THE SAND-PIPE, CREATED BY THE PELECYPODS: *Platyodon nipponica* n. sp. and *Pholadidea* (*Penitella*) *kamakurensis* (YOKOYAMA).

By

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(With 5 plate and 7 Text-Figure)

(Contribution from the Department of Geology and Mineralogy, Faculty of Science, Hokkaido University, Sapporo; No. 638)

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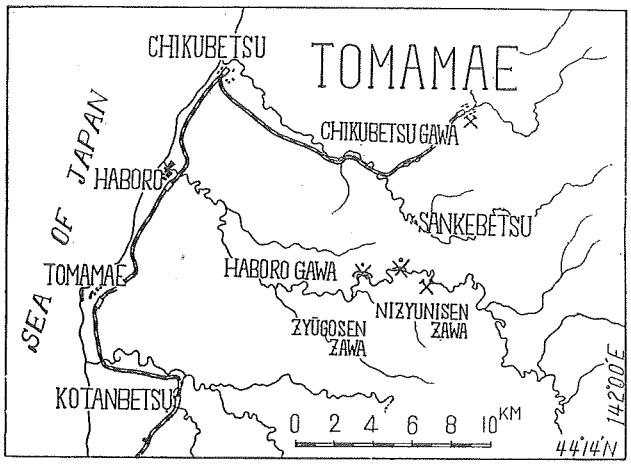
I. Introduction

A few years ago, YUKIO HATTORI and YASUKUNI HURUHATA collected molluscan fossils from the Miocene deposits, developing at the upper course of the Haboro-Gawa (River), north of Rumoe City, Hokkaido. They kindly submitted their specimens to the present writers for study.

Among the collections there was a specimens, greatly attracting the writers' attention, namely a sand-pipe of long club-like form, containing some peculiar pelecypods. Unexpectedly, one of these pelecypods agrees



Text-Fig. 1. Map showing the fossil localities in the Haboro Coal-field.

generically with the genus *Platyodon*.

So far as the writers are aware, only a single species belonging to the genus *Platyodon* has previously been known; *Platyodon cancellata* (CONRAD), and this species has been found to be confined to a relatively limited area, the sea of California. Meanwhile, the same species being referable to the genotype, has later, also been discovered from the Tertiary deposits in California and Western Canada, ranging from the Oligocene to the Pliocene as well as Pleistocene deposits. Except these, no species assignable to this genus, including the genotype has ever been found in the water or from Tertiary deposits of any other country until the present day.

Therefore, the new finding of this genus in Hokkaido may be by no means unimportant from the viewpoint of palaeozoogeography, although the specimens, now in hand may be a new species.

Further, the writers have regarded the particular state of preservation of these shell remains now in hand, to be of much interest in considering the ecological environment of this species.

In 1955, the writers engaged in a field survey of Haboro District from the viewpoint of palaeoecology; many specimens were collected with the assistance of the Haboro Railway Coal-Mining Co., Ltd.

From the results of this observation, the writers have found, they believe, interesting data which throw light on the mode of the occurrence of the sand-pipes and on the relation existing between the sand-pipes and shell remains of pelecypods: namely the writers believe that such sand-

pipes are the fossils of "*Lebenspuren*": they are the trails of the inhabitations of some kinds of pelecypods.

Although the study is now still in progress, the present writers wish to report these interesting occurrences of the sand-pipes and the species of the pelecypods contained in them. Then as a further result of the field study, the writers, in the summary, will discuss the process of the creation of the sand-pipe in view of sedimentary and palaeoecological considerations.

Before going further, the writers wish to record the warmest thanks to Professor MASAO MINATO of the Institute of Geology and Mineralogy, Hokkaido University, for kind suggestions in connection with the present study and for looking over this short note. Acknowledgements are also due to Mr. Y. HATTORI, a geologist of the Haboro Coal-Mining Railway Co., Ltd. and Y. HURUHATA, also a geologist of the same company at the time of the field observation work, for giving facilities for the collection of the specimens.

II. General stratigraphic succession of the Haboro Coal-field

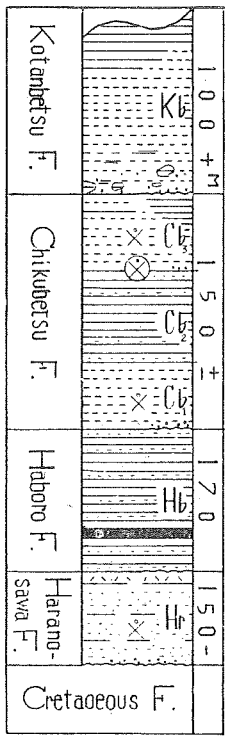
The Haboro coal-field is situated in the western part of central Hokkaido. In this district, the Cenozoic formation consists of strata belonging to the geologic ages from Miocene to Pliocene, which are directly underlain by Cretaceous formation. The general stratigraphic succession is as follows.

Pliocene .....Mochikubetsu formation

Miocene ....
- Kotanbetsu formation
- ---------- local unconformity
- Chikubetsu formation
- ---------- local unconformity
- Haboro coal-bearing formation
- ---------- local unconformity
- Haranosawa formation

---------- Unconformity

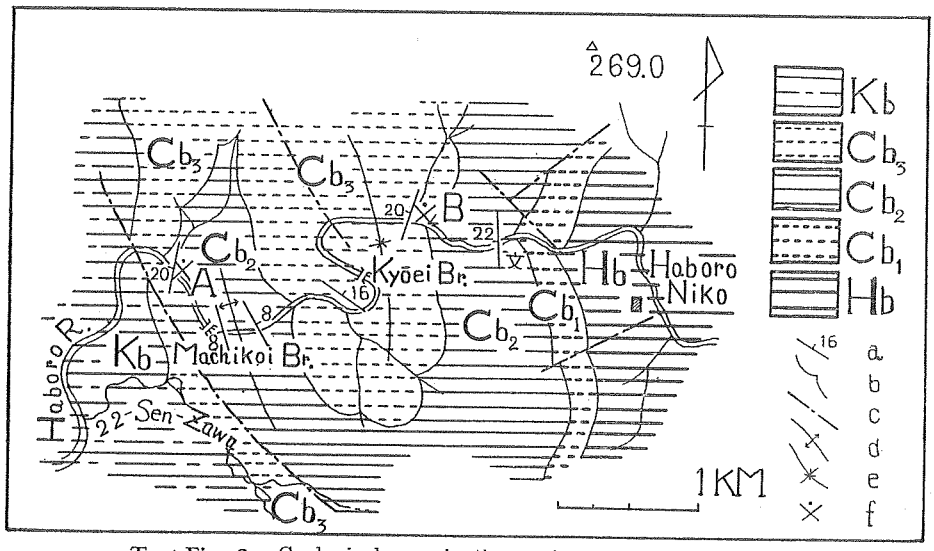
Cretaceous formation



Text-Fig. 2. Generalized columnar section.

Of the above, the Haboro coal-bearing formation, exposed along the Haboro-Gawa in the eastern portion of this region and the Kotanbetsu formation in the western portion, are both distributed monoclinally with low angles (10°–). The Chikubetsu formation is widely exposed in the central regions and folded with two axes trending nearly N–S. Their distribution is illu-

strated in Text-Figure 3.



