MOLLUSCAN FAUNA OF THE KUKINAGA GROUP IN TANE-GA-SHIMA, SOUTH KYUSHU, JAPAN

Rep. Fac. Sci., Kagoshima Univ., (Earth Sci., Biol.), No. 2, p. 33-52, 1 fig., 2 tables, 3 pls., 1969. 33

MOLLUSCAN FAUNA OF THE KUKINAGA GROUP IN TANÉ-GA-SHIMA, SOUTH KYÛSHÛ, JAPAN

By

Shozo HAYASAKA

(Received Oct. 6, 1969)

Institute of Earth Sciences, Faculty of Science,
Kagoshima University

Introduction

Since Dr. Shoshiro HANZAWA gave the results of his studies on the Tané-ga-shima island (HANZAWA 1935), it has been known as one of the representative localities of *Vicarya* (OTUKA 1938, MATSUO 1951, KAMADA 1960, IWAI 1960). HANZAWA reported the occurrence of the following molluscan fossils from several localities of the Kukinaga group: *Arca* (*Arca*) cf. *abdita* MAKIYAMA, *A.* (*A.*) *daitokudoensis* MAKIYAMA, *Ostrea gigas* THUNBERG, *Taras semiasperoides* (NOMURA), *Vicarya callosa* JENKINS, *Cerithidea* cf. *cingulatum* (GMELIN), *Batillaria* cf. *zonalis* (BRUGUIÈRE).

Although several authors studied the geology and paleontology of the island after the HANZAWA's work (OZAKI 1954, CHISHIKI 1954, IJUIN 1964, OCHIAI 1964, FUKUSHIGE 1964, TANAKA 1965, HIRAKAWA 1965, ÔTA 1968, TAIRA 1968, BABA 1968), most of the studies has not been published except for the one concerning the supposed "Paleogene" Kumagé group (HASHIMOTO 1956). Among the studies cited above, the most comprehensive work is the one carried out by OZAKI (1954), who reported the occurrence of various kinds of fossils in the Miocene and Pliocene formations, such as pollen and spore (26 species), Brachiopoda (6 species), Gastropoda (18 species), Pelecypoda (34 species) and Foraminifera (58 species). It is unfortunate, however, that the results of his studies have not been published but merely had read before the 61st annual meeting of the Geological Society of Japan (1954).

Through the course of study attempting to synthesize the up-to-date knowledge on the geology of Tané-ga-shima, the writer had the chance to collect a lot of molluscan fossils and to study them together with the specimens accumulated in the Institute of Earth Sciences, Kagoshima University during the past decade of year under the guidance of Professor N. HATAÉ. In the present article, the writer intends to describe the molluscan species from the Miocene Kukinaga group and to give some remarks on the molluscan fauna, such as the stratigraphic and geographic distribution pattern of them, biostratigraphic implication and

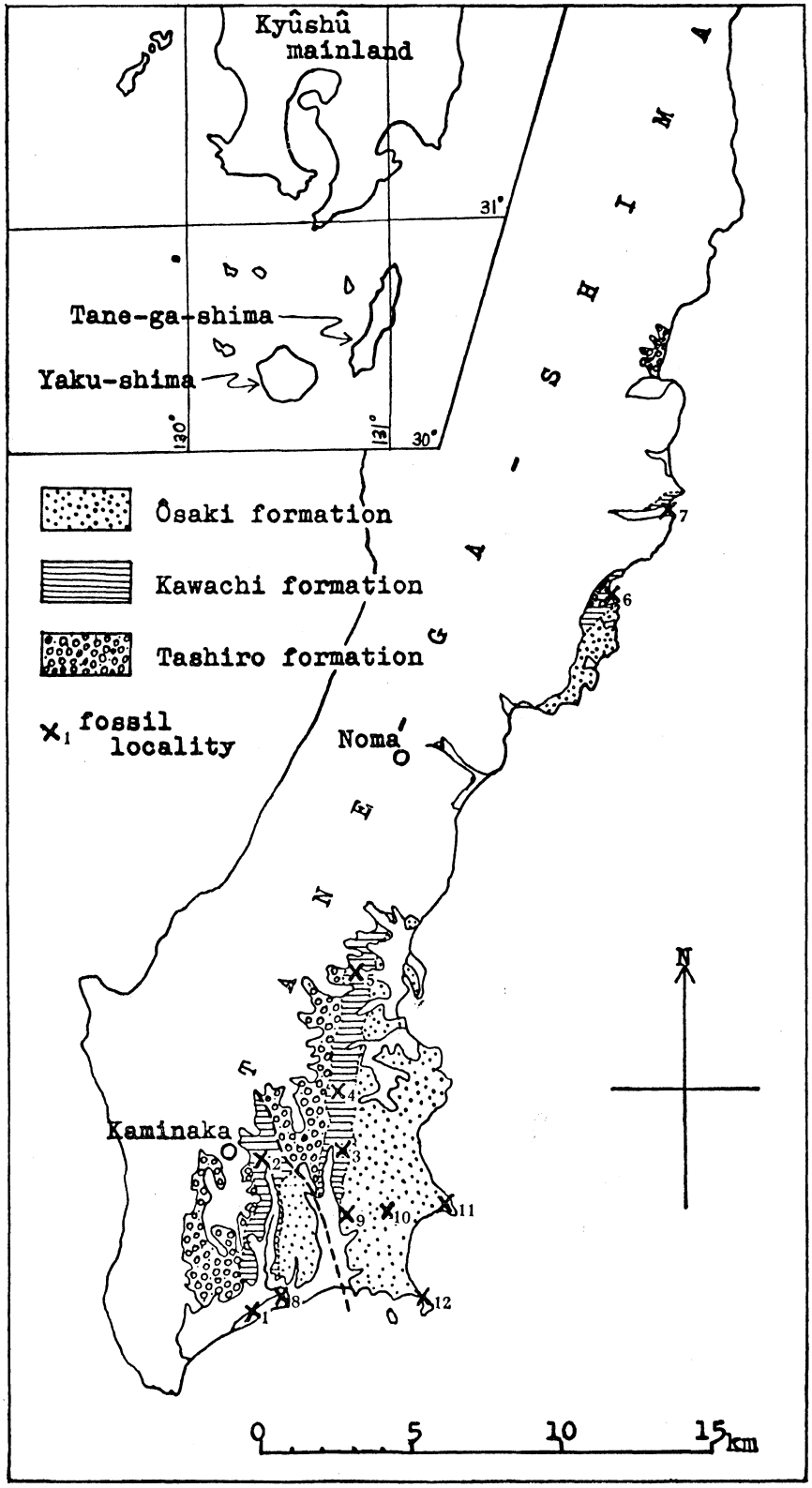


Fig. 1. Sketch map showing the Miocene geology and the fossil localities of Tané-ga-shima.

so on. Before going further, the writer has to mention that the materials treated here are not all of the Miocene molluscan fossils at hand. The rest of them will be separately described at another opportunity, because of their mode of occurrence being quite different from that of the present specimens. They were derived from several large blocks of calcareous sandstone, of which source of supply is still unknown.

Acknowledgements

The writer expresses his hearty thanks to Professor Kotora HATAI of the Tôhoku University for his suggestions and aid in identifying the species of this fauna. Particular appreciation is due to Dr. Nobuhiro HATAÉ, Professor Emeritus of the Kagoshima University, for his valuable suggestions which stimulated the present work. Thanks are also due to Mr. Kimihiko ÔKI of the Kagoshima University for his assistance in photographic work.

Outline of Geology and Occurrence of Fossils

The Tané-ga-shima island lies about 40 kilometers southeast of the headland of Satamisaki, southern extremity of the Kyûshû mainland. The elongate outline extending in a NNE–SSW direction with longer axis of about 60 kilometers and rather low and flat topography of this island form a striking contrast to the neighbouring island Yaku-shima, which is nearly circular in outline and forming the highest mountain (1935 m) in the Kyûshû region. Both the Tané-ga-shima and the Yaku-shima islands have been referred to the outermost belt of the Ryûkyû Island Arc, or of the Shimanto Terrain in the southwest Japan from the tectonic viewpoint.

According to the unpublished results of studies proceeding in our Institute, the following groups and formations are recognized in the southern part of the present island, where is the type area of the Miocene Kukinaga group.

The exposed foundation rocks in the island have been collectively called the Kumagé group since the HANZAWA's first study, and it consists of thin-bedded, hard and compact, dark gray shale, massive hard, gray-coloured and fine-to medium-grained sandstone and the alternation of them. Although no fossils have been found and its definite geological age is still unknown, the Kumagé group is generally regarded to be Paleogene in age (HANZAWA 1935, HASHIMOTO 1956, MATSUMOTO et al. 1962).

The Kumagé group is overlain by the Miocene Kukinaga group with an angular unconformity. The Kukinaga group comprises three formations, namely, the Tashiro with the predominant conglomerate, the Kawachi characterized by thick siltstone, and the Ôsaki of the sandstone facies. The latter two formations are recognized to be marine in origin based on the occurrence of marine molluscan

Table 1. Stratigraphic succession of the rocks developed in the type area of the Miocene Kukinaga group.

