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On the Lower Cretaceous Fossils Found near the Ominé Mine, Iwaté Prefecture, Northeast Japan

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Abstract

After a palaeontological study of the molluscan fossils found near the Ominé Mine in Iwaté Prefecture had been made, the fossil-bearing beds, which had been considered to be Permian, were confirmed to be Neocomian in age. This conclusion is supported by gelogical evidences. These fossils constitute a fauna distinct from that of the other correlative formations. Fourteen pelecypod and four gastropod species are described, among which five pelecypods are new to science, and most of the other indeterminable fossils are not common to the other districts.

Preface and Acknowledgement

Nearly twenty years ago Mr. IBUKI, the present Head of Ominé Mining Station of Rasakogyo Co. Ltd. collected several slabs of sandy shale hornfels crowded with molluscan fossils at Kanayama-zawa, a small valley west of Ominé Copper Mine in Tono City, Iwaté Prefecture, Northeast Japan. The Ominé Mine is situated immediately to the west of Kamaishi Mine, the largest iron mine in Japan. Since then these fossils had been left neglected till they were sent to the senior author (K.N.) for identification in 1962 through the courtesy of Prof. H. KANO of Akita University. Examining them his attention was attracted by the fact that the most abundant fossils among them belong to the Mesozoic pelecypod genus *Protocardia*, while the strata around the fossil locality were considered to be Permian in age.

Recently Mr. TADA, a prospecting engineer of Ominé Mining Station confirmed their origin at the upper course of Kanayama-zawa, and further discovered another fossil locality at Kanabori-zawa to the north of the former valley. In the meanwhile

Prof. Y. ONUKI and the junior author, both of Tohoku University, visited these fossil localities, and ascertained the Mesozoic age of the fossil-bearing rocks. Based on these data MORIAI (1963) referred to these rocks as the Jurassic and divided them into two formations. The senior author made a preliminary field survey in collaboration with Prof. KANO in 1962 and 1963, and found two more fossil localities at Kanayama-zawa and at Obiraki-zawa to the south of Kanayama-zawa. Consequently four fossil occurrences have been known in this area till now. As a result of a palaeontological and geological study, the authors came to the conclusion that the age of the rocks around the fossil localities is Lower Cretaceous (upper Neocomian) as will be discussed in the following section.

Before going into description and consideration, the authors wish to express their most sincere thanks to Prof. H. KANO who collaborated with them in the field survey and enlightened them on the petrology of this area. They are also much obliged to the present Head Mr. IBUKI, the former Head Mr. Y. WATANABE, and Chief Prospecting Engineer Mr. M. TADA, of Ominé Mining Station, for giving them a chance to carry out this study and for their kind help in field survey. Prof. Y. ONUKI of Tohoku University gave them useful information about the geology of the neighbouring area. Dr. I. HAYAMI of Kyushu University gave them useful suggestions about the identification of pelecypod fossils. Prof. W. HASHIMOTO of Tokyo University of Education and Dr. Y. YABE of Science Information Center kindly allowed the authors to examine their Lower Cretaceous collections. Prof. K. ICHIKAWA of Osaka City University made necessary literatures accessible to the authors. Acknowledgement is also due to these persons. The authors wish to dedicate this paper to Prof. S. MATSUSHITA of Kyoto University who has instructed them in various ways for a long time.

Geological Note and Considerations on Age

Brief Note on Geology

Although a detailed geological survey has not yet been completed, the geology of this area will be briefly mentioned below based mainly on the results of KANO and the senior suthor (Fig. 1). The Permian and the Lower Cretaceous formations are surrounded and intruded by granodiorite (the so-called Tono granite) on the east, west and north sides in this area. The Lower Cretaceous rocks are sandwiched between the Permian formations by fault, and extend in a north-south direction. The Permian sediments distributed on the east side of the Cretaceous rocks is called the Kanayama Formation (MORIAI, 1957 and 1963), which is composed mainly of black slate interca-

lating sandstone and conglomerate beds in the upper part. Fossils of crinoid stems, bryozoans and mould of *Neoschwagerina* or *Yabeina* are found rarely in sandstone and sometimes in black slate. The conglomerate bears round pebbles of granitic rocks (trondhjemitic granophyre and porhyry) and is similar to the Usuginu conglomerate. *Yabeina multiseptata* (DEPRAT), *Y.* sp., *Pseudodoliolina pseudolepida* (DEPRAT), *Parafusulina* (*Monodiexodina*) *matsubaishi* FUJIMOTO, *P.* (*P.*) sp., *Kahlerina pachytheca* KOCHANSKY-DEVIDÉ and *Codonofusiella* sp. were reported by HANZAWA and MURATA (1963) from a conglomerate bed in Kanayama. The main part of the formation is correlated to the upper Kanokura Series (upper Middle Permian, *Yabeina* zone).

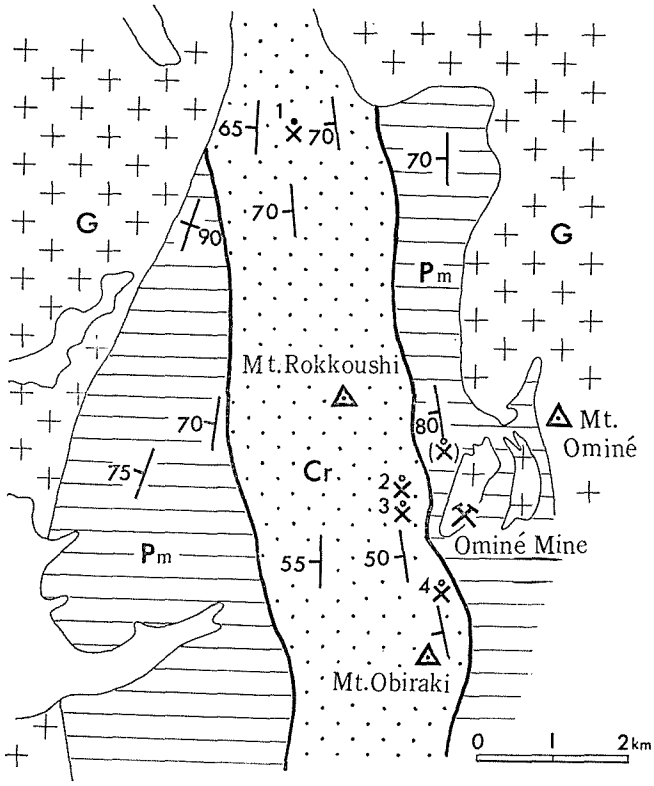

Figure 1. Simplified geological map of the neighbourhood of Ominé Mine. G: granodiorite and quartzdiorite, Cr: Lower Cretaceous Kamihei Group, Pm: Permian, 1-4: fossil localities, 1: Kanabori-zawa, 2: upper course of Kanayama-zawa, 3: lower course of Kanayama-zawa, 4: Obiraki-zawa

The Palaeozoic lying to the west of the Cretaceous is made by black slate intercalating sandstone and limestone. The exact age is not ascertained because of the lack of fossil in this area, although it is considered to be the northern extension of the Lower Permian Sakamotozawa Series called the Kasshi Formation. The Lower Cretaceous rocks are characterized by green volcanic tuffs and lavas such as quartz-keratophyric tuff, andesitic or dacitic tuffs and spilitic lava, intercalating a small amount of bluish grey, fine-grained sandstone and dark grey sandy shale which contain the fossils in problem near the lowest horizon of this area. These beds were classified into two formations by MORIAI (1963), the upper Kamigo Formation rich in sandstone and the