Text-Fig. 3. Geological map in the environs of fossil localities.

The fossils and sand-pipes now in problem are observed to be contained only in the Chikubetsu formation.

Detailed description of the Chikubetsu formation.

The Chikubetsu formation is marine in origin. It is widely found in the Haboro coal-field. It is directly overlain by the Kotanbetsu formation and underlain by the Haboro coal-bearing formation.

This formation consists mainly of fossiliferous tuffaceous sandstone and dark grey mudstone which are intercalated by a coarse sandstone or fine conglomerate. From its lithologic characters it has been subdivided into three parts as a result of the work Messrs. HATTORI and HURUHATA: they are Upper, Middle and Lower parts of the Chikubetsu formation.

a) Lower part (Cb_1) . . . . The lower part of this formation consists of the fossiliferous medium or coarse grey tuffaceous sandstone and is directly underlain by the Haboro coal-bearing formation with local unconformity.

b) Middle part (Cb_2) . . . . The next strata above the lower part, are almost entirely dark grey unstratified mudstone, which is sometimes intercalated by thin beds of sandstone, especially in its upper-most part, and by conglomerate near its base. This Middle part is bare of fossils.

c) Upper part (Cb_3) . . . . The uppermost part consists of light grey massive fine or medium sandstone, containing many marine molluscan fossils.

This present fossils, treated in this paper, have been collected from the beds near the boundary between Cb_2 and Cb_3.

Geologic age of the Chikubetsu formation.

The Chikubetsu formation is characterized by the so-called "Chikubetsu fauna", which was first discussed by M. YOKOYAMA (1927) under the name of the "Haboro-Chikubetsu fauna". It is present known that the Chikubetsu formation bears many marine molluscas together with teeth of *Desmostylus*, from which facts, the writers are inclined to conclude that the Chikubetsu formation may be contemporaneous with the Kawabata formation in the Ishikari coal-field, Hokkaido, and the Kadonosawa formation, Iwate Prefecture. That is to say, this formation is correlated, surely, to Middle Miocene in age.

The following are some common species of this fauna: *Solemya tokunagai* YOK., *Yoldia* (*C.*) *notabilis* YOK., *Yoldia bremis* UOZ. (MS), *Portlandia* (*P.*) *watasei* (KAN.), *Acila gottschei* (BÖHM), *Mytilus grayanus* DUNK., *Venericardia magaribuchiensis* UOZ. (MS), *V. akagii* KAN., *Thyasira bisecta* (CONRAD), *Fulvia mutica* (REEVE), *Nemocardium yokoyamai* TAK., *Papyridea haboroensis* UOZ. (MS), *Serripes fujiensis* (YOK.), *S. groenlandica* (BRUG.), *Spisula onnechiuria* (OT.), *Macoma optiva* (YOK.), *Peronidea t-matsumotoi* OT., *Panope japonica* (AD.), *Mya cuneiformis* (BÖHM), *M. truncata* LIN., *Pholadidea* (*P.*) *kamakurensis* (YOK.), *Periploma besshoensis* (YOK.), *Trochocerithium wadanum* (YOK.), *Phalium onishibetsuensis* OT., *Neptunea oomurai* OT., *Buccinum* sp., *Psephea antiquior* TAK., *Trophonopsis felix* (YOK.), etc.

III. Observations in the outcrop from the lithologic viewpoint

The exposures along the Haboro-Gawa at the two points A and B, shown in Text-Figure 3, exhibit many sand-pipe zones with the following lithologic facies.

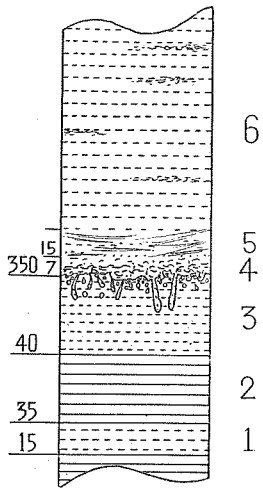
a) A-point: Outcrop at about 500 m. down stream from the Matikoi-bashi over the Haboro-Gawa.

Here, the middle part (Cb_2) of the Chikubetsu formation with its alternation of sandstone and mudstone, is exposed for a 100 m. width at the eastern part of its outcrop. It is overlain by massive fine sandstone (Cb_3) in the west 50 m. The detailed lithologic succession in fossil zones is shown in Text-Figure 4: namely:

Cb_3 {
- Pale greenish grey massive fine sandstone, which is intercalated by thin fossils beds, scattered mudstone, coal fragments and fine pebbles....300 cm
- Greenish grey medium or fine sandstone, which is intercalated by thin laminated mudstone containing at certain places shell fragments and fine pebbles ..... 15 cm
- Light grey hard medium sandstone containing many marine molluscus, mudstone and coal fragments, and fine pebbles in irregular arrangement ..... 7 cm

Wave-cut surface

Cb_2 {
- Loose greenish grey massive fine sandstone containing the sand-pipes which are treated in this paper ..... 40 cm
- Dark grey mudstone..... 35 cm
- Light greenish grey hard medium sandstone .... 15 cm



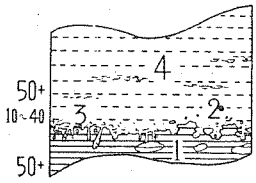
Text-Fig. 4.
The columnar section at the outcrop of A-point.

b) B-point: Outcrop and river floor to the right side 1500 m up-stream from the Kyoei-bashi of the Haboro-Gawa.

This outcrop is situated on the eastern wing of the Kyoei-bashi syncline. At this point, the Chikubetsu formation belonging to Cb_2 and Cb_3 is excellently exposed along the river side for about 150 m; the former of which (Cb_2) is composed of alternation of sandstone and mudstone, while the latter mainly consists of massive sandstone. These beds strike in N 10°～20° E direction with slightly westward dip.

The detailed lithologic succession is as follows:

Cb_3 {
- Greenish coarse sandstone, sporadically containing molluscan remains, together with fragments of mudstone, coal and also small pebbles ..... 50 cm
- Mostly conglomerate with round or subangular pebbles or greenish coarse sandstone containing flakes of marl, fragments of fossils and pebbles in irregular arrangements ..... 40 cm
- But in places the writers find thin sandstone layer about 10 cm in maximum thickness between two beds as stated above, which is composed of greenish massive coarse sandstone, sporadically containing molluscan remains in good preservation, together with fragments of mudstone and coal and also small pebbles.



Text-Fig. 5.
The columnar section at the outcrop of B-point.

Wave-cut surface

Cb_2 {
- Dark grey massive mudstone containing sand-pipes, and intercalated by thin marl layer..... 50 cm

IV. Observations in the outcrop from the palaeontological viewpoint

Description of the sand-pipes.

Generally speaking, the sand-pipes are observed to be positioned almost perpendicular or nearly so to the bedding plane. Their form is long club-like: the one part is relatively narrow becoming gradually wider toward the other part. They are distinguishable into two forms (I- and II-form), by the characters of their form, filling material and the mode of their occurrence.

