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July 30, 1984

The ostracoa carapace on the cover is an adult specimen of *Manawa konishii* NOHARA (Suborder Palaeocopina, Family Punciidae) from the East China Sea. (photo by K. ABE, x190)

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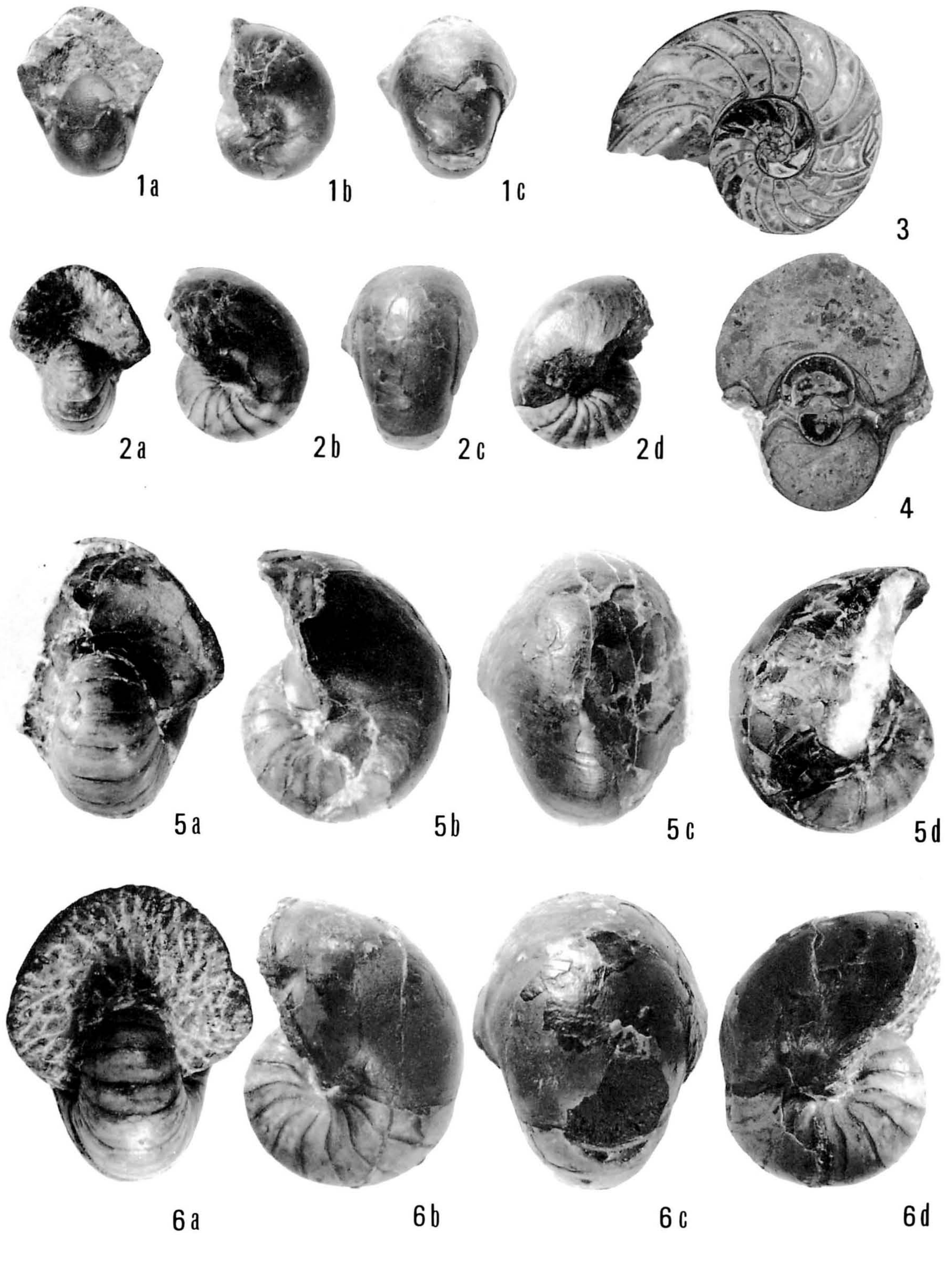
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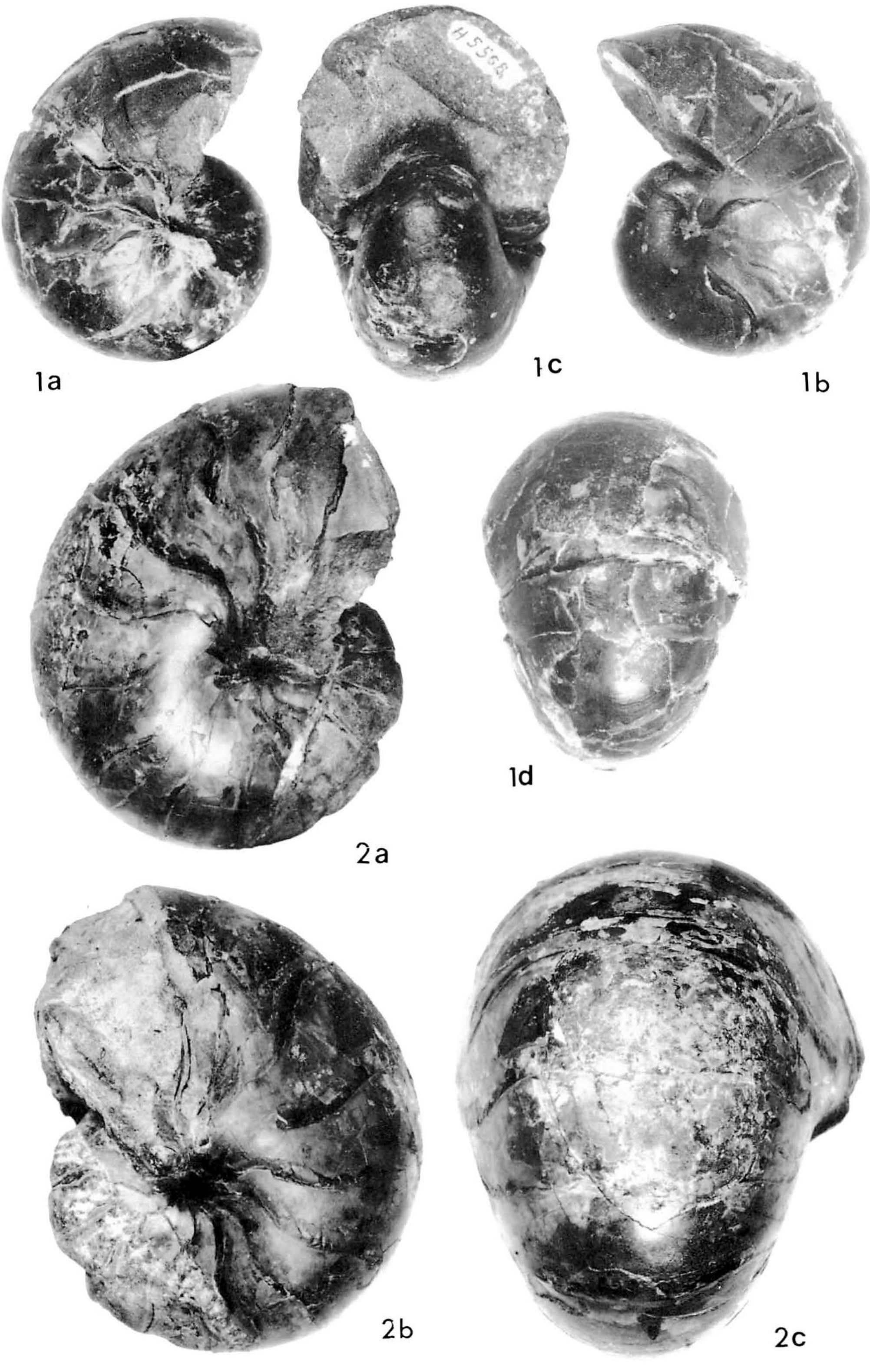
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777. CRETACEOUS NAUTILOIDS FROM HOKKAIDO—V*

TATSURO MATSUMOTO[1)], TOSHIYA MIYAUCHI[2)], YASUMITSU KANIE[3)], YUICHIRO MIYATA[1)] and YOSHIRO UEDA[4)]

Abstract. This paper contains Parts 5, 6 and 7 of the Cretaceous nautiloids from Hokkaido. Part 5 concerns with the species from the Lower Cretaceous. The descriptions are given under 3 sections by different coauthors. Section A by T. Matsumoto and T. Miyauchi is on *Cymatoceras* sp. aff. *C. virgatum* (Spengler) from the Albian of Oyubari and Soya, which differs from the holotype from India by less inflated whorl. Section B by T. Matsumoto, Y. Kanie and Y. Miyata is on *Cymatoceras* sp. cf. *C. sakalavum* Collignon from the Albian at a locality (Text-fig. 1) about 17 km NNW of Urakawa. Section C by T. Matsumoto and Y. Ueda is on *Cymatoceras* sp. aff. *C. mikado* (Krenkel) from the Neocomian of Rebun Island, which resembles *C. mikado* from Tanzania but differs in having subtrapezoid instead of subcircular whorl section.

Part 6 by T. Matsumoto is on an additional species from the Santonian of Ikushumbets based on T. Takahashi's collection. It is identified with *Cymatoceras sharpei* (Schlüter), being especially similar to the Gosau form.

Part 7 is a summary of results by T. Matsumoto. (1) The described 15 species are listed with the age of the original beds (see p. 341). (2) The phylogeny of the Nautilidae is tentatively presented (Text-fig. 4), showing the relationships of the newly established genus *Kummeloceras* with other revised genera. (3) In Hokkaido nautiloid species are different from a stage to another. Certain species are characteristic of a particular zone. Some are well correlated with the allied ones in extra-Japanese provinces. (4) Many nautiloid genera show world-wide distribution during the Cretaceous Period, but at specific level there are regional differences. This is exemplified also by the species from Japan. (5) Discussion is given on the palaeoenvironment on some species from Hokkaido.

This article consists of the following three parts:

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PART 5. SOME NAUTILOIDS FROM THE LOWER CRETACEOUS OF HOKKAIDO

T. Matsumoto, T. Miyauchi, Y. Kanie, Y. Miyata and Y. Ueda

Introduction

The Lower Cretaceous deposits of Hokkaido are not so prolific in cephalopods as the Upper Cretaceous ones. Fortunately, however, some nautiloid specimens have been obtained during our geological field works. The persons concerned with the field works cooperate with the first author in describing the species. Accordingly, this part is subdivided into three sections, A, B and C, with the authorships indicated in parentheses under respective subtitles.

A. A Nautiloid Species from Soya and Oyubari (T. Matsumoto and T. Miyauchi)

Family Cymatoceratidae Spath, 1927

Genus *Cymatoceras* Hyatt, 1884

Cymatoceras sp. aff. *C. virgatum* (Spengler)

Pl. 62, Fig. 1; Pl. 63, Fig. 1; Pl. 64, Fig. 1

Compare:—

1910. *Nautilus* (*Cymatoceras*) *virgatus* Spengler, *Beitr. Paläont. Geol. Österr.-Ungarns u. d. Orients*, vol. 23, p. 130, pl. 11, fig. 3; pl. 12, fig. 7c.

Material:—MNH. 145, obtained by H. Honma on the eastern coast of Cape Soya, and GK. H5726, obtained by T. Matsumoto at loc. Y632 of the Oyubari area.

Description:—In MNH. 145, the left half of the body-chamber with the test and the preceding septate part are preserved. GK. H5726 consists mostly of the internal mould of a septate whorl and a portion of the body-chamber, with only a part of the test preserved.

The shell is fairly large. The diameter at the end of the phragmocone is 110 mm in MNH. 145 and 130 mm in GK. H5726.

The whorl is well rounded in cross-section. It is somewhat (but not much) broader than high, with the maximum breadth in the lower part. The umbilicus is almost closed in MNH. 145, which has shelly layers, and very narrowly opened in the internal mould of GK. H5726.

The *Cymatoceras* type ornamentation is well shown on the shell of MNH. 145 and partly on that of GK. H5726. On the shell of late growth-stage the so-called ribs are flat-topped and separated by narrower groove-like interspaces. They are somewhat sharper on the earlier whorl. They are scarcely impressed on the internal mould. The rib bifurcation is frequent and multiple, occurring near the umbilical margin, again at various places on the flank and even on the ventral part. The backward sinus of the ribs on the venter form an obtuse angle of 110°—130°. On the venter of the body-chamber, with heights of about 70 to 80 mm, the ribs number 5 in MNH. 145 and 6 in GK. H5726 within the distance of 30 mm.

The septa are moderately frequent. They number 10 in GK. H5726 and 9 in MNH. 145 in a half whorl. The suture is gently sinuous, showing a very shallow external lobe, low and asymmetric saddle at the ventrolateral part, shallow and broad lobe on the main part of the flank, and a small and low saddle at about the umbilical shoulder.

The position of siphuncle is unknown.

Table 1. Measurements (in mm) of *Cymatoceras* sp. aff. *C. virgatum*.

Specimen	Diameter	Umbilicus	Height	Breadth	B/H
MNH. 145	145	0 (?)	90 (.62)	94* (.65)	1.04
〃 (−180°)	—		55	58	1.05
GK. H5726	144.0	12.0 (.08)	83.5 (.58)	94.0 (.65)	1.13
〃 (−210°)	—	—	46.4	54.5	1.11

*restored (47 x 2)

Comparison:—With respect to the general shell-form, the characteristically branching ribs and the gently sinuous suture, the two specimens from Hokkaido closely resemble the holotype (by monotypy) of *Cymatoceras virgatum* (Spengler) (1910, p. 130, pl. 11, fig. 3; pl. 12, fig. 7c), from the Upper Albian of southern India. That holotype, however, has a much broader whorl than ours, for its B/H = 1.24 even if B is assumed to be 8.6 as measured from his illustration. We, therefore, hesitate to conclude the specific identity, unless the extents of variation be proved to overlap considerably between the two provinces. According to Spengler, *C. virgatum* has tripartite ribs in addition to the frequently bipartite ribs. On MNH. 145 an apparent tripartite state is seen where the points of bifurcation are approximated.

The holotype of *C. carlottense* (Whiteaves) (1900, p. 269), from the Albian Haida Formation of the Queen Charlotte Islands, British Columbia (Canada), whose replica has been gifted to Kyushu University from the Geological Survey of Canada by courtesy of Dr. J. A. Jeletzky, shows a similar mode of rib branching but its ribs are narrower and more numerous than those of our form and also the holotype of *C. virgatum*. Furthermore, that Canadian species has a less rounded whorl, with less convex flanks and a broader venter. Its body-chamber has a shallow groove along the median line of the venter. This character is undeveloped in the Indian and the Japanese species.

Occurrence:—MNH. 145 is in a calcareous nodule of pumiceous siltstone. It was transported to loc. So. 367 on the coast of Chiyenaibo, eastern side of Cape Soya, northern Hokkaido. At the same place another transported nodule contained a fragmentary ammonite resembling *Pictetia* or *Argonauticeras*. As the geologic structure is complicated in the eastern coastal area of Cape Soya, the original bed of MNH. 145 has not yet been determined, although the existence of the Albian is suggested. At the nearby localities in the south, there occur *Parajaubertella imlayi* Matsumoto and *Desmoceras kossmati* Matsumoto, suggesting the Lower Cenomanian.

GK. H5726 is in a calcareous nodule from the dark grey siltstone exposed at loc. Y632, on the first branch of the Hikageno-sawa, a tributary to the River Shiyubari, Oyubari area, central Hokkaido. The rock is assigned to Unit If, the top member of the Lower Yezo Group. This unit is Albian on the ground of stratigraphic position and the occurrence of *Tetragonites* cf. *T. timotheanus* (Mayor) (see Matsumoto, 1942).

B. A Nautiloid Species from the Urakawa District (T. Matsumoto, Y. Kanie & Y. Miyata)

Cymatoceras sp. cf. *C. sakalavum* Collignon

Pl. 64, Fig. 2

Compare:—

1949. *Cymatoceras sakalavum* Collignon, *Ann. Géol. Serv. Mines*, no. 16, p. 41, pl. 6, figs. 1, 2; pl. 21, fig. 1.

Material:—A single specimen obtained by Y. Miyata and Y. Kanie at loc. U 1092 in the field work of 1978, now kept at the Yokosuka City Museum, YCM. Ur 1092001.

Description:—Both the phragmocone and the body-chamber are distorted. The diameter, without reconstruction, is 135 mm, but it must have been originally somewhat smaller.

The whorl is somewhat higher than broad under the crushed condition but must have been originally slightly or somewhat broader than high, with more rounded outline. The umbilicus is almost closed.

The surface of the shell is ornamented with rather flat ribs, which are separated by narrower interspaces. The number and coarseness of the ribs are moderate for the genus, 32 being counted on the venter of the last half whorl. The rib branching is seen fairly frequently at or below the middle of the flank. The ribs show some flexuosity on the flank, beginning to curve backward at about the middle of the flank or slightly above it. The ventral sinus of the ribs looks to be rather gentle on some part but fairly pronounced on other parts. Probably there is effect of secondary deformation in some degree.

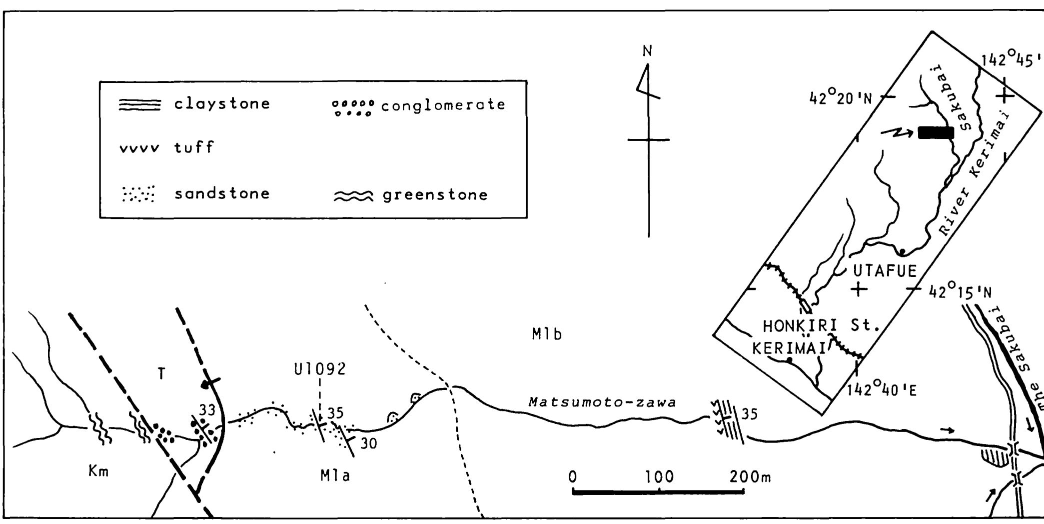
The suture is partly exposed, showing the gentle sinuosity, but again the curvature seems to have been modified by the secondary deformation. The siphuncle position is unknown.

Comparison:—The above described specimen is so poorly preserved that it is hardly identified with certainty. On the ground of the observed characters, however, it is best comparable with *Cymatoceras sakalavum* Collignon, 1949, from the Albian of Madagascar.

C. carlottense (Whiteaves) (1900, p. 269), from the Albian of the Queen Charlotte Island (British Columbia), is somewhat similar to *C. sakalavum*, but has more numerous ribs which show a narrower angle of ventral sinus. There is a shallow depression along the median line of the venter on the living chamber of that Canadian species.

C. pseudoneokomiense Shimizu (1931, p. 18, pl. 1, figs. 1—4), from the Upper Aptian of the Miyako area (Northeast Japan), has a subtrapezoidal whorl-section and its ribs are separated by wider interspaces and show less frequent branching than those of the present species. In that species the ribs run almost radially from the umbilical margin to the ventrolateral shoulder, without showing such flexuosity as seen on the present specimen or on the typical specimens of *C. sakalavum*.

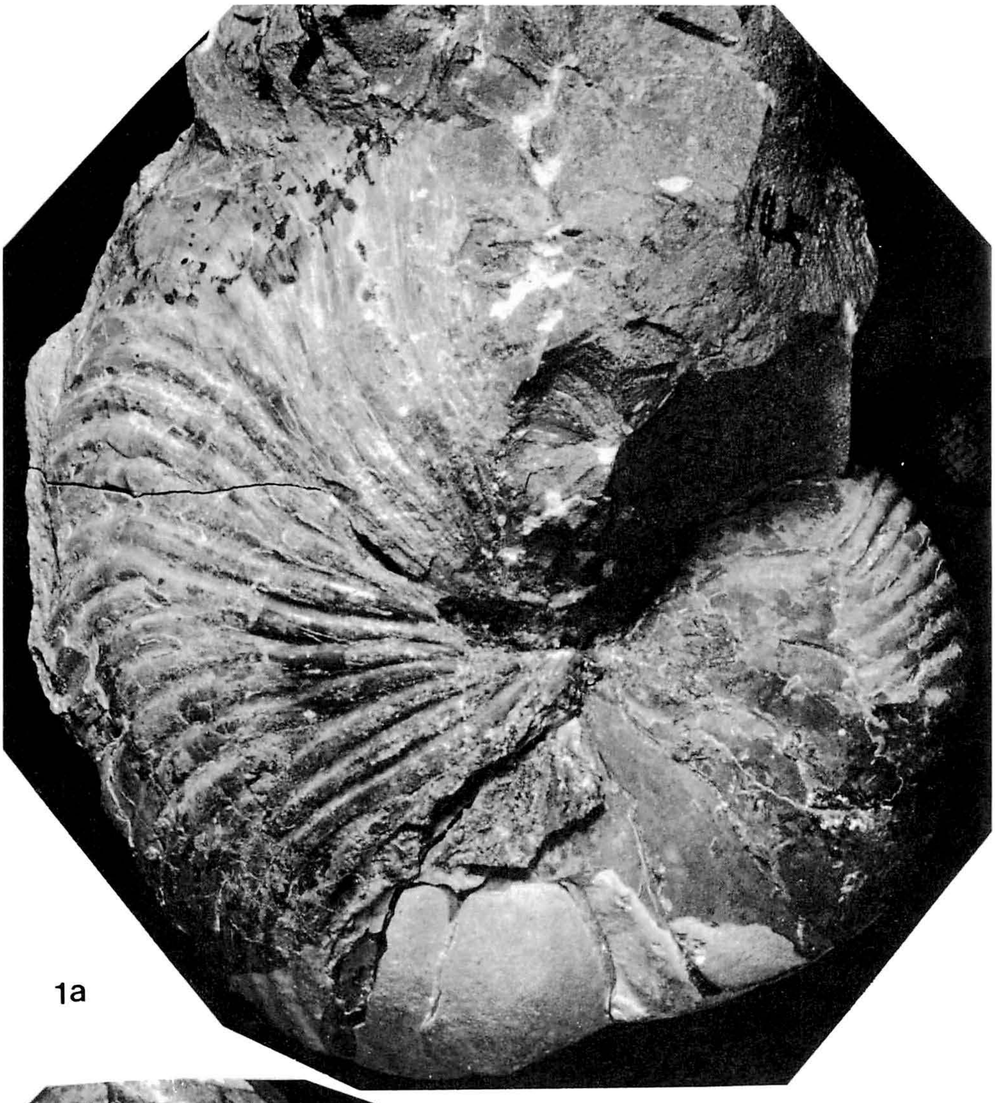
Occurrence:—Loc. U 1092, on a branch stream (called the Matsumoto-zawa) of the Sakubai, a tributary to the River Kerimai, Mitsuishi, Urakawa district, southern central Hokkaido; solitarily found in massive fine-



Text-fig. 1. Geological route map along the Matsumoto-zawa, showing the locality (U 1092) of the described nautiloid. Km: Kamuikotan Metamorphics, Mla, Mlb: Subdivisions of the Middle Yezo Group (Mid-Cretaceous), T: Tertiary (Miocene). Inset at the upper right corner is the index map. (Y. Kanie *delin.*)

Explanation of Plate 62

Fig. 1. *Cymatoceras* sp. aff. *C. virgatum* (Spengler) . . . . Page 336
MNH. 145, obtained by H. Honma from loc. So. 367, Chiyenaibo, on eastern coast of Cape Soya. Lateral (a) and ventral (b) views, x 1.
All photos in Pls. 62 — 66 by courtesy of Dr. M. Noda.



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grained sandstone of Member Mla, lower part of the Middle Yezo Group (Text-fig. 1).

C. A Nautiloid Species from the Neocomian of Rebun Island (T. Matsumoto and Y. Ueda)

Cymatoceras sp. aff. *C. mikado* (Krenkel)

Pl. 65, Fig. 1; Text-fig. 2

Compare:—

1910. *Nautilus Mikado* Krenkel, *Beitr. Paläont. Geol., Österr.-Ungarns u. d. Orients*, vol. 23, p. 219, pl. 23, figs. 4, 5; pl. 22, fig. 14.

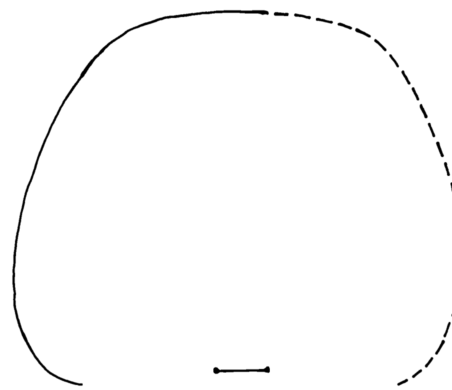
Material:—GK. H5927, obtained by Y. Ueda from Jizo-iwa, Rebun Island.

Description:—As only the right half of a fragmentary whorl is preserved, the shell form cannot be exactly reconstructed. The preserved part shows a gently inflated flank, well rounded ventrolateral part and a rather flat venter. The original whorl-section seems to be subtrapezoid and broader than high (Text-fig. 2). The umbilicus seems to be narrowly opened.

