D; Depth

M.s. field of *Mercenaria stimpsoni* (after CHINZEI, 1960). Open squear symbol; holotype of *M. chitaniana* (after YOKOYAMA, 1926b). Open triangle symbol; type specimens of *M. yokoyamai* (after MAKIYAMA, 1927). Open circle symbol; *M. yokoyamai* from the Fujina Formation of the type area. Black circle symbol; *M. yokoyamai* from the present area.

trigonal individuals with *M. yokoyamai*.

However, the truth is that the morphological discontinuity between these two forms is hardly recognizable (Textfig. 3). Thus, the *Mercenaria* species of the Fujina Formation is considered to have a wide intraspecific variation. Concerning that the Miocene *Mercenaria* species has very variable shell outline, another instance was given by IWASAKI (1970) in the Shiobara-type molluscan fauna of the Kubota formation, but he nominated *M. chitaniana* for the specific name. In the case of the Fujina specimens the writer adopts *M. yokoyamai* as the specific name according to the identification by MAKIYAMA (1927) and the opinion of CHINZEI (1960).

In the connection of the specific variation, some interesting facts are recognized in the Fujina Formation. The obliquely elongated from of this species shows a tendency to increase in number in the muddy facies, on the other hand, the ovately trigonal form is generally dominant in the sandy facies. Additionally, the latter form is frequently found in the small or young individuals as pointed by SUEHIRO (1979). Although this point should be further studied in detail, the facts mentioned above will be of useful hints in considering the adaptive radiation and the phylogeny of the Neogene *Mercenaria* species.

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Explanation of Plate I

(All figures in natural size)

Figs. 1, 2. *Turritella* (*Idaella*) *tanaguraensis* KOTAKA

Fig. 1, DGSU coll. cat. no. T. 1736; fig. 2, DGSU coll. cat. no. T. 1735.

Figs. 3a–4b. *Anadara* (*Anadara*) *tozawensis* TANAKA

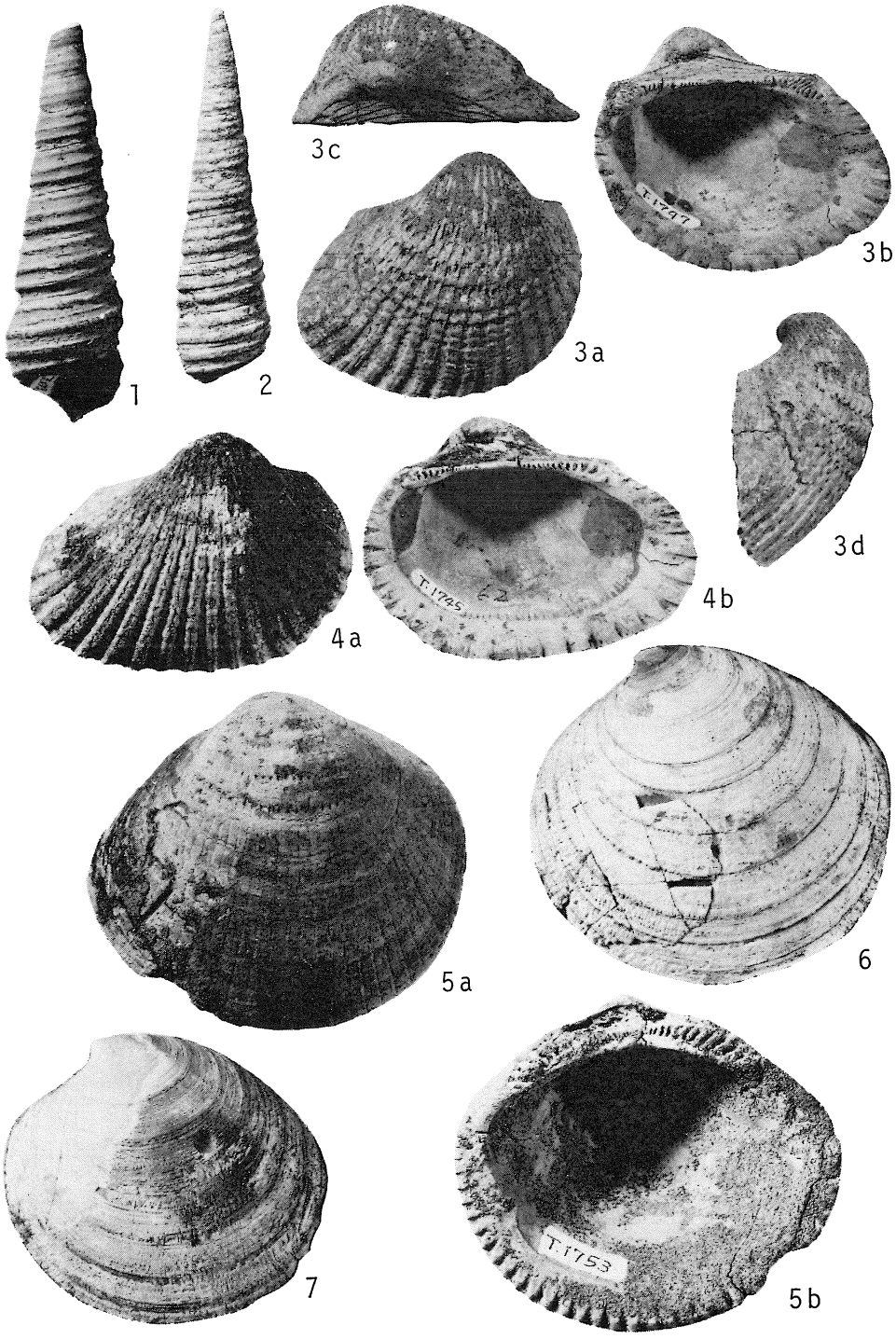
Fig. 3, DGSU coll. cat. no. T. 1747, 3a, right view, 3b, interior view, 3c, dorsal view, 3d, posterior view; fig. 4, DGSU coll. cat. no. T. 1745, 4a, right view, 4b, interior view.