I-form (Plate 3, Figures 4, 5)

Sand-pipe, rather, large, attained about 14–20 cm. in length; long club-like in outline; the direction of its length, straight, not bent as the one of II-form; one side (upper part) relatively narrow, and gradually expanded towards the other side (lower part) which is closed and rather sharply rounded in its end; the distal portion of upper part is usually observed to be quite ambiguous and tends gradually to the sediment (Cb_3) without any sharp boundary therein; its cross section heart-shape throughout the entire length; the furrow on the dorsal part, running from upper end to lower end, shows V-shape in its bottom and is sunken deeply on a half of upper part and more feebly on that of lower part; ventral margin nearly straight but slightly convex near the lower end; dorsal margin feebly convex in a half of the lower portions. The surface smooth without any sculpture.

II-form (Plate 3, Figures 1-3)

II-form, medium or small in size, long club-like or flask-shape in outline; upper part generally very narrow, (smallest diameter about 5 mm.) and expanded toward the lower end which is closed and regularly rounded; upper end open and continued to the covered layer; longitudinal axis of the sand-pipe bent bluntly midway of its length; its cross section circular without regard to size of diameter; surface smooth.

This form is easily distinguishable from I-form by its circular cross section, and bent longitudinal axis.

Dimensions (in cm):—

	Length	Diameter		Angle between the axis of the sand-pipe and bedding plane
		Largest	Smallest	
I-form:	21.2	6.3	2.1	80
	20.1	4.7	—	75
	17.1	5.8	—	—
	16.5	6.2	—	—
	15.5	3.8	—	—
	12.4	6.2	—	—
	11.3	3.6	—	80
	16.5	4.5	—	70
	14.5	6.0	—	60
	11.3	3.8	—	80
	10.0	4.5	—	70
II-form:	12.6	3.6	—	70
	10.1	3.0	—	75
	10.0	3.0	—	—
	8.4	1.9	—	70
	16.0	3.5	—	70
	12.3	3.3	—	43
	12.0	3.3	—	60
	11.5	2.6	—	85
	11.5	2.6	—	70
	11.0	3.4	—	65
	10.0	2.5	0.5	80
	9.5	2.5	0.7	65
	9.0	1.5	0.5	74
	—	2.1	—	68
	8.2	2.6	—	62
	—	1.4	0.2	75
	7.0	2.5	—	70
	5.7	1.5	0.3	62
	3.5	0.8	—	70
	—	0.8	0.6	80

Comparison:—The sand-pipes previously reported from Japan, are very few in number; they are as follows:

1) One, created in origin by *Decapoda*....Suenomatsuyama formation (S. NOMURA et K. HATAI, 1936).

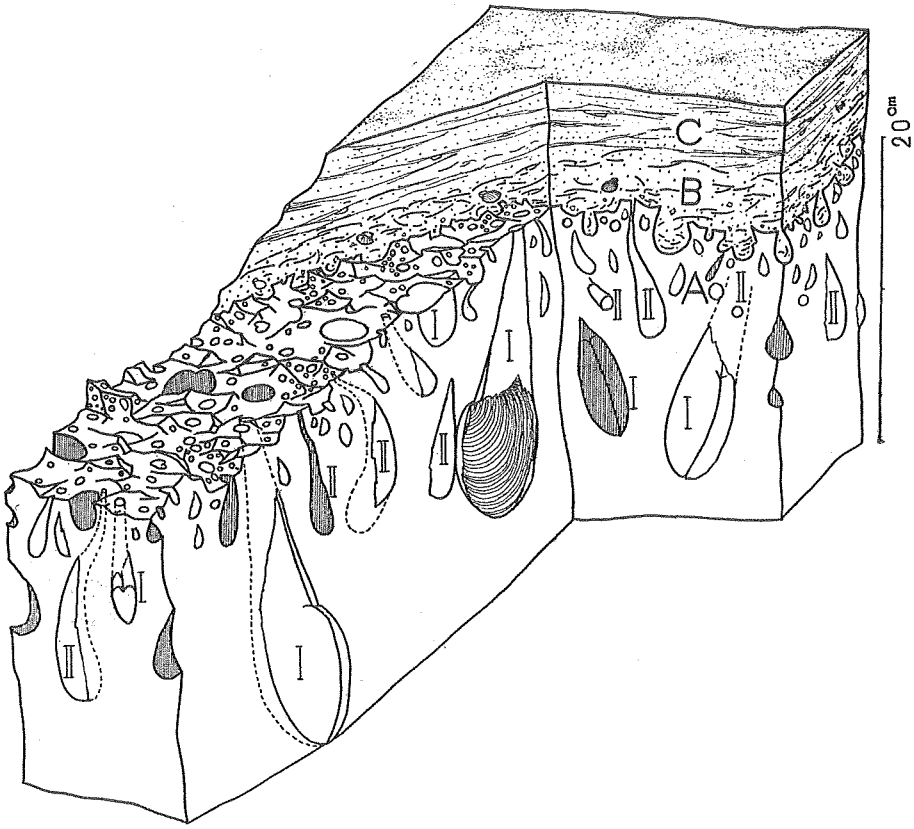
2) One created in origin by *Polychaeta*....Hatatate formation (K. HATAI, 1951); and Akabira formation (J. ARAI, 1955).

3) Unknown in origin....Yanagawa shell beds (S. NOMURA et K. HATAI, 1937); and Glauconitic sandstone (I. HAYASAKA, 1935).

4) One, containing pelecypods: *Mya*, *Cardium*, and *Venericardia*. ....Wakimoto formation, Byoritsu formation (K. HATAI, 1938).

5) One, collected from sea-bottom.... (H. NIINO, 1933, 1952).

These sand-pipes as stated above are either U-, V-, Y-, or I-shape in outline. Generally both ends are open or unknown, so that they are easily distinguishable from the present specimens in form. Moreover they differ in respect to the filling material and the mode of occurrence of the latter.



Text-Fig. 6. Idealized diagram illustrating the mode of occurrence of the sand-pipes.
A: Rock of mudstone of fine sandstone; I: The sand-pipe of I-form;
B: Rock of fossilifereous sandstone; II: The sand-pipe of II-form.
C: Rock of massive medium sandstone:

The material filling the sand-pipe.

The sand-pipes consist generally of fine or medium sandstone, containing many scattered shells and coal fragments, but upon strict observation, the sand-pipes may be distinguished into two parts (upper and

lower) from the characters of the filling material. The lower part includes shell remains which are almost in a complete state of preservation. In this part, the sand material which usually may be exfoliated, covers thinly the surface of the shells and the inner space of the shells is filled with coarse-grained sand like that in covering layer (Cb_3). The upper part is also filled with coarse-grained sand. However, in many cases, the material of the upper part is finer than that of the lower part.

The relation between the mother rock and the sand-pipes.

In the outcrop at A-point, the material which forms the sand-pipes is seemingly quite indistinguishable from the mother rock, as a whole. However, the material of the former is generally composed of more coarse grained compact sand, while that of the latter is very fine sand which is somewhat more loose than the former. Besides, in the outcrop at B-point, the mother rock is entirely mudstone and the mother rock is different from the material of the sand-pipes which consist of sandstone like the ones at A-point.

Furthermore, there is a discontinuous plane between a sand-pipe and its mother rock, so that the sand-pipe is easily separable from the mother rock. However, there cannot be recognized any clear boundary or special wall between them, although there is a thin layer (-1 mm.) which is usually tinged to red-brown in colour.

The preservation of the sand-pipes.