The surface of shell is ornamented with numerous fine ribs, which are rather flat-topped and separated by narrower groove-like interspaces. At the whorl-heights of 65 to 75 mm 9 ribs are counted on the venter within the interval of 30 mm. Branching of the rib takes place near the umbilicus and also occasionally on the ventrolateral part. The ribs are gently flexuous on the ventrolateral part, forming a sinus of moderate sharpness (about 100—120°) on the venter.

The suture is partly exposed, showing a shallow and broad lateral lobe and an asymmetric small saddle near the umbilicus, passing to a descending line on the umbilical wall. The siphuncle position is unknown.

Comparison:—The Rebun specimen is somewhat similar to *C. mikado* (Krenkel), from the Neocomian (probably Barremian) of Tanganyika (Tanzania), in the numerous and fine ribbing, but it has a subtrapezoidal, rather than a semicircular, whorl-section, a flatter top of venter and a wider umbilicus.



Text-fig. 2. *Cymatoceras* sp. aff. *C. mikado* (Krenkel).
Whorl-section. Broken line: restored part. Scale bar: 10 mm. (T. Matsumoto *delin.*)

With respect to the shell-form, it is rather allied to *C. elegantoides* (d'Orbigny) (1840, p. 69; Foord and Crick, 1890, p. 549, fig. 2), from the Albian of England and France, but the rib-branching is multiple in that species.

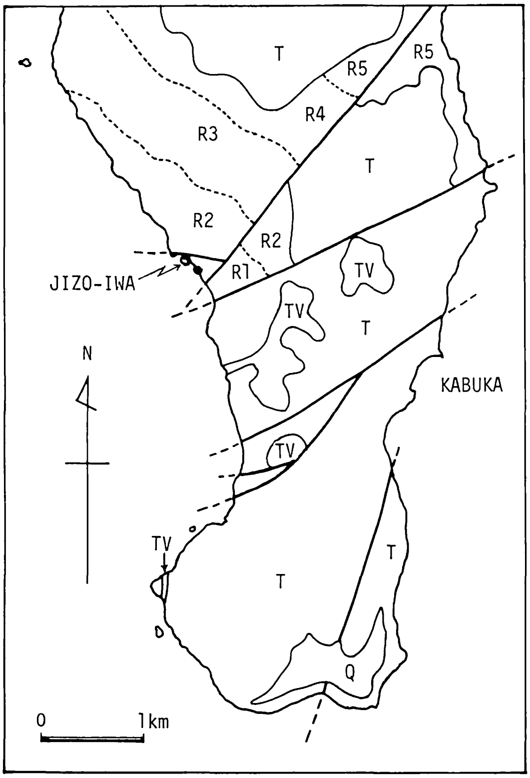
The siphuncle is subcentral and slightly deviated to the dorsum in *C. mikado*, whereas it is evidently subdorsal in *C. elegantoides*. This point cannot be examined in the specimen from Rebun.

Although some affinities and distinctions are recognized as in the above comparison, the present specimen is too incompletely preserved to establish a new species.

Occurrence:—From dark coloured, fine-grained sandstone (wacke) exposed on a cliff, about 100 m southeast of Jizo-iwa, on the southwestern coast of the island of Rebun, off the west coast of northern Hokkaido (45°10′40″ N., 141°1′30″ E.) (Text-fig. 3). The rock is assigned to the lowest member of the 2000 m sequence of the volcanogenic deposits called the Rebun Group (Nagao *et al.*, 1963). At the same locality some ammonites, including a pulchelliid, were found.

PART 6. AN ADDITIONAL NAUTILOID FROM THE SANTONIAN OF HOKKAIDO

T. Matsumoto



Text-fig. 3. Geological outline map of the southern part of Rebun Island, indicating the nautiloid locality with a solid circle (●). R1—R5: Members of the Lower Cretaceous Rebun Group in ascending order, T: Tertiary formations, TV: Tertiary andesite, Q: Quaternary. Upper line of the map quadrangle: 45°20′ N., left line: 141°0′ E. For the location of Rebun Island see text-fig. 1 of Part 1 (Matsumoto, 1983). [Geological outline adopted from Nagao *et al.*, 1963.]

After the manuscript of Part 2 was submitted to the editor of the Society, an interesting specimen was kindly provided me for this study by Mr. Takemi Takahashi, to whom I am much obliged. This has given an addition to the Santonian nautiloids.

Cymatoceras sharpei (Schlüter)

Pl. 66, Fig. 1

1876. *Nautilus sharpei* Schlüter, *Palaeontographica*, vol. 24, p. 171, pl. 46, figs. 5—7.
1982. *Cymatoceras sharpei* (Schlüter); Immel *et al.*, *Zitteliana*, vol. 8, p. 8, pl. 1, figs. 1—2.

Material:—A single specimen of Takemi Takahashi's Collection (TTC. 370713), from Ikushumbets.

Description:—The shell seems to be rather small for the genus, for its diameter is about 80 mm at the end of the phragmocone and about 110 mm at the end of the body-chamber which is preserved for about a half whorl.

The whorl is nearly as high as broad, although there may be some effect of secondary compression. The ventral part is moderately rounded, passing to the moderately inflated flanks. The maximum breadth is at about the lower one third of the whorl-height. The umbilicus is very narrow or almost closed.

The surface of the shell is ornamented with numerous fine ribs, which are hardly impressed on the internal mould. Rib branching is seen frequently near the umbilical margin and occasionally on the lower part of the flank. The backward sinus of the ribs on the venter is gentle.

Suture is nearly linear, with slight sinuosity on the main part of the flank, and descending towards the umbilicus, showing an indistinct saddle near the subrounded umbilical shoulder. The septa are fairly distant.

The siphuncle position is unknown, unless this single specimen be cut appropriately.

Explanation of Plate 63

Fig. 1. *Cymatoceras* sp. aff. *C. virgatum* (Spengler) . . . . Page 336
GK. H5726, obtained by T. Matsumoto at loc. Y 632, Shiyubari, Member If of the Oyubari sequence. Frontal (a) and lateral (b) views. Scale bar: 20 mm.

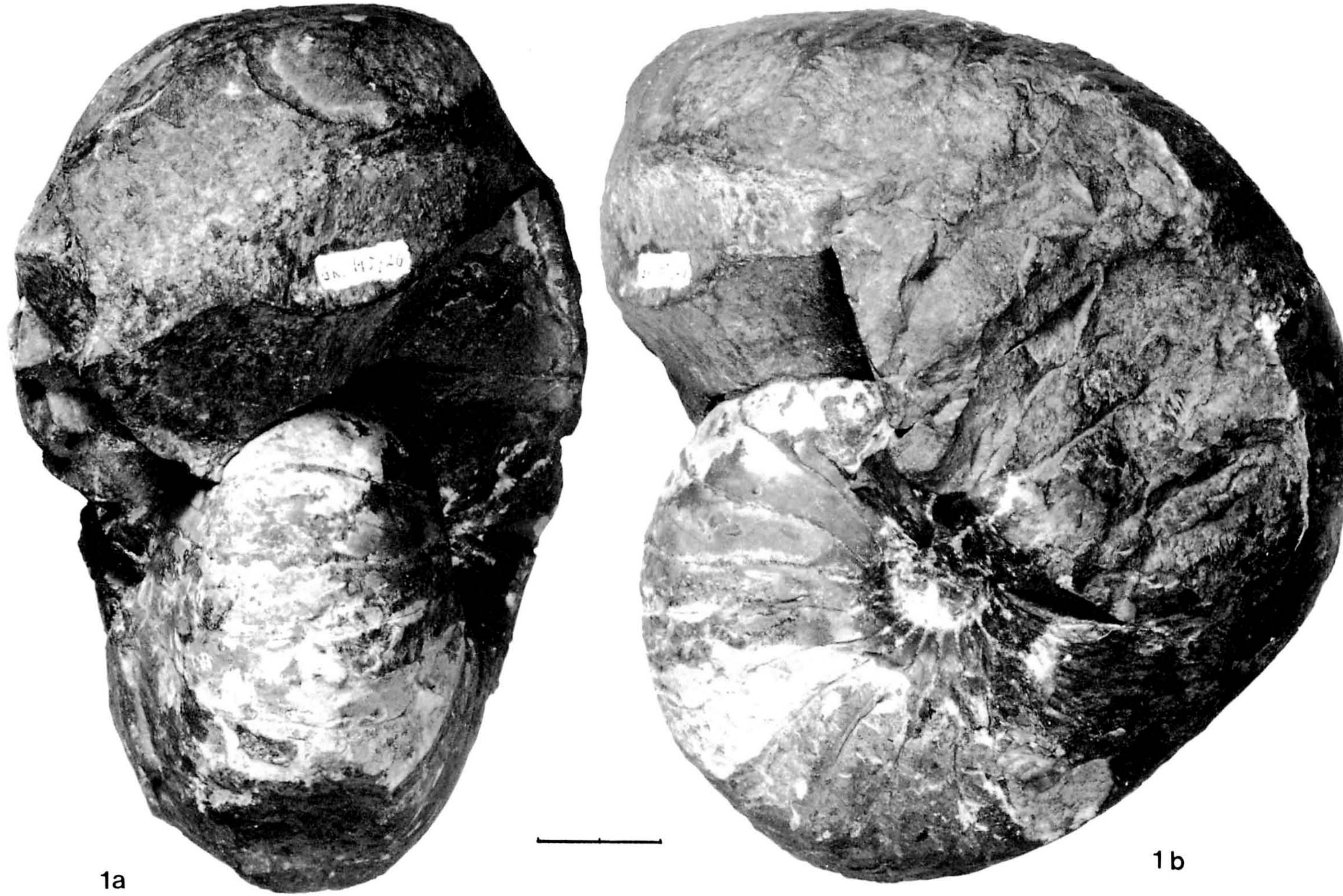


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Table 2. Measurements of *Cymatoceras sharpei*.

	Diameter	Umbilicus	Height	Breadth	B/H
This specimen	105.5	5.2 (.05)	67.0 (.64)	65.0 (.62)	0.97

Comparison:—With respect to the fairly distant, almost linear sutures and the numerous fine ribbing, this specimen is closely allied to the lectotype* (here designated: illustrated specimen of Schlüter 1876, p. 171, pl. 46, figs. 5—7), from the Cenomanian of West Germany. It is, however, smaller and has a less inflated whorl with a more narrowly rounded venter. Accordingly, it is more similar to the specimens from the Santonian part of the Gosau Group (Austria) described by Immel *et al.* (1982, p. 8, pl. 1, figs. 1—2) under *C. sharpei*. The difference in the whorl-shape as compared with the lectotype may be due partly to the secondary compression and partly to individual variation. It could be suggested, however, that the Santonian form might be generally smaller and less inflated than the typical Cenomanian form.

Occurrence:—17 km point on the forestry railway (now abandoned) along the main stream of the Ikushumbets. The strata at and around this point are referred to the Santonian, as evidenced by the co-occurrence of *Hyphantoceras orientale* (Yabe).

PART 7. CRETACEOUS NAUTILOIDS FROM HOKKAIDO —SUMMARY OF RESULTS

T. Matsumoto

In this final part I attempt to summarize concisely the results of the serial study on the Cretaceous nautiloids from Hokkaido described in Parts 1—6 and also Matsumoto (1967).

1. *Summarized list of the described species with their stratigraphical occurrences*:—

Eutrephoceratinae (Nautilidae)

- *Kummeloceras yamashitai* Matsumoto (Turonian)
- *Kummeloceras yezoense* Matsumoto (Coniacian)
- *Kummeloceras kamuy* Matsumoto et Muramoto (Santonian)
- *Eutrephoceras nodai* Matsumoto (Turonian)
- *Eutrephoceras kobayashii* Matsumoto (Santonian?)
- *Eutrephoceras soyaense* Matsumoto et Miyauchi (Campanian)

Cymatoceratidae

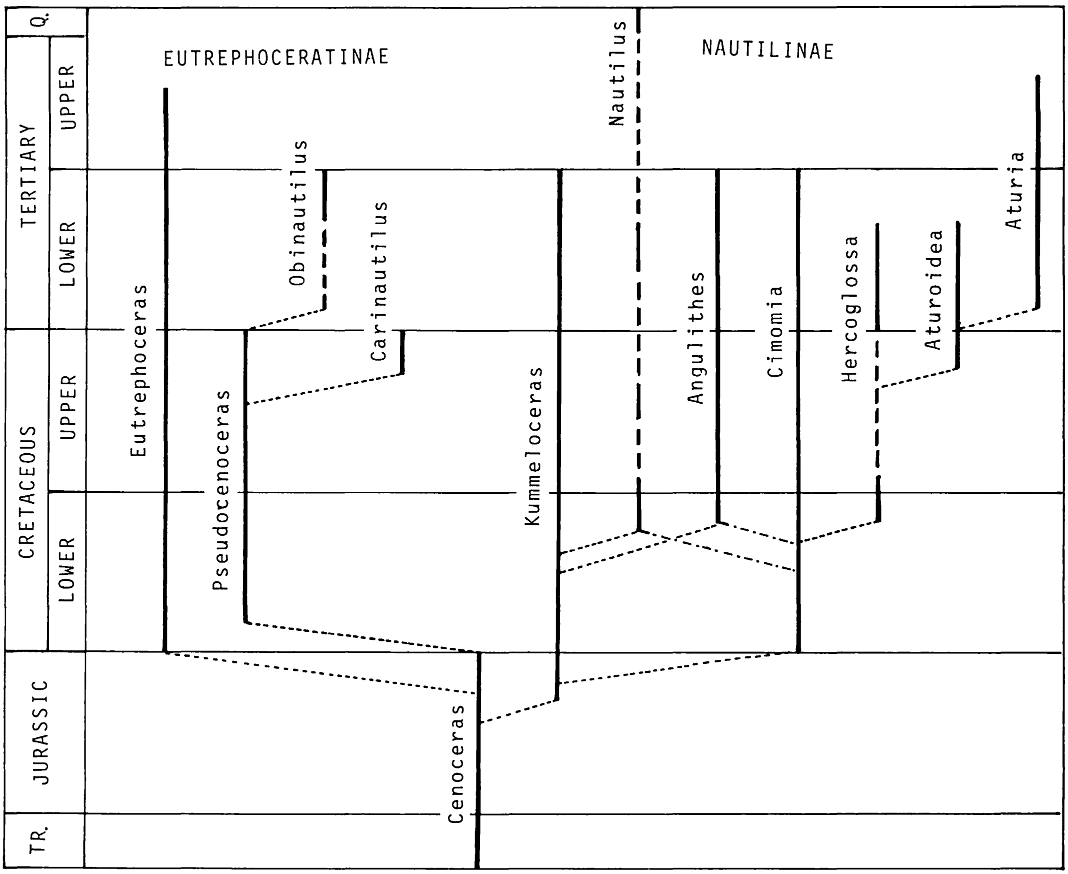
- *Cymatoceras* aff. *C. mikado* (Krenkel) (Barremian)
- *Cymatoceras* cf. *C. sakalavum* Collignon (Albian)
- *Cymatoceras* aff. *C. virgatum* (Spengler) (Albian)
- *Cymatoceras pseudoatlas* (Yabe et Shimizu) (Santonian)
- *Cymatoceras sharpei* (Schlüter) (Santonian)
- *Cymatoceras pacificum* Matsumoto et Muramoto (Campanian)
- *Cymatoceras honmai* Matsumoto et Miyauchi (Campanian)
- *Anglonautilus japonicus* Matsumoto et Takahashi (Cenomanian)
- *Anglonautilus mamiyai* Matsumoto et Miyauchi (Campanian)

2. *Systematic classification*:—The genus *Kummeloceras* Matsumoto has been introduced to accommodate a group of species whose sutures are similar to but more sinuous than those of *Cenoceras* but less sinuous than those of *Cimomia* or *Nautilus*. It is regarded as representing a transitional stage in the evolutionary development from *Cenoceras* to *Cimomia* and *Nautilus*. It is suggested that there are several Cretaceous (and possibly also Tertiary) species which can be assigned to *Nautilus*. The type species (*K. yamashitai*) and several other exam-

*This was indicated as the holotype by Immel *et al.* (1982, p. 8), but Schlüter evidently dealt with at least nine specimens (i.e. syntypes).

ples of *Kummeloceras* are rather high-whorled and could possibly be regarded as directly ancestral to *Nautilus*, whereas the less compressed subgroup of *Kummeloceras* could lead to *Cimomia*. As another alternative, *Nautilus* might have been derived from *Kummeloceras* by way of *Cimomia*.

The family Eutrephoceratidae Miller, 1951 was revived in Part 1 (Matsumoto, 1983). I now think it better to rank it down to a subfamily of the family Nautilidae, because *Nautilus* seems to be intimately related to *Cenoceras* by way of *Kummeloceras* as mentioned above. Its main stock is represented by *Cenoceras* and *Kummeloceras*, whereas *Eutrephoceras* (emend.) has simplified reducing sutures. There are certain other specialized genera (e.g., *Pseudocenoceras*, *Carinautilus* and *Obinautilus*) which can be

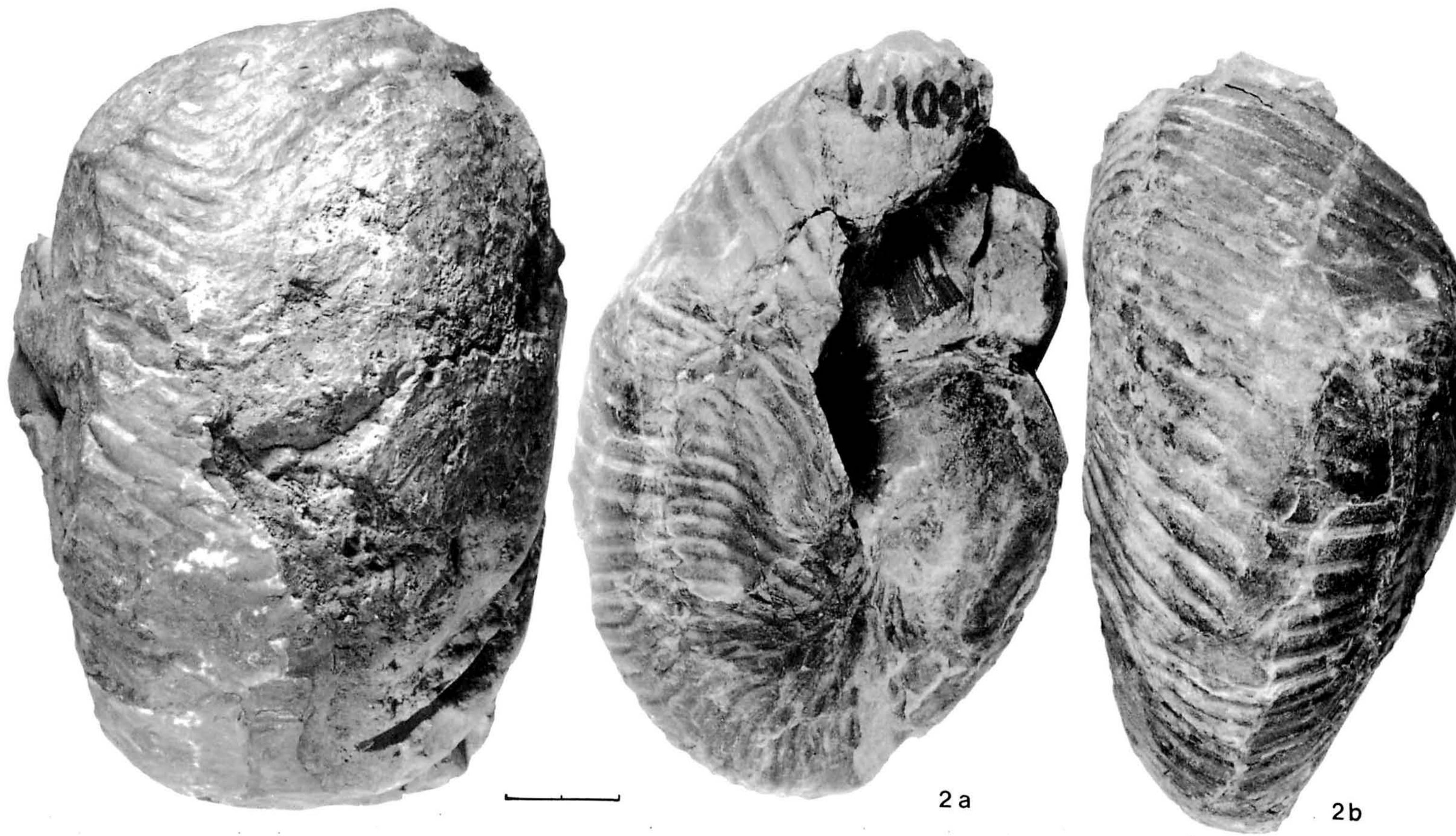


Text-fig. 4. Presumed phylogeny of the Nautilidae.

Explanation of Plate 64

Fig. 1. *Cymatoceras* sp. aff. *C. virgatum* (Spengler) . . . . Page 336
GK. H5726, ventral view. (See Pl. 63 for other views.)

Fig. 2. *Cymatoceras* sp. cf. *C. sakalavum* Collignon . . . . Page 337
YCM. Ur 1092001, obtained by Y. Miyata and Y. Kanie at loc. U 1092, Matsumoto-zawa, branch of the Sakubai, a tributary to the River Kerimai, NNW of Urakawa. Lateral (a) and ventral (b) views. Scale bar: 20 mm.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included in Eutrephoceratinae in a revised sense.

Angulithes (=*Deltoidonautilus*) is a derivative of *Kummeloceras*, acquiring more sinuous sutures and triangular whorl-sections. *K. yezoense*, for example, represents a transitional state from *Kummeloceras* to *Angulithes*.

The sutures of the recent species of *Nautilus* are as sinuous as (or somewhat more sinuous than) those of many species of *Cimomia*, which, in turn, has been regarded as ancestral to *Hercoglossa* and other related genera. Accordingly the Hercoglossinae falls in a synonym of Nautilinae.

The presumed phylogeny of the discussed genera is shown in Text-fig. 4. This is tentative and two alternative interpretations are indicated by different lines of descent. If one of them be proved by sufficient evidence, the subdivision of the Eutrephoceratinae and the Nautilinae might become unwarrantable.

Some genera of the Cymatoceratidae have been discussed (mainly in Part 2), without giving a great alteration. *Anglonautilus* is well represented in Japan by the three species from the Aptian (outside Hokkaido), the Cenomanian and the Campanian respectively. Descriptions in details have been given in Part 4 on a species from the Lower Cenomanian of the Ikushumbets area, on the basis of well-preserved specimens of various growth-stages. It shows the intimate relationships of *Anglonautilus* with *Cymatoceras* and *Paracymatoceras*.

3. *Biostratigraphical implications*:—So far as the available material from the Cretaceous of Hokkaido is concerned, every stage has species which are particular to it. In other words, no species from Hokkaido shows a long stratigraphical range which goes through more than one stage. This might have come from the collection failure or from the environmental conditions and the apparent range may be local or partial. There are, however, examples whose actual occurrences are stratigraphically restricted and geographically extensive. *Cymatoceras pseudatlas*, for instance, occurs in the Lower Santonian Zone of *Inoceramus amakusensis* in Hokkaido and Kyushu. It may be reckoned as one of the members in the assemblage of that zone.

Aside from the distribution in the Japanese province, certain species are closely allied to the contemporary species in other provinces. *Cymatoceras* aff. *C. mikado*, *C.* cf. *C. sakalavum* and *C.* aff. *C. virgatum*, as well as *C. sharpei* (Gosau form) are such examples. *C.* aff. *C. virgatum* is also somewhat similar to *C. carlottense* (Whiteaves), from the Albian on the Pacific side of Canada.

4. *Palaeobiogeography*:—The three species from the Lower Cretaceous of Hokkaido (described in Part 5) seem to have a close affinity with *Cymatoceras mikado* (Krenkel), from the Barremian of eastern Africa, *C. sakalavum* Collignon, from the Albian of Madagascar and *C. virgatum* (Spengler), from the Albian of southern India, respectively. The differences of our forms from the original types could possibly be proved subspecific, if sufficient material were obtained in both provinces. The original species are all distributed on the coastal area of the Cretaceous Indian Ocean which had free connection with the eastern Tethys and the western Pacific (see reconstructed palaeogeographic maps by Barron *et al.*, 1981).

Aside from *Cymatoceras sharpei* (Schlüter), eleven species from the Upper Cretaceous of Hokkaido are all seemingly endemic, as none of them has been known outside the Japanese province of the Late Cretaceous times.

In general, many genera of the Cretaceous nautiloids show worldwide distribution, but at specific level there seem to have been provincial differences. For instance, very few species are common between western Europe and North America, although the Cretaceous Atlantic Ocean must have been much narrower than the Recent one. This is a remarkable contrast to the fact that certain species of the Ammonoidea had really worldwide distribution.

There is much to be worked out to understand the true implications of the above facts.

5. *Palaeoenvironments*:—I can state little about the palaeoenvironments of the Cretaceous nautiloids. Although the life history of the recent species of *Nautilus* is being studied intensively (e.g., Hirano *et al.*, 1982), how to apply that knowledge to Mesozoic nautiloids may

involve another problem. Since the living *Nautilus* is so to speak a relict at the end of the long-continued evolutionary history of the Nautiloidea, it may have some peculiarity in its mode of life. Anyhow, I give here concisely the following notes through the study of the Cretaceous nautiloids from Hokkaido.

(1) The nautiloid fossils have been obtained from the strata in which ammonites and inoceramids occur commonly.

(2) The body-chamber is preserved in many of the studied specimens, although it may be incomplete in some cases.