Alluvial deposits and dune sands		
(unconformity)		
Volcanic ash: 4 to 7 meters in thickness.		
(unconformity)		
Hasé formation : Subangular, ill-sorted, cobbles and boulders of sandstone and shale. 5 to 6 meters in thickness.		
(unconformity)		
Tajima formation : Fine- to medium-grained muddy sandstone with the intercalation of several siltstone beds. 30 to 120meters in thickness.		
(unconformity)		
Kukinaga group	Ôsaki formation	: Reddish to yellowish brown coloured medium- to fine-grained sandstone with subordinate granule conglomerate and thin siltstone beds. About 1500 meters in thickness.
	Kawachi formation	: Bluish gray siltstone with the intercalation of thin sandstone beds in its lowermost and uppermost parts. About 500 meters in thickness.
	Tashiro formation	: Rounded boulder conglomerate, except for the angular boulder of the basal part and the upper part with the intercalation of sandstone. About 900 meters in maximum thickness.
(unconformity)		
Kumagé group : Thin-bedded, dark gray shale, massive gray-coloured fine- to medium-grained sandstone and the alternation of them. Base unknown.		

fauna, which is the main theme of the present study. As shown in Fig. 1, the Kukinaga group reprsents a general trend of strike in nearly N-S direction and always dips eastwards. A fault cutting both the Kumagé and the Kukinaga groups is recognized in the southern part of the island and it seems to be the right-lateral wrench fault extending in NW-SE direction. The localities from where the Miocene molluscan fossils were collected are also shown in Fig. 1 and listed in the following lines.

Fossil localities of the Kawachi formation:

(1) Sea cliff at the south coast of the island, south of the Shimonaka village.
(2) Cuttings along the road leading from Kawachi to Kaminaka.
(3) Cutting at the midway between Hirayama and Kukinaga.
(4) Cuttings along the road leading from Hirayama to Jûmonji.
(5) Cuttings along the road leading from Sakai to Shioya.
(6) Sea cliff at Injô, central part of the east coast of the present island.
(7) Road-side cutting at Tateyama, about four and a half kilometers north of the locality no. 7 (Injô coast).

Fossil localities of the Ôsaki formation:

(8) Sea cliff near the mouth of the Kôrigawa River at the south coast.
(9) Cliffs near the Kukinan Primary School at Kukinaga.
(10) Cuttings along the road leading from Kukinaga to Ôsaki.
(11) Sea cliff at the Ôsaki coast.
(12) Sea cliff at Takezaki, southeast headland of the island.

The Tajima and its correlative formations, horizontally resting on the denuded surface of the monoclinal Kukinaga and the Kumagé groups, consist of fine- to

medium-grained sandstone bearing abundant marine molluscan fossils probably of Pliocene age.

The Tajima formation is overlain by the terrestrial Hasé formation with a para-unconformity. The Hasé formation seems to be restricted in distribution to the area higher than 100 meters above sea level in the southern part of the island. This formation attains to the thickness of about six meters and consists of subangular, ill-sorted gravels of cobble to boulder sized sandstone and shale derived from the underlying Kumagé group.

The volcanic ash formation composed of several ash and pumice beds covers all over the island. Sand dunes are recognized to develop in the southern, eastern and northwestern coast of the present island.

Remarks on the Molluscan Fauna

As a whole, the most remarkable feature of the present fauna is that the number of species is rather small in spite of the abundant occurrece of fossils. It is expected, however, that the considerable differences exist between the fossil assemblages of the two consecutive formations, the Kawachi and the Ôsaki, or in other words, the composition of fossil assemblage must be changed from the lower to the upper formation with their lithofacies changes. To clarify the problem, vertical and lateral distributions of each species in the present area will be mentioned on the following lines (Table 2).

The fossil species from the Kawachi formation are as follows:

Anadara (*Hataiarca*) *shimonakaensis* HAYASAKA, n. sp.
Striarca sp.
Promantellum orientalis (ADAMS and REEVE)
Anomia chinensis PHILIPPI
Ostrea gigas THUNBERG
Joannisiella cumingii kukinagaensis HAYASAKA, n. subsp.
Cyclina (*Cyclina*) *orientalis* (SOWERBY)
Cyclina (*Cyclinorbis*) *lunulata* MAKIYAMA
Vicarya (*Shoshiroia*) *callosa japonica* YABE and HATAI
Cerithidea (*Cerithidea*) *kanpokuensis* MAKIYAMA
Cerithidea (*Cerithideopsilla*) *cingulata* (GMELIN)
Cerithidea (*Cerithideopsilla*) *sirakii* MAKIYAMA
Batillaria cf. *toshioi* MASUDA
Ocenebra sp.

Among them, *Ostrea gigas* is the species occuring most frequently sometimes forming oyster bed of considerable thickness. The important species known only from the Kawachi formation is the five gastropod species of the three genera (*Vicarya, Cerithidea* and *Batillaria*), all of which belongs to the Family Potamididae

(WENZ 1940). The combination of these five species of Potamididae represents a model of the so-called *Vicarya* fauna from the middle Miocene of the central to western Japan (OTUKA 1938, MASUDA 1955, 1956, 1966, 1967) and of North Korea (MAKIYAMA 1926, 1963). Besides them, the occurrences of the species of *Cyclina*, especially *C. lunulata* and of *Anadara* (*Hataiarca*) *shimonakaensis* n. sp. are quite harmonious with the *Vicarya* fauna in other localities in Japan and Korea. *C. lunulata* was originally described by MAKIYAMA (1926) from North Korea together with the typical *Vicarya* fauna. *A.* (*H.*) *shimonakaensis* n. sp. represents a close alliance to *A.* (*H.*) *kakehataensis*, one of the important elements of the *Vicarya* fauna in Japan. Although *A.* (*H.*) *shimonakaensis* n. sp. is widely distributed in both formations, it is noticeable that the occurrences of this anadarid shell seem to be concentrated in the southern part of distribution. Regarding the Kawachi formation only, abundant occurrence of *A.* (*H.*) *shimonakaensis* n. sp. with rarely occuring *Vicarya* in the south (Shimonaka coast) forms a contrast to the rare occurrence of *Anadara* with abundant *Vicarya* in the north (Injô coast). This may imply the response to the ecological condition being different between the two species. *Joannisiella cumingii kukinagaensis* n. subsp. occurs from almost all the horizons in the two formations, but does not coexist with *Vicarya*.

The fossils from the Ôsaki formation are listed below.

Barbatia (*Cucullaearca*) *obtusoides* (NYST)
Anadara (*Hataiarca*) *shimonakaensis* HAYASAKA n. sp.
Ostrea (*Crassostrea*) *gigas* THUNBERG
Joannisiella cumingii kukinagaensis HAYASAKA, n. subsp.
Meretrix cf. *meretrix lusoria* (RÖDING)
Cyclina (*Cyclina*) *orientalis* (SOWERBY)
Paphia (*Paphia*) *exilis exils* SHUTO
Clementia nakosoensis KAMADA
Mactra sp.
Fabulina? sp.
Cultellus izumoensis jobanicus KANNO
Solen gordonis Yokoyama
Barnea (*Anchomasa*) aff. *manilensis* (PHILIPPI)
Babylonia sp.
Conus sp.

Among the species listed above, predominant species is *Joannisiella cumingii kukinagaensis* n. subsp. as already pointed out by HANZAWA(1935) under the name of *Taras semiasperoides* (NOMURA). *Anadara* (*Hataiarca*) *shimonakaensis* n. sp. and *Ostrea gigas* also occur abundantly in the Ôsaki formation. Together with *Cultellus izumoensis jobanibus*, *Clementia nakosoensis* which is the only species occuring abundantly among the species restricted to the Ôsaki formation suggests the faunal character com-

mon to the Miocene fauna of the Jôban coal-field, from where these two forms were described originally.

It is noticeable that the common species between the two formations are only four in number. This suggests a remarkable change of environmental condition

Table 2. Molluscs discriminated from the Kawachi and the Ôsaki formations of the Kukinaga group.

(Abbreviation: A-Abundant; C-Common; F-Few; R-Rare.)

