

Fossil Molluscs from the Miocene Masuda Group at Okuda, Masuda City

—Molluscan Fossils from Various Localities
in Shimane Prefecture, Part 2—

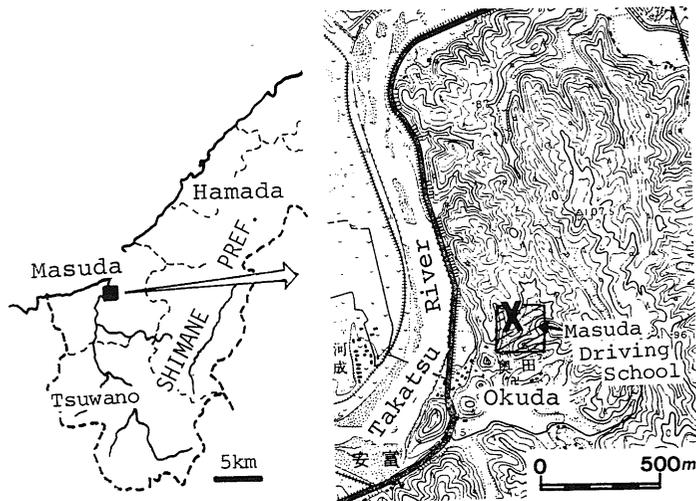
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(Received September 5, 1981)

Introduction

Abundant fossils of *Vicarya* and other molluscs were found by the students of a junior high school at Okuda in the south of Masuda City in December of 1977 (Textfig. 1). Recently the details were reported by TANAKA (1981). After this discovery, many specimens have been collected on the chance of the geological training for students of Shimane University and some excursions at the site. Here to fore, twenty species of molluscs have been identified by the author's examination of these specimens and TANAKA's collections. In this paper, they will be described.

The author wishes to express his hearty thanks to Mr. Ikutaro TANAKA of Kuraki Junior High School, Muika-ichi-cho, Shimane Prefecture, for providing fossil specimens



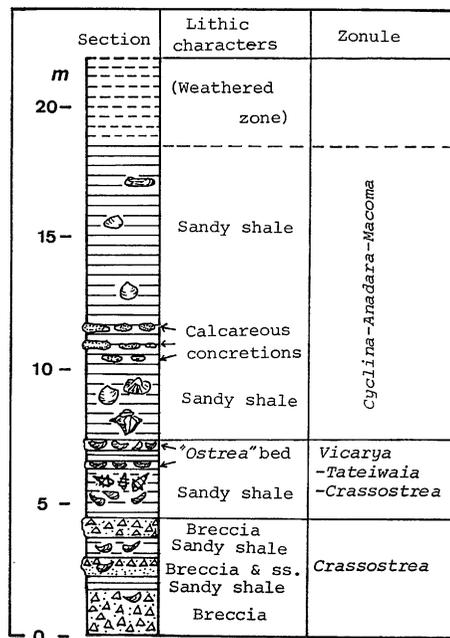
Textfig. 1. Map showing the fossil locality. (Taken from the topographical map "Iwamiyokota", 1: 25,000 in scale)

and Dr. Junji ITOIGAWA of Nagoya University, Professor Masahiro OKUBO and Dr. Takao TOKUOKA of Shimane University for their helpful advice.

Geologic Outline

The Miocene marine sediments distributed in Masuda City are named the Masuda Group and is divided into a lower unit, the Toyoda Formation, and an upper unit, the Yasuda Formation (FUJITA, 1964). The Toyoda Formation is about 110 meters in thickness, and consists of conglomerates, sandstones and alternating beds of sandstone and shale. The Yasuda Formation exceeds 80 meters in thickness, and is represented by black shale interbedded with sandstones and tuffs. Fourteen fossil localities were shown in FUJITA (1964) and he listed 21 species of mollusca, 4 species of plant, some crabs and fish scales. On the basis of such fossil molluscs as *Batillaria tateiwai*, *Cardium ogurai* and *Placopecten cf. nomurai*, he regarded the Masuda Group as the early Middle Miocene in age and correlated it with the Bihoku Group of the Setouchi province.

The fossil locality of Okuda newly reported by TANAKA (1981) belongs to the lower part of the Toyoda Formation. As shown in Textfig. 2, the strata of about 23 meters thick at this locality consist mostly of dark colored sandy shales, but some beds of breccia of the underlying Sangun metamorphic rocks are contained in the basal part.



Textfig. 2. Geologic column of the fossil locality.

Notes on the Molluscan Assemblage

The molluscan assemblage of this locality can be divided into three zonules which are the *Crassostrea* zonule, *Vicarya-Tateiwaia-Crassostrea* zonule and *Cyclina-Anadara-Macoma* zonule in ascending order (Textfig. 2). The *Crassostrea* zonule is composed exclusively of *C. gravitesta* which is swarmed in a few beds. The *Vicarya-Tateiwaia-Crassostrea* zonule is composed mainly of *Vicarya japonica*, *Tateiwaia tateiwai* and *Crassostrea gravitesta* with minor amount of *Tateiwaia yamanarii*. *Vicarya* and *Tateiwaia* are swarmed in a bed of about 1.5 meters thick. Bivalves except *Crassostrea* are scarcely found in this zonule. The *Cyclina-Anadara-Macoma* zonule is represented by *Cyclina? hwabongriensis*, *Anadara (Hataiarca) daitokudoensis* and *Macoma (Macoma) izurensis*, and contains other various species of mollusca. In this zonule, *Crassostrea* does not swarm but is contained sporadically, and *Vicarya* is hardly found.

The upward sequence of the representative molluscs mentioned above indicates the environmental change from the brackish embayment to the coastal water area near the bay-mouth.

Systematic Description

Class GASTROPODA

Order ARCHAEOGASTROPODA

Family TROCHIDAE

Subfamily CALLIOSTOMINAE

Genus *Tristichotrochus* IKEBE, 1942

Tristichotrochus sp.

(Pl. I, fig. 10)

Description:— Shell small trochiform. Post nucleus whorls five in number. External surface of the body whorl sculptured with fine, slightly beaded spiral threads. Shell base flat and with about 10 spiral grooves. Umbilicus closed.

Dimensions:—

DGSU* coll. cat. no.	Height (mm)	Diameter (mm)
T1800	16.5+	20.4

Remarks:— The spire is crushed axially, and owing to the poor preservation, the surface sculpture is not clear. This specimen somewhat resembles *Tristichotrochus*

* Abbreviation for Department of Geology, Faculty of Science, Shimane University, Matsue

takeharai ITOIGAWA and SHIBATA (1976) from the Miocene Mizunami Group in outline, but differs from the latter in its large and rather solid shell.