(3) *Anglonautilus*, a truly ribbed nautiloid, occurs in the sediments of near shore, shallow sea environments. For example, numerous specimens of *A. japonicus* were embedded in the sandstone of shallow open sea facies in which ornated ammonites such as *Mantelliceras* and *Hypoturrilites* occurred commonly. *A. mamiyai* was found in a nodule which contained drifted fragments of land plants.

(4) *Eutrephoceras soyaense* was found fairly commonly in a bed of near shore, shallow open sea facies in which the nodules contain abundantly drifted fragments of land plants. In North America and other regions, *E. dekayi* and other related species, which are characterized by globose shells with inflated whorls and nearly linear sutures, occur also in a shallow shelf facies.

(5) As to *Kummeloceras* only the general account mentioned in (1) is applicable and no particular point has been noted.

(6) *Cymatoceras* has many kinds of species, showing varieties of shell-form, ribbing and sutural sinuosity. Accordingly, there must have been a considerable difference in the habitat and mode of life of *Cymatoceras* from a species to another. Examples from Hokkaido seem to support this general statement, but it is still difficult to give precisely an ecological interpretation on each of the described species. Incidentally, no example of *Cymatoceras* has been known from the Turonian of Hokkaido, whereas specimens of *Kummeloceras* have been obtained not rarely from that stage. Whether this is due to collection failure and just accidental or has some ecological meaning is a question to be answered in the future.

In conclusion, the serial papers in Parts 1 to 7 have given the present knowledge as to what kinds of species occur in what strata of which ages in Hokkaido. This is, however, a start for further study which should be developed by the cooperation of zealous naturalists.

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Explanation of Plate 65

Fig. 1. *Cymatoceras* sp. aff. *C. mikado* (Krenkel) . . . . Page 339
GK. H5927, obtained by Y. Ueda from Jizo-iwa, lowest member of the Rebun Group (Neocomian), Rebun Island. lateral (a) and ventral (b) views. Scale bar: 20 mm.

1a

1b

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Chiyenaibo チエナイボ, Hikage-no-sawa 日蔭の沢, Ikushumbets [Ikushunbetsu] 幾春別, Jizo-iwa 地蔵岩, Kerimai 毛舞, Matsumoto-zawa 松本沢, Mitsuishi 三石, Oyubari 大夕張, Rebun 礼文, Sakubai サクバイ, Soya 宗谷, Shiyubari 主夕張, Urakawa 浦河, Yezo 蝦夷[エゾ]

北海道産白亜紀オウムガイ類—V. その5-7を含む, その5. 下部白亜系産同類。

A. 宗谷と大夕張産の1種: *Cymatoceras* sp. aff. *C. virgatum* (Spengler). インドのアルビアン産模式標本に類似するが, 殻側面がそれ程膨れず B/H が1に近く, 肋は2分岐を何回か示すが3分岐は認められない。大夕張のはアルビアン; 宗谷のは層位未定。(松本達郎・宮内敏哉)

B. 浦河地域産の1種: *Cymatoceras* sp. cf. *C. sakalavum* Collignon. 浦河北々西 17 km の毛舞川支流の1地点, 中部エゾの M1a 砂岩産。二次変形しているがマダガスカル島アルビアン産の標記種に類似。(松本達郎・蟹江康光・宮田雄一郎)

C. 礼文島ネオコミアン産1種: *Cymatoceras* sp. aff. *C. mikado* (Krenkel). タンザニアのネオコミアン産のに類似するが, 螺環断面が準梯形でへそも広い。地蔵岩近傍の礼文層群最下部層産。(松本達郎・植用芳郎)

その6. サントニアン産の追加1種: *Cymatoceras sharpei* (Schlüter). ドイツのセノマニアン産原標本よりはむしろオーストリア Gosau 層群サントニアンから最近報告のものによく似る。幾春別川上流サントニアンより高橋武美氏採集。(松本達郎)

その7. 北海道産白亜紀オウムガイ類 成果の要約。(1)記載した15種を表示, 産出層の時代を併記 (p. 341). (2) *Kummeloceras* 属を設立し, 系統分類について新知見を提示 (第4図の系統樹参照). (3)各階ごとに異なる種が産しており, 中には化石帯構成種のメンバーたり得るものもある。海外類似種との対比のできるものもある。(4)古生物地理, (5)古環境についても, 若干のまとめを試みた。(松本達郎)

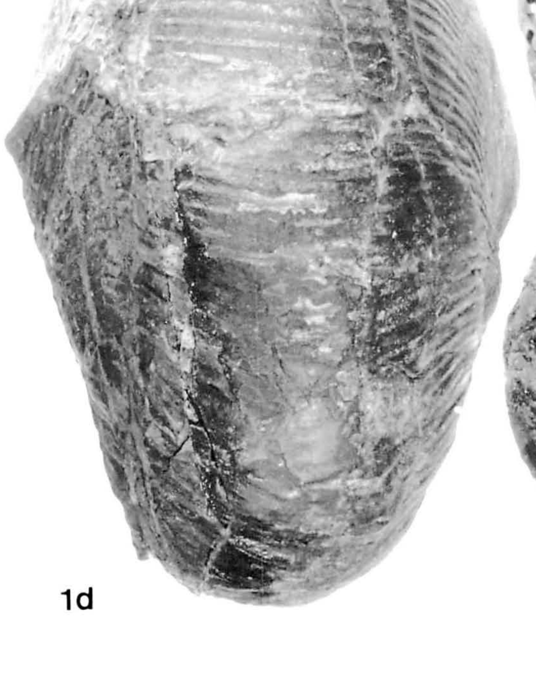
Postscript. The generic name *Kummeloceras* Matsumoto, 1983 was preoccupied by *Kummeloceras* Shimansky, 1967 (*Bull. Palaeont. Inst. Acad. Sci. USSR*, vol. 115, p. 121), which was proposed for *K. sibiricum* Shimansky, from the Permian of Siberia and referred to the family Temnocheilidae with a query. I hereby propose ***Kummelonautilus*** to replace *Kummeloceras* Matsumoto, 1983 (this series, part 1, p. 12). I sincerely thank Dr. V. N. Shimansky for his kind information about the work in the Soviet Union. (Tatsuro Matsumoto)

Explanation of Plate 66

Fig. 1. *Cymatoceras sharpei* (Schlüter) . . . . Page 340
TTC. 370713, collected by T. Takahashi from 17 km point along the main stream of the River Ikushumbets. Two lateral (a, b) frontal (c) and back (d) views, × 1.

1a

1c



1d

1b

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 134, pp. 347—360, pl. 67, July 30, 1984

778. A VISEAN BRACHIOPOD FAUNA FROM THE MANO FORMATION, SOMA DISTRICT, ABUKUMA MOUNTAINS, NORTHEAST JAPAN*

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Abstract. An Early Carboniferous (Late Visean) brachiopod fauna is described from the top of the Mano Formation of the Abukuma Mountains, northeast Japan. It includes the following species: *Leptagonia analoga*, *Rugosochonetes* cf. *celticus*, *Yanishewskiella* cf. *angulata*, *Spirifer* sp., *Brachythyris* sp., *Syringothyris* sp. and *Tylothyris laminosa*.

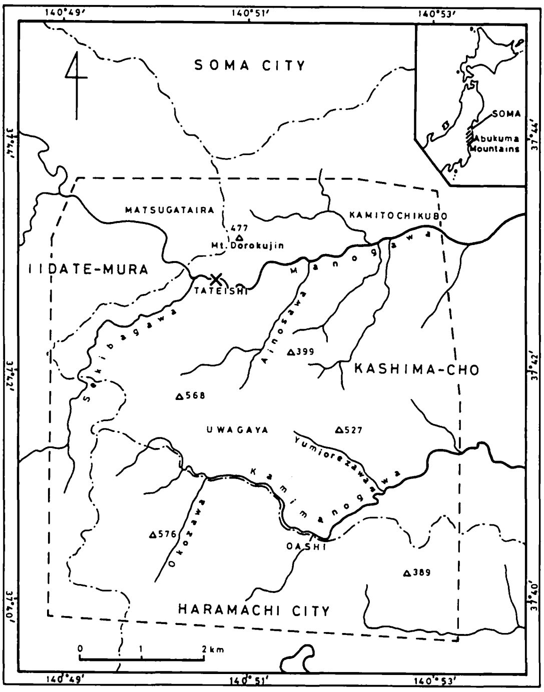
The Late Visean age assignment for this fauna matches well with the stratigraphic data suggesting that the Mano Formation is overlain conformably by the Upper Visean Tateishi Formation.

Introduction

The Carboniferous brachiopods described below were collected at a locality in Tateishi (lat. 37°42′45″N, long. 140°50′39″), Kashima-cho, Soma-gun, Fukushima Prefecture, i.e. the Soma district in the Abukuma Mountains of northeast Japan (Text-fig. 1). They came from sandstone in the uppermost part of the Mano Formation.

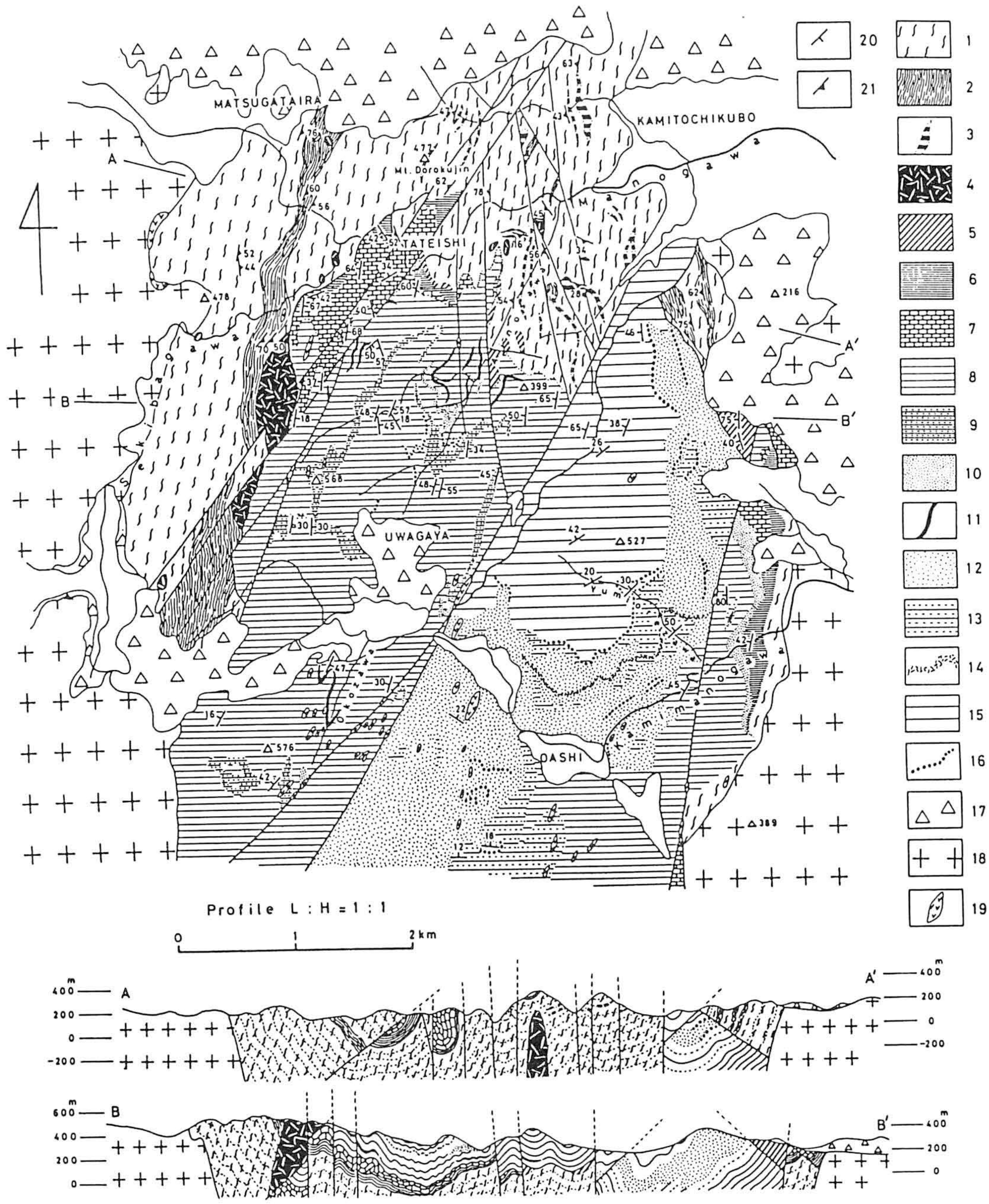
The Mano Formation named by Sato in 1956, was regarded as Early Carboniferous (Sato, 1956, 1974) or Tournaisian (Minato, 1960; Konishi, 1963; Minato, Gorai and Hunahashi, 1965; Ichikawa, Fujita and Shimazu, 1970; Yoshida, 1977; Minato and Kato, 1978; Minato et al., 1979) in age without firm evidence. Until now only some species of brachiopods, a species of rugose coral and a species of trilobite were recorded from this formation (Sato, 1956, 1974; Minato et al., 1979), but they were not described or illustrated.

In this paper the brachiopods of Tateishi are described and the age of the fauna is discussed. Stratigraphic relationship between the

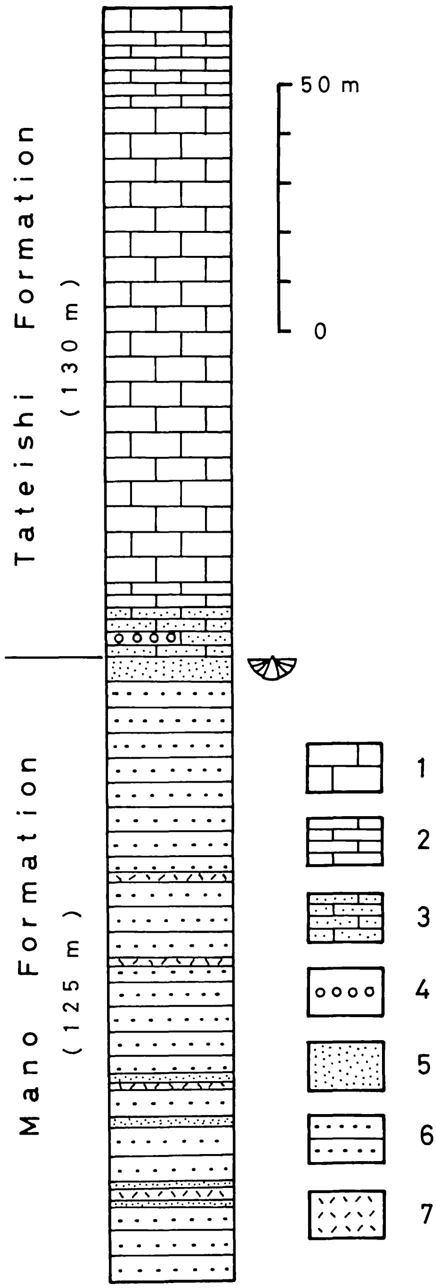


Text-fig. 1. Map showing the fossil locality (×) and the Soma district.

*Received April 13, 1983.



Text-fig. 2. Geologic map of the Soma district. 1—4: Matsugadaira Formation (Pre-Upper Devonian; 1: Mafic schist and phyllite; 2: Pelitic schist and phyllite; 3: Chert; 4: Metabasite); 5: Ainosawa Formation (Upper Devonian); 6: Mano Formation (Lower Carboniferous); 7: Tateishi Formation (Lower Carboniferous); 8—11: Uwagaya Formation (Lower Permian; 8: Shale; 9: Alternation of sandstone and shale; 10: Sandstone; 11: Limestone); 12—14: Oashi Formation (Middle Permian; 12: Sandstone; 13: Alternation of sandstone and shale; 14: Acidic tuff); 15: Yumiorezawa Formation (Upper Permian); 16: Conglomerate of the Uwagaya, Oashi and Yumiorezawa Formations; 17: Neogene Tertiary; 18: Granitic rocks; 19: Dyke rocks; 20: Dip and strike of bedding plane; 21: Dip and strike of bedding schistosity.



Text-fig. 3. Columnar section of the Lower Carboniferous of the Soma district, showing the stratigraphic position of the fossil locality shown on index map, see Text-fig. 1. 1: Massive limestone; 2: Bedded limestone; 3: Sandy limestone; 4: Conglomerate; 5: Sandstone; 6: Alternation of sandstone and shale; 7: Acidic tuff.

Mano Formation and the overlying Tateishi Formation is also mentioned. This has been one of the most important problems for the Carboniferous stratigraphy and geohistory of the Abukuma Mountains, since Minato (1955) noted that there is a sharp angular unconformity under the base of the Tateishi Formation.

In the present study description of the stratigraphy was prepared by Gunji, Mori and Tazawa while the systematics and correlation were prepared by Tazawa. The brachiopod specimens are stored in the Institute of Geology and Palaeontology, Faculty of Science, Tohoku University.

Stratigraphy

The Mano Formation crops out in two areas, around Tateishi and east of Oashi, both in the Soma district (Text-fig. 2). In the former, the formation forms a synclinorium plunging with $20^{\circ}-30^{\circ}$ to the SSW. It consists of fine-grained sandstone and shale in alternation, with several, thin, acidic tuff intercalations, about 125 m in total thickness (Text-fig. 3). The Mano Formation overlies with probable conformity the Ainosawa Formation, and is in turn overlain conformably by the Tateishi Formation. Fossils are rare in the Mano Formation, except for the top, 5 m thick, massive, dark grey, fine-grained, calcareous sandstone, in which there are rather numerous brachiopods, bryozoans and crinoids.

The underlying Ainosawa Formation (125 m thick) consists mostly of tuffaceous shale and yields *Cyrtospirifer*. It has been correlated with the upper part of the Tobigamori Formation (Upper Famennian) of the southern Kitakami Mountains, northeast Japan by brachiopods (Hayasaka and Minato, 1954; Minato and Kato, 1979).

The overlying Tateishi Formation consisting of dark-grey to black limestone, 130 m in thickness, has been correlated with the Upper Visean Onimaru Formation of the southern Kitakami Mountains, based on the similarities of lithofacies and the coral fauna (Sato, 1956). In the present work, we also collected some rugose corals such as *Lonsdaleia* sp., *Cyathaxonia* sp. and *Dibunophyllum* cf. *D. biparticum* (M'Coy) from the limestone.

Age of the Fauna

The brachiopods of Teteishi described herein, and the number of specimens are shown as follows:

Leptagonia analoga (Phillips) 4
Rugosochonetes cf. *R. celticus* Muir-Wood rev. Brand 1
Yanishewskiella cf. *Y. angulata* (Yanishevsky) 1
Spirifer sp. 3
Brachythyris sp. 1
Syringothyris sp. 5
Tylothyris laminosa (M'Coy) 8

Among these species, *L. analoga* and *T. laminosa* are long ranging forms; both occur in Tournaisian to Visean rocks. However, the genus *Yanishewskiella* is restricted to the Upper Visean and Namurian (Winkler Prins, 1982). *Spirifer* (s.s.) occurs mainly in the Visean (Thomas, 1971). *Rugosochonetes* is common in the Visean to Namurian (Muir-Wood, 1962; Afanasjeva, 1975). The *Rugosochonetes* from Tateishi is close to *R. celticus* Muir-Wood (rev. Brand) from the Upper Visean and Namurian of Britain. *Syringothyris* sp. differs from the Tournaisian forms; it resembles *S. fontanalis* Roberts from the Upper Visean of northwestern Australia.

Stratigraphically, the sandstone yielding the brachiopods is apparently lower than the limestone of the Upper Visean Tateishi Formation. The age of the brachiopod fauna does, therefore, not range up into Namurian.

The Tateishi fauna from the top of the Mano Formation can be estimated to be of Visean age, probably Late Visean.

Description of Species

Order Strophomenida Öpik, 1934

Suborder Strophomenidina Öpik, 1934

Superfamily Strophomenacea King, 1846

Family Leptaenidae Hall and Clarke, 1894

Subfamily Leptaeninae Hall and Clarke, 1894

Genus *Leptagonia* M'Coy, 1844

Leptagonia analoga (Phillips, 1836)

Pl. 67, Figs. 2—4

1836 *Producta analoga* Phillips, p. 256, pl. 7, fig. 10.
1842—1844 *Leptaena depressa* var. *analoga* (Phillips): de Koninck, p. 215, pl. 13, figs. 6a—6c.
1844 *Leptagonia analoga* (Phillips): M'Coy, p. 117.
1861 *Strophomena rhomboidalis* var. *analoga* (Phillips): Davidson, p. 119, pl. 28, figs. 1—6, 9—13.
1863 *Strophomena analoga* (Phillips): Davidson, p. 173, pl. 9, fig. 18.
1872 *Strophomena rhomboidalis* var. *analoga* (Phillips): Etheridge, p. 333, pl. 18, fig. 1.
1900 *Leptaena analoga* (Phillips): Frech (in Frech and von Arthaber), p. 200.
1909 *Leptaena rhomboidalis* (Wilckens): Sommer, p. 626, pl. 29, figs. 14, 14a.
1909 *Leptaena rhomboidalis* (Wilckens): Weller, p. 292, pl. 12, figs. 2, 3.
1913 *Plectambonites rhomboidalis* var. *analoga* (Phillips): Mansuy, p. 31, pl. 5, fig. 3.
1914 *Leptaena analoga* (Phillips): Weller, p. 49, pl. 2, figs. 1, 2, 5—10 only.
1916 *Leptaena analoga* (Phillips): Frech, p. 237, pl. 2, figs. 2, 3d.
1920 *Leptaena analoga* (Phillips): Girty, pl. 54, fig. 3.
1924 *Leptaena analoga* (Phillips): Tolmatchoff, p. 209, pl. 13, fig. 8.
1927 *Leptaena analoga* (Phillips): Girty, pl. 22, figs. 6—8.
1934 *Leptaena analoga* (Phillips): Demanet, p. 61, pl. 5, figs. 1—14; text-figs. 11—14.
1938 *Leptaena analoga* (Phillips): Branson, p. 24, pl. 5, fig. 31.
1951 *Leptaena analoga* (Phillips): Minato, p. 361, pl. 3, fig. 1.
1952 *Leptaenella analoga* (Phillips): Sokolskaja (in Sarytcheva and Sokolskaja), p. 36, pl. 3, fig. 18.
1954 *Leptaena* cf. *L. analoga* (Phillips): Maxwell, p. 33, pl. 4, figs. 1—3.
1957 *Leptaenella* cf. *L. analoga* (Phillips): Campbell, p. 41, pl. 13, figs. 20, 21.

1958 *Leptagonia* cf. *L. analoga* (Phillips): Cvancara, p. 860, pl. 110, figs. 6—13; text-figs. 3, 4.
1961 *Leptaena analoga* (Phillips): Nelson, pl. 4, fig. 26.
1962 *Leptaena analoga* (Phillips): Armstrong, pl. 6, fig. 25.
1963 *Leptaenella analoga* (Phillips): Sokolskaja (in Sarytcheva et al.), p. 80, pl. 3, figs. 9—14.
1966 *Leptaenella analoga* (Phillips): Gretchischnikova, p. 94, pl. 1, figs. 19—20; pl. 2, figs. 1—6.
1968 *Leptagonia analoga* (Phillips): Brunton, p. 29, pl. 3, figs. 26—31; pl. 4, figs. 1—9; text-figs. 6—17.
1970 *Leptaenella analoga* (Phillips): Abramov, p. 108, pl. 1, figs. 11, 12.
1971 *Leptagonia analoga* (Phillips): Bublitschenko, p. 37, pl. 3, figs. 1—5.
1971 *Leptagonia analoga* (Phillips): Thomas, p. 30, pl. 18, figs. 1—8; text-figs. 11a—11d.
1973 *Leptaenella analoga* (Phillips): Nalivkin and Fotieva, p. 20, pl. 1, figs. 9—13.
1974 *Leptagonia analoga* (Phillips): Kalashnikov, p. 23, pl. 3, figs. 5a, 5b.
1974 *Leptagonia distorta* (Sowerby): Jing and Liao, p. 277, pl. 142, figs. 20—22.
1975 *Leptagonia analoga* (Phillips): Litvinovich, Aksenova and Martynova, p. 53, pl. 16, fig. 11.
1976 *Leptagonia analoga* (Phillips): Bublitschenko, p. 22, pl. 1, fig. 10.
1977 *Leptagonia analoga* (Phillips): Yang, Ni, Chang and Zhao, p. 316, pl. 131, figs. 2a, 2b.
1978 *Leptagonia analoga* (Phillips): Tong, p. 213, pl. 77, figs. 7a—7c.
1978 *Leptagonia distorta* (Sowerby): Feng and Jiang, p. 237, pl. 86, figs. 3, 4.
1979 *Leptagonia analoga* (Phillips): Nalivkin, p. 18, pl. 3, figs. 1—3, 5, 6.
1979 *Leptagonia distorta* (Sowerby): Jing, Ye, Xu and Sun, p. 76, pl. 22, figs. 10—12.

Material:—Four specimens: (1) external and internal moulds of a brachial valve, IGPS coll. cat. no. 97912; (2) external moulds of three brachial valves, IGPS coll. cat. nos. 97913—97915.

Description:—Brachial valve wider, trapezoidal in outline, with the greatest width at hinge line, flat to slightly concave on visceral disc, surrounded by a deep, rounded depression at the anterior and lateral margins of visceral disc, strongly geniculated nearly at right angles just anterior to the depression, with a trail about 10 mm long; cardinal extremities blunt, angular; length 23 mm, width 33 mm in the best preserved specimen (IGPS coll. cat. no. 97913).

External ornament of brachial valve consisting of irregular, strong, concentric rugae and numerous, fine capillae on visceral disc; 17 rugae and numerous capillae with a density of 18 to 20 per 5 mm at the mid portion of visceral disc; rugae lacking on trail.

Dorsal internal structure unknown, except for a median septum and some vascular markings partly and faintly preserved in a specimen numbered IGPS coll. cat. no. 97912.