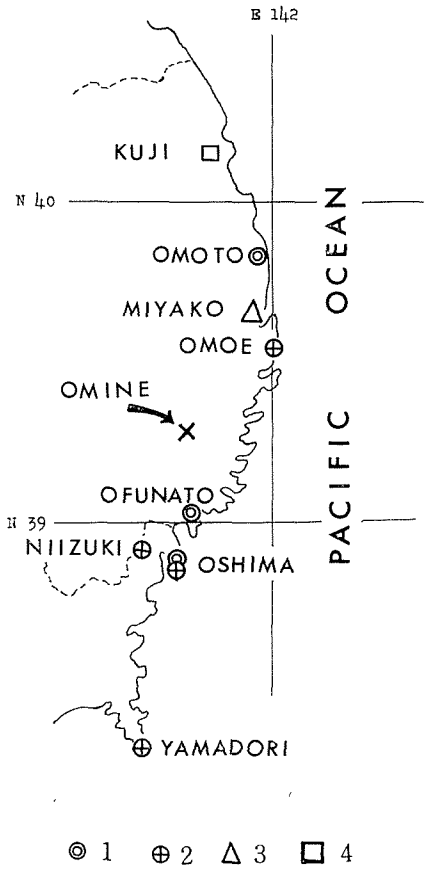

Figure 2. Index map showing the distribution of the Cretaceous rocks in the Kitakami massif.
1: Aritan (upper Neocomian) sedimentary rocks, 2: Aritan effusive and pyroclastic rocks, 3: Miyako Group (Aptian-Albian), 4: Urakawan Kuji Group (Senonian)

lower Aozasa Formation represented mainly by schalstein. But the subdivision is rather difficult, and moreover, the Aozasa Formation is in reality higher than the Kamigo Formation. A more detailed stratigraphy requires further examination. Temporarily we will adopt the collective name, Kamihei Group by ONUKI, in this paper. The group as well as the Palaeozoic formations runs in general with a strike of nearly north-south direction dipping westwards at 50 to 80 degrees, and seemingly conformable with each other. This is the reason why they were condisered to be Palaeozoic as a whole.

Faunal Considerations

The fossil occurrences are listed in the annexed table. Locality 1 is an outcrop of hard, fine-grained sandstone of bluish grey colour, localities 2 and 4 are represented by slabs of very fine-grained, silty sandstone or sandy shale, and locality 3 is a hard, grey, andesitic tuff cropping out on the stream floor. All fossil specimens have been affected by granite intrusion and considerably deformed by later crustal movements.

Table 1. List of fossil occurrences

Species \ Locality	1	2	3	4
Bakevellia (*Neobakevellia*) *ominensis* n. sp.	VR	R		C
Bakevellia tadai n. sp.				VR
Cuneigervilla quadrata n. sp.	VR	?		VR
Waagenoperna elongata n. sp.		VR		
Pseudoptera aff. *viana*				VR
Isognomon sp.	C			R
Protocardia ibukii n. sp.	VR	A	?	A
"*Eomiodon*" *ominensis* n. sp.	R	A		A
Filosina aff. *jusanhamensis*		VR		VR
Venilicardia? sp.			VR	
Liostrea sp.		C		R
Lopha sp.		R		R
Modiolus sp.				VR
Pleuromya? sp.				VR
Craginia cf. *neumayri*				VR
Nerinea sp.			VR	
Trochactaeon aff. *crisimensis*		C		C
Procerithium? sp.		C		C
Nerinella? sp.	A			

1: Kanabori-zawa, 2: Kanayama-zawa (upper course), 3: Kanayama-zawa (lower course), 4: Obiraki-zawa; A: abundant, C: common, R: rare, VR: very rare.

The identification of fossils therefore is not so easy. Among them four gastropod and fourteen pelecypod species are identified, but many of them cannot be determined specifically as shown in the table.

The fossil assemblage indicates rather shallow, near-shore environment. It is not certain whether the sea was affected by fresh water inflow, although the presence of streids and corbiculids suggests brackish or low salinity condition. It is worthy of note that all of them except one species is new to science, or not common to other area's although specifically indeterminable. Therefore it is rather difficult to fix the accurate age of this fauna. The only species common to the other regions is *Craginia* cf. *neumayri*, which is found in the Funayawara Formation of the Ofunato Group*. In addition to it, the upper Neocomian (Hauterivian?) age is inferred from the fact that *Nerinea* sp. is related to Valangian species, *Filosina* sp. is closely allied to Purbeckian or Wealden *F. jusanhamensis*, *Protocardia ibukii* n. sp. is nearly identical to Miyakoan (Aptian-Albian) species from Sanchu Graben, *Trochactaeon* sp. to Aptian-Cenomanian *T. crisimensis*, *Pseudoptera* sp. to Cenomanian *P. viana*, and "*Eomiodon*" *ominensis* n. sp. to Aritan-Miyakoan (Hauterivian-Albian) "*Cyrena*" *radiatostriata*. These allied species as a whole suggest a little higher horizon than the lower Neocomian.

Geological Considerations

The Lower Cretaceous epoch (probably upper Neocomian) suggested by molluscan fossils is supported by geological evidence. The Kamihei Group suffered thermal metamorphism by Tono granite, whose absolute age was determined very recently as 120×10^6 years ago by K-A dating (KAWANO and UEDA, 1965). Similar granite of nearly same absolute age is overlaid unconformably by the Miyako Group (type of Miyakoan, Aptian-Albian). Furthermore, the strata of the Kamihei Group are steeply inclined and undergone strong shearing, while those of the Miyako Group are gently dipping and the shearing is negligible. It is therefore beyond doubt that the Kamihei Group is older than the latter and is pre-Miyakoan in age. The Neocomian Ofunato Group is distributed along the coast of Ofunato about 30 km south of this area. The group consists of sandstone, shale, tuffaceous conglomerate, tuff and schalstein extending in N-S or NWN-SES direction, which suggests the continuation of the group to this area. It is also steeply dipping and intruded by granite. Judging from the lithology, the geological structure and the geographical distribution, the Kamihei Group is correlated to the Ofunato Group. It is a noticeable fact that, according to

* The speeies was listed as *Glauconia* n. sp. by ONUKI and MORI (1961, p. 647) and tabulated to occur in the Funagawara to Takonoura Formations, but the authors could examine the specimen only collected from the Funagawara Formation.

SATO's recent study*, the latter group developing in the east side of the Ofunato Bay is characterized by basic and andesitic volcanism in the lower part, whereas by acidic volcanism in the upper, and also that the tuffaceous rock facies marked by quartz-keratophyre of the Kamihei is comparable to that of the Harachiyama Formation** which is correlated to the basal formation of the Ofunato Group. Basic or andesitic effusive rocks and their pyroclastic rocks which are considered to be Valanginian or Hauterivian are rather widely distributed along the Pacific coast of Miyagi and Iwaté Prefectures, for instance, Yamadori Formation in Ojika Peninsula, Kanaegaura Formation in Oshima Island and Niizuki Formation west of Kesennuma City. It is reasonable to correlate the Kamihei Group to these rocks and the lower part of the Ofunato Group (Hakoneyama and a part of Funagawara Formation on the west side of Ofunato or Ryori Formation on the east side). It is very interesting that the Kamihei fauna has no species common to that of the Ofunato except *Craginia* sp., in spite of the fact that the former group is considered to be the northern extension of the latter. It may be explained by considering that the Kamihei Group represents mainly the unfossiliferous lower part of the Ofunato. As to the absence of *Nipponitrigonia-Pterotrigonia* fauna commonly found in correlative fossiliferous strata in other districts, it may be explained by different environmental conditions. If this correlation is true, it is important in two points. Firstly the Neocomian sea is proved to have invaded northwestwards into the interior part of the Kitakami massif. Secondarily the effusive rocks are considered to have been activated in the upper Neocomian (probably Hauterivian) rather than in the lower Neocomian.

Description of species

Class Pelecypoda

Family Bakevelliidae

Genus *Bakevellia* KING, 1850

Subgenus *Neobakevellia* NAKAZAWA, 1959

Bakevellia (*Neobakevellia*) *ominensis* NAKAZAWA and MURATA, n. sp.