The sand-pipes are included in mudstone or fine sandstone of Cb_2, and generally are observed to be positioned almost perpendicular to the bedding plane (about $70° \sim 90°$). It may be safely concluded that the preservation is generally very good. However, it is remarkable that the upper part of some are occasionally in poor condition, in spite of the fact that the lower parts of all specimens are always very well preserved. Some specimens of all lengths have lost up to 2/3 of the upper parts. Furthermore, it is occasionally found that the test of shell, included in the lower part of a sand-pipe, is broken or dissolved, even if the outline of the sand-pipe is completely preserved.

On the other hand, the number of individuals which are yielded on 2 meters of line are totally 77, and those of II-form are remarkably abundant comparing with those of I-form: the ratio of individual number of I-form to those of II-form is about 1/5–1/10.

The mutual relations of the respective sand-pipes.

In both A- and B-points, some sand-pipes were noticed intercrossing

with each other. There are two different sorts of intercrossing: one sort is where I-form is intercut by II-form and the other where II-form is intercut by another individual of the same form.

1) Where I-form is intercut by II-form (Pl. 1, Fig. 1)

II-form which stands close to I-form in the upper part, bends at about 90° towards I-form in the midst of its length, and perforates from the ventral to the dorsal side of I-form at a point 8 cm. above the lower distal end of the I-form.

2) Where II-form is intercut by another pipe of the same form.

One of II-form is intercut by another sand-pipe of the same form at a point 15 cm. from the lower end. (Pl. 1, Fig. 2)

3) However, it is remarkable that II-form is never intercut by I-form.

Pelecypods, contained in the sand-pipes.

Just as there are two different forms of the sand-pipes, so is there a difference in the shells contained in the sand-pipes: one is *Platyodon nipponica* n. sp. in the sand-pipe of I-form and the other is *Pholadidea* (*Penitella*) *kamakurensis* (YOKOYAMA) in the II-form.

Genus *Platyodon* CONRAD 1837

Platyodon nipponica UOZUMI et FUJIE n. sp.

Plate 4 Figures 1–6, Plate 5 Figures 4–6.

Shell medium in size, ventricose; subquadrate in outline; decidedly inequilateral; beaks situated near posterior end and spirogyrate; anterior dorsal margin very long, nearly straight and gradually merges into regularly rounded anterior end, which in turn merges into a very broadly rounded ventral margin; ventral margin parallel to anterior dorsal margin and sloping upwards rapidly to the anterior end; posterior dorsal margin very short, sloping down from the beaks very sharply at first and then much more gently to the posterior end, which is sharply truncated and gapes; the beaks worn away by rubbing against the opposite valve. Surface ornamented with distinct lamelli-form growth lines which are jagged slightly and irregularly; pallial sinus, extending deep into the shell a distance of one-half the length of the shell; pallial line indistinct. Chondrophore of the left valve, small very concave and trigonal spoon-shape, divided into three parts by anterior and posterior ridges: posterior ridge short, prominent and smaller than that of typical *Mya*; anterior portion

broadly flattened, and distinctly separated from the anterior margin by a deep furrow, incised horizontally below the margin of front of the umbo; posterior portion which is rather small trigonal, deeply concaved. The whole surface of chondrophore ornamented with fine concentric striae. In the right valve, chondrophore small semi-circular, hidden under the umbo; a peculiar denticle existing between chondrophore and posterior margin, somewhat produced, and trapezoidal.

Dimensions (in mm):—

	Length	Height	Thickness
U. H. Reg. No. 12146 (Holotype).	72.1	52.2	48.7
12147 (Paratype).	75.0	58.9	50.6
12148 (Paratype).	83.5	65.0	61.7
	58.8	39.7	45.0
	52.1	33.4	29.4

Type locality:—The right outcrop about 12 km. upstream of the Haboro-Gawa, Haboro-Machi, Tomamae-Gun, Teshio Province as shown in Text-Figure 1.

Repository:—U.H. Reg. No. 12146, 12147, 12148, 12151–12180, 12206. (U.H. = Department of Geology and Mineralogy, Faculty of Science Hokkaido University, Sapporo.)

Comparison:—This species apparently resembles the genotype of the genus, Platyodon cancellata as is represented in CONRAD (1837), GRANT and GALE (1931), WEAVER (1942) and other, but is specifically different from it in certain respects. Firstly, the present species is higher, more convex and more inequilateral than the California species. Secondly, the posterior truncate margin is proportionally shorter in the Japanese shell.

Remarks:—The Recent species of this genus which had ever been included under the genus *Mya* is an animal with armour on the siphonal end as in *Mya truncata*. It is said to bury itself in the heavy clay and sand in the low-water levels of the littoral zone. The distribution of genus *Platyodon* has been limited narrowly until recently, in both living and fossil state.

According to CONRAD (1837), DALL (1898), GRANT and GALE (1931), and WEAVER (1942), in living state, it has the following distribution: Sook Bay, Vancouver Island and Baulinas Bay, Middle California, to San Diego. In fossils state, this genus occurs in the following localities: in sea cliff between the mouths of Muir and Kirby creeks, West of Otter Points; Sooke Bay Vancouver Island (Upper Oligocene?); Santa Margarita San Pablo of Middle California (Miocene); Upper San Pedro series

of Deadman Island, San Pedro, and vicinity Los Angeles Co. near Goleta, Santa Barbara Co. (Pleistocene).

Accordingly, the discovery of *Platyodon* from Hokkaido may suggest that this genus was once distributed on both sides of the Northern Pacific Ocean.

Genus *Pholadidea* TURTON 1819

Pholadidea (*Penitella*) *kamakurensis* (YOKOYAMA)

Plate 5 Figures 1–3

1922 *Jouannetia kamakurensis* YOKOYAMA: Jour. Coll. Sci. Imp. Univ. Tokyo, Vol. 44, p. 120, pl. 6, fig. 10.

Shell medium in size, ovate, posterior part longer than anterior one, and obliquely separated from the latter by a broad sulcus which is running from the beaks to the middle of the ventral margin; anterior parts circular, and ornamented with crowded, elevated, and undulated concentric laminae, and moreover decussaled by acutely radiated ribs which are arranged in pairs; anterior ventral gaping, but mostly covered by callum; anterior dorsal margin reflected in front of the beaks; posterior margin rounded, sub-cuneiform in outline, and its surface ornamented by somewhat rough and concentric sculpture with intersecting lines. Accessory plate exists on the anterior dorsal margin; the two parts of the protoplax confluent; the mesoplax rounded posteriorly.

Dimensions (*in mm.*):—

Length	Height	Thickness
63.8	35.5	33.4
58.2	32.6	30.4
57.2	34.4	?
45.5	23.4	?
42.8	20.0	?
39.9	19.8	20.0

Repository:—U.H. Reg. No. 12138, 12141, 12143–12145, 12149–12150, 12181–12208.

Remarks:—Genus *Pholadidea*, together with such genera as *Barnea*, *Zirfaea*, *Martesia* and *Parapholas*, are called as a "Boring shell". It has seemed that these boring shells usually bore mechanically or chemically in the soft rocks of the shallow sea such as sandstone, shale, mudstone, coal and tuff. That is to say, the boring is effected by a mechanical activity of

a bivalve and by slight chemical secretions at the same time.