Formation Name	Kawachi Formation							Ôsaki Formation				
Locality / Specific Name	1	2	3	4	5	6	7	8	9	10	11	12
Barbatia (Cucullaearca) obtusoides (NYST)								F				
Anadara (Hataiarca) shimonakaensis HAYASAKA, n. sp.	A	F	R		F	F		F	C	C		C
Striarca sp.						R						
Promantellum orientalis (ADAMS and REEVE)						R						
Anomia chinensis PHILIPPI	F											
Ostrea (Crassostrea) gigas THUNBERG	A	C	F	C	F	A		F	C			
Joannisiella cumingii kukinagaensis HAYASAKA n. subsp.		C		F	C			F	A	C		C
Meretric cf. *meretrix lusoria* (RÖDING)									R			
Cyclina (Cyclina) orientalis (SOWERBY)	F					R			R			
Cycylina (Cyclinorbis) lunulata MAKIYAMA	R											
Paphia (Paphia) exilis exilis SHUTO										R	F	
Clementia (Clementia) nakosoensis KAMADA								R	C			
Mactra sp.								F		R		
Fabulina ? sp.										F		
Cultellus izumoensis jobanicus KANNO								R		R		
Solen gordonis YOKOYAMA									F			
Barnea (Anchomasa) aff. *manilensis* (PHILIPPI)								F				
Vicarya (Shoshiroia) callosa japonica YABE and HATAI	F					A	R					
Cerithidea (Cerithidea) kanpokuensis MAKIYAMA	R				R							
Cerithidea (Cerithideopsilla) cingulata (GMELIN)	C	R		C								
Cerithidea (Cerithideopsilla) sirakii MAKIYAMA	F			C	R	F						
Batillaria cf. *toshioi* MASUDA				F								
Ocenebra sp.						R						
Babylonia sp.										R		
Conus sp.										R		

from time of the Kawachi to that of the Ôsaki formation. Judging from a lack of Potamididae, decrease of cyclinids, and the occurrence of *Meretrix*, *Paphia*, *Clementia*, *Mactra*, *Fabulina*, *Cultellus*, *Solen*, *Barnea*, *Babylonia* and *Conus*, the depositional environment of the Ôsaki formation is assumed to be under the normal marine, shallow, open sea condition, while that of the Kawachi formation to be under brackish water or embaymental condition.

Concerning the geological age of the Kukinaga group, HANZAWA (1935) stated that "the geological age of the Kukinaga beds is, on paleontological evidence, ascribed to the Burdigalian or the Lower Mizuho". Through the examination of the fossil molluscan assemblages, the geological age of the Kunkiaga group can be discussed on each formation of the group. The geological age of the Kawachi formation is undoubtedly ascribed to the Burdigalian or the Middle Miocene in the up-to-date meaning (ASANO and HATAI 1967) based on the occurrence of the typical *Vicarya* fauna. On the other hand, the Ôsaki formation is judged to be Helvetian or early Late Miocene in age from the occurrence of the three characteristic species, *Paphia* (*Paphia*) *exilis exilis*, *Clementia nakosoensis* and *Cultellus izumoensis jobanicus*.

Description of New Species and Remarks on Some Species

Family Arcidae

Genus *Barbatia* GRAY, 1847

Subgenus *Cucullaearca* CONRAD, 1865

Barbatia (*Cucullaearca*) *obtusoides* (NYST)

Pl. 1, figs. 1a, b.

1844 *Arca obtusoides* NYST, Mem. Acad. Roy. Belg., Vol. 22, p. 50. (inaccessible)

1935 *Barbatia obtusoides* (NYST), OTUKA, Bull. Earthq. Res. Inst. Tokyo Imp. Univ., Vol. 13, Pt. 4, p. 883, pl. 42, figs. 197-198.

1961 *Barbatia* (*Savignyarca*) *obtusoides* (NYST), KIRA, Coloured Illust. of Shells of Japan (Enl. & Rev. Ed.), p. 109, fig. 11.

1966 *Barbatia* (*Cucullaearca*) *obtusoides* (NYST), NODA, Sci. Rep. Tohoku Univ., Sec. Ser. (Geol.) Vol. 38, No. 1, p. 63, pl.1, fig. 7, table 31.

Dimensions (*in mm*) :- Length about 29. 3, height about 20.

Occurrence:- Locality No. 8, Ôsaki formation.

Geologic Distribution:- Miocene to Recent. Miocene occurrence was here recognized for the first time. Pliocene and Pleistocene occurrences were completely surveyed and listed by NODA (1966).

Geographic Distribution:- Honshû, Japan and southwards.

Remarks:- An imperfect left valve and a few fragmental specimens are in the collection. The former specimen is roundly ovate in outline, not inflated, and

has no ridges on the shell surface sculptured with many radials, which are coarsely arranged on the posterior-dorsal surface. There have been described three species of *Barbatia* from the Japanese Miocene, namely *B. osawanoensis*, *B. minoensis* and *B. kubara*, all of which differs from the present one in having radial ridges on the surface.

Genus *Anadara* GARY, 1847

Subgenus *Hataiarca* NODA, 1966

Anadara (*Hataiarca*) *shimonakaensis* HAYASAKA, n. sp.

Pl. 1, figs. 2a~c, 3a~e, 4a, b, 5; Pl. 2, figs. 1a, b, 2a, b

Shell thick and stout, of moderate size for the genus, inequilateral, equivalve, slightly longer than high with somewhat depressed area along the posterior side from beak to posterior ventral corner. Anterior side narrowly rounded, posterior one produced, subquadrate, ventral margin broadly arcuated, posterior ventral end somewhat angular. Beak prominent, situated somewhat anteriorly. Ligamental area high triangular in outline, with chevron shaped wavy incised grooves. Hinge line straight, teeth numerous, large and strong, perpendicular to hinge line. Ventral inner surface strongly crenulated. Pallial line smooth, weakly depressed. Muscular scars well depressed, anterior one small and subquadrate, posterior one much larger than the anterior and squarish rounded. Surface with 23-24 strong flat-topped radial ribs, nodulous on the anterior half and slightly narrower than interspaces.

Dimensions (*in mm*):- Length about 40.0, Height about 41.60, Depth 22.20 (Holotype). Length about 35, Height 35.5, Depth 18.35; Length 36.25, Height 32.0, Depth 15.50; Length 40.05, Height 39.75, Depth 19.10 (Paratypes).

Type Locality and Repository:- Locality No. 1, Kawachi formation, ESK*) Reg. No. F-5001 (Holotype); No. F-5002 (Paratypes).

Occurrence:- Locality Nos. 1, 2, 3, 5 and 6, Kawachi formation; Nos. 8, 9, 10 and 12, Ôsaki formation.

Remarks:- Although the present species seems to be fairly variable in outline, thick and stout shell with rather small number of radial ribs, prominent beak and strongly depressed posterior area can be recognized as the characteristic and stable features of the present species.

In general outline, the present species resembles *A.* (*H.*) *kakehataensis* HATAI and NISIYAMA (1949), a representative Miocene species associated with the *Vicarya* fauna, but differs from the latter in having thicker shell with stronger teeth and fewer radial ribs. In having thick and stout shell with 23-25 radial ribs, *A.* (*H.*) *rhombea* BORN (HAYASAKA and HAYASAKA 1960) ranging from Pliocene to Recent in the

*) Abbreviation for the Institute of Earth Sciences, Faculty of Science, Kagosima University.

southeast Asia closely resembles the present species, but the latter has much higher beak and strongly depressed posterior area.

Family Limidae

Genus *Promantellum* IREDALE, 1939

Promantellum orientale (ADAMS and REEVE)

Pl. 2, figs. 7

1850 *Lima orientalis* ADAMS et REEVE, Zool. "Samarang", Moll., p. 75, pl. 21, fig. 7 (*fide* OYAMA 1943).

1943 *Limea* (*Promantellum*) *orientalis* (ADAMS et REEVE), OYAMA, Conchologia Asiatica, Volumen primum, pars prima, p. 29, pl. 2, figs. 4a-b.

1961 *Promantellum orientale* (ADAMS et REEVE), KIRA, Coloured Illust. of Shells of Japan, p. 128, pl. 52, fig. 2.

Dimensions (*in mm*) :- Length about 17.5, Height about 21.

Occurrence :- Locality No. 6, Kawachi formation.

Geologic Distribution :- Miocene to Recent. Miocene: Shirado formation in Ibaragi Prefecture.

Geographic Distribution :- Central part of Honshû, Japan and southwards.

Remarks :- Only a single left valve is in the collection.

Family Anomiidae

Genus *Anomia* LINNÉ, 1758

Anomia chinensis PHILIPPI

Pl. 2, figs. 3a, b.

1849 *Anomia chinensis* PHILIPPI, Zeitschr. f. Malak., (1848), Vol. 5, No. 9, p. 130 (*fide* Habe 1953).

1953 *Anomia chinensis* PHILIPPI, HABE in KURODA, Illust. Cat. of Japanese Shells, Vol. 1, No. 24, p. 198, pl. 27, fig. 12; pl. 28, fig. 21.

1961 *Anomia chinensis* PHILIPPI, HAYASAKA, Sci. Rep. Tohoku Univ., Sec. Ser. (Geol.), Vol. 33, No. 1, p. 33, pl. 3, fig. 7 (with full reference prior to 1961).

Occurrence :- Locality No. 1, Kawachi formation.

Geologic Distribution :- Miocene to Recent. Miocene: Moniwa formation in Miyagi Prefecture. Pliocene: Tatsunokuchi formation in Miyagi Prefecture; Shigarami formation in Nagano Prefecture; Koshiba and Naganuma formation in Kanagawa Prefecture; Byôritsu formation in Formosa.

Remarks :- Several imperfect specimens are in the collection.