Pl. 3, figs. 1-7.

Description: Shell subtrapezoidal, inequivalve, inequlateral, longer than high,

* K. SATO divided the Ofunato Group into four formations. The lowest Ryori Formation is mainly composed of andesitic or basaltic tuffs and tuff breccias, 1000-1200 m thick, and correlated to the Hakoneyama Formation and a part of the Funagawara Formation in the west side. (Geology around Ryori, Sanriku-mura, Kesen-gun, Iwaté Pref., Graduation thesis of Tohoku Univ., 1965).

** Personal communication of Prof. KANO.

right valve a little inflated and less convex than the left; anterior wing very small in adult, but well defined from the rest by a distinct furrow or depression; posterior wing broad and gradually depressed from the main body; posterior margin straight making a roundly obtuse angle with the hinge-margin which is straight and shorter than the shell-length; umbo weak, not salient above the hinge-margin. Ligament plate narrow and straight, gradually tapering backward, provided with five or six ligament-pits, among which the anterior two or three are slender and narrowing dorsally and the rear ones become wider and weaker; hinge consists of a obliquely elongated cardinal tooth in each valve and a long lateral in the left and two laterals in the right; mascular impression not preserved excepting a small pedal retractor scar in the umbonal cavity and a rudimentary anterior adductor scar in the interior of the anterior wing. Surface nearly smooth.

Observation and comparison: The incomplete holotype specimen is compressed secondarily showing a taller outline than actual, but well exhibits the hinge and ligament characters. There are several immature valves which differ from the adult in some points. The cardinal tooth and socket are rudimentary, sometimes crenulated transversally, and divergent from under the beak; the ligament-pits are less in number (3 or 4); the anterior wing relatively larger and more sharply marked from the rest of shell. These ontogenetic changes are also seen in many other Bakevellias such as the Triassic *B. matsushitai* NAKAZAWA (1954 p. 214, pl. 3, figs. 1-5, 8) and the Jurassic *B. magnissima* (YOKOYAMA) (HAYAMI, 1957, p. 52, figs. 6-10). The present species is similar to the Liassic *B. nagoensis* HAYAMI (ibid, p. 54, pl. 3, figs. 6a, b) from Central Japan and *Aguilaria cummingsi* WHITE (1887, p. 39, pl. 2, figs. 1-3) from the Cretaceous of Texas in subtrapezoidal shape with straight posterior margin, but differs from the former in the less convexed shell and smaller anterior wing in the adult, and from the latter in dentition.

Occurrence: Kanabori-zawa (very rare), Kanayama-zawa (rare) and Obiraki-zawa (common). Reg. nos. JM 11131-40, 11151, 52 and IGPS Coll. No. 85763.

Bakevellia (*Neobakevellia*?) *tadai* NAKAZAWA and MURATA, n. sp.

Pl. 3, figs. 8a, b.

Description: Only a left valve is procured. Shell medium in size, subtrapezoidal, moderately inflated, inequilateral; umbo subterminal, not salient above the dorsal margin; hinge-margin straight, relatively short, posterior one gently sinuated, ventral margin broadly arcuate, rather suddenly rising up to nearly linear anterior

margin; anterior wing roundly trigonal, sharply defined from the body; posterior wing larger, gradually depressed from the main body; ligament-area rather wide, quadrangular ligament-pits; higne consisting of three, granular, rudimentary cardinal teeth, and lateral tooth not observable; two small pedal retractor scars impressed in the umbonal cavity, a small anterior adductor scar on the inner surface of the anterior wing connected with large oval posterior muscle scar by a series of small pits indicating a pallial line. Surface smooth except for weak growth-lines.

Observation and comparison: Near the shell margin there is seen a linear impression parallel to the periphery. It is thought to be a boundary line of the nacreous layer and the outer prismatic layer as seen in the Permian *B. gujoensis* NAKAZAWA (1959, p. 198, textfig. 3 and pl. 3, fig. 8). It is not sure that the lateral tooth is actually lacking or it is not preserved by some causes, although the latter case is probable. The species is very similar to the Liassic *Cuneigervillia hagenowi* (DUNK.) (1864, p. 37, pl. 6, figs. 9-11; COX, 1954, p. 48, textfig. 1) in general outline and obscure dentition, but is distinguished in the development of anterior wing. It is most similar to "*Gervillia*" *renauxiana* MATHERON from the Turonain in France (d'ORGIGNY, 1843, p. 490, pl. 398, figs. 1-3) in form and ligamental features. D'ORGIGNY's illustrations do not show any dentition, but the presence of crenulation along the hinge-margin is suggested by MATHERON. If this is true, the species is congeneric with *Aguileria*. The present species differs from *renauxiana* in broader shape of the ventral half of the body and in the complete lacking of radial sculptures.

Reg. no. JM 11142.

Genus *Cuneigervillia* COX, 1954

Cuneigervillia quadrata NAKAZAWA and MURATA, n. sp.

Pl. 3, figs. 9-11.

Description: Shell medium or large, roundly quadrangular, subequivalve, a little inflated; dorsal margin nearly straight, posterior margin slightly sinuated, meeting with the former making roundly rectangular angle, ventral margin broadly arcuate, anterior one concave forward with inflexed wall suggesting abyssal opening at this place; anterior wing absent, posterior wing large, not sharply defined from the main body; ligament-area nearly parallel sided, provided with eight, slender, subvertical ligament-pits which become obscure towards the rear extremity; hinge consisting of a slender, oblique cardinal and a tooth relatively short lateral socket bounded by tooth-like ridges on both sides, all of these teeth is lacking in full grown specimen;

a rudimentary anterior adductor muscle scar, a pedal retractor scar and a series of small pits (pallial line) starting from anterior adductor scar are impressed in the younger internal mould.

Remarks and comparison: The species is considered to be placed in the genus *Cuneigervillia* in the terminal umbo, absence of anterior wing and edentulous adult stage, but it is not neglected that the species is very similar to edentulous *Bakevellia* of full grown stage such as *B. magnissima* HAYAMI (1957, p. 52, pl. 2, figs. 6-10) from the Liassic of Japan, although it differs from the latter in the absence of anterior wing. This fact suggests the direct descendant of this genus from *Bakevellia*. The species is distinguished from any other species of *Cuneigervillia* in the quadrangular shape.

Occurrence: Very rare in Kanabori-zawa and Obiraki-zawa. Reg. nos. JM 11143, 45, 48?

Family Isognomonidae

Genus *Waagenoperna* TOKUYAMA, 1959

Waagenoperna elongata NAKAZAWA and MURATA, n. sp.

Pl. 4, figs. 1a-c.

Description: An incomplete, right internal mould with external mould of the umbonal part is at hand.

Shell moderate in size, elongate subtrigonal, nearly flat excepting a little inflated umbonal portion, strongly inequilateral; umbo subterminal, situating 3 mm back from the anterior end, not conspicuous, low and nearly leveled with the hinge-margin; posterior wing broad and flat, seemingly not demarcated from the main body; anterior wing very small, not sharply defined from the body; anteroventral margin steep and linear, slightly sinuated under the anterior wing, ventral margin broadly arcuate, posterior one not accurately known, but presumably well rounded below and subtruncated above making a rectangular postero-dorsal corner with straight dorsal margin; hinge edentulous; ligament area broad and low, 53 mm long, occupying whole hinge-length and provided with six quadrangular ligament-pits which are arranged distally towards the posterior extremity; surface nearly smooth judging from the partly preserved external mould.