Order MESOGASTROPODA

Family POTAMIDIDAE

Genus *Tateiwaia* MAKIYAMA, 1936

Tateiwaia tateiwai (MAKIYAMA, 1926)

(Pl. I, figs. 6, 7)

Batillaria tateiwai MAKIYAMA, 1926, pp. 147–148, Pl. 12, figs. 5, 6; OTUKA, 1934, p. 624, Pl. 49, fig. 71; NOMURA, 1935, p. 228, Pl. 17, figs. 30–33.

Cerithium sakamotoi YOKOYAMA, 1929, p. 367, Pl. 25, fig. 4.

Tateiwaia tateiwai (MAKIYAMA), TAGUCHI, ONO and OKAMOTO, 1979, Pl. 3, figs. 24–26.

Description: — Shell relatively small, turreted. Each whorl sculptured with about 12 axial ribs and 3 primary spiral threads; the uppermost thread makes a row of shoulder spines crossing the axial ribs.

Dimensions: —

DGSU coll. cat. no.	Height (mm)	Max. diameter (mm)	Pleural angle
T1709	20.2+	8.5	ca. 10°
T1710	22.0	7.6	9°
T1711	25.3	9.4	10°
T1712	22.7	7.8	9°

Remarks: — The species somewhat resembles *Tateiwaia yamanarii* (MAKIYAMA) in outline, but the former has characteristic shoulder spines and is smaller than the latter. Even if it remains as the inner mould, the shoulder spines are obvious, therefore it is clearly distinguishable from *yamanarii*.

Tateiwaia yamanarii (MAKIYAMA, 1926)

(Pl. I, figs. 8, 9)

Batillaria yamanarii MAKIYAMA, 1926, pp. 148–149, Pl. 12, fig. 4; OTUKA, 1934, p. 624, Pl. 49, figs. 80, 81; NOMURA, 1935, p. 228, Pl. 17, figs. 27, 28; KANNO and Ogawa, 1964, Pl. 2, fig. 17; MIZUNO, 1964, Pl. 1, figs. 1–3.

Cerithium proavitum YOKOYAMA, 1929, p. 366, Pl. 25, fig. 3.

Batillaria (Tateiwaia) yamanarii (MAKIYAMA), OKAMOTO and TERACHI, 1974, Pl. 47, fig. 12.

Tateiwaia yamanarii (MAKIYAMA), ITOIGAWA, SHIBATA and NISHIMOTO 1974, p. 134, Pl. 40, figs. 23–24b; ITOIGAWA and NISHIKAWA, 1976, Pl. 35, fig. 15; TAGUCHI, ONO and OKAMOTO, 1979, Pl. 3, figs. 27, 28.

Description: — Shell moderately small, turreted. Each whorl sculptured with 8 to 9 axial ribs and 3 primary threads; intercalated secondary spiral threads appeared on the penultimate and body whorls. Axial ribs rise to prominent tubercles on the intersection with the middle primary spiral threads.

Dimensions: —

DGSU coll cat. no.	Height (mm)	Max. diameter (mm)	Pleural angle
T1707	ca. 34.3	12.2	11°
T1708	ca. 31.5	10.8	11°
T1799	25.0+	ca. 10.0	11°

Remarks: — This species, unlike *T. tateiwai*, has no shoulder spines and its lateral sinus of growth-line is shallower than that of the latter.

Genus *Vicarya* D'ARCHIAC and HAIME, 1854

Vicarya japonica YABE and HATAI, 1938

(Pl. II, fig. 1)

Vicarya callosa JENKINS, TAKEYAMA, 1933, pp. 137–140, Pl. 14, figs. 1a–c, 2a–b, 3.

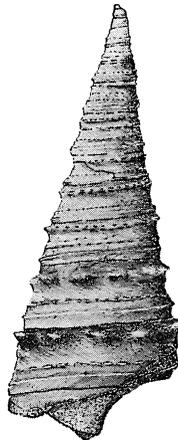
Vicarya callosa japonica (SAGA, MS), YABE and HATAI, 1938, p. 156, Pl. 31, figs. 12, 13.

Vicarya callosa japonica YABE and HATAI, MASUDA, 1956, Pl. 26, figs. 1a–b; YAMANA, 1966, p. 34, Pl. 1, figs. 1a–b; OKAMOTO and TERACHI, 1974, Pl. 47, fig. 11.

Vicarya (Shoshiroia) callosa japonica YABE and HATAI, KAMADA, 1960, Pl. 30, figs. 2a–b, 7, 8, Pl. 31, figs. 2a–b; HAYASAKA, 1969, p. 48, Pl. 3, figs. 7, 8.

Vicarya japonica YABE and HATAI, ITOIGAWA and NISHIKAWA, 1976, Pl. 35, fig. 10; TAGUCHI, ONO and OKAMOTO, 1979, Pl. 4, figs. 1, 2.

Description: — Shell large, turreted, with about 15 whorls presented. First seven or eight preserved whorls ornamented with three spiral cords; uppermost or subsutural cord with a distinct row of beads, and other cords with no remarkable structure. In ninth or tenth whorl, beaded row on subsutural cord becoming a distinct granular row, and the middle cord with weakly beaded structure. From about 12th whorl, subsutural row of granule becoming rapidly a distinct row of spinose tubercles; tu-



Textfig. 3. Surface ornamentation of the *Vicarya japonica* from the Masuda Group $\times 1$.

bercles eight to ten in number in each whorl, and several fine secondary threads running on the tuberculous row of the last two or three whorls. Middle and lower primary cords rather indistinct on the lower whorls. Growth-lines observable on the lower whorls, sigmoidal, deeply incurved backwards at the interspace between middle and lower primary spiral cords (Textfig. 3).

Dimensions: —

DGSU coll. cat. no.	Height (mm)	Max. diameter (mm)	Pleural angle
T1704	91.4+	ca. 42.0	ca. 19°
T1705	88.5+	37.5	ca. 19°
T1706	83.6+	32.2	ca. 18°

Remarks: — TAKEYAMA (1933) divided the Japanese *Vicarya* into *V. callosa* and *V. verneuili yokoyamai*. The each typical specimen has been obtained from the Bihoku Group in the western Setouchi province and from the Mizunami Group in the eastern Setouchi province respectively. According to TAKEYAMA, the chief differences between them are as follows; in *callosa*, the number of tubercles on subsutural band is almost constant in all whorls, but in *verneuili*, there is no tubercle in the young stage excepting many fine knots on spiral cords and a part of knots grades into the spinose tubercles in the adult stage. YABE and HATAI (1938) insisted that the Japanese *callosa* differs from the typical form of *callosa* from Java in having obliquely produced tubercles, and gave the Japanese *callosa* a new subspecific name, *japonica*. They also regarded *yokoyamai* as a subspecies of *callosa*, and pointed out that *yokoyamai* is distinguished from *japonica* by having auxiliary row of delicate beads or knots. However, IKEBE (1939) supported TAKEYAMA's view that *yokoyamai* is not a subspecies of *callosa*, because the former differs from the latter not only in the sculptures on the young whorls but also in the number of primary spiral cords below the subsutural band; three in *yokoyamai* and two in *japonica*.