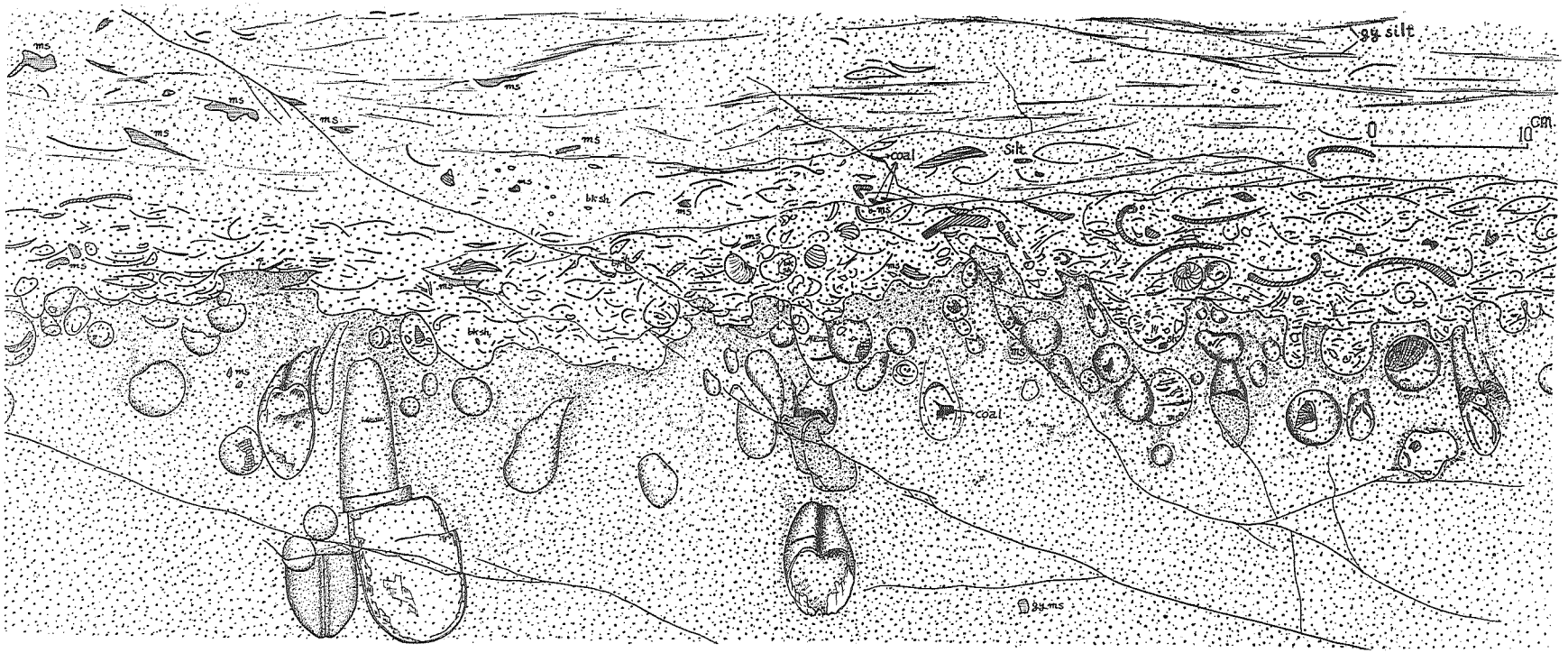
C. M. YONGE (1949) has observed and reported on the boring activity of *Pholas* and *Pholadidea* which are now living in England: "Boring is effected by alternate contractions of the two adductor muscles running between the front and hind halves of the shell valves. The absence of a ligament and the presence of the ball joint permits a sea-saw movement of the valves. The normal opening and closing action of the typical bivalve is not needed when the animal is already well protected in a deep rock burrow. The teeth on the shell are largely restricted to the front half of the valves so that when these are pulled apart by contraction of the hinder adductors the teeth rasp the surface of the rock and boring proceeds. During this laborious process the animal continually alters the position of the foot, turning first to one side and then to the other, so that an even round-bore hole is cut with slow efficiency through the rock."

On the other hand, remarkable notes discussing the problem of some recent animal "*Lebenspuren*" in the sea shore of Japan, has been published recently by S. UTASHIRO and K. SUYAMA (1953, 1955). In their paper, the features and shape of the boring cavity have been described.

Taking these reports into consideration, the present writers feel assured that the method of boring activity and the ecology of the present fossil species do not coincide with those of the creature treated in YONGE's report nor with recent *Pholadidea*, but are not far from those of them, though the present specimens are of a Miocene animal.

The mode of occurrence of Pelecypods.

Generally speaking, the available specimens now at hand were obtained from sand-pipes, containing shell remains. In this case there was found a shell which is almost in perfect state of preservation in the expanded lower part of the sand-pipe. The direction of the greatest length of the shell (anterior-posterior) is nearly coincident with the elongation of the sand-pipe. Furthermore, pelecypods are noticed standing upright with the siphonal ends pointed upwards in relation to the lay of the strata. Especially, in the I-form of the sand-pipe, the heart shape of its cross section represents the shape of the cross section of the shell, *Platyodon nipponica* in the lower parts of the sand-pipe. Further, the point of the heart shape is positioned in one side from the upper end to lower one, thus in the opposite side of the sand-pipe, a V-shaped concavity appears along the pipe, and this concavity is observed to face always to the beaks of the shell at the bottom of the sand-pipe.



Text-Fig. 7. Sketch of one part of the exposure (A-point), at about 12 km. upstream of the Haboro-Gawa, Haboro-Machi, Tomamae-Gun, Teshio Provice.

This shows the assemblage of molluscan remains, together with the mode of occurrence of the sand-pipes.

V. Summary of the evidence from the detailed stratigraphic and palaeontologic observation

Briefly, the result of observations concerning the sand-pipe can be outlined in the following few sentences.

1) The sand-pipes are yielded from the beds near the boundary between Cb_2 and Cb_3. Strictly speaking, they extend vertically downwards from the wave cut surface to the uppermost bed of Cb_2.

2) The mother rocks containing the sand-pipes are not always of the same material: it is sandstone at A-point, and mudstone at B-point. Besides, the sediments of Cb_3, covering the mother rock are composed of sandstone in the outcrops of both A- and B-points.

3) The sand-pipes are long club-like in form, being expanded towards the lower portion, and are noticed standing almost vertically to the bedding planes. They are open at the top and rounded at the bottom.

4) The sand-pipes are divided between two different forms from the characters of the outline, the filling material and the mode of occurrence: one (I-form) is heart shape in cross section, contains the shell of *Platyodon nipponica* and stands at 70°–80° angles to the bedding plane, while the other (II-form) shows circular in cross section, contains *Pholadidea* (*Penitella*) *kamakurensis* and stands at various angles to the bedding plane.

5) The shells contained in the sand-pipes are found always in the expanded bottom of it, and the direction of the length of shell shows to be parallel to the elongation of the sand-pipes, with shiphonal end pointing upward. It is suggested that such shell remains have been buried alive *in situ* at the bottom of the creature's inhabitation.

6) Some sand-pipes are occasionally intercrossed by others; in the one case, the sand-pipe of I-form is intercrossed by one of II-form, and in the other a II-form specimen is intercrossed by the same form. However, it is remarkable that there is not any evidence at all that a II-form is intercrossed by I-form.