Remarks and comparison: The specimen is considerably flattened and somewhat compressed secondarily. So the shell is considered to have been more inflated, taller and less oblique. This species is undoubtedly referred to the Jurassic-Cretaceous

genus *Cuneigervillia* or the Upper Triassic genus *Waagenoperna* in edentulous and cuneiform outline. The latter genus was separated from *Cuneigervillia* in having no *Bakevellia* stage through ontogeny and placed in the Family Isognomonidae (TOKUYAMA, 1959, p. 151). The present species is represented by a single adult secimen, and cannot be identified genetically. In general shape it is more similar to *Waagenoperna* such as *W. triangularis* (KOBAYASHI and ICHIKAWA) (1952, p. 268, textfigs. 1, 2; TOKUYAMA, 1959, p. 153, pl. 16, figs. 8-15), *planata* BROILI (1904, p. 191, pl. 12, figs. 23, 24) and *lateplanata* WAAGEN (1907, p. 97, pl. 34, figs. 16, 17) than usual species of *Cuneigervillia*, but differs from above-mentioned species of *Waagenoperna* in more elongated and more oblique shape.

Occurrence: Kanayama-zawa. IGPS Coll. No. 85764.

Genus *Isognomon* SOLANDER, 1786

Isognomon sp. indet.

Plate 4, figs. 3-5 and 6?

There are several specimens which are considered to belong to *Isognomon* by multivincular ligament, edentulous hinge, absence of anterior wing and obscure posterior wing. But all of them is severely compressed secondarily, showing very tall outline than actual. From these materials it cannot be identified specifically. For the genus the present species has less numerous ligament-pits (seven in number) and broad cardinal area.

Occurrence: Common at Kanabori-zawa, rare at Obiraki-zawa. Reg. nos. JM 11146, 47, 49, 88, 87?

Family Pteriidae

Genus *Pseudoptera* MEEK, 1873

Pseudoptera n. sp. aff. *P. viana* STEPHENSON

Pl. 4, figs. 2a-c.

Description: Shell of medium size, elongate subtrigonal, pteriform in outline, strongly inequilateral, moderately inflated; umbo small, not prominent, slightly salient above the straight hinge-margin, situated 5 mm back from the anterior extremity; posterior wing broad, triangular, flat, well defined from inflated main body; anterior wing short, trigonal, sharply defined from the rest of the body; on the main part of the body a rounded ridge, though exaggerated by secondary deformation, extending from

the umbo to the postero-ventral extremity, in front of which the shell curves rapidly downward; postero-dorsal side of the ridge the valve is flattened or slightly depressed and delimited from the posterior wing by broad, very low radial swelling; judging from the growth-lines posterior margin somewhat angulated at the end of the umbonal swelling; anterior and ventral margins merge in a broad convex curve; posterior wing ornamented with five, faint radial ribs which become obsolete posteriorly; anterior wing sculptured by relatively broad, flat radial ribs separated by faint grooves; rounded umbonal ridge of the main part is ornamented with weak radial ribs which consist of alternation of first and second orders, but the rest is smooth; growth-lines well developed, regular, rather strong on both wings and faint on the main body. Hinge and musculature unknown.

Remarks and comparison: The specimen suffers from later compression and the main body is flexed at the antero-ventral side. The shell is, therefore, more inflated than the present state.

Although the internal characters are unknown, the species belongs most probably to *Pseudoptera* judging from the characteristic external shape and ornaments. This is most similar to the Cenomanian *P. viana* STEPHENSON (1952, p. 72, pl. 15, figs. 3-7) from Texas, but distinguished by the absence of sharp radial ribs delimiting the umboal depression, the broader posterior wing, and more sharply defined anterior wing.

Occurrence: A single external mould occurred from Kanayama-zawa. Reg. no. JM 11144.

Family Cardiidae

Genus *Protocardia* BEYRICH, 1845

Protocardia ibukii NAKAZAWA and MURATA, n. sp.

Pl. 4, figs. 7a, b; Pl. 5, figs. 1-4.

Description: Shell small to medium in size, equivalve, inequilateral, subtrigonal, moderately inflated, a little longer than high; posterior carina distinct and rounded; umbo prominent, lying anterior to the middle of the shell, nearly orthogyrous or opisthogyrous, rising highly above hinge margin and incurved; ventral margin broadly rounded, abruptly rising up to nearly straight posterior margin making a rounded postero-ventral angulation; posterior area umbonal slope sculptured by eight to thirteen radial ribs; escutcheon narrow, depressed, not clearly defined from the posterior area; flank of the shell covered by faint concentric growth-lines and sculp-

tured by one or four radial ribs close to the posterior carina where the marginal crenulation is seen in the inner mould; hinge consisting of two cardinal teeth and a pair of laterals in the left valve, anterior cardinal is conical and strong, posterior 4b is small, slender and obscure, lateral teeth short, situated more or less apart from the cardinals, especially, in the anterior lateral; in the right valve posterior cardinal 3b is conical and strong, anterior one obscure, a pair of laterals being lamellar. Pallial line and muscular scar not impressed.

Remarks and comparison: Abundant specimens are obtained, all of which is strongly deformed. Among them the holotype specimen is least subject to modification (pl. 2, figs. 7a, b). Medial part of the flank is nearly flat or even concave near the umbo. Sometimes feeble radial threads are found on the anterior part of the flank. The present species is similar to the Upper Triassic *P. contusa* HEALEY from Burma (1908, p. 71, pl. 9, figs. 22-29), the Liassic *P. onoi* HAYAMI (1959, p. 77, figs. 16-18) from West Japan in general shape. The former species is distinguished in more numerous radial ribs, regular concentric ornaments and in having a distinct adductor muscle scar. The latter has more numerous radials and more rounded carina. The Cretaceous *P. hillana* SOWERBY (1913, p. 41, pl. 14) is another allied species, but differs from this in more central position of the umbo, taller outline and more regular concentric ornaments. Almost identical species is found in the Miyakoan in Sanchu Graben which differs only in having adductor muscle impressions and in a little larger escutchenonal part.

Occurrence: Kanabori-zawa (very rare), Kanayama-zawa (abundant) and Obiraki-zawa (abundant). Reg. nos. JM 11153-57, IGPS Coll. No. 85765, 66.

Family Neomiodontidae

Genus *Eomiodon* COX, 1935

"*Eomiodon*" *ominensis* NAKAZAWA and MURATA, n. sp.

Pl. 5, figs. 5-12, 15.

Description: Shell small, trigonally ovate, a little inflated, equivalve, subequilateral; umbo not prominent, prosogyrous, situating at about a middle of the shell or a little anterior to the middle; antero-dorsal margin nearly straight but concave near the beak; postero-dorsal margin slightly convex, ventral margin broadly arcuate, somewhat truncated postero-ventrally; escutcheon and lunule long and narrow strongly depressed occupying nearly whole length of postero-dorsal or antero-dorsal margin, both are clearly defined from the flank by a ridge; weak carina running from umbonal portion to postero-ventral corner delimits a posterior area. Surface covered

by concentric and radial ornaments, both of which make a lattice appearence; concentric sculpture is stronger than radials, and more distally disposed; radial scupture consisting of numerous fine ribs interrupted by concentric sculpture and diminish on the posterior truncated area; hinge *Eomiodon* type as formulated below,

AIII	AI	3a	3b	(5b)	PI
AII		2	4b		PII

In the right valve 3a is slender, not clearly distinguished from anterior lateral tooth (AIII), medial cardinal 3b strong, trigonal, 5b is rudimentary, not always preserved; anterior laterals well developed along the shell margin, of which A III is represented by marginal thickening; in the left valve anterior cardinal 2 distinct but slender, posterior 4b lamellar, not so developed, AII and PII are well developed along the shell-margin; pallial line entire? connecting both adductor scars which are situated close to the antero- and postero-ventral corners.