Family Ungulinidae

Genus *Joannisiella* DALL, 1895

Joannisiella cumingii kukinagaensis HAYASAKA, n. subsp.

Pl. 2 figs. 4a-b, 5a-b, 6a-c.

Shell thin and rather small in size, suborbicular or more or less roundly triangular in outline, strongly inequilateral, rather inflated, central portion strongly convex, more or less flattened marginally. Beaks small, situated somewhat anteriorly, rather prominent, pointed and incurved, touching one another. Posterior-dorsal margin high, straightly inclined and making an obtuse angle with the roundly curved anterior margin; ventral margin broadly arcuated asymmetrically; anterior extremity somewhat narrowed, produced and roundly angulated; anterior dorsal margin shorter than posterior dorsal one. Surface smooth, only with very fine concentric growth lines. Interior unknown except for cardinal area; cardinal plate rather broad but thin, having two cardinal teeth directly under beak, one of which, namely, posterior cardinal on the right valve and anterior one on the left, subdivided.

Dimensions (in mm):- Length 24.30, Height 21.00, Width 16.05 (Holotype). Length 21.45, Height 18.85, Width 15.10; Length 21.00, Height 18.60, Width 13.80; Length 20.95, Height 18.70, Width 14.55 (Paratypes).

Type Locality and Repository:- Locality No. 9, Ôsaki formation. ESK Reg. No. F-5003 (Holotype); No. F-5004 (Paratypes).

Occurrence:- Locality Nos. 2, 4 and 5, Kawachi formation; Nos. 8, 9, 10 and 12, Ôsaki formation.

Remarks:- In 1935, Hanzawa reported the occurrence of *Tarus semiasperoides* Nomura from the Miocene formation of Tané-ga-shima based on the specific identification by S. NOMURA. *Tarus semiasperoides* was first proposed by NOMURA (1932) for the specimens illustrated and described by YOKOYAMA (1920) under the name of *Diplodonta semiaspera* (PHILIPPI) from the Pliocene Koshiba formation. In 1938, however, *T. semiasperoides* was regarded by Nomura himself, to be synonymous with *T. cumingii* (HANLEY) based on the specimens from the Pliocene Tatsunokuchi formation. Although these species are now referred to the genus *Joannisiella* by many authors, opinion concerning the validity of *semiasperoides* has been divided (IKEBE 1936, KURODA and HABE 1952, TAKI and OYAMA 1954, KIRA 1961, HABE 1961). According to the latest opinion presented by HABE (1961), *semiasperoides* of Nomura is referred to the genus *Diplodonta* having thick and spherical shell.

In its fundamental features, the present form is quite similar to the species *J. cumingii* (HANLEY) living in our seas, but can be distinguished therefrom by its small and strongly inflated shell with extremely inequilateral outline.

In having thin and inflated shell of strongly inequilateral outline, the present species closely resembles *J. oblonga* (HANLEY) living in Formosa and southwards, but is easily discriminated by its narrowed and produced anterior margin, which gives an outline approaching to that of the genus *Pitar*.

Family Veneridae

Genus *Meretrix* LAMARCK, 1799

Meretrix cf. *meretrix lusoria* (RÖDING)

Pl. 2, fig. 8.

Compared with:

1954 *Meretrix meretrix lusoria* (RÖDING), TAKI and OYAMA, Palaeont. Soc. Japan, Special Papers, No. 2, p. 43, pl. 31, fig. 4.

1961 *Meretrix meretrix lusoria* (RÖDING), KIRA, Coloured Illust. of Shells of Japan, p. 140, pl. 56, fig. 1.

Dimensions (*in mm*): Length about 71, Height about 56, Width about 34.

Occurrence:- Locality No. 9, Ôsaki formation.

Geologic Distribution of the Compared Species:- Unknown as fossil.

Geographic Distribution of the Compared Species: Honshû to Kyûshû, Japan.

Remarks:- Only a single internal mold specimen is in the collection. There have been recorded three fossil species of the Genus *Meretrix* from the Japanese Tertiary. The present specimen, however, most resembles *M. meretrix lusoria* of our seas in general outline.

Genus *Cyclina* DESHAYES, 1850

Subgenus *Cyclina* s. str.

Cyclina (*Cyclina*) *orientalis* (SOWERBY)

Pl. 2, figs. 10a, b.

1855 *Artemis orientalis* SOWERBY, Thes. Conch., Vol. 2, p. 661, pl. 144, fig. 79.

1869 *Cyclina orientalis* PFEIFFER in MARTINI and CHEMNITZ, Vol. 11, Pt. 1, p. 113, pl. 28, figs. 7-9.

1936 *Cyclina sinensis* (GMELIN), NOMURA and HATAI, Saito Ho-on Kai Mus. Res. Bull., No. 10, p. 128 (not of GMELIN).

1950 *Cyclina orienalis* (SOWERBY), OYAMA, Miner. & Geol., Vol. 3, No. 6, p. 2.

1952 *Cyclina* (*Cyclina*) *orientalis* (SOWERBY), KAMADA, Trans. Proc. Palaeont. Soc. Japan, N. S., No. 6, p. 167, pl. 15, figs. 7a-b.

1961 *Cyclina* (*Cyclina*) *orientalis* (SOWERBY), HAYASAKA, Sci. Rep. Tohoku Univ., Sec. Ser. (Geol.), Vol. 33, No. 1, p. 46, pl. 5, figs. 3a-b.

Occurrence:- Locality Nos. 1 and 6, Kawachi formation; No. 9, Ôsaki formation.

Geologic Distribution:- Miocene to Recent. Miocene: Tanagura formation in Fukushima Prefecture. Pliocene: Dainenji formation in Miyagi Prefecture. Pleisto-

cene: Otsu Shell Bed in Kanagawa Prefecture. Post-Pleistocene: Raised Beach Deposits in Kanagawa and Chiba Prefectures.

Geographic Distribution:- "From Mutsu Bay, Aomori Prefecture, southwards along the Pacific coast to Kagoshima and Nagasaki Prefectures in Kyûshû, along the Tung-hai, and along the Japan Sea northwards to Mikata, Fukui Prefecture. Also west coast of Korea" (KAMADA 1952).

Remarks:- Several specimens, all of which are intact and deformed to various extent, were examined. Through the careful examination on the present specimens, it was clearly recognized that they originally have thick and solid shells of rather rounded outline with somewhat angular corner between the posterior-dorsal margin and posterior border, upon which the identification to the named species is based.

Subgenus *Cyclinorbis* MAKIYAMA, 1926

Cyclina (*Cyclinorbis*) *lunulata* MAKIYAMA

Pl. 2, fig. 9.

1926 *Cyclina* (*Cyclinorbis*) *lunulata* MAKIYAMA, Mem. Coll. Sci. Kyoto Imp. Univ., Ser. B. Vol. 2, No. 3, Art. 8, p.158, pl. 13, fig. 1.

1936 *Cyclina* (s.s.) *lunulata* MAKIYAMA, ibid., Vol. 11, No. 4, Art. 8, p. 212.

1938 *Cyclina lunulata* MAKIYAMA, NOMURA and HATAI, Jap. Jour. Geol. Geogr., Vol. 16, Nos. 1-2, p. 5.

1952 *Cyclina* (*Cyclinorbis*) *lunulata* MAKIYAMA, KAMADA, Trans. Proc. Palaeont. Soc. Japan. N. S., No. 6, p. 170, pl. 15, figs. 5-6.

Dimensions (*in mm*):- Length 18.0, Height 17.75.

Occurrence:- Locality No. 1, Kawachi formation.

Geologic Distribution: Miocene. Heiroku formation in North Korea; Tanagura formation in Fukushima Prefecture.

Geographic Distribution:- Living unknown.

Remarks:- A few, rather small specimens are in the collection. According to KAMADA (1952) who gave redefinition of the subgenus *Cyclinorbis* MAKIYAMA, "*C. lunulata* is characteristic in its moderate thickness of the shell, which is a little longere than high, produced anterior end, rather small convexity" and "sculpture with fine concentric lines and no radial striae". The present specimens have faint radial striae on the limitted marginal area of the anterior-dorsal surface This does not seem to agree with the KAMADA's definition, but, on the other hand, another character of *lunulata*, namely that the crenation of inner margin develops only on the anterior-dorsal border seems to be quite harmonious with the occurrence of the faint radials of the present specimens. Therefore, it may be reasonable to say that the development of radial striae on the shell surface of *C. lunulata* is to be added to its definition as an unstable feature.

Genus *Paphia* RÖDING, 1798

Subgenus *Paphia* s. str.

Paphia (Paphia) exilis exilis SHUTO

Pl. 3, fig. 1.

1957 *Paphia (Paphia) exilis exilis* SHUTO, Jap. Jour. Geol. Geogr., Vol. 28, p. 142, pl. 12, figs. 3, 4, 8.

Dimensions (in mm):- Length 33.0, Height 18.65.

Occurrence:- Locality Nos. 10, 11, Ôsaki formation.

Geologic Distribution:- Miocene. Tano member of Higashimorokata formation and Boroishi member of Udo formation, in Miyazaki Prefecture.