Remarks:—The Soma specimens can be identified with *Leptagonia analoga* (Phillips, 1836) by their medium-sized, wider trapezoid-shaped brachial valves with subangular cardinal extremities, a deep, rounded depression at the antero-lateral margins of the visceral disc, and the external ornament of irregular concentric rugae and numerous capillae. The dorsal depression which bounded the visceral disc was noted by Campbell (1957, p. 41) on the Australian specimens.

L. analoga has been reported from the Tournaisian and Visean of Europe, Asia, North America and Australia. It seems to be worthy to note that this species occurs commonly in the Visean of Britain (Muir-Wood, 1948; Brunton, 1968), Germany (Sommer, 1909), the Soviet Union (Abramov, 1970; Kalashnikov, 1974), China (Jing and Liao, 1974; Feng and Jiang, 1978; Jing, Ye, Xu and Sun, 1979), Laos (Mansuy, 1913) and eastern Australia (Campbell, 1957; Cvancara, 1958).

Suborder Chonetidina Muir-Wood, 1955

Superfamily Chonetacea Bronn, 1862

Family Chonetidae Bronn, 1862

Subfamily Rugosochonetinae Muir-Wood, 1962

Genus *Rugosochonetes* Sokolskaja, 1950

Rugosochonetes cf. *R. celticus* Muir-Wood, 1962 rev. Brand, 1970

Pl. 67, Figs. 1a—1c

Compare:—

1962 *Rugosochonetes celticus* Muir-Wood, p. 68, pl. 7, figs. 3, 4, 5, 7, 8 only.

1968 *Rugosochonetes celticus* Muir-Wood: Brunton, pl. 7, figs. 28—31; pl. 8, figs. 1—9.

1970 *Rugosochonetes celticus* Muir-Wood pars: Brand, p. 108, pl. 10, figs. 12—20; pl. 13, figs. 5, 6, 9.

Material:—One specimen, internal mould of a pedicle valve with the external mould of the posterior portion attached, IGPS coll. cat. no. 97916.

Description:—Shell large size for the genus, semicircular in outline, with the greatest width at hinge line; length 14 mm, width 13 mm.

Pedicle valve moderately convex, with a shallow sulcus on the anterior half of the valve. Ventral interarea well developed, 1.2 mm high at both sides of delthyrium; delthyrial angle 37°.

In the pedicle valve, a median septum sharp and high in the posterior portion, rather blunt and low in the anterior portion, totalling 5.9 mm long. Teeth massive, subtrigonal, demarcated from interarea by grooves. A pair of smooth, elongate adductor scars at the postero-median portion of the valve. Diductor scars large, flabellate, radially striated on the surface, occupying half the area of visceral disc and bounded by a pair of ridges of about 3.5 mm long. Papillae strong over ear regions and the posterior halves of lateral slopes.

Remarks:—This specimen is quite similar to the pedicle valve of *Rugosochonetes celticus* Muir-Wood, 1962 pars, figured by Brand (1970, pl. 10, fig. 12) from the Upper Visean of Scotland, in size, shape and internal features of the pedicle valve.

R. celticus was proposed by Muir-Wood in 1962 for materials from the Upper Visean and Namurian of Britain. Subsequently, the type specimens were examined by Brand (1970), in which he noted that only those paratypes from Flint, North Wales and Beith, Scotland are considered to be conspecific with the holotype, and the majority of the other paratypes are determined as *Rugosochonetes speciosus* (Cope, 1938).

Rugosochonetes sp. from the top of the Karaumedate Formation (Upper Visean) in the Nagasaka district, southern Kitakami Mountains, northeast Japan (Tazawa, 1980, p. 361, pl. 41, figs. 1a, 1b) differs from the present form in its more transverse shell outline and having a pair of prominent vascular trunks in the pedicle valve.

In southwest Japan two *Rugosochonetes* species have been known: *Rugosochonetes* sp. from the Lower Visean of Hina, Okayama Prefecture (Hase and Yokoyama, 1975, pl. 18, figs. 2, 3) and *Rugosochonetes* aff. *R. hardrensis* (Phillips, 1841) from the Lower Namurian of Akiyoshi, Yamaguchi Prefecture (Yanagida, 1965, p. 115, pl. 27, figs. 2—8). But the comparison to these forms is difficult, because they are lacking information on the ventral internal structure.

Order Rhynchonellida Kuhn, 1949

Superfamily Rhynchonellacea Gray, 1848

Family Tetracameridae Likharev, 1956

Genus *Yanishewskiella* Likharev, 1957

Yanishewskiella cf. *Y. angulata* (Yanishevsky, 1910)

Pl. 67, Figs. 5a, 5b

Compare:—

1918 *Goniophoria angulata* Yanishevsky: Yanishevsky, p. 67, pl. 6, fig. 27; pl. 7, figs. 9, 10.

1965 *Yanishewskiella angulata* (Yanishevsky): McLaren, p. H589, figs. 466 2a—2c, 467.

1974 *Janishewskiella*(?) *angulata* (Yanishevsky): Kalashnikov, p. 100, pl. 38, fig. 8.

Material:—One specimen, external mould of a brachial valve, IGPS coll. cat. no. 97917.

Remarks:—This specimen is characterized by its small, rhynchonelliform shell (length 21 mm, width 16 mm) with a few, broad and subrounded costae (7 costae are counted) on the brachial valve.

The Soma specimen resembles shells of *Yanishewskiella angulata* (Yanishevsky, 1910) described or figured by Yanishevsky (1918), McLaren (1965) and Kalashnikov (1974) from the Upper Visean and Lower Namurian of the Urals and Fergana in size, shape and external ornament of the brachial valve. But the poor preservation of this material makes the accurate comparison difficult.

Yanishewskiella? sp., from the uppermost part of the Karaumedate Formation of the Kitakami Mountains (Tazawa, 1980, p. 364, pl. 42, figs. 1a—4), can be easily distinguished from the present form by its smaller dimensions.

Order Spiriferida Waagen, 1883

Suborder Spiriferidina Waagen, 1883

Superfamily Spiriferacea King, 1846

Family Spiriferidae King, 1846

Subfamily Spiriferinae King, 1846

Genus *Spirifer* Sowerby, 1816

Spirifer sp.

Pl. 67, Figs. 12—14

Material:—Three specimens: (1) internal moulds of two pedicle valves, IGPS coll. cat. nos. 97918, 97919; (2) external cast of a brachial valve, IGPS coll. cat. no. 97920.

Description:—Shell small size for the genus, wider subquadrate in outline. Hinge line a little less than the greatest width of shell, the latter occurring at anterior to hinge line but slightly posterior to midvalve. Cardinal extremities rounded. Length about 30 mm, width 54 mm, width of hinge line 44 mm in the largest specimen (IGPS coll. cat. no. 97918).

Both valves moderately convex in lateral profile, with maximum convexity posterior to midvalve, having a shallow sulcus and a low dorsal fold. Pedicle valve ornamented by numerous costae and irregular, strong concentric rugae on lateral slopes and sulcus; costae often bifurcating; 24 costae on each of lateral slopes, 12 costae on sulcus. Brachial valve with external ornament of numerous, simple or bifurcating costae and irregular, concentric rugae; 24 or 25 costae on each lateral slopes, 11 costae on fold.

Pedicle valve interior with a heart-shaped muscle field situated at just anterior to the umbonal region. The muscle field radially and longitudinally striated, divided by a median ridge (myophragm) posteriorly on two-thirds of the length of the field. Other internal structure obscure owing to thick apical callus.

Remarks:—In the present material, the external ornament of the pedicle valve is faintly preserved on the surface of the internal mould.

These specimens are referred to the genus *Spirifer* (s.s.) Sowerby, 1816 on account of their large, transverse shells with hinge line slightly shorter than the greatest width, rounded cardinal extremities, numerous bifurcating costae on the lateral slopes and the sulcus, and the absence of long dental plates or a median septum in the pedicle valve.

The Soma specimens resemble shells of *Spirifer crassus* de Koninck, described and figured by de Koninck (1842—1844, p. 262, pl. 15, fig. 5) from the Visean of Belgium, and by Davidson (1858, p. 25, pl. 6, figs. 20—22; pl. 7, figs. 1—3) from the Visean of Ireland in shape and external ornament, but the European specimens are much larger in size.

Spirifer cf. *S. crassus* de Koninck, from the Visean(?) of Omi, central Japan (Hayasaka, 1924, p. 43, pl. 6, fig. 6), differs from the present form in its smaller dimensions and more rectangular shell outline.

Family Brachythyrididae Fredericks, 1919 (1924)

Genus *Brachythyris* M'Coy, 1844

Brachythyris sp.

Pl. 67, Fig. 15

Material:—One specimen, internal mould of a brachial valve, IGPS coll. cat. no. 97921.

Description:—Brachial valve wider suboval in outline, slightly convex except for the strongly convexed posterior portion and highly elevated medial portion. Hinge line much shorter than the greatest width of the valve; the latter occurring at about midvalve. Cardinal extremities rounded. Fold high and broad anteriorly. Dimensions of the brachial valve: length about 31 mm, width 36 mm, width of hinge line 24 mm.

External ornament of the brachial valve consisting of strong costae and very fine growth lines. Costae broad, rounded and simple; 10 costae on lateral slopes. Numerous, very fine growth lines on the whole surface of the valve.

None of the internal structure of the brachial valve observed.

Remarks:—This specimen is assigned to the genus *Brachythyris* M'Coy, 1844 on the basis of its suboval shell outline and broad, simple costae on the brachial valve, but is too poorly preserved for specific determination. In the present material the external ornament of the brachial valve is impressed on the surface of the internal mould.

In size and shape the Soma specimen resembles the brachial valve (holotype) of *Brachythyris pseudovalis* Campbell, 1957, figured by Campbell (1957, pl. 14, fig. 13) from the Upper Visean of Watts, Babbinboon, New South Wales.

Brachythyris kitakamiensis Minato (1951, p. 368, pl. 3, fig. 3; pl. 4, fig. 1) from the Hikoroichi Formation of Choanji in the Hikoroichi district, southern Kitakami Mountains differs from the present form in its larger, more transverse shell and more numerous costae (14 costae) on the brachial valve.

Superfamily Syringothyridacea Fredericks, 1926

Family Syringothyrididae Fredericks, 1926

Subfamily Syringothyridinae Fredericks, 1926

Genus *Syringothyris* Winchell, 1863

Syringothyris sp.

Pl. 67, Figs. 6—7

Material:—Five specimens: (1) external and internal moulds of a pedicle valve, IGPS coll. cat. no. 97922; (2) external moulds of two pedicle valves, IGPS coll. cat. nos. 97923, 97924; (3) internal mould of a pedicle valve, IGPS coll. cat. no. 97925; (4) external and internal moulds of a brachial valve, IGPS coll. cat. no. 97926.

Remarks:—These specimens are assigned to the genus *Syringothyris* on the basis of their simple costae, deep, smooth sulcus, the presence of long dental plates and a syrinx, and the absence of median septum in the pedicle valve. The Soma species is characterized by its small shell size (width about 60 mm in the largest specimen, IGPS coll. cat. no. 97923) and the low ventral interarea (about 7 mm high).

In size and shape of the shell, *Syringothyris* sp. from Soma closely resembles *Syringothyris fontanalis* Roberts (1971, p. 249, pl. 54, figs. 5—18) from the Upper Visean of the Bonaparte Gulf Basin, northwestern Australia. But accessary costae on sulcus, a characteristic of *S. fontanalis*, cannot be observed in the present material.

The Soma species has an exterior resemblance to *Syringothyris japonica* Tachibana (1969, p. 22, pl. 3, figs. 1—5; pl. 4, figs. 1—8; pl. 5, figs. 1—7; pl. 6, figs. 1—4; text-fig. 1) and *Syringothyris sakamotoi* Tachibana (1969, p. 24, pl. 6, figs. 5—7) from the Karaumedate Formation of the southern Kitakami Mountains, but it differs from them in having less diverging dental plates in the pedicle valve.

Syringothyris kitakamiensis Minato, 1952 from the Arisu Formation of the southern Kitakami Mountains (Minato, 1952, p. 165, pl. 5, fig. 5) is also small in size, but is distinguished from the present form by its high ventral interarea.

Suborder Delthyrididina Ivanova, 1972

Superfamily Delthyridacea Waagen, 1883

Family Delthyrididae Waagen, 1883

Subfamily Tylothyridinae Carter, 1972

Genus *Tylothyris* North, 1920

Tylothyris laminosa (M'Coy, 1844)

Pl. 67, Figs. 8—11

1844 *Cyrtia laminosa* M'Coy, p. 137, pl. 21, fig. 4.
1858 *Spirifera laminosa* (M'Coy): Davidson, p. 36, pl. 7, figs. 17—19 only.
1905 *Syringothyris* aff. *S. laminosa* (M'Coy): Vaughan, p. 300.
1915 *Syringothyris laminosa* (M'Coy) forma 2 Vaughan, p. 43, pl. 6, figs. 1—3.
1920 *Tylothyris laminosa* (M'Coy): North, p. 197, pl. 13, figs. 1, 2, 12, 13, 16; text-figs. 4a, 4b.
1929 *Tylothyris laminosa* (M'Coy): Dehée, p. 23, pl. 3, figs. 12—14.
1937 *Spirifer* (*Tylothyris*) *laminosus* (M'Coy): Nalivkin, p. 109, pl. 33, figs. 3, 4.
1952 *Delthyris* aff. *D. clarksvillensis* (Winchell): Minato, p. 162, pl. 7, figs. 2, 5.
1966 *Tylothyris laminosa* (M'Coy): Gretchischnikova, p. 158, pl. 16, figs. 11—14; text-fig. 38.
1970 *Tylothyris laminosa* (M'Coy): Plodowski, p. 21, pl. 1, figs. 3—4; text-fig. 9.
1979 *Tylothyris laminosa* (M'Coy): Nalivkin, p. 131, pl. 49, fig. 15.

Material:—Eight specimens: (1) external mould of a pedicle valve and internal mould of a conjoined valve, IGPS coll. cat. no. 97927; (2) external and internal moulds of two pedicle valves with the external moulds of the posterior portions attached, IGPS coll. cat. nos. 97928, 97929; (3) external mould of a pedicle valve, IGPS coll. cat. no. 97930; (4) internal moulds of three pedicle valves with the external moulds of the posterior portions attached, IGPS coll. cat. nos. 97931—97933; (5) internal mould of a brachial valve, IGPS coll. cat. no. 97934.

Description:—Shell wider trigonal in outline, twice as wide as long; hinge line forming the widest part of the shell; cardinal extremities acute or slightly produced; length 20 mm, width about 39 mm in the largest specimen (IGPS coll. cat. no. 97927).

Pedicle valve moderately and unevenly convex in lateral profile, with the greatest convexity at umbo. Umbo narrow, pointed, strongly incurved and protruding beyond interarea. Ventral interarea apsacline, high, slightly arched; 4 mm high on a shell 17 mm long, 21 mm wide (IGPS coll. cat. no. 97933). Delthyrium open; delthyrial angle 27°—33°. Sulcus deep, angular, originating at beak and extending to the anterior margin of the valve.

External ornament of the pedicle valve consisting of simple, subrounded costae and regular, imbricating lamellae. Costae gradually decreasing the size and strength towards the lateral margins of the valve, with narrow, subangular intercostal grooves; 6 to 7 costae on each side of lateral slopes. Concentric lamellae being with a density of 6 to 8 per 5 mm at midvalve.

In the pedicle valve, a sharp, low median septum of one-half of the valve length occurring between adductor scars; the posterior portion of septum completely embedded in apical callus. Dental plates continuing from the edges of teeth to the valve floor. Adductor scars smooth, narrow and elongate. Diductor scars dendritic, ovate, situated on the flanks of sulcus.

In the brachial valve, a low median septum extending to about one-half of the length of the valve. Cardinal process having about 16 sharp, very thin plates of 0.5 to 1.2 mm long. Sockets narrow. Crural plates sharp, situated between cardinal process and sockets.

Remarks:—The specimens from Soma are referred to *Tylothyris laminosa* (M'Coy, 1844) because of similarities in size, shape, external ornament and internal structure.

T. laminosa has been described or figured from the Lower and Upper Tournaisian of Britain, Belgium and the Soviet Union (M'Coy, 1844; Davidson, 1858; Vaughan, 1905, 1915; North, 1920; Dehée, 1929; Nalivkin, 1979), the Upper Tournaisian to Lower Visean of the Soviet Union (Nalivkin, 1937; Gretchischnikova, 1966), the Lower and Upper Visean of Afghanistan (Plodowski, 1970) and the Upper Visean of Japan (Minato, 1952).

Delthyris aff. *D. clarksvillensis* (Winchell, 1865), described and figured by Minato (1952, p. 162, pl. 7, figs. 2, 5) from the Lower Carboniferous (=Upper Visean Karoyama Formation, after Tazawa, Itabashi and Mori, 1981; Tazawa, 1981) of Okuhinotsuchi in the southern Kitakami Mountains, appears to be assigned to *T. laminosa* in size, external ornament and internal structure of the brachial valve. Ijiri and Minato (1948, p. 167) reported *Tylothyris* cf. *T. laminosa* from the same locality of Okuhinotsuchi, although it was not described or illustrated.

Hase and Yokoyama (1975, pl. 18, figs. 2, 3) figured *Tylothyris* sp. from the Lower Visean of Hina, Okayama Prefecture, southwest Japan, but the Hina specimens are too poorly preserved for comparison to the present form.

Tylothyris planimedia Cvancara (1958, p. 876, pl. 112, figs. 8—10, 12; pl. 113, figs. 1—5; text-fig. 7) differs from *T. laminosa* in having more numerous costae (9 to 14 costae on either side of the sulcus) and a sulcus with flattened bottom.

Tylothyris transversa Roberts (1971, p. 224, pl. 50, figs. 1—19; text-figs. 71—73) from the Lower Tournaisian of the Bonaparte Gulf Basin, northwestern Australia can be distinguished from *T. laminosa* by its more transverse shell outline, lower ventral interarea and wider delthyrial angle (50°—55°).

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阿武隈山地相馬地域の真野層産ビゼー世腕足類化石：阿武隈山地，相馬地域（福島県相馬郡鹿島町立石）の真野層最上部の砂岩から後期ビゼー世（前期石炭紀）を示す腕足類化石が得られた。従来真野層の地質時代は前期石炭紀トルネー世とされていたが，少なくとも同層の最上部は後期ビゼー世の堆積物であると考えられる。また真野層と上位の上部ビゼー統立石層との間には著しい傾斜不整合が存在するといわれていたが，野外で不整合の証拠は認められず，しかもこの腕足類化石の産出により両層間に想定されていた時間間隙はないことが明らかになった。このたび採集・同定された腕足類は次の7種である：*Leptagonia analoga* (Phillips), *Rugosochonetes* cf. *R. celticus* Muir-Wood rev. Brand, *Yanishewskiella* cf. *Y. angulata* (Yanishevsky), *Spirifer* sp., *Brachythyris* sp., *Syringothyris* sp., *Tylothyris laminosa* (M'Coy)。

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Explanation of Plate 67

(Natural size unless otherwise indicated)

Figs. 1a—1c. *Rugosochonetes* cf. *R. celticus* Muir-Wood rev. Brand
1a, 1b, 1c. Internal mould of a pedicle valve and the rubber cast, IGPS coll. cat. no. 97916. Figs. 1b, 1c are ×2.

Figs. 2—4. *Leptagonia analoga* (Phillips)
2a, 2b. Dorsal and anterior views of external mould of a brachial valve, 2c. Internal mould of a brachial valve, IGPS coll. cat. no. 97912, 3. Rubber cast of a brachial valve exterior, IGPS coll. cat. no. 97914, 4. External mould of a brachial valve, IGPS coll. cat. no. 97913.

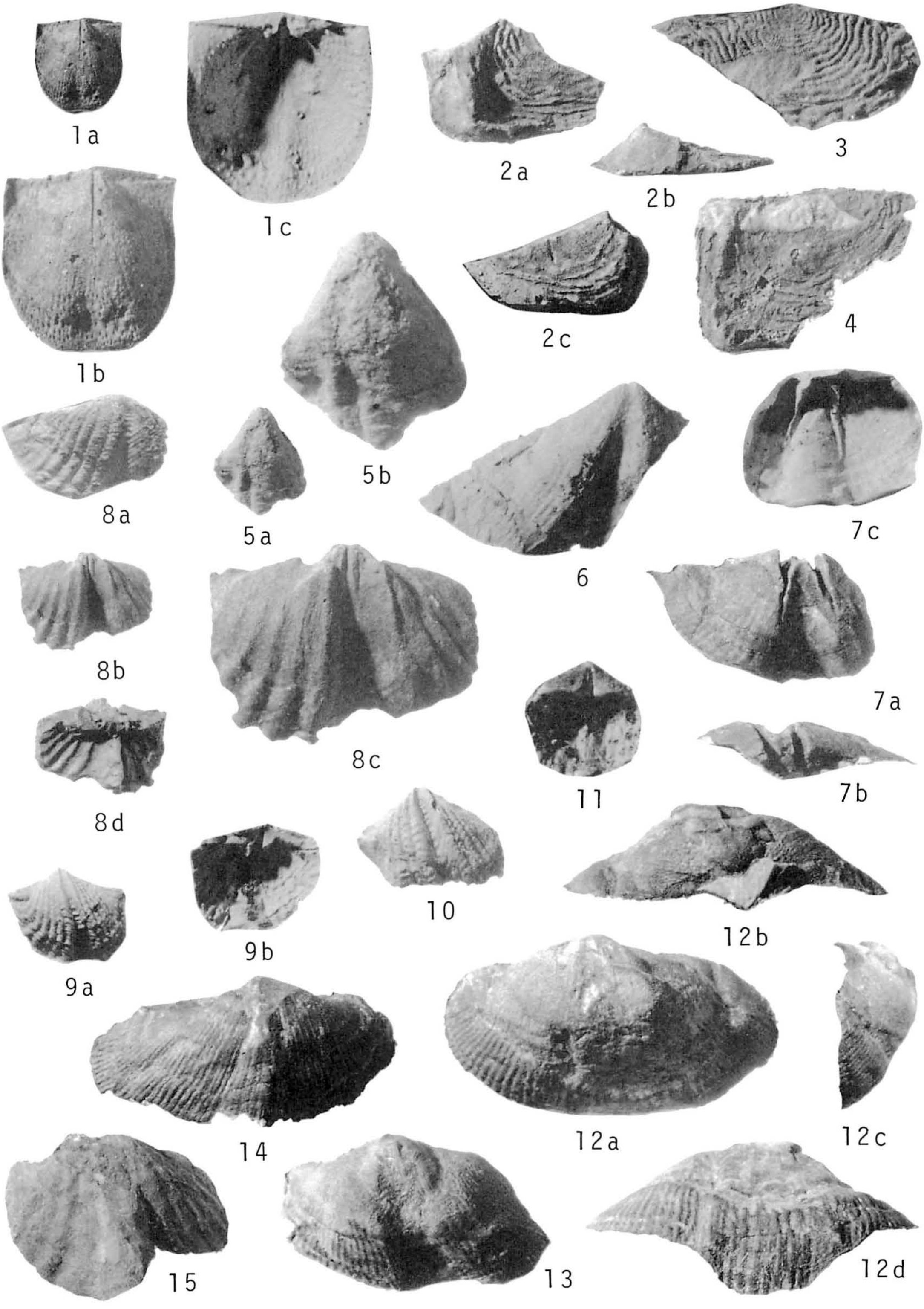
Figs. 5a, 5b. *Yanishewskiella* cf. *Y. angulata* (Yanishevsky)
Rubber cast of a brachial valve exterior, IGPS coll. cat. no. 97917. Fig. 5b is ×2.

Figs. 6—7. *Syringothyris* sp.
6. Rubber cast of a pedicle valve exterior, IGPS coll. cat. no. 97923, 7a, 7b. Ventral and posterior views of internal mould of a pedicle valve, 7c. Rubber cast of a pedicle valve interior, IGPS coll. cat. no. 97925.

Figs. 8—11. *Tylothyris laminosa* (M'Coy)
8a. Rubber cast of a pedicle valve, 8b, 8c, 8d. Ventral and dorsal views of internal mould of a pedicle valve, IGPS coll. cat. no. 97927, 9a, 9b. Rubber casts of a pedicle valve exterior and interior, IGPS coll. cat. no. 97928, 10. Rubber cast of a pedicle valve exterior, IGPS coll. cat. no. 97929, 11. Rubber cast of a pedicle valve interior, IGPS coll. cat. no. 97933. Fig. 8c is ×2.

Figs. 12—14. *Spirifer* sp.
12a, 12b, 12c, 12d. Ventral, posterior, lateral and anterior views of internal mould of a pedicle valve, IGPS coll. cat. no. 97918, 13. Internal mould of a pedicle valve, IGPS coll. cat. no. 97919, 14. A brachial valve, IGPS coll. cat. no. 97920.

Fig. 15. *Brachythyris* sp.
Internal mould of a brachial valve, IGPS coll. cat. no. 97921.


1a
1c
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8d
7b
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9b
12b
9a
14
12a
12c
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12d

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779. OBSERVATIONS ON OCCURRENCES OF JAPANESE NEOGENE NATICIDS (GASTROPODA) BEARING CALCAREOUS OPERCULA*

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Abstract. Twenty-four calcareous opercula of seven naticid species, including *Cryptonatica janthostoma, C. clausa, C. janthostomoides, C. adamsiana, C. ichishiana,* "*Naticarius*" sp. and *Natica vitellus,* which are accompanied by their shells are recorded from fifteen Neogene formations in Japan. The opercula of the Miocene species *Cryptonatica ichishiana,* and the Miocene-Pliocene species "*Naticarius*" sp. (= *Naticarius* cf. *N. niasensis* Wissema of MacNeil, 1961) are recorded for the first time in this paper.