The present specimen from the Masuda Group, in the young stage, somewhat resembles *yokoyamai* in having beaded row on the subsutural cord and later on the middle cord. However, in the adult stage of present specimen, the spiral cords below the subsutural band are two in number and their beaded structure is not so remarkable. In addition, the subsutural spinose tubercles with several secondary spiral threads are rather short and blunt in shape. These characteristics shown in the adult stage are exactly those of *V. japonica*.

Family NATICIDAE

Genus *Euspira* AGASSIZ, 1839

Euspira meisensis (MAKIYAMA, 1926)

(Pl. I, figs. 2, 3)

Polinices (Euspira) meisensis MAKIYAMA, 1926, pp. 150–151, Pl. 12, fig. 7; MASUDA, 1956, Pl. 26,

figs. 8a–b.

Polinices meisensis MAKIYAMA, MASUDA, 1967, Pl. 1, figs. 24a–b.

Natica (Euspira) aff. meisensis (MAKIYAMA), OTUKA, 1938, p. 37, Pl. 3, figs. 25, 28.

Euspira meisensis (MAKIYAMA), SHIKAMA, 1954, Pl. 7, figs. 2a–3b; ITOIGAWA, 1956, Pl. 3, fig. 10; ARAKI, 1960, p. 109, Pl. 9, figs. 11a–14; KAMADA, 1962, p. 158, Pl. 18, fig. 23; SAITO, 1962, Pl. 14, figs. 23–25; HAYASHI and MIURA, 1973, Pl. 2, fig. 23; HAYASHI, 1973, Pl. 4, figs. 6, 7; ITOIGAWA, SHIBATA and NISHIMOTO, 1974, p. 148, Pl. 45, figs. 13a–b, 18–19b; ITOIGAWA and NISHIKAWA, 1976, Pl. 35, fig. 17; TAGUCHI, ONO and OKAMOTO, 1979, Pl. 4, fig. 7; ITOIGAWA, SHIBATA, NISHIMOTO and OKUMURA, 1981, Pl. 34, figs. 10a–b, 14a–b.

Description: — Shell rather small, globose. Spire somewhat elevated, higher than diameter. Whorls convex, about 4 in number; body-whorl very large. Suture deeply impressed. Aperture semilunar, oblique downward. Umbilicus open; callus pad undeveloped.

Dimensions: —

DGSU coll. cat. no.	Height (mm)	Diameter (mm)
T1713	10.5	9.4
T1714	12.7	11.0
T1715	15.0+	14.0
(Tanaka's specimen)	11.0	8.5

Remarks: — This species has been reported from various localities in Japan and the Korean Peninsula. Though the specimens at hand are small in size compared with those from other localities, they can be identified with this species by their obtusely shouldered whorls, rather flattened body-whorl and umbilical characters.

Genus *Neverita* RISSO, 1826

subgenus *Glossaulax* PILSBRY, 1929

Neverita (Glossaulax) cf. coticae (MAKIYAMA, 1926)

(Pl. I, figs. 4, 5)

Polinices (Neverita) coticae MAKIYAMA, 1926, p. 150 Pl. 12, fig. 8; NOMURA, 1939, p. 255, Pl. 13, figs. 13a–14b.

Polinices coticae MAKIYAMA, KANNO and OGAWA, 1964, Pl. 2, fig. 12.

Neverita coticae (MAKIYAMA), KAMADA, 1962, p. 157, Pl. 18, figs. 21a–22; MASUDA and TAKEGAWA, 1965, Pl. 2, fig. 21; MASUDA, 1967, p. 5, Pl. 1, figs. 25a–26b; KOTAKA and NODA, 1967, Pl. 1, figs. 13, 16; ITOIGAWA, SHIBATA and NISHIMOTO, 1974, p. 148, Pl. 45, figs. 5, 10a–b; TAGUCHI, ONO and OKAMOTO, 1979, Pl. 4, figs. 4, 5.

Neverita (Glossaulax) coticae (MAKIYAMA), ITOIGAWA, SHIBATA, NISHIMOTO and OKUMURA, 1981, Pl. 34, figs. 2a–b.

Description: — Shell small, globose. Spire low; body-whorl very large. Suture shallow, rather inconspicuous. Aperture slightly oblique downward. Umbilicus not so wide; callus pad rather heavy, transversely grooved.

Dimensions: —

DGSU coll. cat. no.	Height (mm)	Diameter (mm)
T1716	11.0	11.8
T1798	ca. 9.5	9.8

Remarks: — The present specimens closely resemble *N. coticaeze* in general features, but they are small in size and slightly differ from the latter in the umbilical features.

Order NEOGASTROPODA

Family MELONGENIDAE

Genus *Hemifusus* SWAINSON, 1840

Hemifusus? mimasakensis (YOKOYAMA, 1929)

Strombus mimasakensis YOKOYAMA, 1929, p. 366, Pl. 70, figs. 1a-b.

Description: — Shell large, thick and solid, lacking the upper portion of the spire. Body-whorl relatively well preserved except the outer lip, about 95 mm high and 85 mm in maximum diameter, with large spinose tubercles on the shoulder; tubercles rather prominent and acute, nine in number on the body-whorl. External surface of the body-whorl running longitudinally numerous distinct growth lines, the lower half ornamented many spiral cords of irregular magnitude, and the upper half having no distinct ornamentation except a row of shoulder spines. Siphonal canal rather short, fasciole stout. Inner lip covered with comparatively thick callus. Only one specimen (DGSU coll. cat. no. T1797) is at hand.

Remarks: — This species was first described by YOKOYAMA (1929) from the Bihoku Group in the Tsuyama basin, Okayama Prefecture. The type specimen shown in the original paper lacks the apex as well as the lower portion of the body-whorl. The careful observations of the external surface of the present specimen reveal that the longitudinal growth lines on the body-whorl show only the gentle curve with shallow lateral sinus at the shoulder spinose row, and some remains of notch or a sinus band can not be observed on the lower portion of the body-whorl. In other words, none of the traces of "stromboid notch" characterizing the stromboid shells are observable on the external surface of the body-whorl. Therefore, the original generic name, *Strombus*, is not adopted presumably for this species.