Geographic Distribution:- Living unknown.

Remarks:- A single intact specimen, a left and two right valves, all of which are water-worn and scarecely preserve shell-material, are identified as the named species. The present specimens are quite identical with ***P. exilis exilis*** in having rather small, weakly convex and transversely elongate shell with closely developed lirae.

Genus *Clementia* GRAY, 1842

Subgenus *Clementia* s. str.

Clementia (Clementia) nakosoensis KAMADA

Pl. 3, figs. 2a, b.

1925 *Clementia speciosa* YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, Art. 5, p. 21, pl. 1, fig. 6.

1944 *Clementia papyracea* (GRAY), OYAMA and SAKA, Bull. Sigenkagaku Kenkyusho, Vol. 1, No. 2, p. 141, pl. 15, figs. 15a, b, 16.

1952 *Clementia nakosoensis* HATAI and NISIYAMA, Sci. Rep. Tohoku Univ., Sec. Ser. (Geology), Spec. Vol., No. 3, p. 46.

1962 *Clementia (Clementia) nakosoensis* KAMADA, Palaeont. Soc. Japan, Special Papers No. 8, p. 119, pl. 13, figs. 15a, b.

Dimensions (in mm):- Length 29.0, Height 25.5 (the largest specimen in the present collection).

Occurrence:- Locality Nos. 8, 9, Ôsaki formation.

Geologic Distribution:- Miocene. Kokozura formation in the Jôban coal-field, Fukushima Prefecture; Tsukiyoshi formation in Gifu Prefecture.

Geographic Distribution:- Living unknown.

Remarks:- Several intact specimens were examined. As stated by the original author (KAMADA 1962), *C. nakosoensis* is characterized by rather small and rounded shell outline and rather weak concentric waves on the shell surface. The specimens at hand are quite identical with the named species in every respect. It is

interesting to know that the present species had been ranging on the Pacific side of Japan from the Jôban coal-field southwards to the Tane-ga-shima island during the Miocene age.

Family Solenidae

Genus *Cultellus* SCHUMACHER, 1817

Cultellus izumoensis jobanicus KANNO

Pl. 3, figs. 3a~c.

1925 *Cultellus izumoensis* YOKOYAMA, YOKOYAMA, Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. 45, Art. 5, p. 18, pl. 5, figs. 2, 3.

1935 *Cultellus izumoensis* YOKOYAMA, NOMURA, Saito Ho-on Kai Mus., Res. Bull., No. 6, p. 6, p. 220, pl. 15, figs. 16, 17.

1956 *Cultellus izumoensis jobanicus* KANNO, Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C, Vol. 4, No. 34, p. 214-215, pl. 5, figs. 1, 2.

1962 *Cultellus izumoensis jobanicus* KANNO, KAMADA, Palaeont. Soc. Japan, Special Papers No. 8, p. 137, pl. 17, figs. 2-5.

Dimensions (*in mm*):- Length about 55.3, Height 20.00.

Occurrence:- Locality Nos. 8, 10, Ôsaki formation.

Geologic Distribution:- Miocene. Goyasu, Honya, Nakayama, Numanouchi and Kokozura formations in the Jôban coal-field, Fukushima Prefecture; Chiganoura formation in Miyagi Prefecture.

Geographic Distribution:- Living unknown.

Remarks:- Although only a single intact specimen partially lacking anterior and posterior ends and an immature left valve are in the collection, the features characterizing the present subspecies, namely general outline with rather norrowly rounded ends and concave ventral margin are clearly recognized by growth-line of rather young stage.

Genus *Solen* LINNÉ, 1758

Solen gordonis YOKOYAMA

Pl. 3, fig. 4.

1920 *Solen gordonis* YOKOYAMA, Jour. Coll. Sci. Tokyo Imp. Univ., Vol. 39, Art. 6, p. 111, pl. 7, fig. 23.

1961 *Solen gordonis* YOKOYAMA, KIRA, Coloured Illust. of Shells of Japan, p. 161, pl. 61, fig. 9.

1961 *Solen gordonis* YOKOYAMA, HAYASAKA, Sci. Rep. Tohoku Univ., Sec. Ser. (Geol.), Vol. 33, No. 1, p. 61, pl. 7, figs. 11a-b.

Dimensions (*in mm*):- Length more than 55, Height about 19.

Occurrence:- Loc. No. 9, Ôsaki formation.

Geologic Distribution:- Miocene to Recent.

Geographic Distribution:- Central and western Japan.

Remarks:- Several intact spscimens, opened or closed, were identified as the named species. The present species is characterized by the nearly parallel-sided shell with the height of about one fifth of shell length.

Family Pholadidae

Genus *Barnea* RISSO, 1826

Barnea (*Anchomasa*) aff. *manilensis* (PHILIPPI)

Pl. 3, figs. 5, 6.

Compared with:

1953 *Barnea* (*Anchomasa*) *manilensis* (PHILIPPI), Habe, Genera of Japanese Shells, p. 241, figs. 644, 645, 646.

1961 *Barnes* (*Anchomasa*) *manilensis* (PHILIPPI), KIRA, Coloured Illust. of Shells of Japan (Enl. & Rev. Ed.), p. 168, pl. 62, fig. 23.

Dimensions (*in mm*):- Length about 30, Height 13.65.

Occurrence:- Locality No. 8, Ôsaki formation.

Geologic Distribution of the Compared Species:- Unknown as fossil.

Geographic Distribution of the Compared Species:- Okinawa and southwards.

Remarks:- A rather large, water-worn intact specimen and a left valve lacking the posterior-ventral corner are in the collection. The elongate outline of them with rostrated anterior margin and the surface features clearly show the subgeneric identity. But both specimens scarcely preserve shell material and the detailed surface features of them can not be observed. This is the reason why the specific identification is reserved.

Family Potamididae

Genus *Vicarya* D'ARCHIAC and HAIME, 1854

Vicarya (*Shoshiroia*) *callosa japonica* YABE and HATAI

Pl. 3, figs. 7, 8.

1938 *Vicarya callosa japonica* YABE and HATAI, Sci. Rep. Tohoku Imp. Univ., Sec. Ser. (Geol.), Vol. 19, No. 2, p. 156, pl. 21, figs. 12, 13, 21, 22, 28, 31.

1955 *Vicarya callosa japonica* YABE and HATAI, MASUDA, Trans. Proc. Palaeont. Soc. Japan, N. S., No. 20, p. 125.

1956 *Vicarya callosa japonica* YABE and HATAI, MASUDA, ibid., No. 21, pl. 26, figs. 1a-b.

1960 *Vicarya* (*Shoshiroia*) *callosa japonica* YABE and HATAI, KAMADA, Sci. Rep. Tohoku Univ., Sec. Ser. (Geol.), Spec. Vol., No. 4, p. 282, pl. 30, figs. 2a-b, 7, 8; pl. 31, figs. 2a-b.

Occurrence:- Locality Nos. 1, 6 and 7, Kawachi formation.

Geologic Distribution:- Miocene. Higashi-innai formation in the Noto Peninsula, Ishikawa Prefecture; Middle Miocene formations in Okayama and Hiroshima Prefectures; Meisen series in North Korea.

Geographic Distribution:- Living unknown.

Rmarks:- The occurrence of *Vicarya* in the Kukinaga group exposed at Injô, Nakatané-chô, Tané-ga-shima island has long been known (HANZAWA 1935, YABE and HATAI 1938). At present, however, it is known that *V. callosa japonica* also occurs in a few other localities north and south of Injô. The present subspecies represents the so-called "Tsuyama type"- one of the two types of *Vicarya* well-known in Japan, and its distribution seems to be restricted to the southwest Japan. According to YABE and HATAI (1938) and KAMADA (1960), main differences between the present subspecies and the typical *V. callosa* are as follows. (1) *V. callosa japonica* has the tubercles being flat in its upper part and inclined in its lower while *V. callosa* has tuberculous spines with both surfaces sloping. (2) In the shape of whorls, *callosa* is almost cylindrical, while *callosa japonica* is conical. (3) The distinct groove, which extends over the tips of the tupercles in *callosa*, are usually very obscure in *callosa japonica*. YABE and HATAI (1938) pointed out, however, that in rare cases a groove is found to extend over the tips of the tubercles as in the typical *V. callosa*. In the first two characters mentioned above, the present specimens are quite identical with the named subspecies. It is noticeable, however, that the development of the distinct grooves extending over the tips of the tubercles is clearly recognized in most of the present specimens, and namely that the rare case concerning the spiral groove as pointed out by YABE and HATAI is quite common in the Tané-ga-shima specimens.

Genus *Cerithidea* SWAINSON, 1840

Subgenus *Cerithidea* s. str.