7) The stratigraphical relation between Cb_2 and Cb_3, show that there probably was an erosion interval, because some sand-pipes are observed to be partly eroded prior to the deposition of the covering bed of Cb_3, the boundary plane between two beds shows uneven surface, and moreover the rock fragments of Cb_2 are mingled into the overlying layer (Cb_3).

VI. Considerations on the foregoing evidence

From the observation above stated, it is suggested that there may be some interesting relations between the sand-pipes and the shell remains, and between the sand-pipes and their surrounding sediments.

1) From evidences 3) and 5), the writers feel assured of the conclusion that the sand-pipes with these shell remains, were created in origin by the burial of burrows on the bottom where *Platyodon nipponica* and *Pholadidea* (*P.*) *kamakurensis* were living. In other words, the sand-pipes are the fossils of burrow cavities with the pelecypods that made them buried *in situ* at the bottom of their inhabitations.

2) If the ecology of fossil *Platyodon* and *Pholadidea* were similar to that of recent species of these genera, the former which excavated the tubular cavities of I-form, may be regarded as being an animal of heavy clay or sand burrowing form, while the latter may be regarded as organisms which have excavated the inhabitation of II-form in solid rock which was near enough sea-level so that they could attack it.

3) If that is really so, the writers are strongly inclined to regard the relation of intercross of II- and I-form of the sand-pipes as representing the lapse of time when I- and II-form had been excavated by each of the pelecypods respectively rather than the effect of some other condition. Namely, it is reasonable to say that *Pholadidea* have excavated in solid rock shore, after the time when the sediments of sea-bottom where *Platyodon* lived, had solidified.

4) The wave-cut surface lying between Cb_2 and Cb_3, represents some erosion interval, after the deposition of Cb_2 and Pre-Cb_3, and during this time interval, the following events might have been in progress: inhabitation of *Platyodon* on the deposit of $Cb_2 \rightarrow$ their death and burial $\rightarrow$ solidification of the deposit of Cb_2, and fossilization of the sand-pipes of I-form and *Platyodon nipponica* $\rightarrow$ inhabitation of *Pholadidea* (*P.*) *kamakurensis* on the rocky shore until the beginning of deposition of Cb_3.

VII. Tentative conclusion as to the process of the creation of the sand-pipe

If the presumption above stated, were really true, it may be safe to say that the sand-pipes were created as results of the following sequences.

[Sea-bottom]	[Sediments]	[Animal and fossils]
Muddy or sandy shoes	Deposits of the sediments of Cb_2	Inhabitation of *Platyodom nipponica* on sea-bottom
	Filling the burrow of *Platyodon nipponica*	Death of *Platyodon*
Rocky shore	Solidification of the sediments of Cb_2	Fossilization of I-form of the sand-pipe and shell of *Platyodon*
	Erosion	Inhabitation of *Pholadidea* and excavation of its habitation
	Filling the excavation of *Pholadidea*	Death of *Pholadidea*
Sandy shore	Solidification of the sediments of Cb_3	Fossilization of II-form of the sand-pipe and shell of *Pholadidea*

Recently, K. SUYAMA and S. UTASHIRO (1953, 1955) have discussed the problem concerning "*Lebenspuren*" of habitations for some kind of animals, and have pointed out the possibility that the remains of inhabitations of marine organisms (e.g. Pelecypods: *Solen*, *Pholadidea*, and *Zirfaea*, and *Decapoda*: *Upogebia*), become sand-pipes in solidification of filling material of inhabitations.

The sand-pipes of both forms I and II, here treated, may be the writers believe now, presumably referable to that case, as SUYAMA and UTASHIRO stated. But future investigations of further material may be needed to arrive at a final conclusion.

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Explanation of Plate 1

Explanation of Plate 1

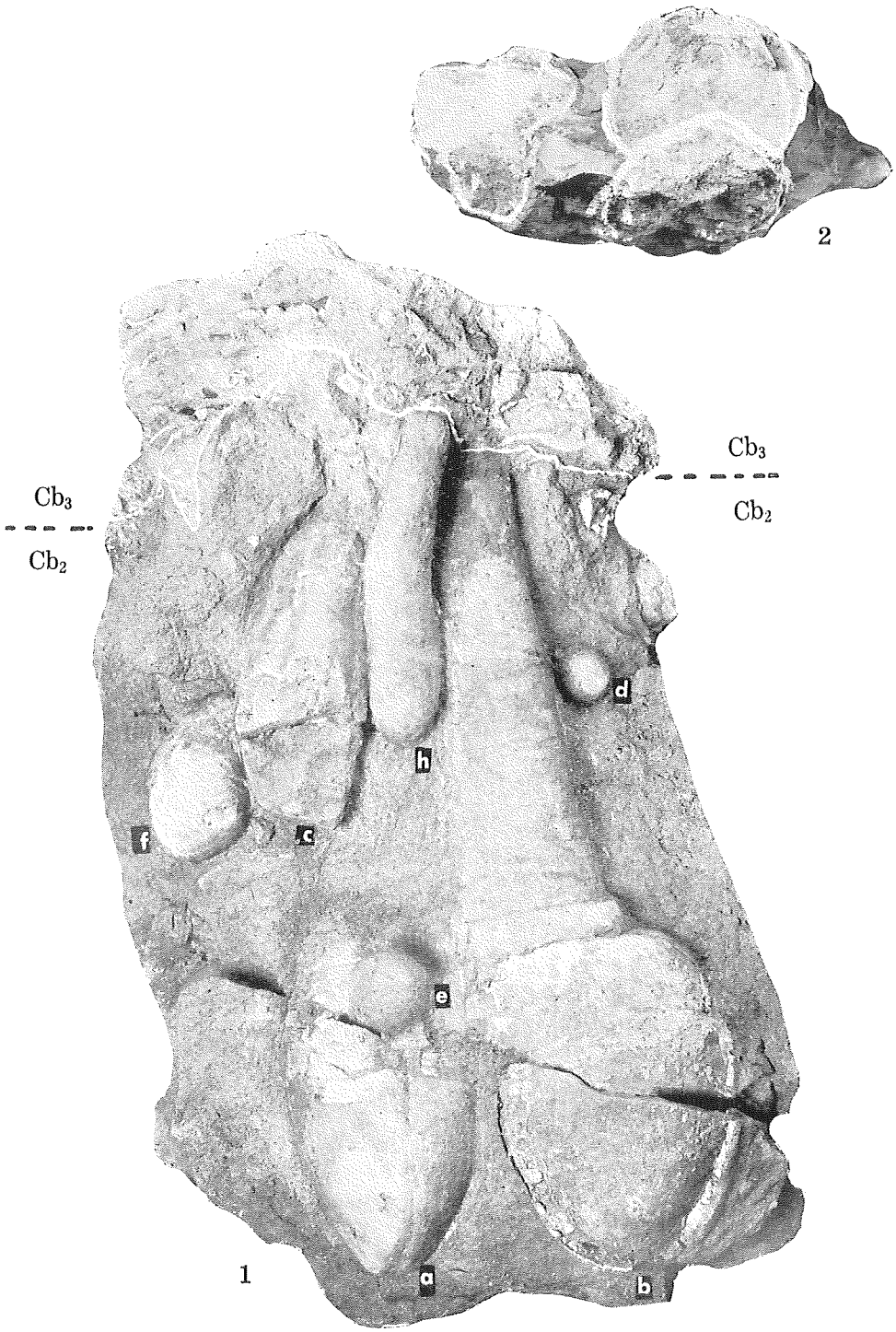
Fig. 1. A hand specimen included numerous sand-pipes were collected at the exposure of A-point (about 12 km. upstream of the Haboro-Gawa, Haboro-Machi Tomamae-Gun, Teshio Province). (×2/3.)