Figs. 5a, b. *Glycymeris cisshuensis* MAKIYAMA

DGSU coll. cat. no. T. 1753, 5a, left view, 5b, interior view.

Figs. 6, 7. *Phacosoma hataii* (MASUDA)

Fig. 6, DGSU coll. cat. no. T. 1751, left view; fig. 7, DGSU coll. cat. no. T. 1752, left view.


1
2
3c
3a
T.1747
3b
3d
4a
T.1745
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T.1753
5b

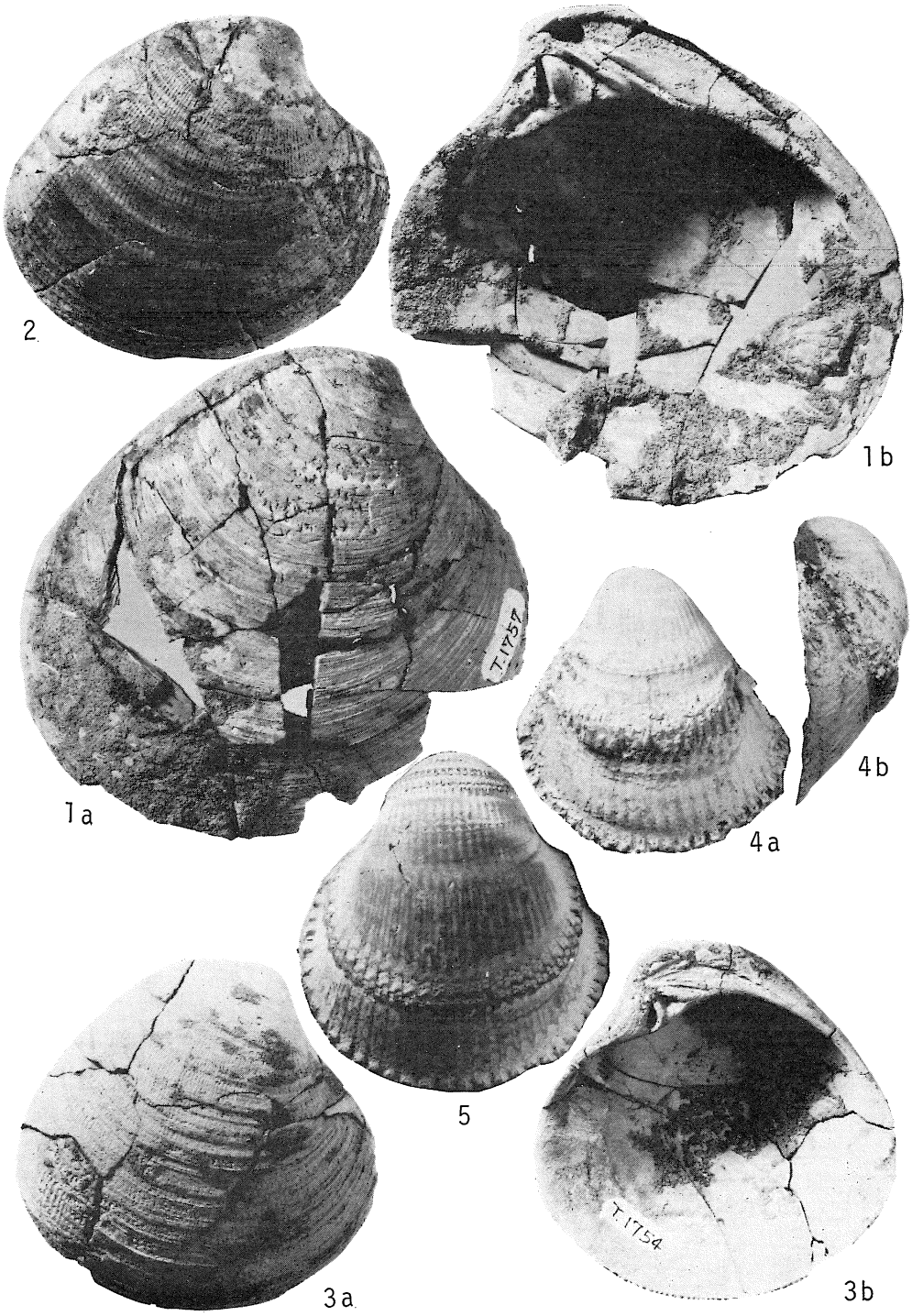
Explanation of Plate II

(All figures in natural size)

Figs. 1a, b. *Kaneharaia kaneharai fujinaensis* (MASUDA)
DGSU coll. cat. no. T. 1757, 1a, right view, 1b, interior view.

Figs. 2–3b. *Mercenaria yokoyamai* (MAKIYAMA)
Fig. 2, DGSU coll. cat. no. T. 1756, right view; fig. 3, DGSU coll. cat. no. T. 1754, 3a, right view, 3b, interior view.

Figs. 4a–5. *Laevicardium shiobarense* (YOKOYAMA)
Fig. 4. DGSU coll. cat. no. T. 1760, 4a, left valve, 4b, anterior view; fig. 5. DGSU coll. cat no. T. 1759, right view.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1b
T.1757
1a
4b
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3a
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