Cerithidea (*Cerithidea*) *kanpokuensis* MAKIYAMA

Pl. 3, figs. 9, 10

1926 *Cerithidea kanpokuensis* MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 2, No. 3, p. 149, pl. 12, figs. 2, 3.
1936 *Cerithidea kanpokuensis* MAKIYAMA, ibid., Vol. 11, No. 4, p. 221.
1955 *Cerithidea kanpokuensis* MAKIYAMA, MASUDA, Trans. Proc. Palaeont. Soc. Japan, N. S., No. 20, p. 125.
1956 *Cerithidea kanpokuensis* MAKIYAMA, MASUDA, ibid., No. 21, p. 167, pl. 26, figs. 5a-b.
1966 *Cerithidea kanpokuensis* MAKIYAMA, MASUDA, ibid., No. 63, p. 289.
1967 *Cerithidea kanpokuensis* MAKIYAMA, MASUDA, ibid., No. 65, p. 16, pl. 1, fig. 4.

Dimensions (*in mm*):- Height about 42, Diameter about 18.

Occurrence:- Locality Nos. 1, 5, Kawachi formation.

Geologic Distribution:- Miocene. Heiroku Conglomerate in North Korea; Higashiinnai formation in the Noto Peninsula, Ishikawa Prefecture.

Geographic Distribution:- Living unknown.

Remarks:- Two, ill-preserved and imperfect specimens were examined. The present species, originally described from the Miocene of North Korea, has been

known to occur in association with the *Vicarya* fauna.

Subgenus *Cerithideopsilla* THIELE, 1928

Cerithidea (*Cerithideopsilla*) *cingulata* (GMELIN)

Pl. 3, figs. 11a, b.

1934 *Tympanotonus cingulatus* (GMELIN), HIRASE, Coll. Jap. Shells with Illust. Nat. Colours, pl. 84, fig. 10.

1935 *Cerithidea cingulata* (GMELIN), NOMURA, Saito Ho-on Kai Mus. Res. Bull., No.6, p. 229, pl. 17, figs. 25, 26.

1961 *Cerithidea* (*Cerithideopsilla*) *cingulata* (GMELIN), Kira, Coloured Illust. of shells of Japan, p. 27, pl. 12, fig. 11.

Occurrence:-Locality Nos. 1, 2 and 4, Kawachi formation.

Geologic Distribution:- Miocene to Recent. Miocene Chiganoura formation in Miyagi Prefecture.

Geographic Distribution:- Honshû to Kyûshû, Japan; Indo-Pacific region and Australia.

Remarks:- Not water-worn but imperfect, many specimens are in the collection.

Cerithidea (*Cerithideopsilla*) *sirakii* MAKIYAMA

Pl. 3, figs. 12, 13.

1936 *Cerithidea* (*Cerithideopsilla*) *sirakii* MAKIYAMA, Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B, Vol. 11, No. 4, Art. 8, p. 321, pl. 5, figs. 10, 15.

1943 *Cerithidea* (*Cerithideopsilla*) *sirakki* MAKIYAMA, OTUKA, Jour. Geol. Soc. Japan, Vol. 50, No. 592, p. 221, pl. 2, figs. 13, 14.

1966 *Cerithidea sirakii* (MAKIYAMA), MASUDA, Trans. Proc. Palaeont. Soc. Japan, N. S. No. 63, p. 289.

1967 *Cerithidea sirakii* (MAKIYAMA), MASUDA, ibid., No. 65, pl. 1, figs. 14a-b, 15a-b.

Occurrence:- Locality Nos. 1, 4, 5 and 6, Kawachi formation.

Geologic Distribution:- Miocene. Lower Banko sandstone and Inan sandstone in North Korea; Higashi-innai formation in the Noto Peninsula, Ishikawa Prefecture.

Geographic Distribution:- Living unknown.

Remarks:- The present specimens are quite identical with the Makiyama's species in almost all features, other than that the lowest one of the three spiral cords of them is a little stronger than of the holotype specimen. The present species, originally described from the Miocene of North Korea, is one of the species associated with the so-called *Vicarya* fauna.

Genus *Batillaria* BENSON, 1842

Batillaria cf. *toshioi* MASUDA

Pl. 3, fig. 14.

Compared with:

1967 *Batillaria toshioi* MASUDA, Trans. Proc. Palaeont. Soc. Japan, N. S., No. 65, p. 2, pl. 1, figs. 7a-b, 8a-b, 9.

Dimensions (in mm):- Height about 40, Diameter about 13.

Occurrence:- Locality No. 4, Kawachi formation.

Geologic Distribution of the Compared Species:- Miocene. Higashi-innai formation in the Noto Peninsula, Ishikawa Prefecture.

Geographic Distribution of the Compared Species:- Living unknown.

Remarks:- Three imperfect specimens are in the collection. As far as the characters preserved are concerned, the present specimens quite agree with *Batillaria toshioi*, which was originally described from the Miocene Higashi-innai formation in the Noto Peninsula associated with the *Vicarya* fauna. But the details of spiral threads are uncertain because of ill-preservation of the present specimens. Therefore, specific identification is reserved until more materials are examined.

References

ASANO, K. and K. HATAI, 1967, Micro- and Macropaleontological Tertiary Correlations within Japanese Islands and with Planktonic Foraminiferal Sequences of Foreign Countries. *Tertiary Correlations and Climatic Changes in the Pacific*, p. 77-87, 2 tables.

BABA, K., 1968, Geology of the Southern Part of Tane-ga-shima Island, Kagoshima Prefecture, Japan. (in Japanese with English abstract). *Graduation Thesis of Inst. Earth Sci. Fac. Sci., Kagoshima Univ.* (MS).

CHISHIKI, C., 1954, Geology of the Southern Part of Tane-ga-shima, Kagoshima Prefecture, Japan (in Japanese). *Graduation Thesis of Inst. Earth Sci., Fac. Sci., Kagoshima Univ.* (MS).

FUKUSHIGE, Y., 1964, Geology of the Southern Part of Nishinoomoté City, Kagoshima Prefecture, Japan (in Japanese). *Graduation Thesis of Inst. Earth Sci., Fac., Kagoshima Univ.* (MS).

HABE, T., 1961, Coloured Illustrations of the Shells of Japan (II). ix+183 p., 66 pls. Hoikusha Book Co., Osaka (in Japanese).

HANZAWA, S., 1935, Topography and Geology of the Riukiu Islands. *Sci. Rep. Tohoku Imp. Univ., Sec. Ser (Geol.)*, Vol. 17, p. 1-61, pls. 1-15, text-figs. 1-7, 1 chart, 5 maps.

HASHIMOTO, I., 1956, Geological Succession and Structure of the Undated Strata in Yaku-shima, and Some Facts concerning the Kumage Group in the Western Par of Tane-ga-Shima, Kagoshima Prefecture. *Rep. Earth Sci., Dept. General Education, Kyushu Univ.*, Vol. 2, p. 23-34, pls. 7-9.

HATAI, K. and S. NISIYAMA, 1949, New Tertiary Mollusca from Japan. *Jour. Paleont.*, Vol. 23, No. 1, p. 87-94, pls. 23, 24.

HAYASAKA, I. and S. HAYASAKA, 1960, Molluscan Fossils from Tungyüping in the Penghu Islands, Taiwan. *Trans. Proc. Palaeont. Soc. Japan*, N. S. No. 38, p. 263-274, pl. 31.

HIRAKAWA, K., 1965, Geology of the Central Part of Nishinoomoté City, Kagoshima Prefecture, Japan (in Japanese). *Graduation Thesis of Inst. Earth Sci., Fac. Fac. Sci., Kagoshima Univ.* (MS).

IJUIN, T., 1964, Geology of the Area covering Nakatané-chô, Kumage-gun, Kagoshima Prefecture (in Japanese). *Graduation Thesis of Inst. Earth Sci., Fac. Sci., Kagoshima Univ.* (MS).

IKEBE, T., 1936, Pleistocene Shell Bed of Toyonari, Tiba Prefecture. *The Venus*, Vol. 6, No. 4, p. 189-205.

IWAI, T., 1960, A New Locality of the *Vicarya* Fauna from Amori Prefecture. *Trans. Proc. Palaeont. Soc. Japan*, N.S., No. 37, p. 201-208, pl. 24.

KAMADA, Y., 1960, On the Associated Occurrence of *Vicarya* and *Vicaryella* in the Japanese Te-

rtiary, with the first Descripton of a Paleogene Species of *Vicarya* from Japan. *Sci. Rep. Tohoku Univ., Sec. Ser. (Geol.)*, Spec. Vol. No. 4, p. 281-295, pls. 30-31.

KIRA, T., 1961, Coloured Illustrations of the Shells of Japan. (Enl. & Rev. Ed.), vii+239 p., 71 pls. Hoikusha Book Co., Osaka (in Japanese).

KURODA, T. and T. HABE, 1952, Check List and Bibliography of the Recent Marine Mollusca of Japan. 210 p.

MAKIYAMA, J., 1926, Tertiary Fossils from North Kankyô-dô, Korea. *Mem. Coll. Sci. Kyoto Imp. Univ., Ser. B, Vol.* 2, No. 3.

——, 1936, The Meisen Miocene of North Korea. *ibid.*, Vol. 11, No. 4, p. 193-228, pls. 4, 5.