The upper part, fossiliferous sandstone, belongs to Cb_3 and the lower part, fine sandstone, is Cb_2.

In this picture, the two different forms of the sand-pipes are shown: I-form are A, B, and C, while II-form are D, E, F, and H. I-form of the sand-pipes contain shell remains of *Platyodon nipponica* and II-form contain *Pholadidea* (*P.*) *kamakurensis*.

Further, this picture shows the mutual relation which I-form (A) is intercrossed by II-form (E) of the sand-pipe. (U. H. Reg. No. 12139)

Fig. 2. The photograph shows the example that II-form of the sand-pipe is intercut by other individual of the same form (×1). (U. H. Reg. No. 12140)



UOZUMI et FUJIE: Sand-pipe, Created by the Pelecypods. S. KUMANO Photo.

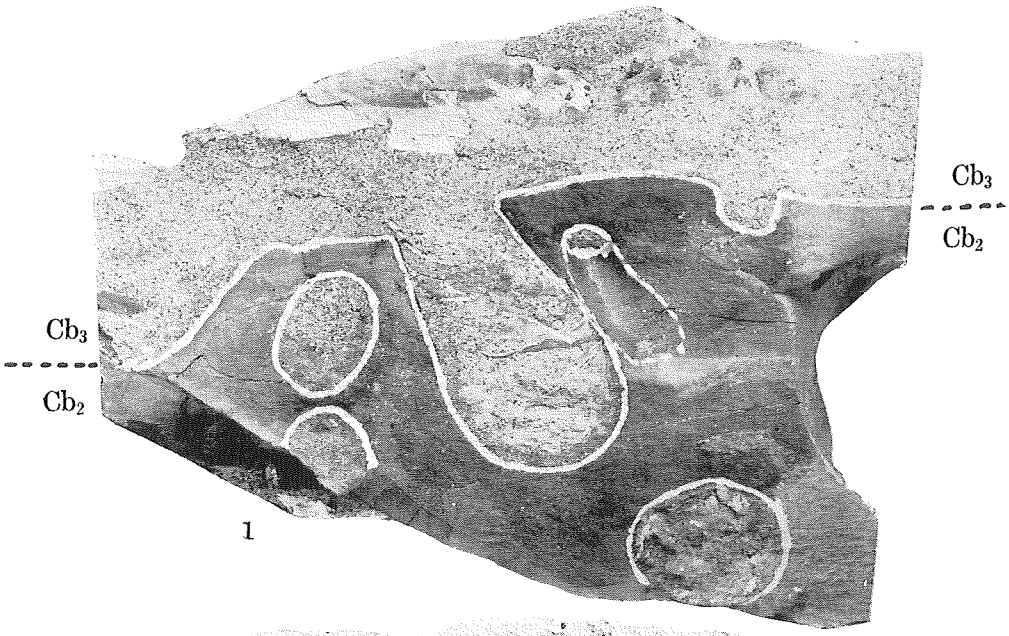
Explanation of Plate 2

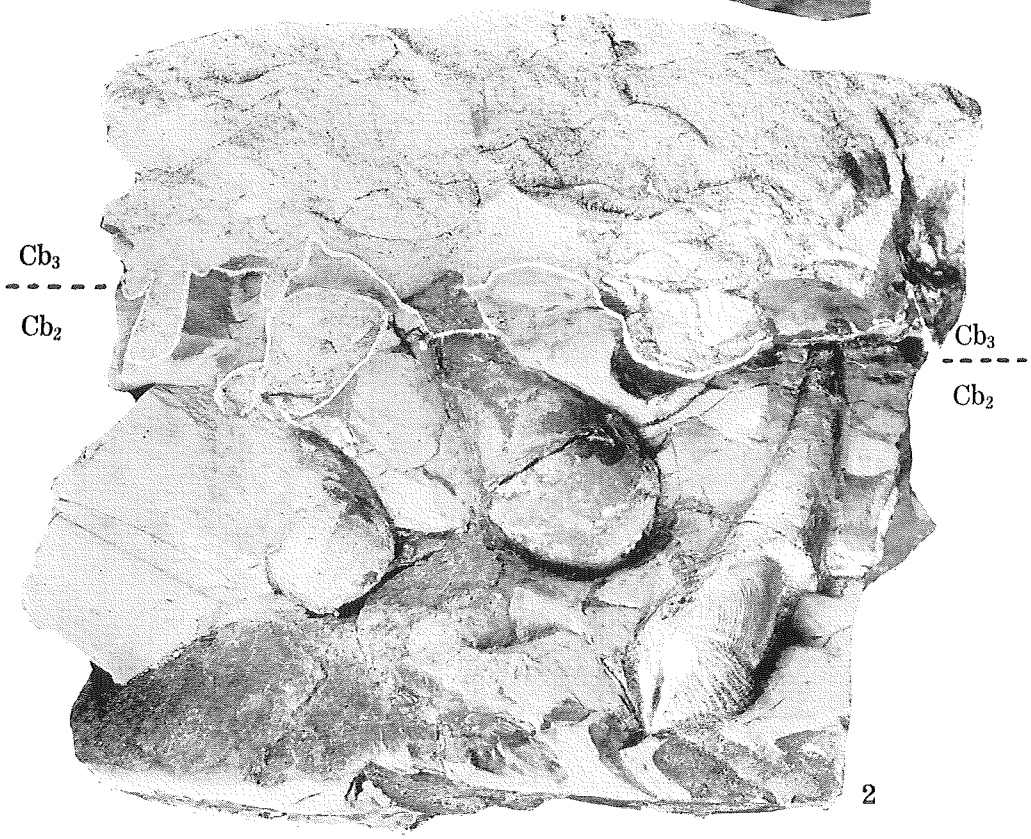
Explanation of Plate 2

These hand specimens derived from the exposure at B-point, showing relation of bottoms to substratum and of filling to burrows.

The lower part is massive mudstone (Cb_2) and above is tuffaceous sandstone (Cb_3).

In Figure 1 ($\times 2/3$), the concavity seen at about central part represent the sand-pipe of II-form, in which shell remains were not discovered. In this case, the shell might be perhaps dissolved. Figure 2 ($\times 2/3$) shows the mode of occurrence of the sand-pipe of II-form with the shell remains (*Pholadidea* (*P.*) *kamakurensis*) that have been buried alive *in situ* at the bottom of the creature's inhabitation. (U. H. Reg. No. 12138, 12141)





UOZUMI et FUJIE: Sand-pipe, Created by the Pelecypods. S. KUMANO Photo.

Explanation of Plate 3

Explanation of Plate 3

(All figures in natural size.)

Fig. 1–3. The sand-pipes of II-form. U. H. Reg. No. 12142, 12143, 12145.