The present species is closely allied to *Hemifusus cochlida* (LINNÉ), a living species of the tropical Indo-Pacific, in having rather short siphonal canal, many irregular, round-topped spiral cords on the lower half of the body-whorl and no distinct sculpture except a row of spinose tubercles on the upper half of the body-whorl. However, the former is about double as large as the latter. It also resembles *Volema osawanoensis* TSUDA (1959) from the Kurosedani Formation, Toyama Prefecture, in the characteristics of the spiral cords, but the former has more acute tubercles and its external surface of the body-whorl is not wrinkled. *Melongena sazanami* KANEHARA (1937) from the Bihoku Group in Okayama Prefecture is distinguished from the

present species in having numerous spiral cords of regular magnitude developed on the entire surface of the whorl.

Class BIVALVIA
Subclass PALAEOTAXODONTA

Order NUCULOIDA

Family NUCULIDAE

Genus *Acila* H. & A. ADAMS

Subgenus *Acila*, s.s.

Acila (Acila) submirabilis MAKIYAMA, 1926
(Pl. II, fig. 6)

Acila submirabilis MAKIYAMA, 1926, pp. 151–152, Pl. 12, fig. 9; HAYASHI and MIURA, 1973, Pl. 1, fig. 2; HAYASHI, 1973, Pl. 5, fig. 4; ITOIGAWA, SHIBATA and NISHIMOTO, 1974, p. 46, NISHIMOTO Pl. 1, figs. 9a–14b; TAGUCHI, ONO and OKAMOTO, 1979, Pl. 1, figs. 1–4; ITOIGAWA, SHIBATA, and OKUMURA, 1981, Pl. 1, figs. 3a–4b.

Acila (Acila) submirabilis MAKIYAMA, WATANABE, ARAI and HAYASHI, 1950, Pl. 1, fig. 2; KANNO, 1960, p. 190, Pl. 31, figs. 3–7; OKAMOTO, TAKAHASHI and TERACHI, 1973, Pl. 14, fig. 1a–b.

Remarks: — The specimen obtained is a ill-preserved right valve, but the posterior ridge and divaricated threads on the shell surface are remarcable. DGSU coll. cat. no. T1733; height 15.2 mm, length 20.0 mm +, depth 5.0 mm +.

Subclass PTERIMORPHIA

Order ARCOIDA

Family ARCIDAE

Subfamily ANADARINAE

Genus *Anadara* GRAY, 1847

Subgenus *Hataiarca* NODA, 1966

Anadara (Hataiarca) daitokudoensis (MAKIYAMA, 1926)
(Pl. II, figs. 2–5b)

Arca (Anadara) daitokudoensis MAKIYAMA, 1926, pp. 153–154, Pl. 2, figs. 10, 14–15.

Anadara daitokudoensis (MAKIYAMA), OTUKA, 1938, p. 25, Pl. 1 figs. 3–4.

Anadara (Hataiarca) daitokudoensis (MAKIYAMA), NODA, 1966, p. 115, Pl. 7, fig. 13; OKAMOTO and TERACHI, 1974, Pl. 47, figs. 5a–7b; ITOIGAWA, SHIBATA and NISHIMOTO, 1974, p. 57, Pl. 4, figs. 10a–b; TAGUCHI, ONO and OKUMOTO, 1979, Pl. 1, figs. 8, 9.

Description: — Four mould specimens of attached valves and several fragments of shell materials are at hand. Shell medium in size, rather convex. Cardinal profile rather flat. Anterior end short, regularly rounded; posterior end sharply rounded. Sculpture consisting 26 to 28 non-dichotomous, granulated, narrow, equal radial

ribs. Muscular scar strongly impressed, subquadrate in shape. Interior margin strongly crenated.

Dimensions: —

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)	Length of ligament (mm)	Apical angle	Number of ribs
T1729 (right)	13.2	17.0	6.0	10.9	86	26
T1793 (core)	(33.6)	(44.3)	(28.8/2)	28.8	88	28
T1794 (core)	(22.8+)	(35.0)	(ca. 20.2/2)	ca. 24.0	ca. 80	—
T1795 (core)	(16.5+)	(23.0)	(ca. 14.7/2)	14.7	81	27
T1796 (core)	(17.3)	(22.5)	(14.3/2)	ca. 14.0	85	28

Remarks: — Young form of the present species is somewhat allied to *Anadara (Scaphaca) abdita* MAKIYAMA, a Miocene *Anadara* frequently associated with *Anad. daitokudoensis*, but the present species is distinguished by its convex shell and its small number of radial ribs.

Subfamily STRIARCINAE

Genus *Striarca* CONRAD, 1862

Striarca uetsukiensis (HATAI and NISIYAMA, 1949)

(Pl. II, figs. 7a–c)

Barbatia (Barbatia) uetsukiensis HATAI and NISIYAMA, 1949, p. 89, Pl. 23, figs. 6–7; UOZUMI and FUJIE, 1966, pp. 144–145, Pl. 11, figs. 2, 3.

Barbatia cf. *uetsukiensis* HATAI and NISIYAMA, MASUDA, 1955, Pl. 19, fig. 1.

Striarca uetsukiensis (HATAI and NISIYAMA), NODA, 1966, p. 74, Pl. 4, figs. 1–3, Pl. 11, fig. 4; ITOIGAWA, SHIBATA and NISHIMOTO, 1974, p. 56, Pl. 4, figs. 6a–b; TAGUCHI, ONO and OKAMOTO, 1979, Pl. 1, fig. 11.

Description: — Shell small, quadrated, rather convex. External surface with fine radial ribs crossed by concentric growth lines. Ligamental area narrow, elongated, with numerous longitudinal striations. Teeth arrangement not clear by ill preservation. Inner margin not crenated.

Dimensions: —

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)
T1727 (right valve)	ca. 13.5	21.5	7.4
T1792 (right valve)	15.8	23.7	8.0

Remarks: — The present specimens are rather large in size compared with the same species from other localities; for example, the specimen from the Mizunami Group is 7.6–8.0 mm high and 10.4–11.5 mm long (ITOIGAWA, SHIBATA and NISHIMOTO, 1974). But other features of the specimens from the Masuda Group are well identical with *S. uetsukiensis*.

Order PTERIOIDA

Family OSTREIDAE

Subfamily OSTREINAE

Genus *Crassostrea* SACCO, 1897*Crassostrea gravitesta* (YOKOYAMA), 1926

(Pl. II, fig. 15)

Ostrea gravitesta YOKOYAMA, 1926, p. 388, Pl. 45, figs. 1, 2; NOMURA, 1938, p. 248, Pl. 33, fig. 15; KASENO, 1956, p. 5, Pl. 1, figs. 5a-c; OGASAWARA, 1973, Pl. 13, fig. 28; HAYASHI, 1973, Pl. 2, fig. 5.