According to the relative positions of the operculum and shell, the following five types of preservation are recognized. Type (1): operculum is preserved at the far inside of body whorl (18 specimens). Type (2): operculum is turned upside down at the base of shell, namely its external surface is attached to the base (3 specimens). Type (3): operculum almost coincides with the apertural margin and is only slightly recessed into the body whorl (1 specimen). Type (4): operculum is normal to the apertural plane. The anterior half protrudes from the aperture and the internal surface is attached to the inner lip (1 specimen). Type (5): operculum is completely detached from the shell (1 specimen).

The position of head-foot mass when naticids died can be reconstructed based on the occurrences of Types (2) and (3). Types (2) and (3) coincide, respectively, with the operculum positions of naticids that died with the head-foot mass protruding from the shell, and those that died with it withdrawn into the shell.

Introduction

Naticid snails are one of the dominant groups in the Neogene molluscan fauna of Japan (Hatai and Nisiyama, 1952; Masuda and Noda, 1976). The fossils of naticid opercula have been illustrated from Japanese Neogene formations by Nomura and Hatai (1937), Kaseno and Matsuura (1965), Itoigawa *et al.* (1974 and 1981), Ogasawara (1977) and Kotaka and Kato (1979), but these opercula were not accompanied by shells.

The associated occurrences of fossil naticid shells and opercula have been reported from other countries, as follows: *Natica duncani* Jenkins and *Natica rostalina* Jenkins from the Miocene Subapennine Formation in Indonesia by Jenkins (1863), *Natica pachyope* Cossmann and Peyrot from the Middle Miocene (Tortonien) in France by Cossmann and Peyrot (1917—1919), *Natica epiglottina* Lamarck and *Natica burtoni* Wrigley from the Paleogene in England by Wrigley (1949), *Stigmaulax guppiana* (Toula) from the Miocene Gatun Formation in Panama by Woodring (1957), *Natica marochiensis* (Gmelin) from the Upper Miocene Palau Lime-

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stone in Palau Island by Ladd (1977), and *Natica* (*Cryptonatica*) *oregonensis* (Conrad) from the Upper Miocene Empire Formation in Oregon, U.S.A. by Marincovich (1977). In Japan, Chinzei (1959) mentioned the occurrence of naticid opercula as "the specimens were found with calcareous operculums" when he described *Natica* (*Cryptonatica*) *russa* (Gould) from the Pliocene Kubo Formation in Iwate Prefecture, and Itoigawa *et al.* (1982) described the associate occurrence of shell and operculum of their *Cryptonatica* sp. 1 from the Miocene Mizunami Group in Gifu Prefecture.

During the paleontological study of Neogene naticids in Japan, the present writer examined twenty-four specimens (seven species) in association with their calcareous opercula from fifteen Neogene formations (Text-fig. 1, Table 1). It is worthwhile to record those occurrences and to compare the operculum positions of fossils with those of living naticids. Detailed taxonomic discussions of the naticids will be given at another opportunity.

Occurrences of Naticid Opercula in Association with their Shells

The term "shell" is used herein in reference to the calcareous part of a naticid specimen except for its operculum. The localities (Text-fig. 1), formations, associate species and positions of opercula for fossil naticids bearing opercula are described according to each species, as follows.

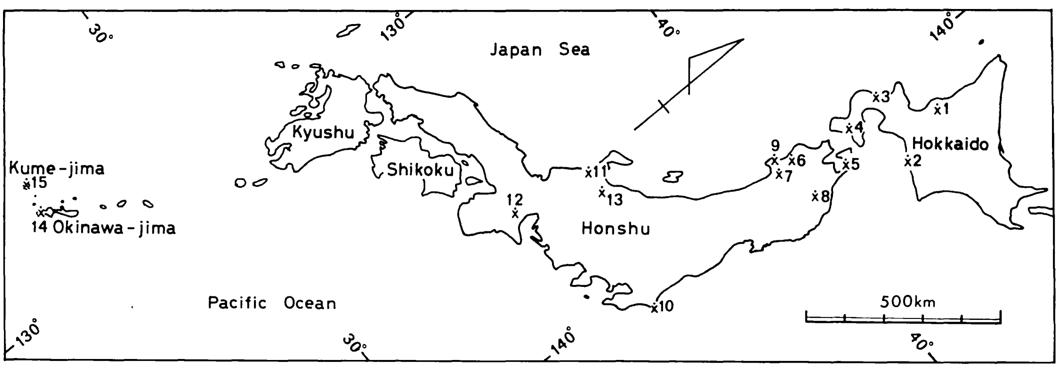
Cryptonatica janthostoma (Deshayes, 1839): Pl. 68, Figs. 1a—2e, Pl. 70, Figs. 5a—b, Text-fig. 2-a.

Cryptonatica janthostoma is characterized by having a narrowly open umbilicus between parietal and umbilical calluses and an almost smoothed operculum. The shells of *C. janthostoma* bearing opercula were collected from Locs. (1) and (7).

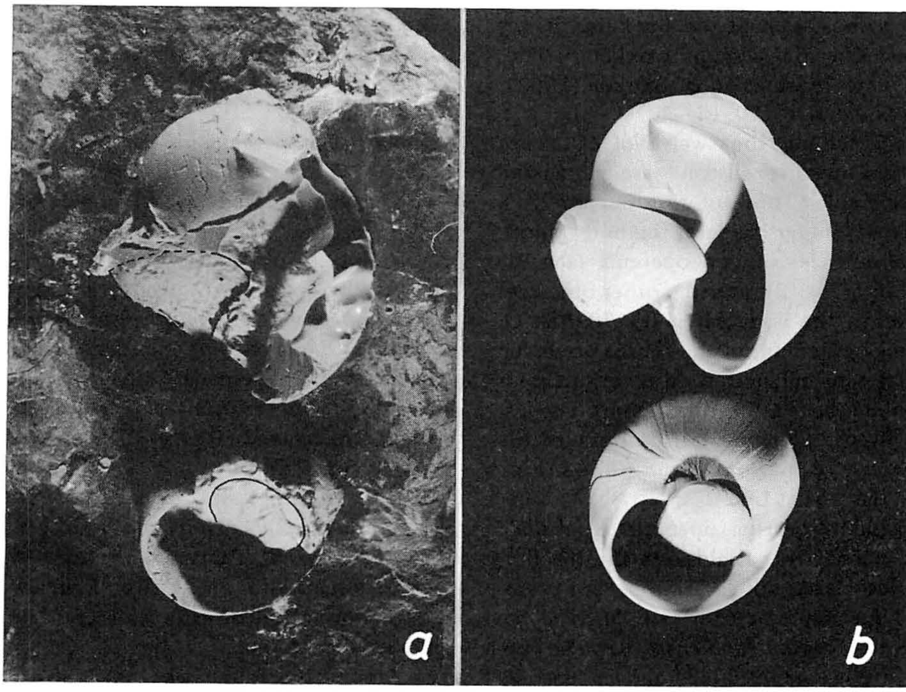
Locality (1): A cliff on the right bank of the Oshirarika River, about 1500 m east from Misawa, Shin-totsugawa-cho, Kabato-gun, Hokkaido; Pliocene Porokaoshirarika Formation of Kobayashi *et al.* (1957); Pl. 68, Figs. 1a—2e, Text-fig. 2-*a*.

Two shells of *C. janthostoma* bearing opercula were obtained from tuffaceous siltstone in association with *Acila gottschei* (Böhm), *Serripes groenlandicus* (Bruguière), *Macoma calcarea* (Gmelin), *Neptunea* sp. and *Balanus* sp. (attaching to *Serripes groenlandicus* and *Neptunea* sp.).

The two shells are almost dissolved. The shells of Figs. 1a—b, 1e, 2a—b, and 2e in Pl. 68 are



Text-fig. 1. Map showing fossil localities. Pliocene: Porokaoshirarika Formation (1), Atsuga Formation (2), Nakanokawa Formation (3), Tomikawa Formation (4), Sunagomata Formation (5), Kobinaizawa Formation (6), Sasaoka Formation (7), Kubo Formation (8), Shibikawa Formation (9), Iioka Formation (10), Omma Formation (11), Fusakina Formation (15). Miocene: Oi Formation (12), Joyama Mudstone Member of Yatsuo Formation (13), Yonabaru Clay Member of Shimajiri Formation (14).



Text-fig. 2. *a*: Occurrences of the shells and opercula of *Cryptonatica janthostoma*, Pliocene Porokaoshirarika Formation, Loc. 1, IGUT no. 15569—1, 2. The shells are rubber casts and the opercula rubber molds. *b*: Models of the specimens of *a* reconstructed by Recent specimens of *C. janthostoma.*

represented by rubber casts. Both their opercula are well preserved at the basal parts of the shells (Pl. 68, Figs. 1d and 2d). Figs. 1c and 2c in Pl. 68, and Text-fig. 2-*a* show the positions of the opercula represented by rubber molds. The external surfaces of both the opercula are attached to the bases of the shells. Models of these occurrences are shown in Text-fig. 2-*b* using Recent specimens of *Cryptonatica janthostoma.*

Locality (7): Road side cut on the ridge, about 400 m northeast of Monzen, Gojome-cho, Minami-Akita-gun, Akita Prefecture; Pliocene Sasaoka Formation of Honda (1978); Pl. 70, Figs. 5a—b.

Only one shell among the six of *C. janthostoma* collected from fine to medium grained sandstone is accompanied by its operculum, which is preserved at the far inside of the body whorl. At the locality, *C. janthostoma* is associated with *Anadara amicula elongata* Noda, *Mizuhopecten poculum* (Yokoyama), *Turritella saishuensis* Yokoyama and *Glossaulax didyma* (Röding).

Cryptonatica clausa (Broderip and Sowerby, 1829): Pl. 69, Figs. 1a—5b, Pl. 70, Figs. 1—4b.

Cryptonatica clausa (Broderip and Sowerby, an umbilicus entirely closed by a semicircular umbilical callus, and an operculum with an almost flat external surface. The shells of *C. clausa* bearing opercula were collected from Locs. (2)—(6), (8) and (10).

Locality (2): A cliff on the right bank, about 200 m upstream of the Fupumopu-zawa, Atsuga-cho, Saru-gun, Hokkaido; Pliocene Atsuga Formation of Yamaguchi (1958); Pl. 69, Figs. 1a—b.

One shell of *C. clausa* bearing an operculum was collected from fine grained sandstone. The operculum is preserved at the far inside of the body whorl. At the locality, *C. clausa* is associated with *Fortipecten takahashii* (Yokoyama), *Callithaca adamsi* (Reeve), *Mya japonica* Jay, *Turritella fortilirata* Sowerby, *Fusitriton oregonensis* (Redfield), *Buccinum* sp. and *Dentalium* sp.

Locality (3): Small outcrop on the left bank, about 1250 m upstream of the Byakutan River, Kuromatsunai-cho, Suttsu-gun, Hokkaido; Pliocene Nakanokawa Formation of Sawada (1962): Pl. 69, Figs. 2, 4a—b, Pl. 70, Fig. 1.

Four shells among the twelve of *C. clausa* collected from massive silstone are associated with their opercula. Three of the four opercula are preserved at the far inside of the body whorl. The external surfaces of two opercula face the aperture (Pl. 69, Fig. 2), and the other one faces the inner wall of the body whorl (Pl. 70, Fig. 1). The remaining operculum of the four is preserved at the base of the shell and its external surface is attached to the base (Pl. 69, Figs. 4a—b). The last occurrence almost coincides with those of the two specimens of *C. jantohostoma* (Pl. 68, Figs. 1a—2e, Text-fig. 2-*a*) at Loc. 1.

The four shells bearing opercula mentioned above were bored by naticids. At the locality, *C. clausa* is associated with *Mizuhopecten yessoensis* (Jay), *Euspira pila* (Pilsbry), *Mitrella* sp. and *Oenopota kuromatsunaiensis* Sawada. Besides the species mentioned above, Sawada (1962) reported the following species from this locality (loc. 7 of Sawada, 1962): *Acila nakazimai* Otuka, *Yoldia johanni* Dall, *Limopsis tokaiensis* Yokoyama, *Macoma tokyoensis* Makiyama, *Turritella nipponica* Yokoyama, and others.

Locality (4): River floor, about 1200 m upstream of Hosokomata-zawa, Tomikawa-cho, Kamiiso-gun, Hokkaido; Pliocene Tomikawa Formation of Mitani *et al.* (1965); Pl. 69, Figs. 3a—b.

Only one shell of *C. clausa* bearing an operculum was obtained from conglomeratic sandstone yielding abundant molluscan fossils, such as *Limopsis tajimae* Sowerby, *Porterius dalli* (Smith), *Mizuhopecten yessoensis* (Jay), *Swiftopecten swiftii* (Bernardi), *Papyridea kurodai* Hatai and Nisiyama, *Pseudamiantis tauyensis* (Yokoyama), *Umbonium akitanum* Suzuki, *Homalopoma amussitatum* (Gould), *Turritella fortilirata* Sowerby and *Euspira pila* (Pilsbry).

The operculum (Pl. 69, Fig. 3b) was preserved at the far inside of the body whorl, but it was detached from the shell (Pl. 69, Fig. 3a) and its posterior part was erroneously broken during preparation.

Locality (5): A large river-side cliff, about 400 m upstream of the Chika River, Chikagawa, Mutsu City, Aomori Prefecture; Pliocene Sunagomata Formation of Imai (1961).

Among the twenty-two shells of *C. clausa* collected from fine grained sandstone, two shells have opercula at the far inside of body whorl. The opercula and apertural parts of the two specimens were conspicuously weathered at the exposure. One shell of the two was bored by a naticid.

At the locality, *C. clausa* is associated with *Mizuhopecten tokyoensis hokurikuensis* (Akiyama), *Chlamys nipponensis* Kuroda, *Swiftopecten swiftii* (Bernardi), *Venericardia ferruginea* Clessin, *Clinocardium chikagawaense* Kotaka, *Callithaca adamsi* (Reeve), *Turritella saishuensis* Yokoyama, *Euspira pila* (Pilsbry), *Glossaulax didyma* (Röding) and *Niotha livescens* (Philippi).

Locality (6): A cliff on the left bank of the Taneume River, Tanosawa, Futatsui-cho, Yamamoto-gun, Akita Prefecture; Pliocene Kobinaizawa Formation of Hirayama and Sumi (1963); Pl. 70, Figs. 4a—b.

Among the four shells of *C. clausa* collected from fine grained sandstone, one shell has its operculum at the far inside of the body whorl. The apertural and basal parts of the specimen were damaged during preparation.

Chinzei (1973) reported the following molluscan fossils from this locality (loc. 24 of Chinzei, 1973): *Nuculana robai* (Kuroda), *Macoma calcarea* (Gmelin), *Turritella nipponica* Yokoyama, *Fulgoraria prevostiana* (Crosse), and others.

Locality (8): A cliff on the right bank of the Umiue River, Ochiai, Ninohe City, Iwate Prefecture; Pliocene Kubo Formation of Chinzei (1959); Pl. 70, Figs. 2a—3b.

Three shells among the six of *C. clausa* collected from fine grained sandstone are associated with their opercula: two at the far inside of body whorl (Pl. 70, Figs. 3a—b) and one completely detached from the shell (Pl. 70, Fig. 2a). The apertural part of the last shell (Pl. 70, Fig. 2c) was damaged by weathering at the exposure.

At the locality, *C. clausa* is associated with *Nemocardium* (*Keenaea*) *samarangae* (Makiyama), *Turritella nipponica* Yokoyama, "*Macron*" *nipponensis* Chinzei and *Propebela* sp.

Locality (10): A quarry, about 1250 m west of Matsugishi National Railway Station, Takano-cho, Choshi City, Chiba Prefecture; Pliocene

Iioka Formation of Ozaki (1958); Pl. 69, Figs. 5a—b.

Three shells among the thirty of *C. clausa* collected from siltstone have their opercula. Two opercula of the three are preserved at the far inside of body whorl, and the other one almost coincides with the apertural margin (Pl. 69, Figs. 5a—b). The adaxial margin of the last operculum is at the inner lip of the aperture, but the abaxial one is slightly recessed into the body whorl and its external surface looks toward the aperture. One of the former two shells and the last were bored by naticids.

At the locality, *C. clausa* is associated with *Nuculana ikebei* Suzuki and Kanehara, *Portlandia* sp., *Palliolum macrocheiricola* Habe, *Cardiomya* sp., *Euspira pallida* (Broderip and Sowerby), *Ancistrolepis trochoideus* (Dall), *Riuguhdrillia engonia* (Watson), *Aforia diomedea* Bartsch, *Rectiplanes sanctiioannis* (Smith) and *Admete couthonyu* (Jay).

Cryptonatica janthostomoides (Kuroda and Habe, 1949): Pl. 70, Figs. 6a—7b.

Cryptonatica janthostomoides is characterized by having a shallowly and narrowly open umbilicus around the margin of the umbilical callus in adults and its operculum sculptured with two strong grooves at the abaxial margin of the external surface. One operculum in association with a small shell obtained from the Shibikawa Formation (Loc. 9) was fragile and the external surface was almost missed during preparation (Pl. 70, Fig. 6b). The umbilicus is wholly covered by the umbilical callus, which is common in juveniles. The adults from the same locality have umbilici open shallowly and narrowly as mentioned above (Pl. 70, Figs. 7a—b).

Locality (9): Sea side cliff, about 500 m southwest of Anden, Iriai, Oga City, Akita Prefecture; Pliocene Shibikawa Formation of Huzioka (1959); Pl. 70, Figs. 6a—b.

Among twenty-five shells of *C. janthostomoides* collected from fine to medium grained sandstone, only one has an operculum at the far inside of the body whorl. At the locality, *C. janthostomoides* is associated with *Acila insignis* (Gould), *Arca boucardi* Jousseaume, *Mizuhopecten yessoensis* (Jay), *Homalopoma amussitatum* (Gould), *Turritella andenensis* Otuka, *Olivella japonica* (Pilsbry), *Euspira pila* (Pilsbry) and *Eunaticina papilla* (Gmelin).

Cryptonatica adamsiana (Dunker, 1860): Pl. 69, Fig. 6.

Cryptonatica adamsiana is characterized by having a deeply open umbilicus around a small umbilical callus lobe, and an operculum sculptured with two weak grooves along its abaxial margin.

Locality (11): A river bed of the Sai River, Ôkuwa, Kanazawa City, Ishikawa Prefecture; Pliocene Omma Formation of Kaseno and Matsuura (1965); Pl. 69, Fig. 6.

Only one shell among the five of *C. adamsiana* collected from fine grained sandstone has an operculum at the far inside of the body whorl. At the locality, *C. adamsiana* is associated with *Acila insignis* (Gould), *Limopsis* sp., *Glycymeris nipponica* (Yokoyama), *Mizuhopecten tokyoensis hokurikuensis* (Akiyama), *Lucinoma annulata* (Reeve), *Paphia schnelliana* (Dunker), *Turritella saishuensis* Yokoyama, *Glossaulax reiniana* (Dunker), *G. hagenoshitensis* (Shuto), *Siphonalia spadicea* (Reeve) and *Dentalium* sp.

Cryptonatica ichishiana (Shibata, 1970): Pl. 69, Figs. 7—9.

Cryptonatica ichishiana is characterized by high spire, well swollen whorls and an umbilicus closed by a small umbilical callus. The operculum of *C. ichishiana* has not previously been found associated with the shell. Two shells of *C. ichishiana* bearing opercula were collected from the type locality of the species (Loc. 12) and from the Yatsuo Formation (Loc. 13). The former operculum has two very weak lineations along the abaxial margin of the external surface, but not the latter one.

The present writer interprets the difference between the two opercula as an intraspecific variation because there are no morphological differences between the shells (Pl. 69, Figs. 7—8).

Locality (12): The river bed of the Nagano River, about 500 m south of Ashizaka, Iono, Misato-mura, Age-gun, Mie Prefecture; Miocene

Oi Formation of Shibata (1970); Pl. 69, Fig. 9.

Fifteen shells of *C. ichishiana* were collected from calcareous concretions in mudstone, in assocaition with *Malletia inermis* (Yokoyama), *Propeamussium tateiwai* Kanehara, *Cardiomya* sp., *Spirotropis subdeclivis mitsuganoensis* Shibata and *Dentalium* sp.

Only one shell among the fifteen has its operculum at the far inside of the body whorl. The anterior and posterior parts of the operculum and apertural side of the whorls (Pl. 69, Fig. 9) were erroneously broken during preparation.

Locality (13): Small outcrop on the left bank of the Kubusu River at Kashio, Yatsuo-cho, Nei-gun, Toyama Prefecture; Miocene Joyama Mudstone Member of the Yatsuo Formation of Sakamoto and Nozawa (1960); Pl. 69, Fig. 7.

One shell of *C. ichishiana* with its operculum was collected from pebble bearing siltstone, in association with *Portlandia watasei* (Kanehara), *Ennucula osawanoensis* (Tsuda), *Glycymeris* sp., *Anadara makiyamai* Hatai and Nisiyama, *Dosinia kawagensis* Araki, *Oxyperas osawanoensis* Tsuda, *Protrotella yuantaniensis* Makiyama, *Tanea minoensis* (Itoigawa), *Babylonia kozaiensis* Nomura, *Oliva osawanoensis* Tsuda, *Conus* sp. and *Acteon osawanoensis* Tsuda.

The operculum is normal to the apertural plane and its internal surface is attached to the inner lip. The anterior half protrudes from the aperture but was erroneously broken during collection. Therefore, the posterior half only is preserved in the body whorl (Pl. 69, Fig. 7).

"*Naticarius*" sp.: Pl. 69, Figs. 10—11b.

The present unnamed species is identified with "*Naticarius* cf. *N. niasensis* Wissema" of MacNeil (1961) from his Miocene-Pliocene Shinzato Tuff Member of the Shimajiri Formation in Okinawa Prefecture. According to MacNeil (1961), "*N. niasensis*" was originally proposed by Wissema in his doctor's thesis (1947) which seems to be invalid by Article 8 of the International Code of Zoological Nomenclature. The present writer has unfortunately had no chance to examine the reference, so it should be entrusted to future work as to whether this scientific name is available or not. The species, therefore, is treated as "*Naticarius*" sp. in the present study.

As was described by MacNeil (1961), the species is characterized by axial wrinkles (Pl. 69, Fig. 10) which are distinct in juveniles but die out on the central part of the body whorl in adults. The genus *Stigmaulax* Mörch, 1852, flourishing in the tropical eastern Pacific and Caribbean seas, also has axial wrinkles, but as mentioned by Woodring (1957) and Marincovich (1977), the external surface of the operculum is sculptured with an elevated central rib. Though MacNeil (1961) compared the present species with *Stigmaulax*, he classified the species into *Naticarius* because the operculum was unknown at that time.

The operculum of "*Naticarius*" sp. has two distinct grooves along the abaxial margin of the external surface (Pl. 69, Fig. 11b), by which the present species is distinguished from *Stigmaulax*. On the other hand, this operculum resembles that of the genus *Tanea* Marwick, 1931, flourishing in the tropical western Pacific and Indian Ocean, but the shell surface of *Tanea* is smooth as mentioned by Oyama (1969).

Locality (14): A cliff, about 400 m east of the Ozato Senior High School, Ozato-son, Shimajiri-gun, Okinawa Prefecture; Miocene Yonabaru Clay Member of the Shimajiri Formation of MacNeil (1961); Pl. 69, Figs. 11a—b.

One shell among the five of the present species collected from siltstone has its operculum at the far inside of the body whorl. The apertural part of the shell was erroneously broken in the field (Pl. 69, Fig. 11a). At the locality, the present species is associated with *Ennucula* sp., *Ancilla chinenensis* MacNeil, *Uromitra noharai* Noda, *Asprella* sp. and *Dentalium* sp.

Natica vitellus (Linnaeus, 1758): Pl. 69, Figs. 12a—b.

Natica vitellus is characterized by a small and subtrigonal umbilical callus along the posterior margin of the umbilicus. The external surface of the operculum is sculptured with two or three distinct grooves along the abaxial margin, and its adaxial edge is crenulated.

Table 1. Occurrences and measurements of fossil naticids bearing calcareous opercula.