Fig. 4–5. The sand-pipe of I-form. 4: Cross section (U. H. Reg. No. 12151); 5: Side view (U. H. Reg. No. 12142).

UOZUMI et FUJIE: Sand-pipe, Created by the Pelecypods. S. KUMANO Photo.

Explanation of Plate 4

Explanation of Plate 4

(All figures in natural size.)

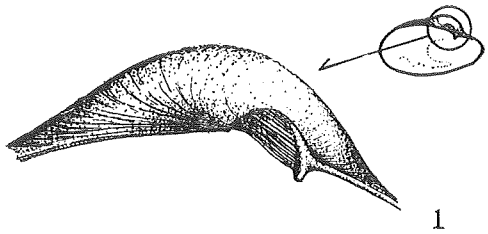
Platyodon nipponica UOZUMI et FUJIE n. sp. U. H. Reg. No. 12146, 12147

Fig. 1-3. Sketch showing the hinge of left and right valves.

Fig. 4. Side view of right valve (Holotype) U. H. Reg. No. 12146

Fig. 5. Dorsal view of same specimen.

Fig. 6. Hinge of right valve (Paratype) U. H. Reg. No. 12147



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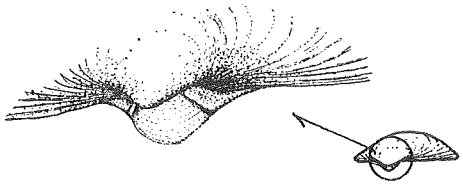

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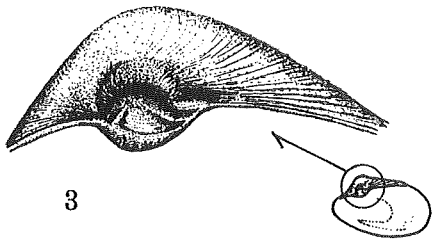

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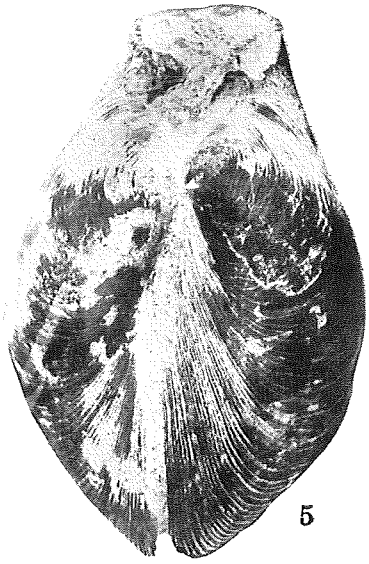

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6

UOZUMI et FUJIE: Sand-pipe, Created by the Pelecypods. S. KUMANO Photo.

Explanation of Plate 5

Explanation of Plate 5

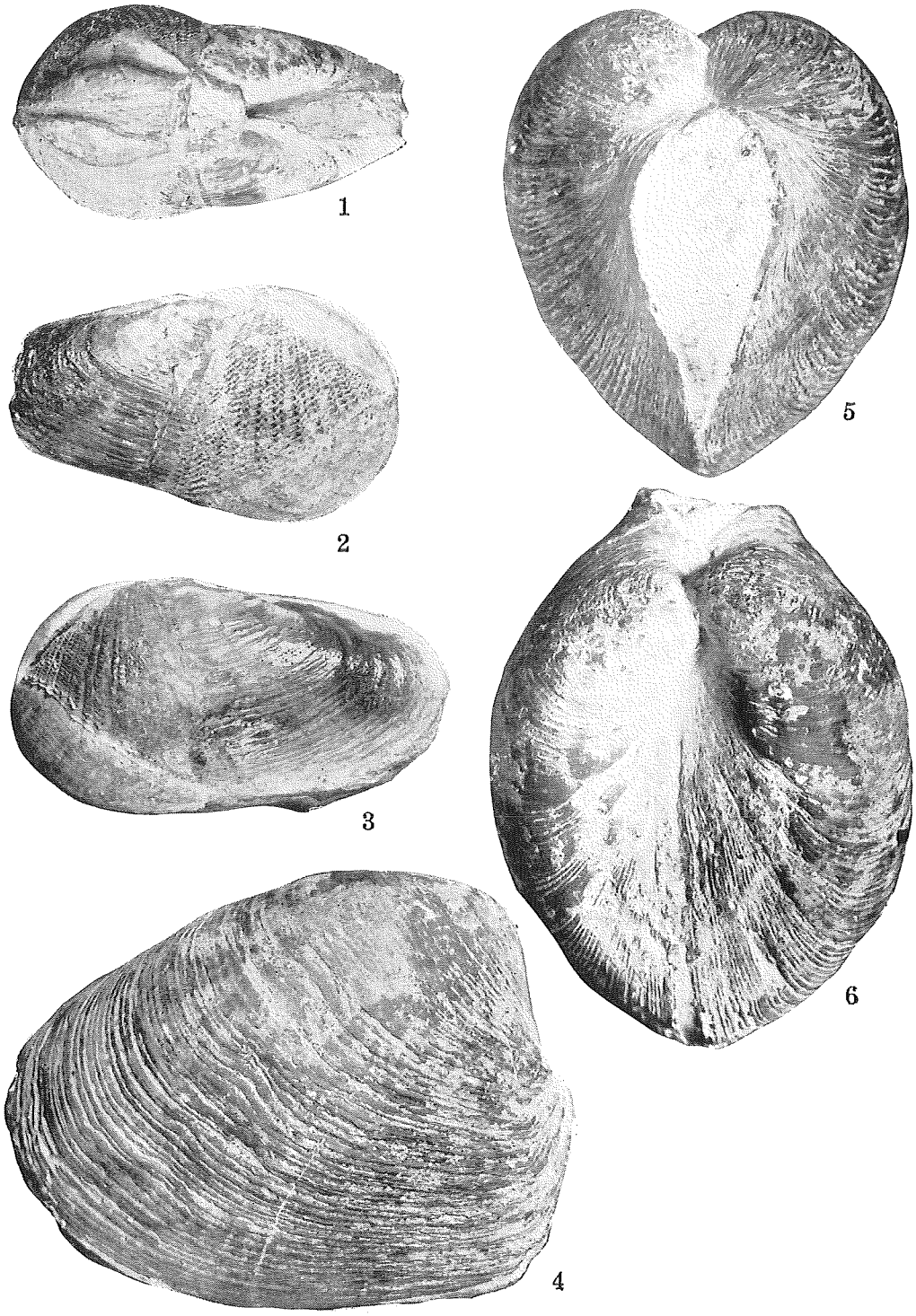
(All figures in natural size.)

Fig. 1–3. *Pholadidea* (*Penitella*) *kamakurensis* (Yokoyama): U.H. Reg. No. 12149, 12150.

1. Dorsal view.
2. Side view of left valve U. H. Reg. No. 12150.
3. Side view of right valve U. H. Reg. No. 12149.

Fig. 4–6. *Platyodon nipponica* UOZUMI et FUJIE n. sp. U. H. Reg. No. 12148 (Paratype)

4. Side view of right valve.
5. Posterior view of the same specimen.
6. Dorsal view of the same specimen.



UOZUMI et FUJIE: Sand-pipe, Created by the Pelecypods. S. KUMANO Photo.