Crassostrea gravitesta (YOKOYAMA), ITOIGAWA, SHIBATA and NISHIMOTO, 1974, p. 72, Pl. 17, fig. 1; ITOIGAWA and NISHIKAWA, 1976, Pl. 33, fig. 11; TAGUCHI, ONO and OKAMOTO, 1979, Pl. 1, fig. 15; AMANO, 1980, p. 106, Pl. 13, figs. 29a-b.

Remarks: — An imperfect specimen (DGSU coll. cat. no. T1734) is at ahd. As already mentioned, this species is swarmed in a few beds of the lower horizon of the outcrop. Shells are irregularly piled up each other, and it is difficult to sample a perfect specimen.

Subclass HETERODONTA

Order VENEROIDA

Family CARDIIDAE

Subfamily TRACHYCARDIINAE

Genus *Vasticardium* IREDALE, 1927*"Vasticardium" ogurai* (OTUKA, 1938)

(Pl. II, fig. 9)

Cardium (Bucardium) ogurai OTUKA, 1938, pp. 28-29, Pl. 1, figs. 1, 2, 8.

Vasticardium ogurai (OTUKA), SHUTO, 1960, p. 213, Pl. 25, figs. 13, 16; OGASAWARA, 1973, p. 143, Pl. 12, figs. 12, 13.

"Vasticardium" cf. *ogurai* (OTUKA), ITOIGAWA, SHIBATA and NISHIMOTO, 1974, p. 81, Pl. 21, figs. 2, 3.

"Vasticardium" ogurai (OTUKA), ITOIGAWA and NISHIKAWA, 1976, Pl. 34, fig. 3; ITOIGAWA, SHIBATA, NISHIMOTO and OKUMURA, 1981, Pl. 11, fig. 9.

Description: — Specimen preserved as almost inner mould, but a small fragment of shell material remaining on the margin. Shell medium in size, subtrigonal, inflated; antero-dorsal margin rounded; postero-dorsal margin rather straight, slightly longer than the antero-dorsal margin. Surface sculptured with about 39 radial ribs; radial ribs flat-topped, nearly equal in width to the interspaces.

Dimensions: —

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)
T1728 (core)	(27.0)	(28.4)	(18.8/2)

Remarks: — The inner mould of this species is at a glance like that of the young form of *Clinocardium shinjiense* (YOKOYAMA, 1923) from the upper Miocene Fujina Formation in Shimane prefecture, but the former is distinguished from the latter by its more prominent umbo, flat-topped radial ribs and shallow interspaces.

Family CARDILIIDAE

Genus *Cardilia* DESHAYES, 1835

Cardilia toyamaensis TSUDA, 1959

(Pl. II, figs. 10a–c)

Cardilia toyamaensis TSUDA, 1959, p. 79, Pl. 3, figs. 6a–9; MASUDA, 1966, Pl. 35, figs. 38a–b; ITOIGAWA, SHIBATA and NISHIMOTO, 1974, p. 95, Pl. 28, figs. 1, 2; TAGUCHI, ONO and OKAMOTO, 1979, Pl. 3, figs. 1–3; ITOIGAWA, SHIBATA, NISHIMOTO and OKUMORA, 1981, Pl. 18, figs. 2a–c.

Description: — Shell small in size, very inflated, longitudinally elongated. Beak anteriorly situated, roundly incurved toward the anterior side. Surface sculptured with irregular concentric wrinkles; posterior half of the surface with flat-topped radial ribs; interspace between radial ribs narrow and shallow.

Dimensions: —

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)
T1791 (core)	(17.2)	(11.8)	(15.5/2)

Remarks: — The shell material of this specimen is almost dissolved out. But it is very thin in original, therefore the sculptures on shell surface are comparatively well impressed on the mould. The characteristics of the present specimen are entirely identical with those of the type specimen originally described by TSUDA (1959) excepting that the former is about 1.5 times large as the latter.

Family DONACIDAE

Genus *Latona* SCHUMACHER, 1817

Latona sp.

(Pl. II, fig. 8)

Description: — Shell medium in size, flat, trigonal; beak small, situating posteriorly; anterodorsal margin long, straight; posterodorsal margin short, slightly rounded. External surface with rather irregular growth lines; internal surface unknown in this specimen.

Dimensions: —

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)
T1790 (right valve)	19.7	27.7	ca. 6.0

Remarks: — The present specimen is distinguished from *Latona minoensis* ITOIGAWA

from the Miocene Mizunami Group by its large size and less rounded posterodorsal margin.

Family TELLINIDAE

Subfamily TELLININAE

Genus *Fabulina* GRAY, 1851

"*Fabulina*" sp.

(Pl. II, fig. 11)

Description:— Shell small in size, trapezoidal; beak small, pointed, situating posteriorly; anterodorsal margin long, slightly rounded; posterodorsal margin short, rather straight; anterior margin moderately rounded; posterior margin truncated; ventral margin rather straight. External surface weathered and being opaque.

Dimensions:—

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)
T1789 (conjoined)	13.5	20.3	7.1/2
(Tanaka's specimen, conjoined)	13.6	20.3	6.5/2

Remarks:— Because of their fragilely weathered shells, detail features are not observable. The precise identification depends on future researches.

Subfamily MACOMINAE

Genus *Macoma* LEACH, 1819

Subgenus *Macoma* s.s.

Macoma (Macoma) izurensis (YOKOYAMA, 1925)

(Pl. II, figs. 12a–14)

Tellina izurensis YOKOYAMA, 1925, p. 19, Pl. 2, fig. 12.

Macoma izurensis (YOKOYAMA), KAMADA, 1962, p. 132, Pl. 15, figs. 7–9; KANNO and OGAWA, 1964, Pl. 2, figs. 4, 5; MASUDA and TAKEGAWA, 1965, Pl. 2, figs. 6a–7; HAYASHI and MIURA, 1973, Pl. 1, figs. 23, 24; HAYASHI, 1973, Pl. 4, fig. 13, Pl. 6, fig. 6; ITOGAWA, SHIBATA and NISHIMOTO, 1974, Pl. 30, figs. 1a–11.

Macoma (Macoma) izurensis (YOKOYAMA), ITOGAWA, SHIBATA, NISHIMOTO and OKUMURA, 1981, Pl. 19, figs. 21a–b.

Description:— Shell small in size, ovate, relatively inflated in the anterior portion; fold running from beak to posteroventral margin on the left valve; posterior margin slightly turned to right; beak situating somewhat posteriorly. Pallial sinus large, deep.