Types	Species	Pred.	Loc.	H.S.	W.S.	H.O.	W.O.	Cat. no.	Illustrations
(1)	*Cryptonatica clausa*	—	2	30.7	26.1+	—	13.7	IGUT no. 15606	Pl. 69, Figs. 1a–b
(1)	*C. clausa*	C	3	12.6	11.7	8.3+	5.2	IGUT no. 15064–2	Pl. 69, Fig. 2
(1)	*C. clausa*	C	3	10.3+	9.3+	7.6	4.4	IGUT no. 15064–3	Pl. 70, Fig. 1
(1)	*C. clausa*	C	3	15.9+	14.8	9.6+	6.4	IGUT no. 15064–4	
(1)	*C. clausa*	C	4	11.2	9.4	5.0+	3.0	IGUT no. 15065	Pl. 69, Figs. 3a–b
(1)	*C. clausa*	B	5	10.9	10.0	5.7+	2.8+	IGUT no. 15572–1	
(1)	*C. clausa*	—	5	16.8	15.2	6.8+	4.0+	IGUT no. 15572–2	
(1)	*C. clausa*	—	6	14.5+	15.1	—	6.2	IGUT no. 15573	Pl. 70, Figs. 4a–b
(1)	*C. janthostoma*	—	7	21.4	22.9	15.5	10.0	IGUT no. 15574	Pl. 70, Figs. 5a–b
(1)	*C. clausa*	—	8	29.5	26.0	17.5	11.8	IGUT no. 15575–2	Pl. 70, Figs. 3a–b
(1)	*C. clausa*	—	8	30.4	25.9	—	11.2	IGUT no. 15575–3	
(1)	*C. janthostomoides*	B	9	14.6	13.9	8.0	5.0	IGUT no. 15576–1	Pl. 70, Figs. 6a–b
(1)	*C. clausa*	A	10	11.7	10.2	—	—	IGUT no. 15570–2	
(1)	*C. clausa*	—	10	14.0	12.1	8.1	6.6	IGUT no. 15570–3	
(1)	*C. adamsiana*	—	11	21.2	19.7	12.5	7.2	IGUT no. 15571–1	Pl. 69, Fig. 6
(1)	*C. ichishiana*	?	12	8.9+	7.1+	3.9+	2.8	IGUT no. 15066–1	Pl. 69, Fig. 9
(1)	*"Naticarius" sp.*	—	14	13.7+	11.0+	9.0	5.7	IGUT no. 15067–1	Pl. 69, Figs. 11a–b
(1)	*Natica vitellus*	B	15	14.0	14.0	8.9	5.2	GIYU no. 560	Pl. 69, Figs. 12a–b
(2)	*Cryptonatica janthostoma*	—	1	35.0	31.3	—	16.8	IGUT no. 15569–1	Pl. 68, Figs. 1a–e, Text-fig. 2
(2)	*C. janthostoma*	—	1	44.4	33.1+	27.9	18.1	IGUT no. 15569–2	Pl. 68, Figs. 2a–e, Text-fig. 2
(2)	*C. clausa*	B	3	20.2	—	—	8.0	IGUT no. 15064–1	Pl. 69, Figs. 4a–b
(3)	*C. clausa*	A	10	12.5	10.9	—	4.5	IGUT no. 15570–1	Pl. 69, Figs. 5a–b
(4)	*C. ichishiana*	—	13	17.7	15.9	7.0+	6.7+	IGUT no. 15577	Pl. 69, Fig. 7
(5)	*C. clausa*	—	8	24.8	21.8	16.9	10.8	IGUT no. 15575–1	Pl. 70, Figs. 2a–c

Types: Types of occurrences of operculum and shell. Pred.: Hole bored by naticids at ventral side of body whorl (A), left side of body whorl (B), between A and B (C); not bored (—), unknown (?) because of imperfect specimen. Loc.: Localities (shown in Text-fig. 1). Measurements (in mm): H.S. = Height of shell, W.S. = Width of shell, H.O. = Height of operculum (Maximum length parallel to the axis of adaxial margin of operculum), W.O. = Width of operculum (Maximum length perpendicular to H.O.), — = Measurement impossible. Cat. no.: Catalogued numbers of the collections of Institute of Geoscience, University of Tsukuba (IGUT) and the Geological Institute of Yokohama National University (GIYU).

Locality (15): An exposure about 200 m northeast of Kategaru, Nakazato-son (Kume-jima), Shimajiri-gun, Okinawa Prefecture; Pliocene Fusakina Formation of Makino (1975, MS); Pl. 69, Figs. 12a—b.

Only one shell among the seven of *N. vitellus* had its operculum at the far inside of the body whorl. The operculum was detached from the shell during preparation. The left side of body whorl was bored by a naticid.

Types of Occurrences of Naticid Opercula with their Shells

The occurrences of naticid opercula with their shells are classified into the following five types (Table 1):

Type (1): This is a type in which the operculum is preserved at the far inside of the body whorl. Eighteen specimens of the twenty-four belong to this type. But the positions of the opercula within this type are slightly different in each specimen: the anterior parts of some opercula (Pl. 69, Figs. 1a—b, 6, 9, Pl. 70, Figs. 3a—b, 5a—6b) and the posterior parts of others (Pl. 68, Figs. 2, 11a, Pl. 70, Figs. 4a—b) are deeply recessed into the body whorl. The external surfaces of many opercula face the aperture (Pl. 69, Figs. 1a—2, 6, 9, 11a, Pl. 70, Figs. 3a—6b) but only one faces the inner wall of the body whorl (Pl. 70, Fig. 1).

Type (2): In this type, the operculum is turned upside down at the base of the shell, namely the external surface is attached to the base. The two specimens of *Cryptonatica janthostoma* from the Porokaoshirarika Formation (Loc. 1) and one of *C. clausa* from the Kuromatsunai Formation (Loc. 3) belong to this type.

Type (3): This is a type in which the operculum almost coincides with the apertural margin. The adaxial margin is at the inner lip of the aperture and the abaxial one is slightly recessed into the body whorl. The external surface of the operculum faces the aperture. One specimen of *Cryptonatica clausa* from the Iioka Formation (Loc. 10) belongs to this type.

Type (4): In this type, the operculum is normal to the apertural plane and its anterior half protrudes from the aperture. The internal surface is attached to the inner lip. One specimen of *Cryptonatica ichishiana* from the Joyama Mudstone Member of the Yatsuo Formation (Loc. 13) belongs to this type. This type resembles one operculum belonging to Type (2), namely one specimen of *C. janthostoma* (Pl. 68, Fig. 1c, below specimen of Text-fig. 2) at Loc. 1, but the internal surface of the latter faces the outer lip of the aperture.

Type (5): This is a type in which the operculum is completely detached from its shell. One specimen of *Cryptonatica clausa* from the Kubo Formation (Loc. 8) belongs to this type.

Summary of Observations of Naticid Opercula with their Shells

The following two distinct conditions of living naticid opercula can be recognized.

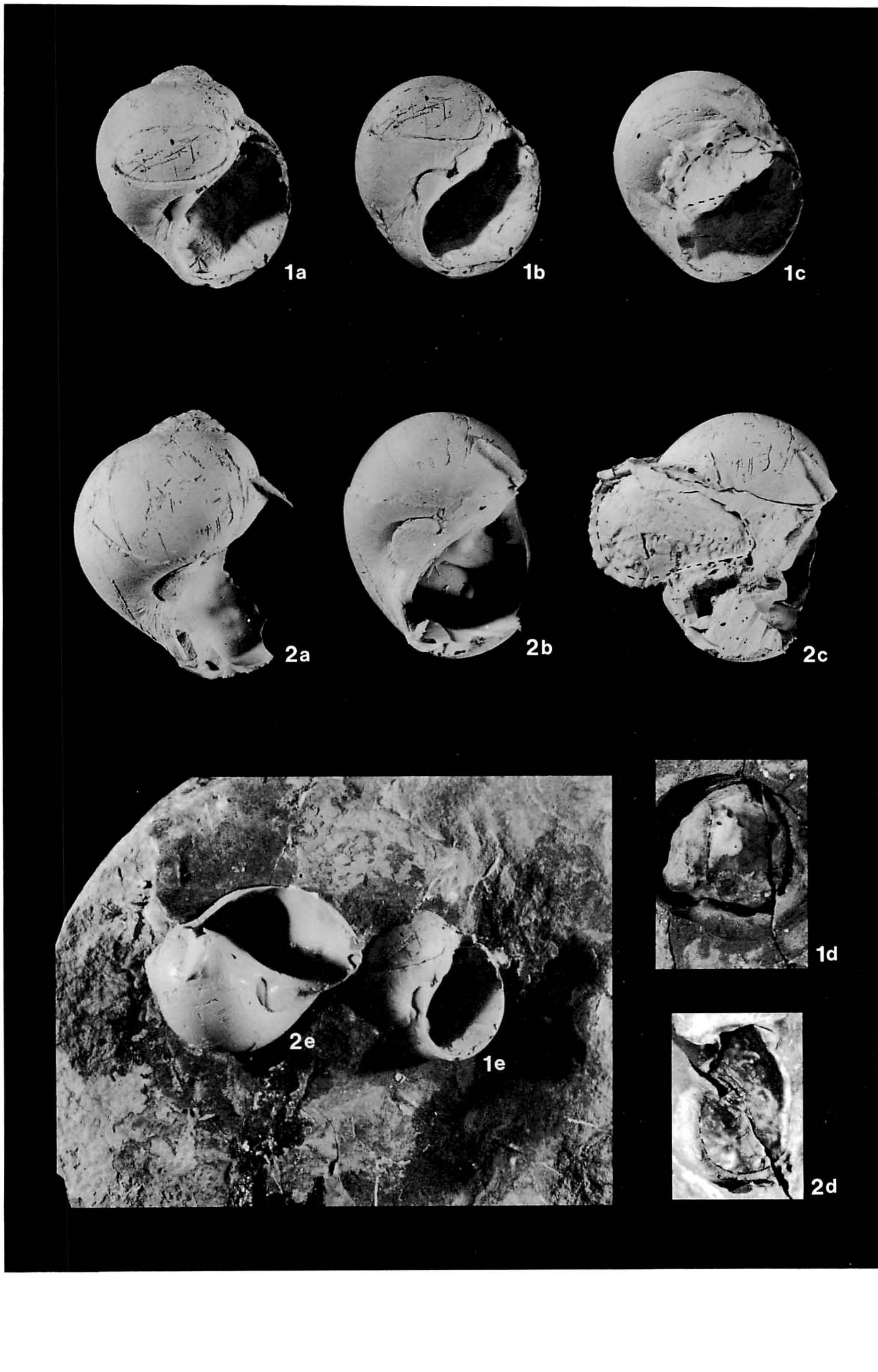
(a): A condition when the head-foot mass is withdrawn in the shell. This condition, in which the operculum closes the aperture, is shown in Text-fig. 3-*a*.

(B): A condition when the head-foot mass protrudes from the shell. It is not easy to observe the operculum in this case, because the operculum is entirely concealed by the head-foot mass.

When Taki (1934) illustrated an anatomical

Explanation of Plate 68

Figs. 1a—e, 2a—e. *Cryptonatica janthostoma* (Deshayes). Pliocene Porokaoshirarika Formation (Loc. 1). Figs. 1a—d, x1.0, Fig. 1e, x0.7, IGUT no. 15569—1; Figs. 2a—d, x1.0, Fig. 2e, x0.7, IGUT no. 15569—2. Figs. 1a—b and 2a—b, rubber casts. Figs. 1d and 2d, opercula in the host rock. Figs. 1c and 2c, rubber molds of opercula on the rubber casts of shells. Figs. 1e and 2e, rubber casts of shells in the host rock.


1a
1b
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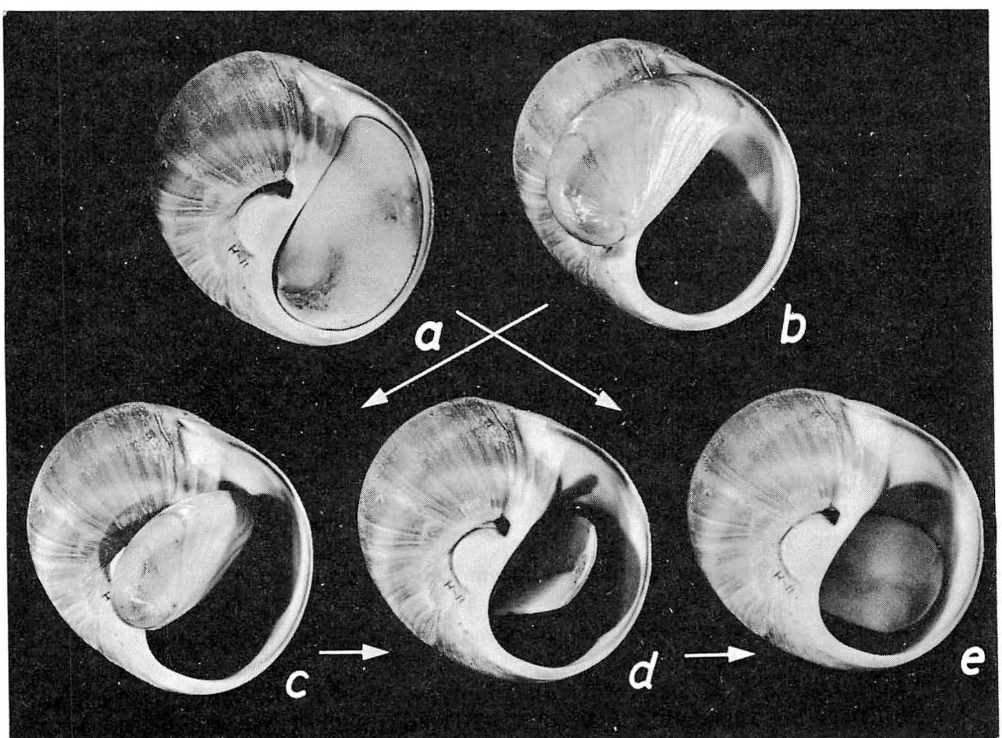
2b
2c
2e
1e
1d
2d

chart of *Glossaulax didyma* protruding its head-foot mass, the external surface of the operculum was attached to the base of shell as shown in Text-fig. 3-*b*. Schileyko (1977) illustrated the mode of movement of the naticid operculum. The position of the external surface of the operculum in Schileyko's figure is identical to Text-fig. 3-*b*, in which the head-foot mass protrudes from the shell.

Condition (A) almost coincides with the fossil operculum position of the Type (3) which is represented by the specimen of *C. clausa* (Pl. 69, Figs. 5a—b) from the Iioka Formation (Loc. 10). The same occurrences of fossil naticid opercula were illustrated by Jenkins (1863, pl. 6, figs. 6, 8), Woodring (1957, pl. 20, fig. 18) and Marincovich (1977, pl. 42, fig. 9). It is thought that the specimen from the Iioka was dead under the condition (A).

Condition (B) almost coincides with the fossil operculum position of Type (2), which is represented by two specimens of *C. janthostoma* (Pl. 68, Figs. 1a—2e, Text-fig. 2-*a*) from the Porokaoshirarika Formation (Loc. 1) and one of *C. clausa* (Pl. 69, Figs. 4a—b) from the Kuromatsunai Formation (Loc. 3). It is thought that these three specimens were dead under the condition (B).

The specimens of Type (1) are the most frequent in occurrence. There may be two way to explain their operculum conditions when they were dead (Text-fig. 3). The Type (1) is probably traced back to the condition (A) as shown by *a*→*e* in Text-fig. 3. But the displace-



Text-fig. 3. Schematic positions of opercula and models of the displacements of operculum. *a*: Position when the head-foot mass of a living naticid is withdrawn into shell (condition (A) in the text). *b*: Position when the head-foot mass protrudes from shell (condition (B) in the text). *e*: Position of fossil operculum preserved at the far inside of body whorl (Type (1) in the text). *a*→*e* and *b*→*c*→*d*→*e*: Models of operculum displacements by sediments, showing the explanations for the original positions of opercula of Type (1).

ment of operculum shown by *b*→*c*→*d*→*e* in Text-fig. 3 is also possible. This is due to the possibility that the operculum may be recessed into the body whorl by sediments displacing the soft parts which are dissolved after the death of the animal.

In the occurrences of the opercula classified as Types (2) and (3), the adaxial margin of the operculum (Pl. 69, Figs. 5a—b, Type (3)) from the Iioka Formation (Loc. 10) is slightly recessed into body whorl, and the posterior half of the operculum (Pl. 68, Fig. 1c, below specimen of Text-fig. 2-*a*, Type (2)) from the Porokaoshirarika Formation (Loc. 1) is recessed into the aperture. These two occurrences, which differ slightly from conditions (A) and (B), are interpreted as an intermediate step of the operculum displacement by sediments mentioned above (Text-fig. 3). The operculum (Pl. 69, Figs. 5a—b) from the Iioka may have been moved by sediments filling up the space left by soft parts which are dissolved after the death of the animal. The position of the operculum from the Porokaoshirarika (Pl. 68, Fig. 1c, below specimen of Text-fig. 2-*a*) almost coincides with that of Text-fig. 3-*c* which shows an intermediate step of operculum displacement by sediments (Text-fig. 3-*b*→*c*→*d*→*e*).

It is difficult to interpret the original conditions of the opercula classified to the Types (4) and (5), because their operculum positions are far from the conditions (A) and (B).

From the considerations mentioned above, it is concluded that there are two possible positions of the head-foot mass when naticids die. The one state is of the head-foot mass protruded from the shell and the other is of it withdrawn into the shell.

It is not easy to consider the common process of fossilization of the specimens treated herein because of the following reasons. (a): There are two modes of the occurrence of molluscan fossils among the fourteen formations at the localities (Loc. 15 unknown). Namely, the formations at the Locs. 4, 5, 9 and 13 yielded abundant molluscan fossils, including the naticid

Explanation of Plate 69

Figs. 1a—b. *Cryptonatica clausa* (Broderip and Sowerby). Pliocene Atsuga Formation (Loc. 2). x1.0, IGUT no. 15606.

Figs. 2, 4a—b. *Cryptonatica clausa* (Broderip and Sowerby). Pliocene Nakanokawa Formation (Loc. 3). Fig. 2, x2.0, IGUT no. 15064—2; Figs. 4a—b, x1.2, IGUT no. 15064—1.

Figs. 3a—b. *Cryptonatica clausa* (Broderip and Sowerby). Pliocene Tomikawa Formation (Loc. 4). Fig. 3a, x2.0, Fig. 3b, x2.2, IGUT no. 15065. Fig. 3b, operculum preserved at the far inside of body whorl of shell (Fig. 3a). The posterior part of operculum was erroneously broken during preparation.

Figs. 5a—b. *Cryptonatica clausa* (Broderip and Sowerby). Pliocene Iioka Formation (Loc. 10). x2.3, IGUT no. 15570—1.

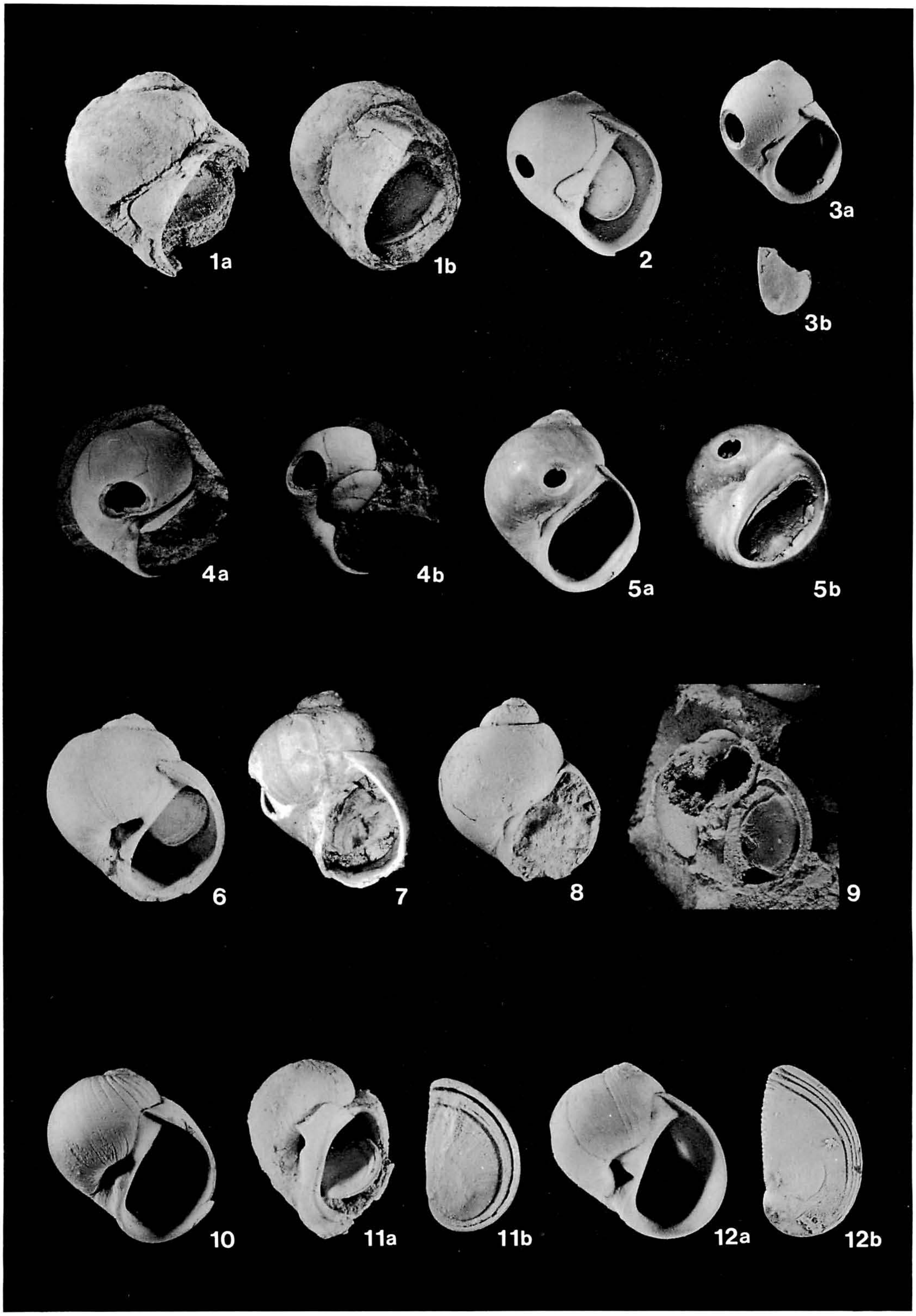
Fig. 6. *Cryptonatica adamsiana* (Dunker). Pliocene Omma Formation (Loc. 11). x1.4, IGUT no. 15571—1.

Fig. 7. *Cryptonatica ichishiana* (Shibata). Miocene Joyama Mudstone Member of Yatsuo Formation (Loc. 13). x1.6, IGUT no. 15577.

Figs. 8, 9. *Cryptonatica ichishiana* (Shibata). Topotype. Miocene Oi Formation (Loc. 12). Fig. 8, x2.0, IGUT no. 15066—2; Fig. 9, x3.5, IGUT no. 15066—1. Fig. 8 shows the whole shell for comparison.

Figs. 10, 11a—b. "*Naticarius*" sp. Miocene Yonabaru Clay Member of Shimajiri Formation (Loc. 14). Fig. 10, x1.8, IGUT no. 15067—2; Fig. 11a, x2.2, Fig. 11b, x2.7, IGUT no. 15067—1. Fig. 10 shows the whole shell for comparison.

Figs. 12a—b. *Natica vitellus* (Linnaeus). Pliocene Fusakina Formation (Loc. 15). Fig. 12a, x2.0, Fig. 12b, x3.0, GIYU no. 560. Fig. 12b, operculum preserved at the far inside of body whorl (Fig. 12a).


1a
1b
2
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4b
5a
5b
6
7
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10
11a
11b
12a
12b

specimens referred to Types (1) and (4), and might have been deposited under high energy conditions, but the other formations yielded sparse molluscan fossils, including the naticid specimens referred to Types (1), (2), (3) and (5), and might have been deposited under low energy conditions. (b): It is well known that naticids live on and within soft substrate, where they may be easily buried and preserved.

The present writer believes that the specimens referred to Types (2) and (3), and many of those in Type (1), might have died within soft substrates. The positions of the opercula of Type (1) and of the two opercula of Types (2) and (3) are interpreted as resulting from displacement by sediments (Text-fig. 3). This interpretation suggests that the specimens were almost enclosed by sediments when they were dead.

As shown in Table 1, ten of twenty-four specimens (43%) are bored by naticids. These predations are the only verified cause of death of naticid specimens treated herein. However, the correlations between predation and the occurrence of Types (1)—(5) are uncertain because of the small number of specimens available for study.

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Explanation of Plate 70

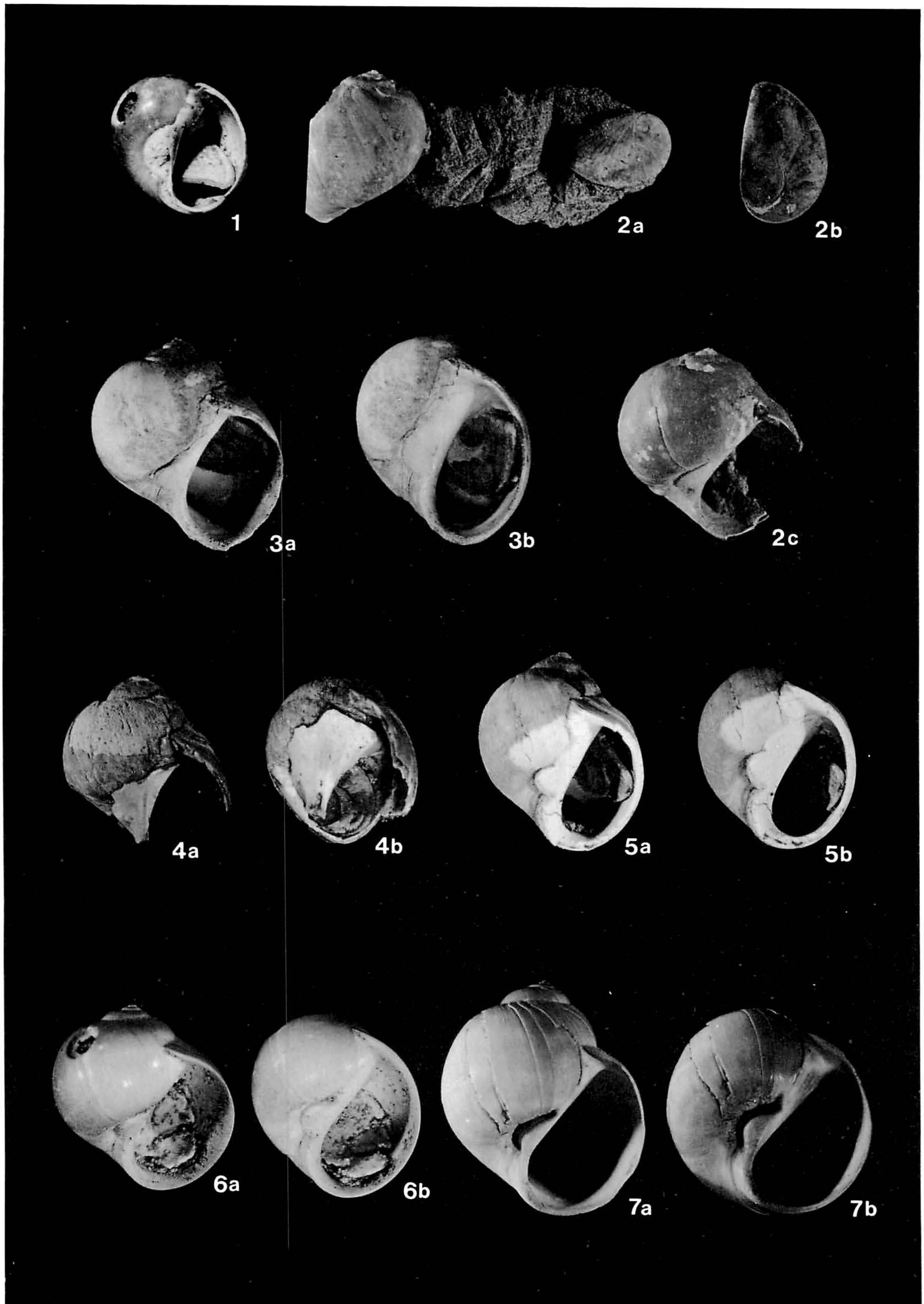
Fig. 1. *Cryptonatica clausa* (Broderip and Sowerby). Pliocene Nakanokawa Formation (Loc. 3). ×2.2, IGUT no. 15064—3. Operculum is turned upside down in the body whorl.