MASUDA, K. 1955, Miocene Mollusca from Noto Penisula, Japan. Part 1 (I). *Trans. Proc. Palaeont. Soc. Japan*, N. S., No. 20, p. 119-127, pl.19.

——, 1956, Miocene Mollusca from Noto Peninsula, Japan. Part 1 (II). *ibid.*, No. 21, p. 161-167, pl. 26.

——, 1966-67, Molluscan Fauna of the Higashi-innai Formation of Noto Peninsula, Japan. *ibid.*, No. 63, p. 261-293; No. 64, p. 317-337, pls. 35, 36; No. 65, p.1-18, pls. 1, 2.

MATSUMOTO, T., M. NODA and M. MIYAHISA, 1962, Kyûshû chihô (in Japanese). 423 p. Asakura Book Co., Tokyo.

MATSUO, H., 1951, On the Geographical Distribution Map of the Genus *Vicarya* in Japan and Korea (in Japanese). *Cenozoic Res.*, No. 9, p. 1-3, 1 fig.

OCHIAI, T., 1964, Geology of the Central Part of Tane-ga-shima, Kagosima Prefecture (in Japanese). *Graduation Thesis of Inst. Earth Sci., Fac. Sci., Kagoshima Univ.* (MS).

ÔTA, K., 1968, Geology of the Coastal Area of the Central Part of Tane-ga-shima, Kagoshima Prefecture (in Japanese). *Graduation Thesis of Inst. Earth Sci., Fac. Sci., Kagoshima Univ.* (MS).

ÔTUKA, Y., 1938, Mollusca from the Miocene of Tyûgoku, Japan. *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec.* 2, Vol. 5, Pt. 2, p. 21-45, pls. 1-4.

OZAKI, H., 1954, Geology of the southern Part of Tane-ga-shima. (Abstract in Japanese). Jour. Geol. Soc. Japan, Vol. 60, No. 706, p. 308.

TAIRA, T., 1968, Geology of the Nishi-no-omoté City Area, Tane-ga-shima, Kagoshima Prefecture (in Japanese with English abstract). *Graduation Thesis of Inst. Earth Sci., Fac. Sci., Kagoshima Univ.* (MS).

TAKI, I. and K. OYAMA, 1954, Matajiro Yokoyama's "the Pliocene and later faunas from the Kwanto Region in Japan". *Palaeont. Soc. Jap., Spec. Papers* No. 2, p. 1-68, pls. 1-49.

TANAKA, H., 1965, Geology of the Northern Part of Nishi-no-omoté City, Kagoshima Prefecture (in Japanese). *Graduation Thesis of Inst. Earth Sci., Fac. Sci., Kagoshima Univ.* (MS).

WENZ, W., 1940, Gastropoda. Part 4, p. 721-960. Verlag von Gebrüder Borntraeger, Berlin.

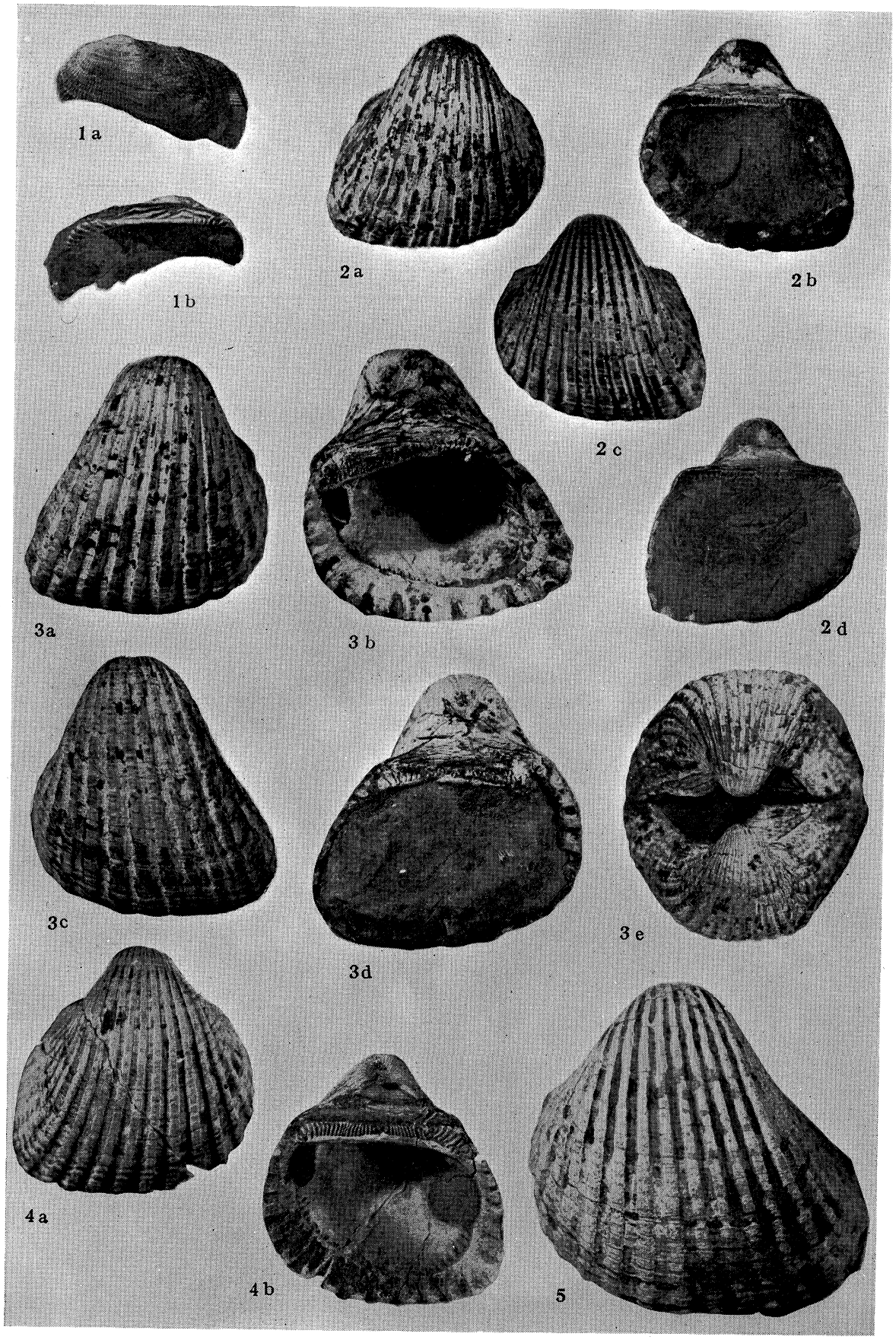
Plates 1–3

Explanation of Plate 1

(All figures are in natural size)

Fig. la, b. *Barbatia* (*Cucullaearca*) *obtusoides* (NYST). a, external view; b, internal view. Loc. No. 1.

Figs. 2a-c, 3a-e, 4a, b, 5. *Anadara* (*Hataiarca*) *shimonakaensis* HAYASAKA, n. sp. 3a-e, holotype, ESK Reg. No. F-5001, Loc. No.1; 2a-c, 4a, b, 5, paratype, ESK Reg. No. F-5002, Loc. No. 1.


1a
1b
2a
2b
2c
2d
3a
3b
3c
3d
3e
4a
4b
5

Explnation of Plate 2

(All figures are in natural size, unless otherwise stated)

Figs. 1a, b, 2a, b. *Anadara* (*Hataiarca*) *shimonakaensis* HAYASAKA, n. sp. Paratype, ESK Reg. No. F-5002, Loc. No. 1.

Figs. 3a, b. *Anomiya chinensis* PHILIPPI. a, external view ; b, internal view. Loc. No. 1.