Remarks and comparison: This species and *Protocardia ibukii* are the most abundant constituents of the Kamihei fauna. Judging from many specimens the species is subequilateral with subcentral umbo, although the holotype specimen is protruded antero-ventrally by secondary deformation. This is undoubtedly congeneric with "*Cyrena*" *radiatostriata* YABE and NAGAO (1926, p. 51, pl. 12, figs. 29-35; pl. 13, fig. 45) from the Aritan- Aptian formations in Sanchu Graven of North Kwanto and undescribed *Polymesoda* (*Costocyrena* MS) "*radiatostriata*" reported from the Albian Yatsushiro Formation in Kyushu by MATSUMOTO and KANMERA (1952, pp. 40, 50, listed) in the characteristic lattice ornaments and *Eomiodon* type dentition. The dentition coincides completely with that of *Eomiodon*. Above mentioned species make a new genus closely related to *Eomiodon* and are considered to belong to Neomiodontidae, although there is no genus having such ornaments in this Family.

Because a new genus *Costocyrena* including these species is now being proposed and dicussed in detail by HAYAMI* (type, *Costocyrena matsumotoi* HAYAMI=*C. radiatostriata* in MATSUMOTO and KANMERA), the present species is tentatively placed here in "*Eomiodon*" to avoid confusion. "*E.*" *ominensisis* is distinguished from *radiatostriata* in subcentral umbo, less inflated shell, and more sharply defined and wider lunule.

Occurrence: Kanabori-zawa (rare), Kanayama-zawa (abundant) and Obiraki-zawa (abundant). Reg. nos. JM 11159, 61-70.

* Personal communication. This genus is described in "Lower Cretaceous Marine Pelecypods of Japan, Part II, Mem. Fac. Sci. Kyushu Univ," now in printing.

Family Corbiculidae

Genus *Filosina* CASEY, 1955

Filosina sp. aff. *F. jusanhamensis* HAYAMI

Pl. 5, figs. 13, 14.

Description: Shell small, inequilateral, trigonally ovate, a little longer than high, moderately inflated; antero-dorsal margin nearly straight, postero-dorsal margin slightly convex, ventral margin broadly arcuate; lunule and escutcheon not impressed; umbo located at a little anterior to the middle; hinge of typical cyrenoid type, consisting of three cardinal teeth and long lateral teeth as formulated below:

AIII	AI	3a	1	3b	PI	(PIII)
AII?		2a	2b		PII	

In the right valve anterior cardinal 3a is very thin, not sharply defined from AIII; medial cardinal 1 trigonal, strong, prosocline and clearly separated from AI; 3a is strongest and slightly bifid near the ventral margin; two anterior laterals (AI, AIII) lamellar, of which AI is stronger; out of the two posterior laterals PIII is represented by marginal thickening; nymph relatively narrow. In the left valve medial cardinal 2b is stout and subvertical; 2a is weak and slender, a posterior lateral PII long and lamellar, AII is not preserved. Surface nearly smooth excepting weak growth-lines; pallial line and muscular scar not preserved.

Remarks and comparison: The specimens have been considerably deformed secondarily. Apparent direction of compression of two illustrated valves seems to be normal with each other, and the above description is made by considering such deformation. Although an accurate specific comparison is difficult to be done, the species is very similar to *Filosina jusanhamensis* HAYAMI (1960, p. 15, pl. 2, figs. 1-7, textfig. 1) from Purbeckian or Wealden of the southern Kitakami massif, but differs in a slightly bifid 3b. In this respect the species is allied to *F. gregaria* CASEY (1955, p. 369, textfigs. 1-3, 6C, D) from the Wealden beds in South England, but the latter has more advanced characters, that is, 1, 2 a and 2b besides 3b are also bifid or serrated longitudinally and the nymph is more developed. Thus the present species is considered to be intermediate between *jusanhamensis* and *gregaria*, although it is more allied to the former species.

Occurrence: Kanayama-zawa (very rare) and Obiraki-zawa (very rare). Reg. nos. JM 11135, 60, 71.

Family Arcticidae

Genus *Venilicardia* STOLICZKA, 1870

Venilicardia? sp. indet.

Pl. 6, figs. 1a, b.

An incomplete, right internal mould is at hand. Shell is medium in size, subcirucular with well rounded shell-margin, and moderately inflated. Test is thick. Hinge consists of two cardinal teeth and one? posterior lateral tooth. Posterior cardinal is well developed, long, arched downward and distinctly furcated; anterior cardinal lies nearly horizontally, somewhat flexiose, and terminates with thickened projection. Posterior lateral tooth is relatively long and strong lying anterior to the lateral socket. Nymph is rather narrow, represented by tooth-like projection. The anterior part of the hinge area is, unfortunately, broken off, and it is not sure whether anterior lateral tooth is present or not, but if present it may be short and situate close to the carinal tooth. Judging from the partly preserved external mould, the surface is covered by closely set, distinct growth-lines. Because of the imperfect state of preservation it is difficult to determin even its generic position, but the species belongs most probably to the Cretaceous genus *Venilicardia* by the characteristic dentition. This species is somewhat similar to *V. protensa* WOODS (1907, p. 137, pl. 21, figs. 4-7, textfig. 20, 21) from the Lower Greensand in England and *Veniella weberi* MORDVILKO (MUROMJEVA, T. L. and JUNING, B. T., 1960, p. 213, pl. 25, figs. 1-4) from the Valagian in Crimea in dentition and in general shape, but seems to differ in more regularly rounded shell-margin without truncation at the postero-ventral margin.

Kanayama-zawa, Reg. no. JM 11174.

Family Pleuromyidae

Genus *Pleuromya* AGASSIS, 1842

Pleuromya? sp. indet.

Pl. 6, figs. 2a, b.

A single, incomplete internal mould of right valve from Kanayama-zawa is available for study.

Shell is medium in size, thin, transversely oblong, very inequilateral, protruded posteriorly, and a little inflated, 37 mm high and more than 55 mm long. Umbo is not conspicuous. Hinge cannot be detected, but probably edentulous, at least, having no lateral tooth. A slender marginal furrow is observed close to the antero-dorsal margin.

Muscle scar is not impressed.

As the material is too imperfect, referring the species to *Pleuromya* is provisional mainly based on external shape.

Reg. no. JM 11175.

Family Mytilidae

Genus *Modiolus* LAMARCK, 1799

Modiolus sp. indet.

Pl. 6, fig. 3.

Description: Only a right internal mould is procured.

Shell moderate, subtrigonal, expanded postero-ventrally, a little inflated, fairly longer than high, 45 mm long, 31 mm high and 5 mm deep, umbo weak and obscure, subterminal, located about 3 mm back of the frontal end, not salient above the hinge-margin; dorsal margin slightly curved, longer than two thirds of the shell-length and passing gradually into broadly rounded posterior margin; antero-ventral margin nearly straight making an umbonal angle of about 45 degrees with dorsal margin; anterior bulge not conspicuous and defined from the body by rounded, low diagonal carina, but not sharply. Hinge edentulous, provided with long slender ridge running parallel to the hinge-margin. Surface unknown.

Remarks and comparison: The specimen is flattened and depressed secondarily, and is considered to be more inflated and higher originally. This species is intermediate between *Modiolus* and *Mytilus* in having subterminal umbo and less developed anterior area. In this respect it is similar to the Upper Triassic *M. raiblina* BITTNER (1895, p. 48, pl. 5, figs. 21, 22) and *paronai* (ibid., p. 48, pl. 5, figs. 19,20), the Jurassic *subaequiplicata* GOLDFUSS (1834-40, p. 197, pl. 131, fig. 7) and the Cretaceous *M. falcatus* AMANO (1957, p. 91, pl. 2, figs. 3-8), but is distinguished from them in larger umbonal angle, less prominent diagonal carina and more broadly expanded outline posteriorly.

Reg. no. JM 11181.

Family Ostreidae

Genus *Liostrea* H. DOUVILLÉ, 1904

Subgenus *Liostrea* s.s.

Liostrea (*Liostrea*) sp. indet.

Pl. 6, figs. 4, 5.