Fig. 2a—c, 3a—b. *Cryptonatica clausa* (Broderip and Sowerby). Pliocene Kubo Formation (Loc. 8). Fig. 2a, ×1.0, Figs. 2b—c, ×1.3, IGUT no. 15575—1; Figs. 3a—b, ×1.1, IGUT no. 15575—2.

Figs. 4a—b. *Cryptonatica clausa* (Broderip and Sowerby). Pliocene Kobinaizawa Formation (Loc. 6). ×1.7, IGUT no. 15573.

Figs. 5a—b. *Cryptonatica janthostoma* (Deshayes). Pliocene Sasaoka Formation (Loc. 7). ×1.7, IGUT no. 15574.

Figs. 6a—b, 7a—b. *Cryptonatica janthostomoides* (Kuroda and Habe). Pliocene Shibikawa Formation (Loc. 9). Figs. 6a—b, ×1.9, IGUT no. 15576—1; Figs. 7a—b, ×0.9, IGUT no. 15576—2. Figs. 7a—b show the adult shell for comparison.


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

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Age 安芸, Anden 安田, Atsuga 厚賀, Byakutan 白炭, Chikagawa 近川, Fusakina フサキナ, Gojome 五城目, Hosokomata-zawa 細小股沢, Iono 五百野, Iriai 五百合, Kabato 樺戸, Kategaru 嘉手苅, Kobinaizawa 小比内沢, Kubusu 久婦須, Misato 美里, Monzen 門前, Nei 婦負, Oi 大仰, Ôkuwa (Omma) 大桑, Ozato 大里, Porokaoshirarika 幌加尾白利加, Sai 犀, Saru-gun 沙流郡, Shibikawa 鮪川, Shimajiri 島尻, Shin-totsugawa 新十津川, Sunagomata 砂子又, Suttsu 寿都, Taneume 種梅, Umiue 海上, Yatsuo 八尾

石灰質の蓋を伴った本邦新第三紀タマガイ類(腹足綱)の産状に関する所見： 本邦新第三紀の15の地層から，24個体の石灰質の蓋を伴ったタマガイ類，*Cryptonatica janthostoma*, *C. clausa*, *C. janthostomoides*, *C. adamsiana*, *C. ichishiana*, "*Naticarius*" sp. および *Natica vitellus* 7種を報告する。中新世の種，*Cryptonatica ichishiana* および MacNeil (1961) によって *Naticarius* cf. *N. niasensis* とされた中新世から鮮新世の種，"*Naticarius*" sp. の2種の蓋は，この論文で，初めて報告される。

蓋と殻の位置に従って，次の5つの蓋の保存の type が認められる。Type (1)：蓋は，体層の奥に保存されている (18標本)。Type (2)：蓋は，殻底にあって反転し，その外表面は，殻底に面している (3標本)。Type (3)：蓋は，わずかに体層内に入りこんだ状態で，ほぼ殻口縁に一致している (1標本)。Type (4)：蓋は，殻口面に垂直で，その前半部を殻口から突き出している。蓋の内表面は，内唇に面している (1標本)。Type (5)：蓋は，殻から完全に離れている (1標本)。

タマガイ類が死んだ時の頭足部の状態は，Type (2) と (3) の産状を基に復元することが出来る。Type (2) は，頭足部を殻から突きだしたときの蓋の状態に，また Type (3) は，頭足部を殻に収めたときの蓋の状態に，それぞれあてはめられる。 間島隆一

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 134, pp. 374–387, pls. 71–74, July 30, 1984

780. SOME DINOFLAGELLATE CYSTS FROM THE NANGGULAN FORMATION IN CENTRAL JAVA, INDONESIA

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Abstract. Some dinoflagellate cysts were found from the Paleogene Nanggulan Formation distributed near Yogjakarta in Central Java, Indonesia. Thirteen species belonging to nine genera of Gonyaulacales were described and classified under the Lineage System. They include following four new species; *Glaphyrocysta circularis* and *G. dentata* of Ceratioid Lineage, and *Exochosphaeridium reticulatum* and *E. brevispinosum* of Gonyaulacoid Lineage.

Introduction

Paleogene dinoflagellate microplaleontology has been much progressed around the North Atlantic Ocean and Europe. Now several biostratigraphic works have been published on the basis of these dinoflagellate cysts (e.g. Bujak et al., 1980). On the contrary, around South East Asia there have been only a few papers dealt with Paleogene dinoflagellate cysts (Jain and Dutta, 1978; Kar, 1979; Kar and Saxena, 1981; Jiabo, 1978; He and Quian, 1979).

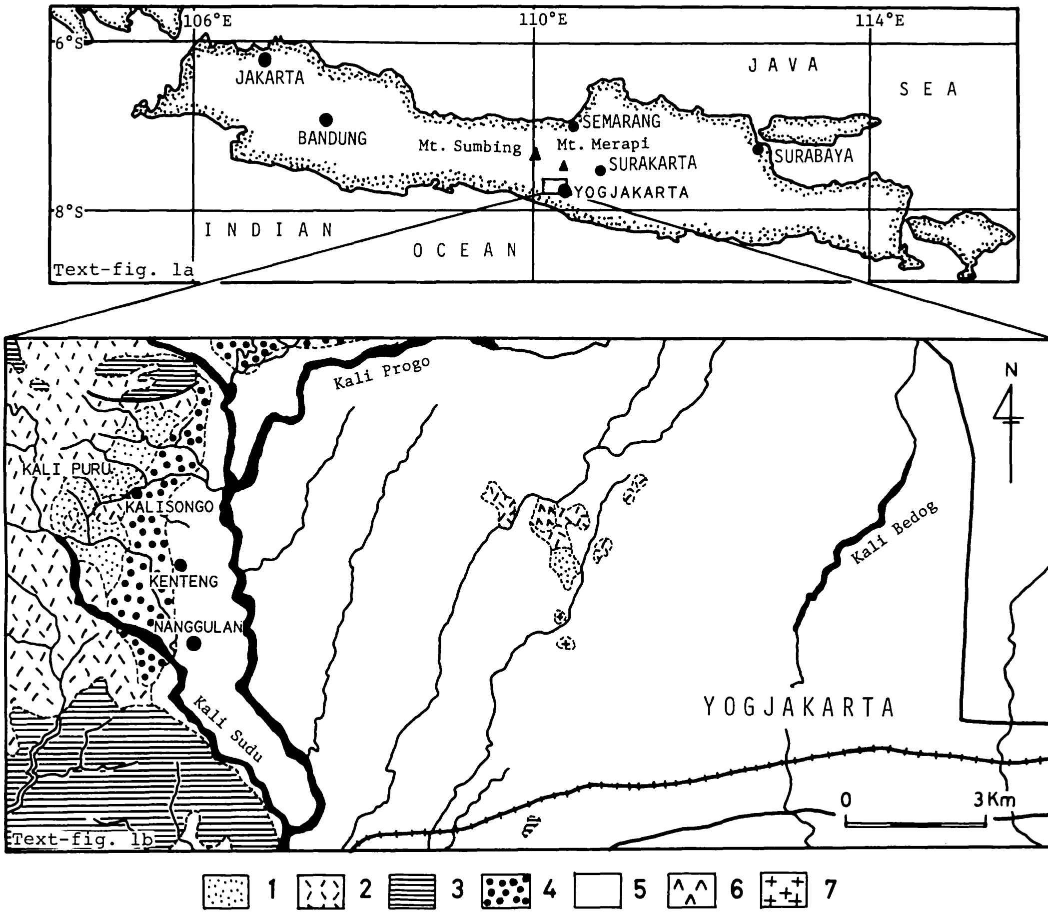
Some interesting dinoflagellate cysts and other algal fossils were preliminarily reported from the Nanggulan Formation in Central Java, Indonesia (Matsuoka in Saito ed., 1981). Further detailed study on these materials reveals that this cyst assemblage contains several new species. One of them assignable to the genus *Danea*, which was temporarily identified as *Danea*? sp. (Matsuoka in Saito ed., 1981) has been already described by the writer (Matsuoka, 1983). The other dinoflagellate cysts containing four new species and two new combinations are described in this paper.

Geological Setting

The Nanggulan Formation is well known as being one of the oldest formations in the Java Island, Indonesia. This formation is mainly exposed around Mt. Mujle located about 3.5 km northwest of the Nanggulan Village near Yogjakarta (Text-fig. 1).

Around the Nanggulan area, following Cenozoic formations are distributed in ascending order; the Nanggulan Formation, Old Andesite Formation, Jonglangan Formation, Sentlo Formation, and unsorted debris derived from the Old Andesite Formation (Purnamaningshi and Harsono, 1981; Wartono, Sukandarrumodi and Rosidi, 1977).

The Nanggulan Formation revised by Purnamaningshi and Harsono (1981) consists mainly of marl, siltstone and sandstone intercalated with several lignite seams, nodules and pyroclastic layers. Hartono (1960, 1969) reported on the occurrence of *Hantkenina*, a planktonic foraminifera, from this formation being Late Eocene in age. Purnamaningshi and Harsono (1981) carried out the biostratigraphic study



Text-fig. 1. 1a: Index map showing Yogjakarta District. 1b: Geological sketch map showing Nanggulan Area by Wartono, R. *et al.* with modification.
1; Nanggulan Formation, 2; Old Andesite Formation, 3; Sentlo and Jonglangan Formations, 4; unsorted debris, 5; pyloclastics of Mt. Merapi, 6; Andesite, 7; Diorite.

of this formation exposed along the Kali Seputih near Kalisongo. They recognized five planktonic foraminiferal zones and concluded that this formation ranges from the Middle Eocene to Oligocene age.

The Old Andesite Formation consists of andestic breccias, tuff, aggomerate and andestic lava, and its geologic age is estimated to be Late Oligocene (Purnamaningshi and Harsono, 1981) or Early Miocene (Kadar, 1981).

The Jonglangan Formation is composed of reef limestone, marls, sandstones interbedding lignite seams, while the Sentlo Formation is made up of marls, limestones, sandstone and conglomerate. The lower part of the Sentlo Formation is isochronous with the Jonglangan Formation (Kadar, 1981).

The Lithology and Geologic Age of the Nanggulan Formation exposed in the Kari Puru Section

The sampling area is located near the Kalisongo Village and on the eastern flank of the low mountains composed of andestic rocks belonging to the Old Andesite Formation.

On the basis of the lithologic description of the Nanggulan Formation in this section carried out by Saito et al. (in Saito, ed., 1981), following three lithologic units are recognized; the lower part is composed mainly of alternation of sandy siltstone and siltstone intercalated with lignite seams and molluscan beds; the middle part is made up of alternation of calcarenite, sandstone and sandy siltstone and characterized by the presence of abundant nodules and such larger foraminifers as *Discocyclina*; the upper part comprises alternation of silty sandstone and fine sandstone, and characterized by such pyroclastic layers as lapilli tuff and tuffite, and turbidite structure.

Okada (in Saito, ed., 1981) reported the occurrence of calcareous nannofossils from the middle to upper parts of the Kali Puru section, and on the basis of these species association concluded that the middle part of the Nanggulan Formation exposed in this section ranges from CP 13 to CP 14 (Middle Eocene) of Okada and Bukry (1980), and the upper part is probably Middle Oligocene in age.

Materials and Preparation Method

The lithologic features of the samples provided for this study are recorded in Saito (ed., 1981). The dinoflagellate cysts described here were obtained from the samples of the lower to middle part in the Kali Puru section. Therefore, as previously mentioned, these materials containing the dinoflagellate cysts are middle Eocene in age on the basis of calcareous nannofossil and planktonic foraminiferal evidences.

The sample number such as NG 39 coincides with the numbers recorded on the figures of the columnar section and the route map of the Kali Puru section in Saito (ed., 1981).

The palynological preparation method used for this study is generally the same as Matsuoka (1974). The specimens illustrated in this paper are deposited in the palynological collection of the Department of Geology, Faculty of Liberal Arts, Nagasaki University.

Systematic Paleontology

The following species are described in this paper.

- *Baticasphaera explanata* (Bujak) comb. nov.
- *Baticasphaera micropapillata* Stover 1977
- *Kallospheridium* sp.
- *Caligodinium* sp. cf. *C. amiculum* Drugg 1970
- *Glaphyrocysta circularis* sp. nov.
- *Glaphyrocysta dentata* sp. nov.
- *Diphyes spinulum* (Drugg) Stover and Evitt 1978
- *Exochosphaeridium reticulatum* sp. nov.
- *Exochosphaeridium brevispinosum* sp. nov.
- *Operculodinium uncinispinosum* (De Coninck) comb. nov.
- *Homotryblium* sp. cf. *H. oceanicum* Eaton 1976
- *Homotryblium pallidum* Davey and Williams 1966
- *Homotryblium plectilum* Drugg and Loeblich 1966

Class Dinophyceae

Order Gonyaulacales Taylor 1980

Ceratioid Lineage

Canningia Group

Genus *Baticasphaera* Drugg 1970

Type species: Baticasphera compta Drugg 1970

Baticasphera explanata (Bujak) comb. nov.

Pl. 74, Fig. 8

1980 *Chytroeisphaeridia explanata* Bujak, p. 44, pl. 13, figs. 13–14.

Description: The proximal cyst is basically subspherical to ovoidal in shape, but occasionally modified by folding. The autophragm is thin, transparent and smooth or very weakly granulated. The apical archeopyle has six or seven sided principle archeopyle parasutures. These features suggest that six paraplates and one anterior sulcal paraplatelet might be present in the cingular and sulcal regions of this species. The operculum is detached.

Dimensions: cyst diameter 39—42 μm.

Number of specimens measured: 5.

Remarks: Bujak in Bujak et al. (1980) described this species bearing an apical archeopyle as belonging to the genus *Chytroeisphaeridea*. But according to the diagnosis of the genus *Chytroeispharidea* emended by Davey (1969), this genus is characterized by possession of a precingular archeopyle. Therefore, this species must be reattributed to the genus *Baticasphaera*. The specimens collected from the Nanggulan Formation are smaller than the original English specimens in cyst diameter.

Baticasphaera micropapillata Stover 1977

Pl. 74, Fig. 9

1977 *Baticasphaera micropapillata* Stover, p. 73, pl. 1, figs. 7—8.

Description: The small spherical cyst is occasionally modified by folding and provides with thin, transparent and finely granulated autophragm. The archeopyle is a large apical type. The operculum is detached.

Dimensions: cyst diameter 26—47 μm.

Number of specimens measured: 5.

Remarks: The morphological features of the Javanese specimens are well concordant with the original description. This species differs from *Baticasphaera explanata* (Bujak) in possessing a finely but clearly granulated cyst surface. The previously known age of this species is middle Miocene in the Atlantic core hole (Stover, 1977).

Genus *Kallosphaeridium* De Coninck 1969

Type species: Kallosphaeridium brevibarbatum De Coninck 1969

Kallosphaeridium sp.

Pl. 74, Fig. 10

Description: The proximate cyst has a subspherical to ovoidal shape. The autophragm is thin and provided with short and slender hair-like projections closely spaced and evenly distributed. The archeopyle is an apical type and has six to seven princeple archeopyle parasutures. The operculum attached with one or two paraplate boundaries. Judging from princeple and accessory archeopyle parasutures, this species might consist of six or seven precingular paraplates including an anterior sulcal paraplate. No other feature indicating a paratabulation is observed and any ornamentation representing the cingulum and sulcus is lacking.

Dimensions: cyst diameter 30 μm, length of hair-like projections 2—4 μm.

Number of specimens measured: 1.

Remarks: The present species is closely similar to *Baticasphera hirsuta* Stover 1975 in showing halo effect of dense hair-like projections, but differs from the latter in possession of an attached operculum. *Kallosphaeridium brevibarbatum* De Coninck differs from this species in having a larger cyst body and a thicker autophragm.

Genus *Caligodinium* Drugg 1970

Type species: Caligodinium amiculum Drugg 1970

Caligodinium sp. cf. *C. amiculum* Drugg 1970

Pl. 74, Fig. 11

Cf. 1970 *Caligodinium amiculum* Drugg, p. 815, Figs. 8A—B; 9A—E.

Description: The small proximate cyst is broadly elongate on lateral view and composed of the autophragm only. Its surface is smooth or finely granulate. The cyst body is partially surrounded by a hyaline and adhesive material. The archeopyle is an apical type, and the operculum is partially attached and composed of one large and two smaller paraplates. Except for the archeopyle, there is not any feature indicating the paratabulation.

Dimensions: length of cyst 30—34 μm, width 28—30 μm.

Number of specimens measured: 3.

Remarks: The present species is closely similar to *Caligodinium aniculum* Drugg except for its smaller cyst size. This species is different from *C. granulatum* (Jiabo) Lentin and Williams in having the smooth or finely punctate cyst surface.

Cyclonepherium Group

Genus *Glaphyrocysta* Stover and Evitt 1978

Type species: Glaphyrocysta retiintexta (Cookson 1965) Stover and Evitt 1978 = *Cyclonepherium retiintextum* Cookson 1965

Glaphyrocysta circularis sp. nov.

Pl. 71, Figs. 2—5

Derivation of name: Latin, *circulus* (dim. *circus*), a ring; with reference to the circular trabecurae in distal margin of annulate complexes.

Diagnosis: Intermediate skolochorate cyst subcircular to elliptical in dorso-ventral view, and occasionally having a small antapical boss. Processes mostly solid and slender, and occurring as annulate, soliate or linear complexes except for a few paraplate areas. Each complex mostly consisting of five to seven processes. Distal part of processes furcated and united by slender and flexous trabeculae with smooth surface and short spines. Archeopyle apical, tetratabular.

Holotype: Slide NG 39—5 (4xI), Pl. 71, Fig. 2. Sample no. NG 39, Nanggulan Formation, Middle Eocene. Location; Kalisongo near Nanggulan, 20 km northwest of Yogjakarta, Central Java, Indonesia.

Dimensions: Holotype; cyst diameter 67.2 μm, length of processes 20.2 μm. Other specimens; cyst diameter 37—68 μm, length of processes 13—21 μm.

Number of specimens measured: 5.

Description: The cyst body consisting of a thin autophragm is lenticular and bears occasionally a small antapical boss. The existence of an apical boss is unknown, because any complete specimen was not encountered. The surface of cyst shows a coarse granulate to reticulate feature. Processes are solid and slender, and occur as annular, soliate and/or linear complexes. Most paraplate areas possesses an annular or soliate complexes made up of five to seven flexous and slender processes, but the 3″ paraplate is represented as a linear complex consisting of three slender processes. The 6″, 1‴ and 6‴ paraplates are often devoided of any process, but rarely are reflected by simple process much reduced. The antapical 1⁗ complex comprises about ten slender processes. The distal extremities of processes are furcate and united by a simple slender but flexous trabeculae with short spines or rarely weakly denticulate margin. Two peripheral process groups are conspicuously developed. They are made up of the 1″, 2″ and 2‴ complexes, and 4″ and 4‴ complexes which joint distally with somewhat larger trabeculae. Other process complexes are soliate. The cingular and sulcal areas are lacking in any process-like ornamentation. The archeopyle is an apical type with seven princeple archeopyle sutures. The paratabulation is indicated by the complexes and the apical archeopyle; 4′(?), 0a, 6″, 0c, as, 6‴, 0p, 1⁗.

Remarks: This species resembles *Glaphyrocysta intricata* (Eaton) Stover and Evitt, *G. retiintexta* (Cookson) Stover and Evitt, and ?*G. reticulosa* (Gerlach) Stover and Evitt in having simple processes. *G. circularis* sp. nov., however, is distinguishable from *G. retiintexta* (Cookson) and *G. intricata* (Eaton) in constantly possessing the 3″ process and two conspicuous process groups made up of jointing trabeculae, and from ?*G. reticulosa* (Gerlach) in having the 3″ linear complex and only one antapical boss.

Glaphyrocysta dentata sp. nov.

Pl. 71, Fig. 1

Derivation of name: Latin, *dentatus*, provided with teeth; with reference to the denticulate margin of trabeculae in distal part of processes.

Diagnosis: Intermediate skolochorate cyst subcircular to elliptical outline in dorso-ventral view. Relatively thin autophragm reticulate. Processes tubiform to buccinate, stout and distally furcate, and occurring as annulate, soliate and linear complexes. Each complex consisting of three to five processes, and distally united by trabeculae with deeply dentate margin. Most complex solitary distally. Apical archeopyle tetratabular. Operculum free.

Holotype: Slide NG 39—5 (2fIII), Pl. 71, Fig. 1, sample no. NG 39, Nanggulan Formation, Middle Eocene. Location; Kalisongo near Nanggulan, 20 km northwest of Yogjakarta, Central Java, Indonesia.

Dimensions: Holotype; cyst diameter 64 μm, length of processes 25 μm. Other specimens; cyst diameter 41—68 μm, length of processes 17—26 μm.

Number of specimens measured: 8.

Description: The dorso-ventrally lenticular cyst is lacking in any apical projection. Processes are relatively broad and tubiform to buccinate, and occur as annular, soliate and linear complexes consisting of three to five processes. Distal extremities are furcate and united by flexous lod-like trabeculae with deep dentate margin at out side. Most process complexes are distally united within a single complex, and become soliate. The apical area has four annulate complexes distally united with trabeculae in each other. The precingular area bears five complexes. The 3″ paraplate is represented by a linear complex made up of three processes. The 6″ paraplate is devoided of any process. The postcingular area consists of five complexes. The 1‴ paraplate is a smaller annulate complex of two processes. The linear complex developed in the dorsal side reflects the 3″ paraplate. The 2″, 4″ and 5″ paraplates are reflected by large annular complexes. The broad space between 1‴ and 5″ paraplates might indicate the 6‴ paraplate and sulcal area. The cingular and sulcal areas are lacking in any process-like ornamentation, but the anterior sulcal paraplatelet is indicated by two accessory parasutures. The apical archeopyle possesses seven main archeopyle parasutures and several accessory arheopyle parasutures. The infered paratabulation is indicated by the distribution of process complexes and the apical archeopyle; 4′, 6″, xc+xs, 6‴, xp, 1⁗.

Remarks: The present new species is similar to *Glaphyrocysta circularis* sp. nov., but differs from the latter in having process complexes consisting of fewer (three to five) and tubiform to buccinate processes, and deeply dentate margin of trabeculae at out side.

Hystrichosphaeroid Lineage

Polysphaeridium Group

Genus *Diphyes* Cookson 1965 emend. Davey and Williams 1966

Synonym: Lingulosphaera Drugg 1970

Type species: Diphyes colligerum (Deflandre and Cookson 1955) Cookson 1965 = *Hystrichosphaeridium colligerum* Deflandre and Cookson 1955

Diphyes spinulum (Drugg 1970) Stover and Evitt 1978

Pl. 73, Figs. 4—7

1970 *Lingulosphaera spinula* Drugg, p. 817, figs. 10G, 11D—E, 12A—B.
1978 *Diphyes spinulum* (Drugg) Stover and Evitt, p. 39.

Description: The specimens of *Diphyes spinulum* (Drugg) collected from the Nanggulan Formation have a spherical to subspherical cyst body with finely granulated periphragm. Processes consists of two types; a single large antapical process and many slender processes. The antapical process basically shows a box-like shape with four to five sided base and is hollow or closed distally. The distal extremities of this process bears a few tubes. Slender processes are many, hollow, mostly tapering or long subconical but occasionally bifurcate on a half way along their length. The distal tips of them are mostly capitate but rarely oblate or bifid. Around the apical archeopyle and the antapical process, groups composed of two or three slender processes occur regularly. This feature strongly suggests that slender processes are not nontabular but basically intratabular. The archeopyle is an apical type with five to six princeple archeopyle parasutures and occasionally accessory archeopyle parasutures. The operculum is free.

Dimensions: cyst diameter 47—45 μm, length of large processes 20 μm, width of large process 17 μm, length of slender processes 10—19 μm.

Number of specimens measured: 12.

Remarks: Diphyes spinulum (Drugg) closely resembles *D. colligerum* (Deflandre and Cookson) in cyst diameter and morphology of antapical process. But the former is different from the latter in having occasionally bifurcate processes. Though some Indonesian specimens sometimes have bifid or oblate distal tips, they are also commonly characterized by possession of bifurcate slender processes.

Gonyaulacoid Lineage

Operculodinium Group

Genus *Exochosphaeridium* Davey, Downie, Sarjeant, and Williams 1966

Type species: Exochosphaeridium phragmites Davey, Downie, Sarjeant, and Williams 1966

Exochosphaeridium reticulatum sp. nov.

Pl. 72, Figs. 1—5

?1979 *Homotryblium* sp. Kar, p. 35, pl. 4, figs. 73, 74.

Derivation of name: Latin, *reticulatus*, netlike, with reference to the reticulate surface of cyst.