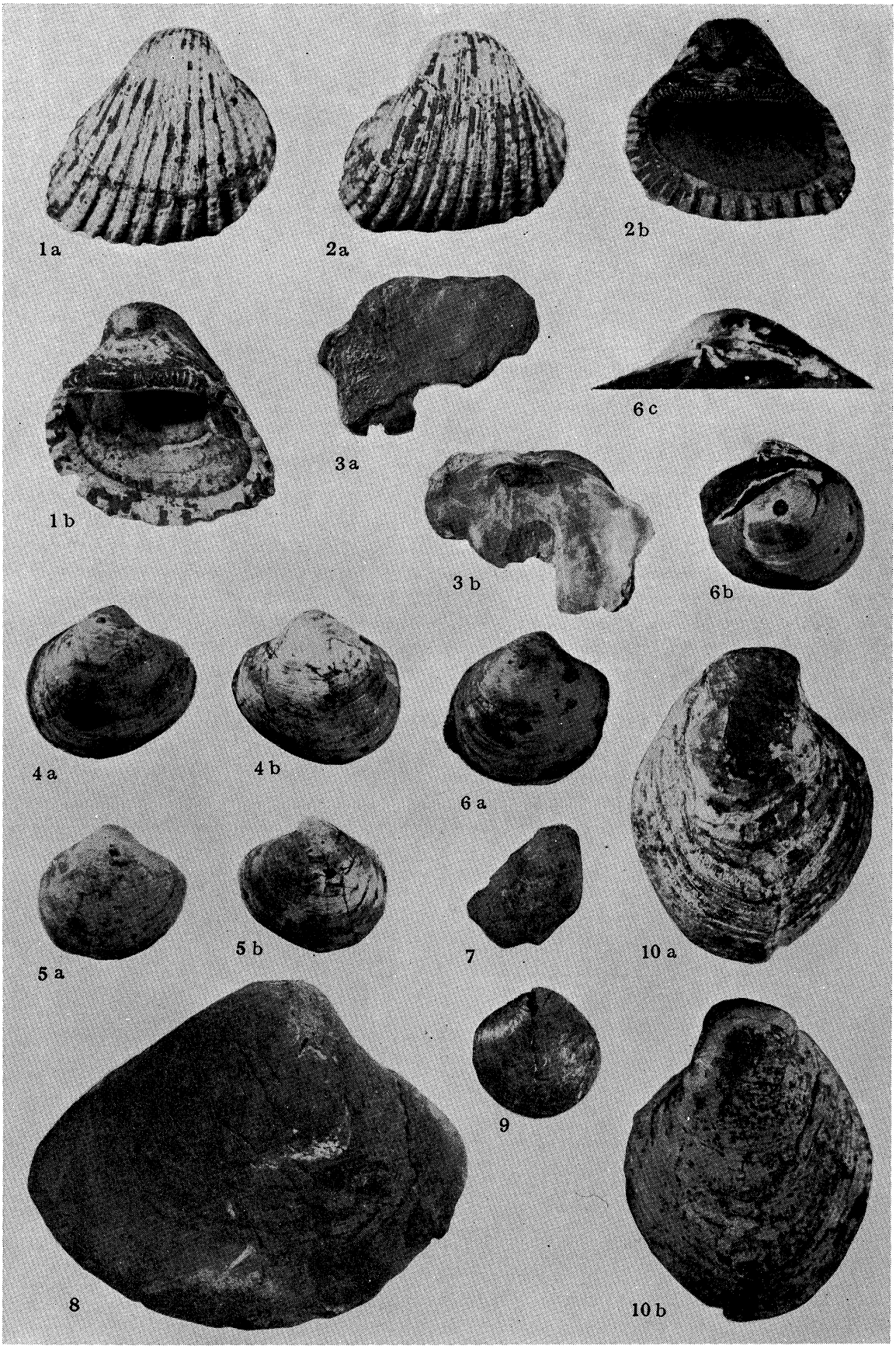
Figs. 4a, b, 5a, b, 6a-c. *Joannisiella cumingii kukinagaensis* HAYASAKA, n. subsp. 4a, b, holotype, ESK Reg. No. F-5003, Loc. No. 9 ; 5a, b, 6a-c, paratype, ESK Reg. No. F-5004, Loc. No. 9 ; 6c, enlarged view of cardinal teeth, ×2.8.

Fig. 7. *Promantellum orientalis* (ADAMS and REEVE). Loc. No. 6.

Fig. 8. *Meretrix* cf. *meretrix lusoria* (RÖDING). Loc. No. 9.

Fig. 9. *Cyclina* (*Cyclinorbis*) *lunulata* MAKIYAMA. Loc. No. 1.

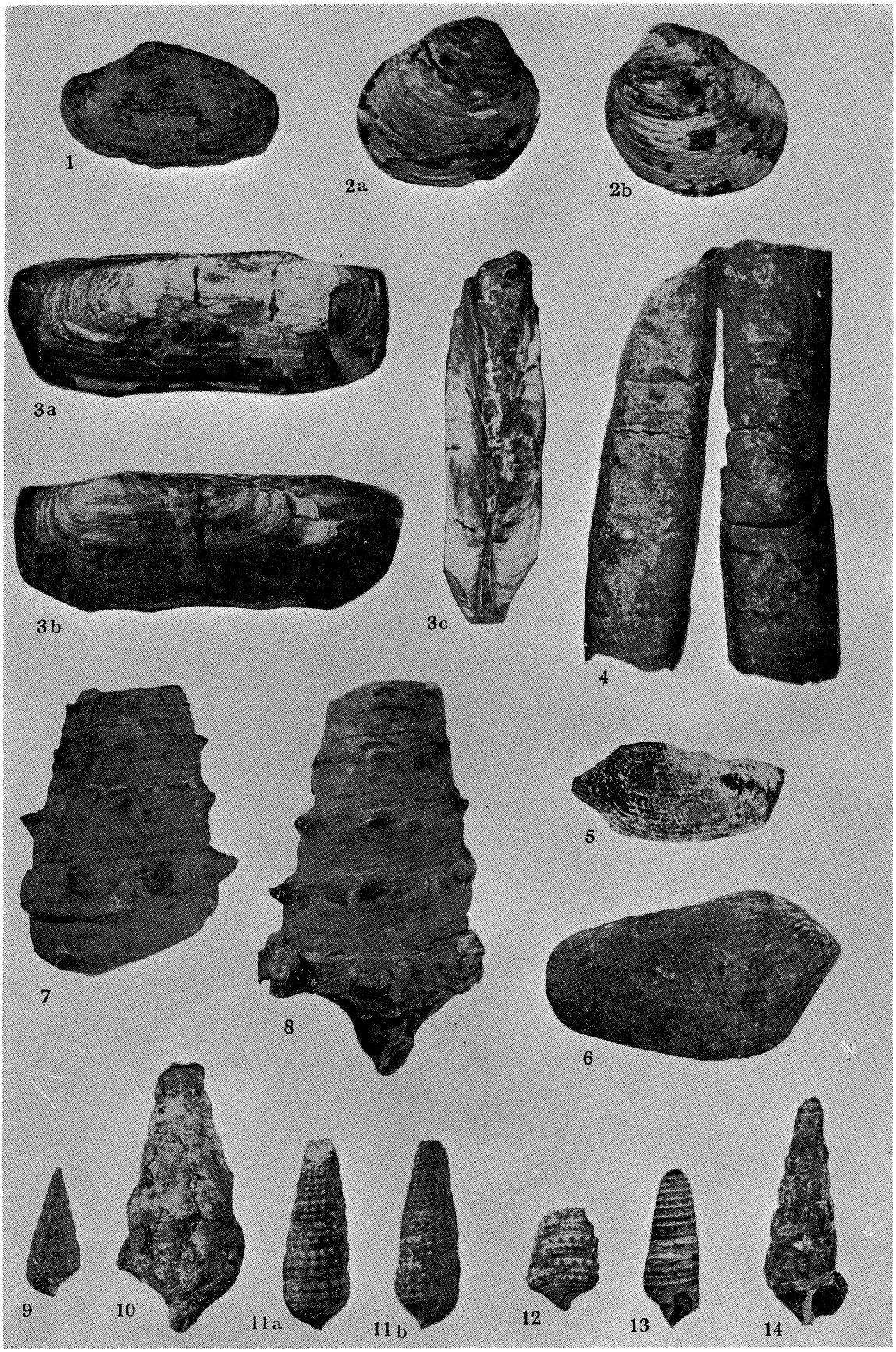
Figs. 10. a, b. *Cyclina* (*Cyclina*) *orientalis* (SOWERBY). Loc. No. 1.


1a
2a
2b
1b
3a
6c
3b
6b
4a
4b
6a
5a
5b
7
10a
8
9
10b

Explanation of Plate 3

(All figures are in natural size)

Fig. 1. *Paphia* (*Paphia*) *exilis exilis* SHUTO. Loc. No. 10.
Figs. 2a, b. *Clementia* (*Clementia*) *nakosoensis* KAMADA. Loc. No. 9.
Figs. 3a-c. *Cultellus izumoensis jobanicus* KANNO. a, b, lateral view; c, dorsal view. Loc. No. 8.
Fig. 4. *Solen gordonis* YOKOYAMA. Conjoined specimen. Loc. No. 9.
Fig. 5, 6. *Barnea* (*Anchomasa*) aff. *manilensis* (PHILIPPI). Loc. No. 8.
Figs. 7, 8. *Vicarya* (*Shoshiroia*) *callosa japonica* YABE and HATAI. 7, Loc. No. 6; 8, Loc. No. 7.
Figs. 9, 10, *Cerithidea* (*Cerithidea*) *kanpokuensis* MAKIYAMA. 9, Loc. No. 1; 10, Loc. No. 5.
Figs. 11a, b. *Cerithidea* (*Cerithideopsilla*) *cingulata* (GMELIN). a, lateral view; b, apertural view. Loc. No. 4.
Figs. 12, 13. *Cerithidea* (*Cerithideopsilla*) *sirakii* MAKIYAMA. 12, Loc. No. 6; 13, Loc. No. 4.
Fig. 14. *Batillaria* cf. *toshioi* MASUDA. Loc. No. 4.


1
2a
2b
3a
3b
3c
4
5
6
7
8
9
10
11a
11b
12
13
14