There are several ostreid specimens which belong to *Liostrea* by smooth surface and ovate shape. All of them is so strongly crushed that the specific comparison is difficult. Shell is usually elongated longitudinally; covexity of both valves is not so different; ligament-pit is relatively weak for the genus. Rarely found from Kanayama-zawa. Reg. nos. JM 11176-77.

Genus *Lopha* RÖDING, 1798

Lopha sp. indet.

Pl. 6, figs. 6, 7.

Several plicated oysters are found from Kanayama-zawa and Obiraki-zawa. Shell is generally suboval, rarely considerably elongated longitudinally. In a right valve (pl. 4, fig. 6) sixteen radial ribs radiate from the umbonal portion without bifurcation. In another incomplete left valve (fig. 7) eight ribs radiate from relatively large attachment area and have a tendency to bifurcate near the periphery.

Reg. nos. JM 11178, 79.

Class Gastropoda

Family Nerineidae

Genus *Nerinea* DEFRANCE, 1825

Subgenus *Nerinea* s.s.

Nerinea sp. indet.

Pl. 4, figs. 8a-c.

Description: An incomplete outer mould and its inner one are found in hard, purplish grey, silicified tuff at Kanayama-zawa. Shell moderate in size, very high-spired, 15 mm wide in widest part of the preserved portion; median spire angle measured from incomplete inner mould about 10 degrees. Spiral whorls with smooth, slightly concave sides and a blunt elevation along the junctional zone, which has very inconspicuous suture; whorl section subquadrate, wider than high. Apical and apertural portions not preserved. Three internal folds present; a columellar fold lying near the base is relatively weak, a parietal one lying near the parieto-columellar corner, a palatal fold deeply incised, basal fold not present.

Remarks and comparison: The specimen is somewhat deformed secondarily and the feature of the folds shows different shape at places. Details of the surface are not preserved partly by secondary silicification. This species is closely allied to Valangian

N. upensis PCELINCEV (1926; GOLOVINOVA and KOSMUITCHENKO, 1960, p. 149, pl. 2, figs. 1a, b) and *N. angustata* PCELINCEV (1926; G. and K., ibid., p. 149, pl. 2, figs. 2a, b) from Crymea, but the flank of the whorl is less concave than in *upensis* and the palatal fold is narrower at its base than that of *upensis* and *angustata*. Externally this species is somewhat similar to the Miyakoan *N. rigida* NAGAO (1934, p. 250, pl. 38, figs. 1, 2), but the latter species bears a distinct suture on the annular swelling and a shallower palatal fold and in the position of parietal fold.

Reg. no. JM 11184.

Family Turritellidae

Genus *Craginia* STEPHENSON, 1952

Craginia sp. cf. *C. neumayri* (NAGAO)

Pl. 6, figs. 9a-c.

cf. 1890. *Turitella* sp. NEUMAYR, p. 35, pl. 3, fig. 5.
1927. *Glauconia neumayri* NAGAO in YABE, pl. 3, figs. 7a, b.
1939. *Glauconia*? *neumayri* KOBAYASHI and SUZUKI, p. 223, pl. 13, figs. 1-8.

Description: The species is represented by only an incomplete outer mould which is somewhat compressed secondarily. Shell moderate in size, turreted with median spiral angle of about 25 degrees. Suture slightly impressed on the middle of deep depression; younger whorls and apertural part not preserved, and five whorls are preserved, each of which ornamented with two prominent spiral ribs, lower of which is a little stronger and separated from the upper one by a narrower and shallower interspaces than the sutural depression; base of body whorl broadly convex, sculptured by three subequal, narrow spiral ribs. Surface of whorls nearly smooth except for spiral ribs mentioned above and feeble spiral lines observed locally. Growth-lines not observed.

Remarks and comparison: The genus *Craginia* STEPHENSON (1952, p. 155) is distinguished by smooth surface from *Cassiope*, which is very similar in general shape and ornamentation to this genus, but has strongly noded whorls. *Cassiope* regarded as a synonym of *Glauconia* by many authors, is valid, because the latter name was preoccupied for a lizard (GRAY, 1845). This species most probably belongs to *Craginia* in its shape and ornamentation. It is most similar to *Glauconia* (?) *neumayri* (NAGAO) from the Kochian (lower Neocomian) Kawaguchi Formation in Kyushu, Ryoseki Formation in Shikoku and Yoshimo Formation in Yamaguchi Prefecture. *Glauconia* (?) *neumayri*, which is transfered to *Craginia*, shows a high variability in shape and orna-

ment as type species *C. turriformis* STEPHENSON (1952, p. 155, pl. 36, figs. 30-36), and three forms were discriminated in it, namely, *neumayri* s.s., var. *angusta* and intermediate form (KOBAYASHI and SUZUKI, 1939). This species is rather similar to *neumayri* s.s. than to other forms in side view, but the depression on the side of the whorls is less prominent. It is distinguished from var. *angusta* in wider sutural depression and consequently in nallower intersticials between two spirals. The spiral angle of the present species seems to be somewhat smaller than that of *neumayri*. Exact comparison can hardly be done because of poor material. A specimen labelled as *Glauconia* n. sp. kept at Tohoku University, which was collected from the lower Aritan (upper Neocomian) Funagawara Formation of the Ofunato Group near Ofunato in Miyagi Pref., Northeast Japan, is referred to be conspecific with this species.

Occurrence: Obiraki-zawa, loc. 4. Reg. no. JM 11136.

Family Actaeonellidae

Genus *Trochactaeon* MEEK, 1863

Trochactaeon sp. aff. *T. crisimensis* CHOFFAT

Pl. 4, figs. 10, 11.

cf. 1895. *Trochactaeon crisminensis* CHOFFAT, p. 112, pl. 1, fig. 12-15.

Description: A nearly complete outer mould and many fragmental ones are obtained from Kanayama-zawa and Obiraki-zawa. Shell medium in size, 28 mm high and 11 mm wide, biconical turbinate; spire low, 6.5 mm high above the body whorl, consisting presumably of five whorls separated by weak suture which can hardly be recognized in the younger whorls; body-shorl large, occupying more than five sevenths of the total height, both sides are slightly convex and nearly parallel at the upper and middle part, but rather rapidly tapering at the lower part making a pointed base. Aperture very narrow and long; outer lip smooth within and inner lip provided with three parallel folds at the lower part. Surface entirely smooth.

Comparison: *Trochactaeon crisminensis* CHOFFAT described from the Aptian to Cenomanian of Portugal is most allied to this species in general shape and in dimensions. It differs only slightly in having somewhat step-like shoulder in spire. In this point this species is similar to *T. boutillieri* COSSMANN (1895, p. 149, pl. 4, figs. 18, 19; BRUNN, CHATELET and COSSMANN, 1916, p. 10, pl. 1, figs. 3-6) from the Barremian of France, but the former is much smaller in size and the body whorl gradually tapers downward.

Occurrence: Common at Kanayama-zawa and Obiraki-zawa. Reg. nos. JM 1133, 85, 86.

Family Cerithiidae

Genus *Procerithium* COSSMANN, 1902

Procerithium sp. indet.

Pl. 6, figs. 12-14.

Description: Shell small, turreted, elongate with medial spiral angle of about 20 degrees. Suture clearly incised, situated at the bottom of depression; protoconch not preserved; whorls 10 in number with moderately convex sides, ornamented with axial and weaker spiral ribs; axial ribs rather thick, regular in strength, extending from suture to suture, 8-10 in number on the whorls near the apex increasing to 14-18 in the body whorl, where the axials fade away adapically; on the early four or five whorls there are three primary spirals, inserted by one or two spiral striae in each interspaces, among which those between first and second primaries are stronger than the others; in later growth stage upper secondary spiral becomes as strong as primaries, and more spiral striae inserted between the lower secondary and second primary one; on the body whorl three primary spirals and four or five interstitial striae are observed on the lower or basal part of the whorl; whorl section oval; aperture not preserved.