Dimensions:—

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)
T1730 (conjoined)	14.9	22.1	6.0/2
T1731 (left int. mould)	14.6	ca. 22.0	—
T1788 (conjoined)	18.8	25.0	8.9/2
(Tanaka's specimen-1 left valve)	14.7	22.6	ca. 3.5
(Tanaka's specimen-2 left valve)	16.9	24.8	4.0

Remarks: — Though the specimens at hand are very small in size compared with the YOKOYAMA's type specimen, their slightly concaved posterodorsal margin and relatively elongated ovate outline are in good agreement with the characteristics of that species. All of the examined specimens are drilled by some carnivorous animals, therefore they may be the young form; the small shells of *M. izuensis* illustrated by ITOIGAWA, SHIBATA and NISHIMOTO (1974, pl. 30, figs. 7–10) closely resemble the present specimens.

Family CULTELLIDAE

Genus *Cultellus* SCHUMACHER, 1817

Cultellus izumoensis YOKOYAMA, 1923

(Pl. III, figs. 10, 11)

Cultellus izumoensis YOKOYAMA, 1923, p. 5, Pl. 2, fig. 1; OTUKA, 1941, pp. 23–24, fig. 4.; KANNO, 1956, p. 213, Pl. 6, fig. 8; IWAI, 1961, Pl. 1, fig. 19; IWAI, 1965, p. 45, Pl. 12; UOZUMI and FUJIE, 1966, p. 153, Pl. 12, fig. 7; HAYASHI and MIURA, 1973, Pl. 1, fig. 22; ITOIGAWA, SHIBATA and NISHIMOTO, 1974, p. 101, Pl. 31, fig. 4, 5; OGASAWARA, 1976, p. 57, Pl. 4, figs. 16, 18; SUEHIRO, 1979, p. 83, Pl. 14, figs. 4a–b; OGASAWARA and NOMURA, 1980, p. 89, Pl. 11, figs. 5a–b, 9; ITOIGAWA, SHIBATA, NISHIMOTO and OKUMURA, Pl. 20, figs. 3a–b.

Cultellus izumoensis izumoensis YOKOYAMA, AMANO, 1980, pp. 110–111, Pl. 13, fig. 23.

Phaxas cf. *izumoensis* (YOKOYAMA), MASUDA, 1955, Pl. 19, figs. 14a–b.

Description: — An inner mould and a fragmental specimen are obtained. Shell medium in size, compressed, transversely elongated; beak situating anteriorly; posterior side about four times as long as the anterior side; anterior margin broadly rounded; posterior margin rather sharply rounded.

Dimensions: —

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)
T1732 (core)	(24.8)	(81.5)	(9.5/2)
T1781 (fragment)	—	—	—

Remarks: — The present specimen resembles *C. izumoensis jobanicus* KANNO (1956) in having slightly concaved ventral margin, but is distinguished therefrom by its more rounded anterior margin; the concaved ventral margin is probably only an appearance owing to the preservation of an inner mould. *Cultellus rectangulus* KANNO (1956) is

another allied species, but its posterior margin is subtruncated.

Family VENERIDAE

Subfamily CYCLININAE

Genus *Cyclina* DESHAYES, 1850

Cyclina takayamai OYAMA, 1950

(Pl. III, fig. 2)

Cyclina sinensis Gmelin, OTUKA, 1938, pp. 32–33, Pl. 2, figs. 13, 15.

Cyclina takayamai OYAMA, 1950, p. 2.

Cyclina takeyamai OYAMA, ITOIGAWA and NISHIKAWA, 1976, Pl. 34, fig. 9.

Cyclina (Cyclina) takeyamai OTUKA, TAGUCHI, ONO and OKAMOTO, 1979, Pl. 2, figs. 17, 18.

Description: — Shell medium in size, suborbicular, moderately inflated; beak small, pointed, oblique anteriorly; antrodorsal margin short, concaved; posterodorsal margin long, broadly rounded. External surface almost smooth except very weak fine radial striations and faint fine concentric growth lines; in the case of weathered surface, fine radial ribs rather remarkable. Whole of interior margin weakly crenated.

Dimensions: —

GDSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)
T1787 (left valve)	30.9	29.1	10.1

Remarks: — The present specimen very resembles *C. japonica* KAMADA (1952) in outline, but the former is distinguished from the latter by its small size and its very weak surface sculptures.

Cyclina? hwabongriensis YOON and NODA, 1976

(Pl. III, figs. 1a–b, 3–8b.)

Cyclina (Cyclina?) hwabongriensis YOON and NODA, 1976, pp. 29–31, figs. 2–5; TAGUCHI, ONO and OKAMOTO, 1979, Pl. 2, figs. 19–23.

Description: — Shell moderate to large in size, suborbicular, generally a little longer than high, moderately inflated; beak small, but not so much pointed; anterodorsal margin slightly concaved, longer than posterodorsal margin; posterodorsal margin broadly rounded, forming a blunt angle with posterior margin. Sculpture consisting of fine, numerous, concentric growth-lines and weak radial ribs on the anterior surface. Anterior part of the interior margin crenated; the other part of the interior margin smooth. Pallial sinus triangular, rounded at end.

Dimensions: —

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)	Depth of pallial sinus (mm)
T1717 (conjoined)	28.3	32.4	17.2/2	—
T1718 (conjoined)	39.0	43.8	24.5/2	—
T1719 (conjoined)	32.2	35.0	12.9/2	11.5
T1720 (core)	(28.0)	(32.3)	(15.7/2)	10.9
T1721 (core)	(33.8)	(36.8)	(17.8/2)	11.0
T1722 (conjoined)	22.9	24.4	11.8/2	8.5
T1723 (core)	(21.5)	(25.5)	(10.5/2)	8.2
T1724 (core)	(16.8)	(17.0+)	(9.3/2)	5.8
T1782 (core)	(19.6)	(21.8)	(10.1/2)	7.8
T1783 (conjoined)	ca. 24.4	28.2	13.2/2	—
T1784 (conjoined)	46.3	47.7	15.6+/2	—
T1785 (conjoined)	644.5	49.5	26.8/2	—
T1786 (conjoined)	55.9	ca. 52.8	31.5/2	—
Tanaka's specimen-1 (core)	(43.1)	(46.2)	(24.0/2)	13.1
Tanaka's specimen-2 (core)	(39.6)	(41.7)	(22.3/2)	14.8

Remarks: — The present specimens closely resemble *C. (Cyclinorbis) lunulata* MAKIYAMA (1926); the original description and the remarks by KAMADA (1952) of *lunulata* are almost applicable to them. The lunule-like sculpture characterizing that species is also observable in some specimens from the Masuda Group. However, the specimens at hand are slightly different from *lunulata* in having rather blunt end of pallial sinus and weak radial ribs on the anterior surface.