As the specimens embryonal conch and aperture are not preserved in any specimens, the generic position is uncertain. No closely allied species is found.

Occurrence: Common at Kanayama-zawa and Obiraki-zawa. Reg. nos. JM 1189-91.

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Explanation of Plate 3

Figs. 1-7. *Bakevellia* (*Neobakevellia*) *ominensis* NAKAZAWA and MURATA, n. sp. .....p. 309

1a, b. Internal mould of right valve (a) and the compound rubber cast (b), holotype, Obiraki-zawa, Reg. no. JM 11131, ×1.

2. Internal mould of left valve, paratype, Kanayama-zawa, IGPS Coll. No. 85763, kept at Tohoku University, ×1.

3. Internal mould of immature left valve, paratype, Obiraki-zawa, Reg. no. JM 11133, ×1.5.

4. Compound rubber cast of the right external mould and ligament area of the left, paratype, Obiraki-zawa, Reg. no. JM 11134, ×1.

5. Gypsum cast of the immature, right external mould, paratype, Reg. no. JM 11137, ×1.

6. Internal mould of the immature right valve, paratype, Kanayama-zawa, Reg. no. JM 11140, ×1.

7. Compound rubber cast of the left external mould, paratype, Kanayama-zawa, Reg. no. JM 11152, ×1.

Figs. 8a, b. *Bakevellia* (*Neobakevellia*?) *tadai* NAKAZAWA and MURATA, n. sp. .....p. 310
Internal mould of left valve (a) and the gypsum cast (b), holotype, Obiraki-zawa, Reg. no. JM 11142,

Figs. 9-11. *Cuneigervillia quadrata* NAKAZAWA and MURATA, n. sp. .....p. 311

9. External mould of the full-grown left valve, paratype, Reg. no. JM 11148, ×1.

10 a, b. A part of external mould (a), internal mould of the preceding (b) attached with the opposite valve (c), paratype, Kanabori-zawa, Reg. no. JM 11145, ×1.

11 a, b. Right internal mould of immature right valve (b) and the compound rubber cast (a), hototype, Obiraki-zawa, Reg. no. JM 11143, ×1.

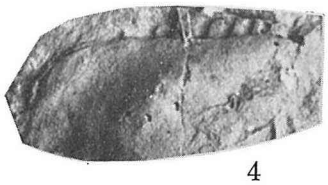
All the specimens without remark are kept in Geological and Mineralogical Institute, University of Kyoto.

1 a

1 b

2

×1.5 3



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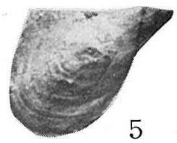

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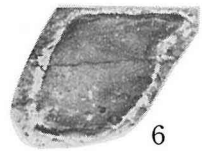

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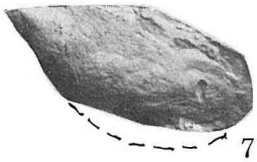

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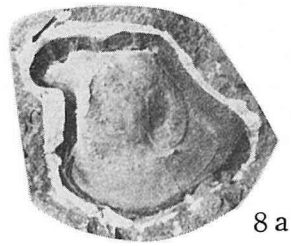
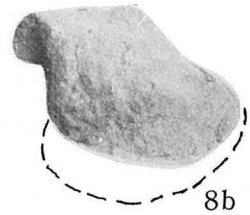


8 a



8b

9

11 a

10

11 b

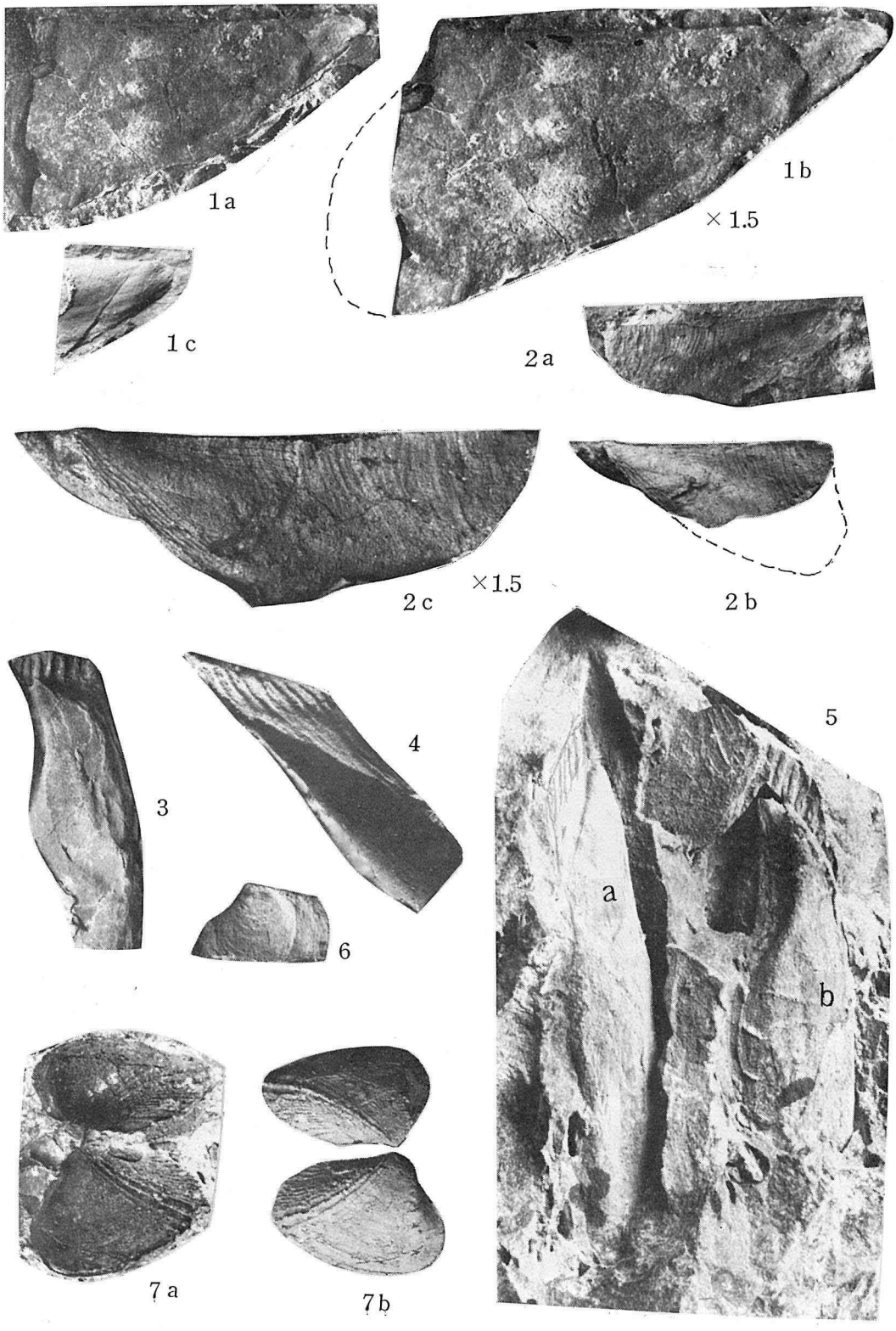
Explanation of Plate 4

Figs. 1a-c. *Waagenoperna elongata* NAKAZAWA and MURATA, n. sp. ..... p. 312
1a, b. Right internal mould, holotype, Kanayama-zawa, IGPS Coll. No. 85764, kept in Tohoku University, (a) ×1, (b) ×1.5.
1c. External gypsum cast of the umbonal part of the preceding, ×1.

Figs. 2a-c. *Pseudoptera* n. sp. aff. *P. viana* STEPHENSON. ..... p. 313
Left external mould (a) and the compound rubber cast (b ×1, c ×1.5), Obiraki-zawa, Reg. no. JM 11144.

Figs. 3-5 and 6?. *Isognomon* sp. indet. ..... p. 313
3. Left internal mould, Obiraki-zawa, Reg. no. JM 11149, ×1.
4. Compound rubber cast of the right internal mould in figure 5-a, ×1.
5 a, b. Internal mould of right (a, Reg. no. JM 11146) and left valve (b, Reg. no. JM 11147), Kanabori-zawa, ×1.
6. Compound rubber cast of the left external mould, Reg. no. JM 11187, ×1.

Figs. 7a, b. *Protocardia ibukii* NAKAZAWA and MURATA, n. sp. ..... p. 314
External mould of univalved specimen (a) and the compound rubber cast (b), holotype, Kanayama-zawa, IGPS Coll. No. 85765, kept at Tohoku University, ×1.


1a
1b
× 1.5
1c
2a
2c
×1.5
2b
3
4
5
a
b
6
7a
7b

Explanation of Plate 5

Figs. 1-4. *Protocardia ibukii* NAKAZAWA and MURATA, n. sp. ..... p. 314

1. Compound rubber cast of the right external mould, paratype, Kanayama-zawa, IGPS Coll. No. 85766, kept in Tohoku University, ×1.
2. Compound rubber cast of the left external mould, showing the posterior area, paratype, Kanayama-zawa, Reg. no. JM 11157, ×1.
3. Compound rubber casts of two internal right valves, Obiraki-zawa, paratype, Reg. no. JM 11154, ×1.
4. Compound rubber cast of the left internal mould, paratype, Kanayama-zawa, Reg. no. JM 11153, ×1.5.

Figs. 5-12, 15. "*Eomiodon*" *ominensis* NAKAZAWA and MURATA, n. sp. ..... p. 315

5 a,b. Right external mould (a, ×1) and the rubber cast (b, ×1.5), holotype, Obiraki-zawa, Reg. no. JM 11159.

6. Compound rubber cast of the left external mould, paratype, Obiraki-zawa, Reg. no. JM 11161, ×1.5.

7, 8. Compound rubber-cast of holotype, anterior view (7) showing lunule and posterior view (8) showing escutcheon, Obiraki-zawa, Reg. no. JM 11162, ×1.5.

9 a, b. Right internal mould (a) and the compound rubber cast (b), paratype, Kanayama-zawa, Reg. no. JM 11163, ×1.5.

10. Compound rubber cast of the right external mould, paratype, Kanayama-zawa, Reg. no. JM 11164, ×1.5.

11, 12. Two external rubber casts of right valves, paratype, Obiraki-zawa, Reg. no. JM 11165, ×1.

15. Compound rubber cast of the left external mould, paratype, Kanayama-zawa, Reg. no. JM 11166, ×1.5.

Figs. 13, 14. *Filosina* sp. aff. *F. jusanhamensis* HAYAMI ..... p. 317

13 a, b. Left internal mould (a) and the compound rubber cast (b), Obiraki-zawa, Reg. no. JM 11171, ×1.5.

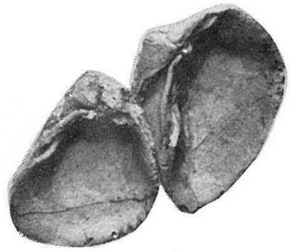
14a-c. Left internal mould (b, ×1.5), the compound rubber cast (c, ×1.5) and rubber external cast (a, ×1), Obiraki-zawa, Reg. no. JM 11160.

Figure 16. *Cuneigervillia quadrata* NAKAZAWA and MURATA, n. sp. ..... p. 311

Right internal mould of immature specimen, Obiraki-zawa, Reg. no. 11148, ×1.

1

2



3

4 ×1.5

5 a

5 b ×1.5

6 ×1.5

7 ×1.5

8 ×1.5

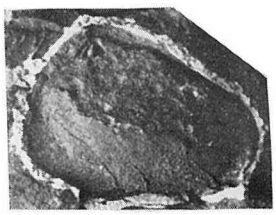
9 a ×1.5

9 b ×1.5

10 ×1.5

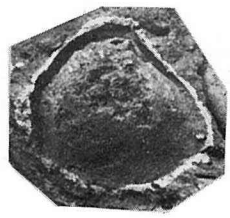
11

12



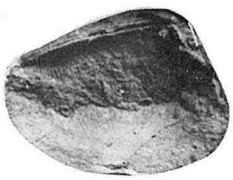
13 a

14 a



14 b

14 c



13 b

15 ×1.5

16

Explanation of Plate 6

Figs. 1a, b. *Venilicardia*? sp. indet. ..... p. 318
Right internal mould (a) and the compound rubber cast (b), Kanayama-zawa, Reg. no. JM 11174, ×1.

Figs. 2a, b. *Pleuromya*? sp. indet. ..... p. 318
Right internal mould, lateral view (a) and dorsal view (b), Obiraki-zawa, Reg. no. JM 11175, ×1.

Figs. 3. *Modiolus* sp. indet. ..... p. 17
Right internal mould, Obiraki-zawa, Reg. no. JM 11181, ×1.

Figs. 4, 5. *Liostrea* (*Liostrea*) sp. indet. ..... p. 319
4. Right internal mould, Kanayama-zawa, Reg. no. JM 11176, ×1.
5. Compound rubber cast of the left external mould, Kanayama-zawa, IGPS Coll. No. 85767, kept in Tohoku University, ×1.

Figs. 6, 7. *Lopha* sp. indet. ..... p. 320
6. Right? external rubber cast, Kanayama-zawa, Reg. no. JM 11178, ×1.
7. Compound rubber cast of the left valve, Kanayama-zawa, Reg. no. JM 11179, ×1.5.

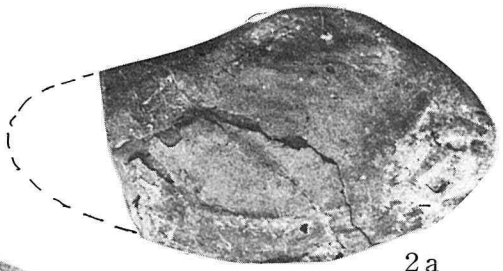
Figs. 8a-c. *Nerinea* (*Nerinea*) sp. indet. ..... p. 320
Compound rubber cast of the external mould (a, ×1), the internal mould (b, ×1) and its cross-section (c, ×1.5) showing inner folds, Kanayama-zawa, Reg. no. JM 11184.

Figs. 9a-c. *Craginia* sp. cf. *C. neumayri* (NAGAO) ..... p. 321
Compound rubber cast of the external mould viewed from three different directions, Obiraki-zawa, Reg. no. JM 11136, ×1.

Figs. 10, 11. *Trochactaeon* sp. aff. *T. crisimensis* CHOFFAT. ..... p. 322
10. Compound rubber cast of the external mould, Obiraki-zawa, Reg. no. JM 11133, ×1.
11. Compound rubber cast of the external mould of the basal half, Reg. no. JM 11185 ×1.

Figs. 12-14. *Procerithium*? sp. indet. ..... p. 323
12. Compound rubber cast of the external mould (a, ×1) and (b, ×1.5), Obiraki-zawa, Reg. no. JM 11189.
13,14. Two external rubber casts, Kanayama-zawa, Reg. nos. JM 11190 (13) and 11191 (14), ×1.

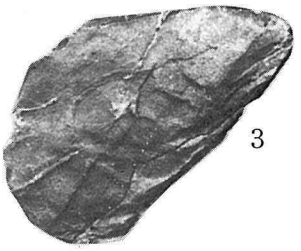
1 a



2 a

1 b

2 b



3

4

5

6

7

8 a

8 b

8 c ×1.5

9 a

9 b

8 c

10

11

12 a×1.5

12 b

13

14