Order MYOIDA

Family CORBULIDAE

Subfamily COLBULINAE

Genus *Anisocorbula* IREDALE, 1930

Anisocorbula osawanoensis TSUDA, 1959

(Pl. III, figs. 9a–b)

Anisocorbula osawanoensis TSUDA, 1959, p. 79, Pl. 3, figs. 10a–c.

Description: — Shell small, thick, inflated, with strong, round-topped, concentric ribs; posterior end rostrate, bluntly pointed; anterior end rounded; right valve slightly larger than the left and overlapping the latter.

Dimensions: —

DGSU coll. cat. no.	Height (mm)	Length (mm)	Depth (mm)
T1725 (conjoined)	8.8	13.6	8.3
T1726 (conjoined)	8.1	12.5	8.0
(Tanaka's specimen, conjoined)	6.6	8.9	5.2

Remarks:— This species somewhat resembles *Solidicorbula succincta* (YOKOYAMA, 1924), a species already reported from the Setouchi province (ITOIGAWA, SHIBATA and NISHIMOTO, 1974; TAGUCHI, ONO and OKAMOTO, 1979), in having coarse, strong, concentric ribs, but the former is distinguished from the latter by its oblong outline and its small umbo.

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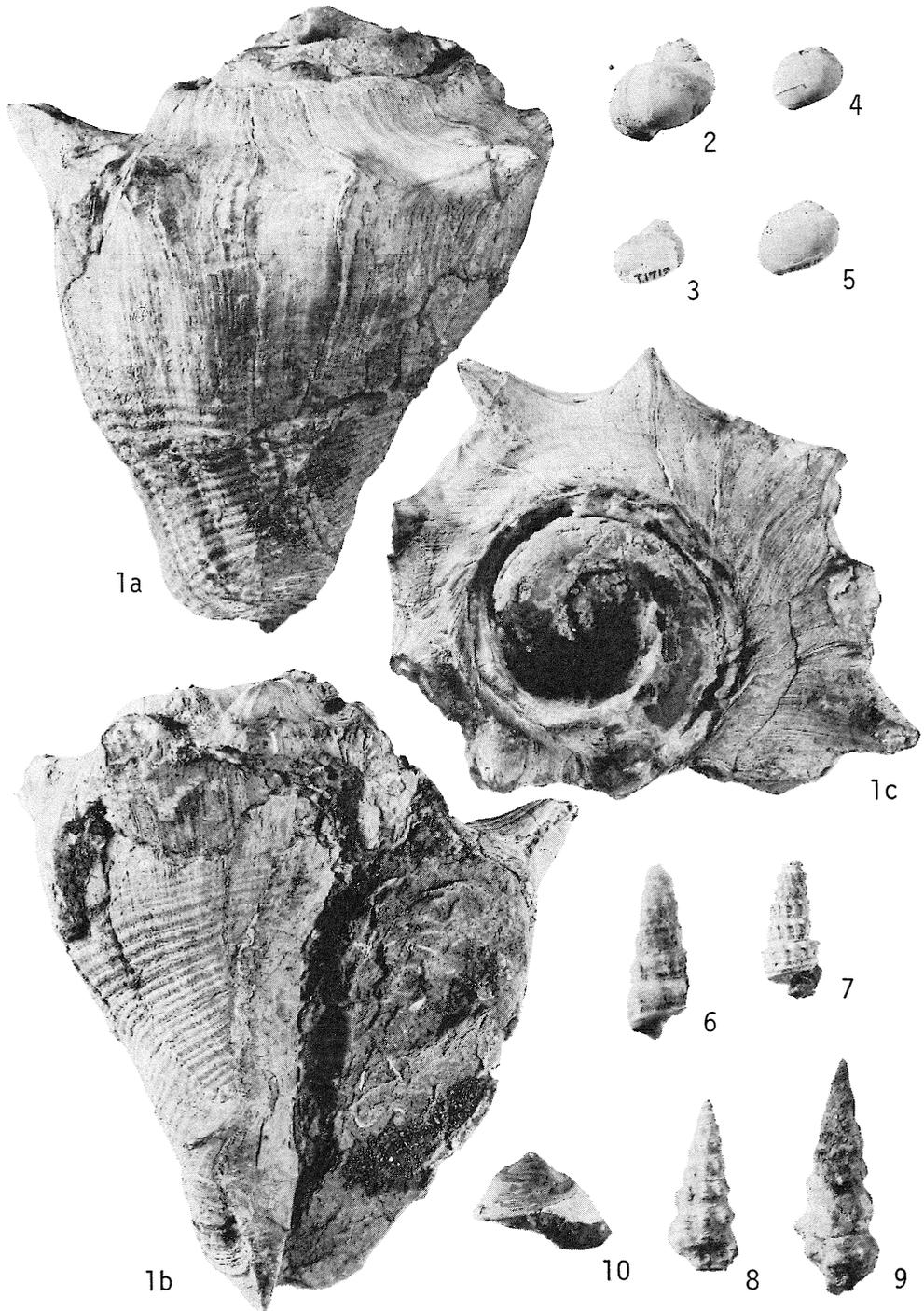
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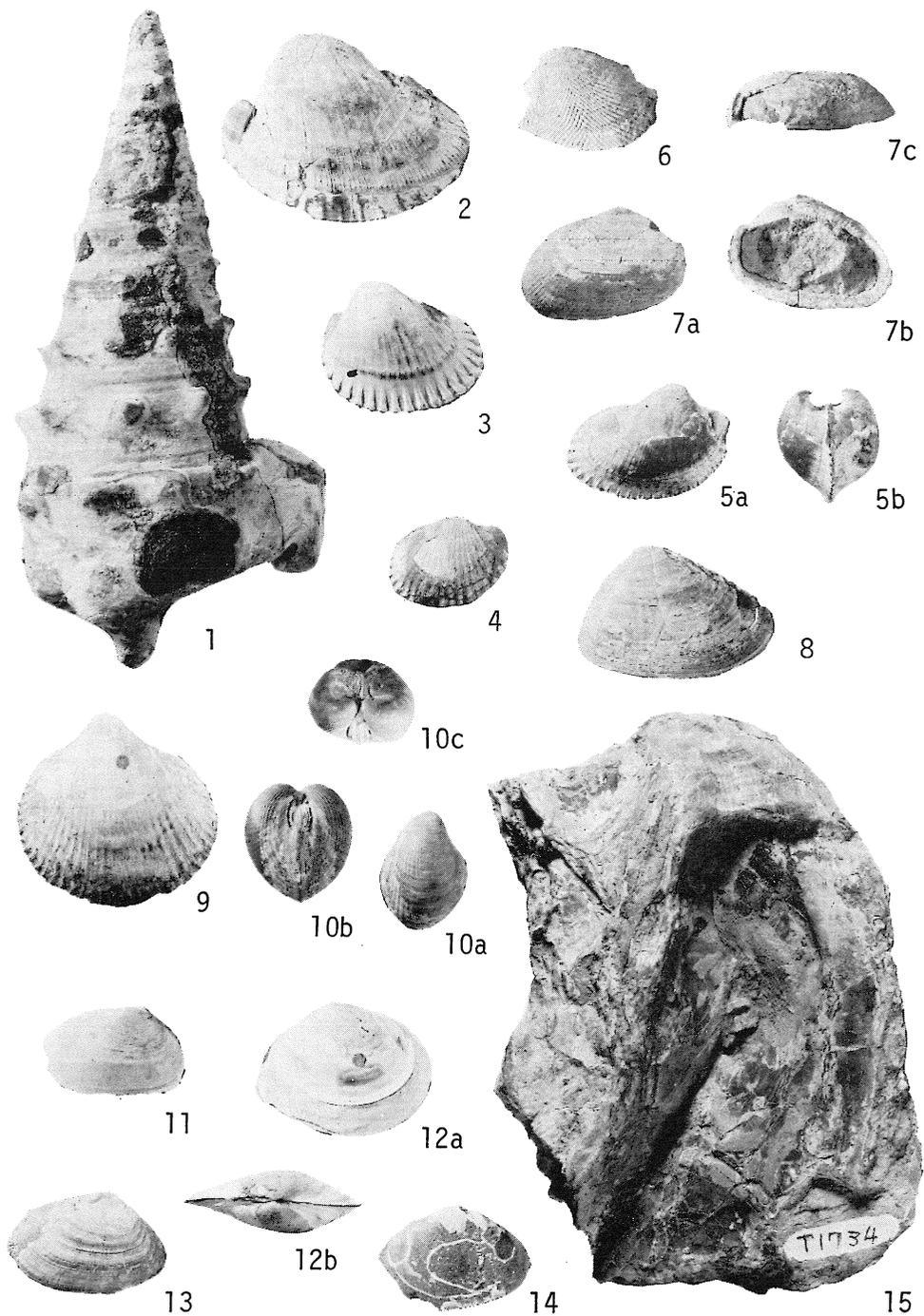
Explanation of Plate I
(All figures in natural size)

- Figs. 1a–c. *Hemifusus? mimasakensis* (YOKOYAMA)
DGSU coll. cat. no. T1797.
- Figs. 2, 3. *Euspira meisensis* (MAKIYAMA)
Fig. 2, DGSU coll. cat. no. T1715; fig. 3, DGSU coll. cat. no. T1713.
- Figs. 4, 5. *Neverita (Glossaulax) cf. coticae* (MAKIYAMA)
Fig. 4, DGSU coll. cat. no. T1798; fig. 5, DGSU coll. cat. no. T1716.
- Figs. 6, 7. *Tateiwaia tateiwai* (MAKIYAMA)
Fig. 6, DGSU coll. cat. no. T1711; fig. 7, DGSU coll. cat. no. T1709.
- Figs. 8, 9. *Tateiwaia yamanarii* (MAKIYAMA)
Fig. 8, DGSU coll. cat. no. T1799; fig. 9, DGSU coll. cat. no. T1707.
- Fig. 10. *Tristichotrochus* sp.
DGSU coll. cat. no. T1800.



Explanation of Plate II
(All figures in natural size)

- Fig. 1. *Vicarya japonica* YABE and HATAI
DGSU coll. cat. no. T1704.
- Figs. 2–5b. *Anadara (Hataiarca) daitokudoensis* (MAKIYAMA)
Fig. 2, left view of core, DGSU coll. cat. no. T1793; fig. 3, left view of core, DGSU coll. cat. no. T1795; fig. 4, right valve, DGSU coll. cat. no. T1729; fig. 5, DGSU coll. cat. no. T1796, 5a, right view of core, 5b, anterior view of core.
- Fig. 6. *Acila (Acila) submirabilis* MAKIYAMA
Right valve, DGSU coll. cat. no. T1733.
- Figs. 7a–c. *Striarca uetsukiensis* (HATAI and NISIYAMA)
7a, right valve, 7b, interior view, 7c, dorsal view, DGSU coll. cat. no. T1972.
- Fig. 8. *Latona* sp.
Right valve, DGSU coll. cat. no. T1790.
- Fig. 9. “*Vasticardium*” *ogurai* (OTUKA)
Left view of core, DGSU coll. cat. no. T1729.
- Figs. 10a–c. *Cardilia toyamaensis* TSUDA
10a, right view of core, 10b, posterior view of core, 10c, dorsal view of core, DGSU coll. cat. no. T1791.
- Fig. 11. “*Fabulina*” sp.
Right valve, DGSU coll. cat. no. T1789.
- Figs. 12a–14. *Macoma (Macoma) izurensis* (YOKOYAMA)
Fig. 12, DGSU coll. cat. no. T1788, 12a, right valve, 12b, dorsal view; fig. 13, left valve, DGSU coll. cat. no. T1730; fig. 14, left internal mould, DGSU coll. cat. no. T1731.
- Fig. 15. *Crassostrea gravitesta* (YOKOYAMA)
DGSU coll. cat. no. T1734.



Explanation of Plate III

(All figures in natural size)

Figs. 1a–b, 3–8b. *Cyclina? hwabongriensis* YOON and NODA

Fig. 1, DGSU coll. cat. no. T1786, 1a, left valve, 1b, dorsal view; fig. 3, right valve, DGSU coll. cat. no. T1783; fig. 4, left valve, DGSU coll. cat. no. T1719; fig. 5, right view of core, DGSU coll. cat. no. T1782; fig. 6, right valve coated with mud, DGSU coll. cat. no. T1718; fig. 7, right valve, DGSU coll. cat. no. T1784; fig. 8, DGSU coll. cat. no. T1785, 8a, right valve, 8b, dorsal view.

Fig. 2. *Cyclina takayamai* OYAMA

Left valve, DGSU coll. cat. no. T1787.

Figs. 9a–b. *Anisocorbula osawanoensis* TSUDA

9a, left valve, dorsal view, DGSU coll. cat. no. T1725.

Figs. 10, 11. *Cultellus izumoensis* (YOKOYAMA)

Fig. 10, left interior view of core, DGSU coll. cat. no. T1732; fig. 11, a part of left valve, DGSU coll. cat. no. T1781.