Diagnosis: Cyst subspherical to ovoidal, composed of two layers, periphragm and endophragm appressed between processes. Periphragm clearly reticulate and endophragm smooth. Processes fibrous and tubiform, and basically intratabular but apparently nontabular. Distal part of processes patilate to denticulate and sometimes recurved. Precingular archeopyle with pentagonal margin; operculum detached.

Holotype: Slide NG 43—2 (1gIV), Pl. 72, Fig. 1, sample no. 43, Nanggulan Formation; Middle Eocene. Location; Kalisongo, 20 km northwest of Yogjakarta, Central Java, Indonesia.

Dimensions: Holotype, length of cyst 66 μm, width 54 μm, length of processes 13—18 μm. Other specimens; length of cyst 66—88 μm, width 54—81 μm, length of processes 13—20 μm.

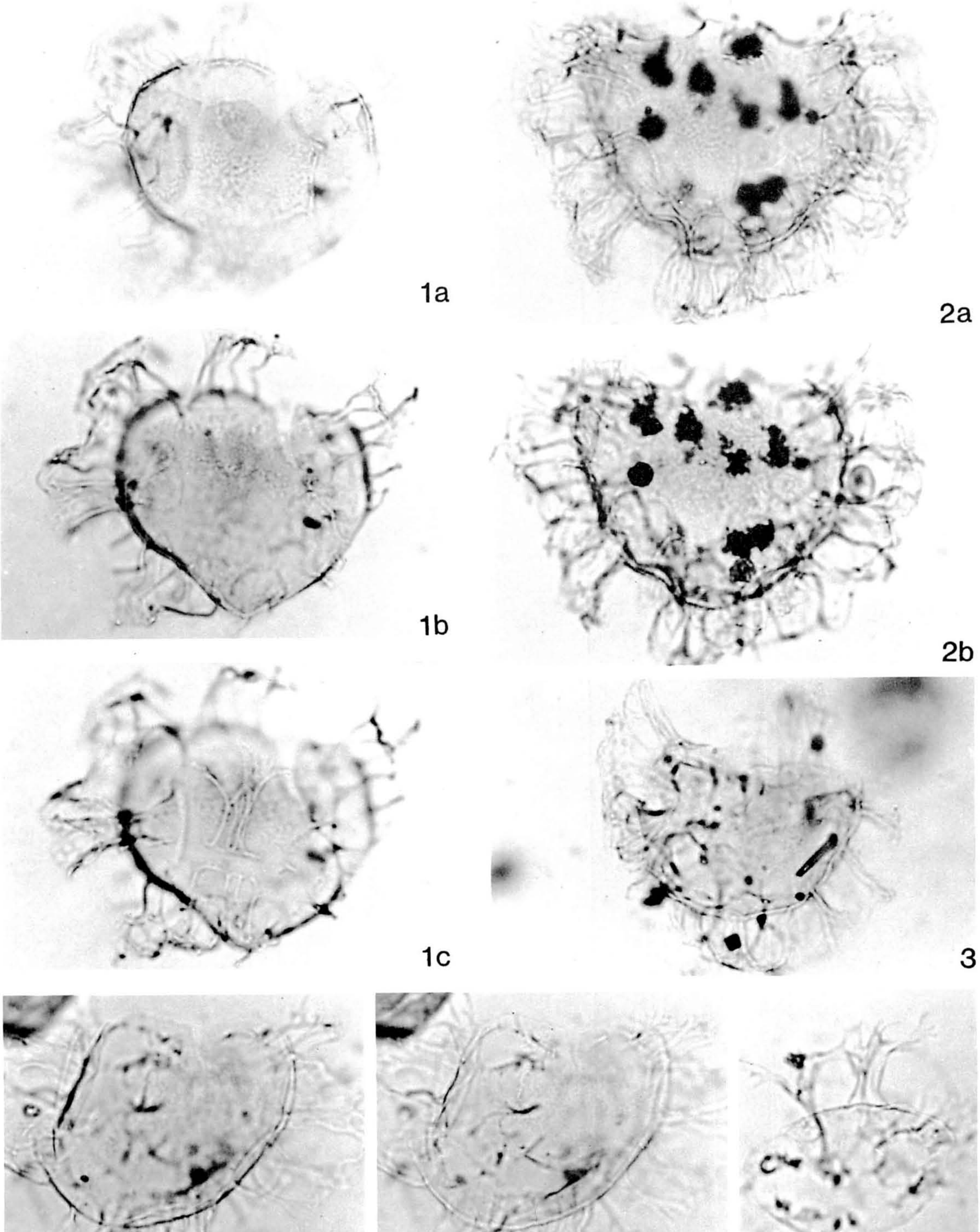
Number of specimens measured: 10.

Description: The proximochorate cyst has a subspherical to ovoidal shape. The periphragm is relatively thick and reticulate, and the endophragm is thin and smooth. The reticulation of periphragm are clearly observed at the basal part of processes. Processes derived from the

Explanation of Plate 71

Fig. 1. *Glaphyrocysta dentata* sp. nov.
a: ventral surface, b: optical corss section of dorso-ventral view showing the antapical boss, c: dorsal surface showing the linear complex 3″ paraplate.
Holotype, slide NG 39—5 (2fIII).

Figs. 2—5. *Glaphyrocysta circularis* sp. nov.
2a: optical cross section of dorso-ventral view, 2b: ventral surface.
Holotype, slide NG 39—5 (4xI).
3: optical cross section of dorso-ventral view.
Slide NG 39—3 (4eII).
4a: optical cross section of dorso-ventral view, 4b: lateral surface.
Slide NG 49—3 (12oII).
5: free operculum showing four apical complex paraplates.
Slide NG 49—3 (12xII).
All figures x 625.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periphragm are fibrous, somewhat flexous and slender tubiform, and have similar length within a single specimen. Apical and antapical processes are not differentiated and similar to other processes. The distal parts of processes show patulate to finely denticulate and occasionally recurved. Their distribution of processes appears to be nontabular especially on ventral side, but around the precingular archeopyle and on the free operculum, processes has basically intratabular or penitabular arrangement. These processes are sometimes reduced and become to be fibrous, linear complex forms. The paracingulum is occasionally represented as a linear arrangement of processes especially beneath the precingular archeopyle, but on the ventral side, it is unclear as well as the parasulcus. The archeopyle formed by displacement of the third precingular paraplate is pentagonal in shape. The free operculum provided with about fifteen processes on it.

Remarks: Exochosphaeridium reticulatum sp. nov. is characterized by possession of reticulate periphragm and fibrous processes being basically intratabular or penitabular. This species resembles *Exochosphaeridium bifidum* (Clarke and Verdier 1967) Clarke et al. 1968 in bearing a fibro-pitted periphragm and fibrous processes, but differs from the latter in having larger number of processes, and lacking in conspicuously branched apical process. The processes of *E. reticulatum* might be hollow, but it is obscure because of slender and fibrous stalks.

Exochosphaeridium brevispinosum sp. nov.

Pl. 72, Figs. 6—9

Derivation of name: Latin, *brevis + spinosum*; short spine, with reference to the short processes.

Diagnosis: Cyst spherical to ovoidal and intermediate in size. Cyst wall composed of two layers, periphragm and endophragm appressed between processes. Processes strongly fibrous, and short and widely cylindrical. Their distribution fundamentally intratabular, but apparently nontabular. The wall of processes becoming loose. Distal extremities of processes denticulate. Archeopyle precingular; operculum free.

Holotype: Slide NG 33—2 (6gI), Pl. 72, Fig. 7, sample no. NG 33, Nanggulan Formation; Middle Eocene. Location; Kalisongo, 20 km northwest of Yogjakarta, Central Java, Indonesia.

Dimensions: Holotype; length of cyst 69 μm, width 63 μm, length of processes 9 μm. Other specimens; length of cyst 53—69 μm, width 53—63 μm, length of processes 7—9 μm.

Number of specimens measured: 5.

Description: The proximochorate cyst is intermediate in size and spherical to ovoidal in shape. The periphragm is moderately thick and strongly fibrous. The fibro-pitted structure is developed around the proximal base of processes. The endophragm is thin and smooth. The processes composed of several strings are short and widely cylindrical and seem to be hollow. Their walls show a reticulate structure and their distal extremities are apparently denticulate. The intratabular distribution of processes is clearly indicated around the archeopyle. About fifteen processes are developed in one paraplate area based on the detached operculum. The processes are similar in length and structure within a single specimen. The cingulum is occasionally represented by a linear distribution of the process beneath the basal parasuture of the precingular archeopyle. Except for the archeopyle, the paratabulation is unclear. The archeopyle might be derived from loss of 3″ paraplate based on the shape of the free operculum.

Remarks: This species is similar to *Exochosphaeridium reticulatum* n. sp. in having a fibro-pitted periphragm and fibrous processes, but distinguishable from the latter in possessing shorter and wider, and strongly fibrous cylindrical processes. Nevertheless the intermediate forms were encountered in the material of the Nanggulan Formation.

Genus *Operculodinium* Wall 1967

Type species: Operculodinium centrocarpum (Deflandre and Cookson 1955) Wall 1967 = *Hystrichosphaeridium centrocarpum* Deflandre and Cookson 1955.

Operculodinium uncinispinosum
(De Coninck 1969) comb. nov.

Pl. 73, Figs. 1—3

1969 *Cordosphaeridium uncinispinosum* De Coninck, p. 32—33, pl. IX, figs. 6—8.
1970 *C. uncinispinosum* De Coninck; Gruns-Gavagenetto, pl. 1, fig. 13.

Emended diagnosis: Intermediate to large cyst spherical to ovoidal. Wall consisting of two layers, fibro-pitted periphragm and endophragm closely appressed between processes. Processes with a smooth stalk, weakly fibrous, long, slender, and apparently nontabular. Processes rarely bifurcate or multifurcate on a way. Distal extremities of processes mostly recurved. Precingular archeopyle pentagonal in shape; operculum completely free.

Dimensions: cyst diameter 75—108 μm, length of processes 37—52 μm, processes ratio 0.5.

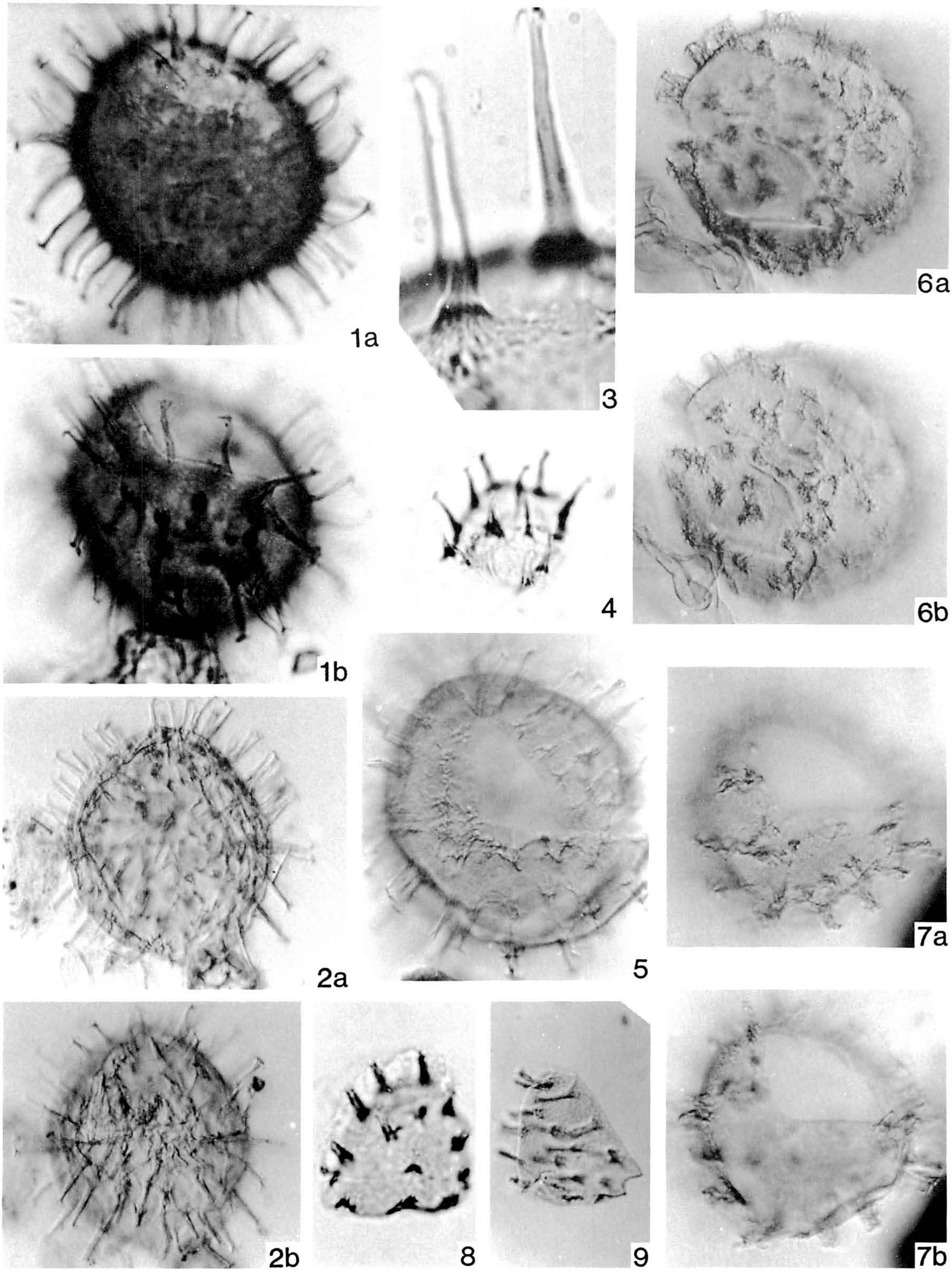
Number of specimens measured: 5.

Description: The proximochorate cyst is large to intermediate in size and subspherical to ovoidal in shape. The periphragm is fibro-pitted and relatively thick, and the endophragm is thin and smooth. Processes composed of several strings of the periphragm and uniform in length, weakly fibrous, slender, flexous and apparently nontabular, and bear a smooth stalk. The proximal part of processes clearly show a pitted structure, and the distal extremities of them are apparently capitate, but actually divided into several aculiate or recurved strings. Some of processes are rarely bifurcate on a way or multifurcate near the base. The simple precingular archeopyle without any accessory archeopyle sutures might be made up of displacement of the third precingular paraplate. The operculum is completely detached.

Explanation of Plate 72

Figs. 1—5. *Exochosphaeridium reticulatum* sp. nov.
1a: ventral surface, 1b: dorsal surface showing the precingular archeopyle and the reticulate periphragm between processes.
Holotype: slide NG 43—2 (1gIV), x 580.
2a°: optical cross section of lateral view, 2b°: lateral surface.
Slide NG 27—4 (2oIV), x 386.
3: processes showing the recurved distal extemity and the fibro-pitted structure observed at proximal base.
Slide NG 45—3 (6qIV), x 1400.
4: free operculum showing intratabular processes.
Slide 39—4 (6QIV), x 800.
5°: dorsal view showing the precingular archeopyle somewhat deformed, and fibrous and intratabular processes.
Slide NG 25—3 (5eIV), x 500.

Figs. 6—9. *Exochosphaeridium brevispinosum* sp. nov.
6a°: optical cross section showing strongly fibrous processes, 6b°: cyst surface.
Slide 33—2 (1AIII), x 500.
7a°: dorsal view showing the precingular archeopyle, 7b°: optical cross section of dorso-ventral view showing short and fibrous processes.
Holotype: slide NG 33—2 (6qI), x 500.
8: free operculum showing intratabular processes.
Slide NG 43—1 (7PII), x 500.
9: free operculum showing the reticulate periphragm between processes.
Slide NG 35—2 (6nIII), x 500.
°: in interference contrast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Remarks: The morphological characteristics of Javanese specimens are well concordant with the original description of *Cordosphaeridium uncinispinosum* De Coninck 1968. But this species has been kept to be a problematical species of *Cordosphaeridium* by Stover and Evitt (1978), because its archeopyle is unclear. The Javanese specimens have a simple precingular archeopyle. Therefore this species is transfered from *Cordosphaeridium* to *Operculodinium.*

Eighteen species belonging to the genus *Operculodinium* have been described. Among them, the following species have an intermediate to large cyst body and relatively long slender processes; *Operculodinium divergens* (Eisenack 1954) Stover and Evitt 1978, *O.* cf. *hirstum* (Ehrenberg 1836) Gocht 1969 and *O. tiara* (Klumpp 1958) Stover and Evitt 1978. The present species differs from former two species in having a fibro-pitted periphragm and characteristic processes with a smooth stalk and mostly recurved distal extremities, and is also different from *O. tiara* (Klumpp) in bearing processes with recurved distal tips and lacking in thick felt-like periphragm.

Homotrybloid Lineage

Genus *Homotryblium* Davey and Williams 1966

Type species: Homotryblium tenuispinosum Davey and Williams 1966

Homotryblium sp. cf. *H. oceanicum* Eaton 1976

Pl. 74, Fig. 2

Cf. 1976 *Homotryblium oceanicum* Eaton, p. 268, pl. 10, figs. 5—8.

Dimensions: diameter of cyst body 54—60 µm, length of processes 15—19 µm, width of processes 4—5 µm.

Number of specimens measured: 2.

Remarks: The specimens collected from the Nanggulan Formation are mostly incomplete without the epicystal part. These specimens are characterized by the epicystal archeopyle and intratabular and hollow processes provided with denticulate or aculeate distal extremities. They, however, slightly differs from the specimens described from the Bracklesham Beds in southern England in having slenderly cylindrical to somewhat tapering processes and the finely but clearly granular periphragm between processes.

Homotryblium pallidum Davey and Williams 1966

Pl. 74, Fig. 1

1966 *Homotryblium pallidum* Davey and Williams, p. 102—103, pl. 12, figs. 4—6, text-fig. 22.

1978 *H. pallidum* Davey and Williams; Jain and Dutta, p. 107, pl. I-12, 13.

1980 *H. pallidum* Davey and Williams; Bujak et al., pl. 1, fig. 1—3.

Dimensions: cyst diameter 55—70 µm, length of processes 20—30 µm.

Number of specimens measured: 5.

Remarks: Homotryblium pallidum Davey and Williams is different from other species in having a thin endophragm and a finely granular to smooth periphragm, and in possessing a circular proximal base of slender processes with variable distal extremities. The specimens of the Nanggulan Formation are larger in cyst diameter than the previously described specimens.

The previously known range of this species is Early Eocene to Late Oligocene (Davey and Williams, 1966; Costa and Downie, 1979; Bujak et al., 1980).

Homotryblium plectilum Drugg and Loeblich 1967

Pl. 74, Figs. 3—7

1967 *Homotryblium plectilum* Drugg and Loeblich, p. 184, pl. 2, figs. 1—9, text-fig. 3.

1975 *H. plectilum* Drugg and Loeblich; Williams, pl. 5, fig. 3.

1978 *H. plectilum* Drugg and Loeblich; Jain and Dutta, p. 107, pl. I-11.

1980 *?Homotryblium floripes* (Deflandre and Cookson) Stover; Bujak in Bujak et al.,

p. 64, pl. 16, figs. 2—3.

1981 *Oligosphaeridium complex* (White) Davey and Williams; Kar and Saxena, p. 115, pl. 4, fig. 79.

Dimensions: cyst diameter 65—80 μm, length of processes 19—24 μm.

Number of specimens measured: 7.

Remarks: The following three species of the genus *Homotryblium* have characteristic intratabular processes composed of two to six tubes closely jointing on the way; *H. floripes* (Deflandre and Cookson) Stover 1975, *H. plectilum* Drugg and Loeblich 1967, and *H. vallum* Stover 1977. Bujak (1980) explained that *H. plectilum* Drugg and Loeblich is a younger synonym of *H. floripes* (Deflandre and Cookson). But these two species have clearly different character concerning a periphragm, that is, *H. floripes* (Deflandre and Cookson) bears relatively thick and irregularly scabrated, apparently granular periphragm, while *H. plectilum* Drugg and Loeblich is characterized by being thin and smooth to finely and delicately granulated periphragm.

H. vallum Stover differs from these two species by having smaller cyst and taeniate processes. But Stover (1977) mentioned that *H. plectilum* Drugg and Loeblich and *H. vallum* Stover occur together and transitional forms were observed.

The specimens obtained from the Nanggulan Formation are identical to those of *H. plectilum* Drugg and Leoblich owing to possession of larger cyst body, thin and finely granular to smooth periphragm and longer processes.

A dinoflagellate cyst described as *Oligosphaeridium complex* (White) by Kar and Saxena (1981) should be assignable to *Homotryblium plectilum* Drugg and Loeblich on the basis of the number of processes and its polytubular processes. These specimens were recovered

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Explanation of Plate 73

Figs. 1—3. *Operculodinium uncinispinosum* (De Coninck 1968) comb. nov.

1a: optical cross section of lateral view showing the elongate cyst body, 1b: surface of lateral view, 1c°: process showing the slender form and the furcate form which have smooth surface of stalks.

Slide NG 27—5 (1iIII), la, lb x 320, 1c x 1250.

2a: dorsal surface showing the precingular archeopyle, 2b: processes showing strongly recurved strings of distal extremities.

Slide NG 1—2 (1cIV), x 320.

3a°: free operculum showing the fibro-pitted structure between processes, 3b°: slender, flexous and long processes on the free operculum.

Slide NG 23—5 (8mIV), x 1250.

Figs. 4—7. *Diphyes spinulum* (Drugg) Stover and Evitt 1978

4a°: apical surface of apical view showing apical archeopyle, 4b°: optical cross section of apical-antapical view, 4c°: antapical surface of apical view showing the roundly pentagonal antapical process.

Slide NG 5—5 (8LII), x 500.

5a°: optical cross section of polar view showing the free operculum within the endocoal. 5b°: antapical surface showing postcingular processes.

Slide NG 7—5 (8AIV), x 500.

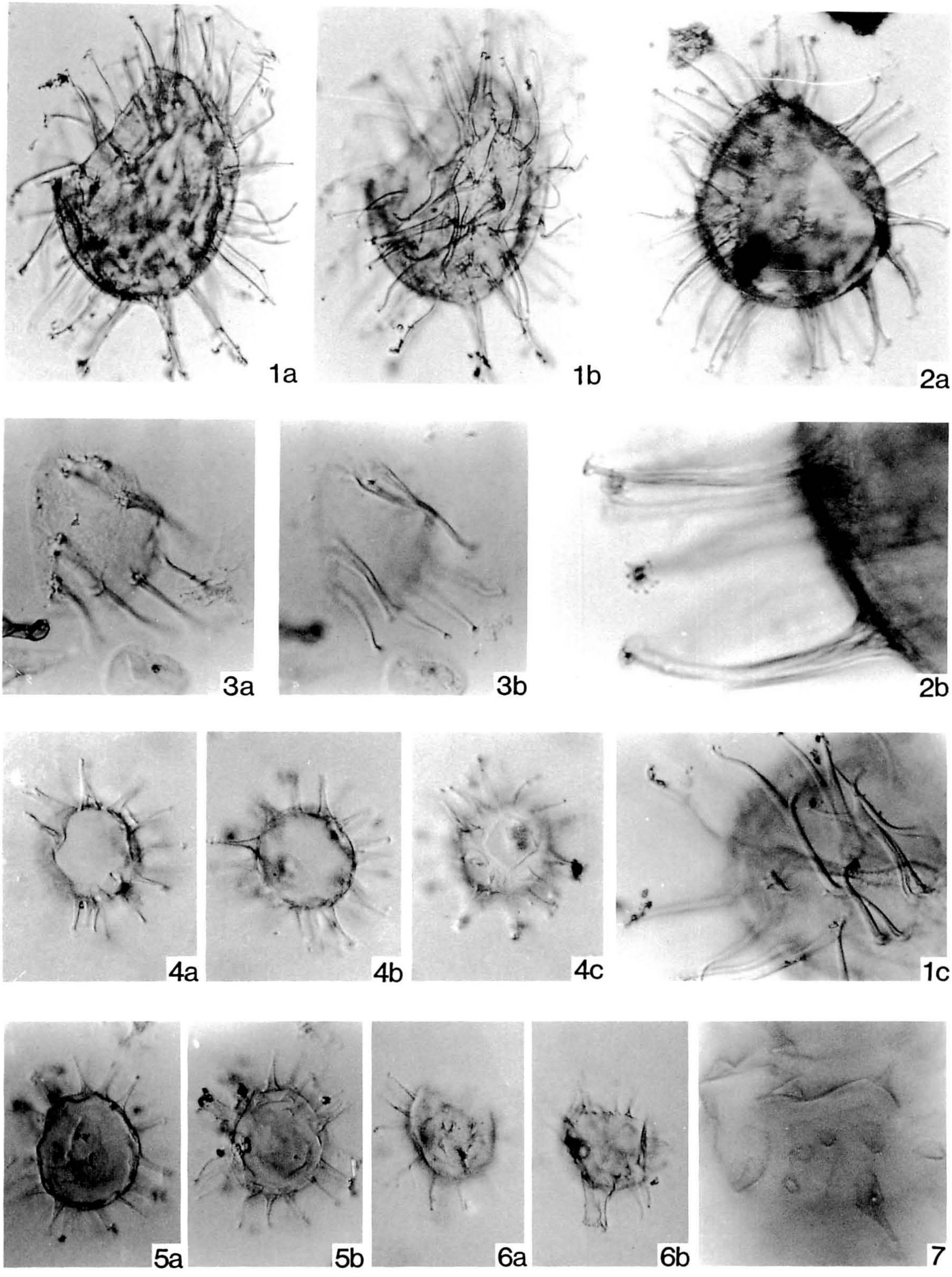
6a°: lateral surface showing the subspherical cyst body. 6b°: optical cross section of lateral view showing the large antapical process.

Slide NG 5—5 (7oI), x 500.

7°: lateral view showing the much deformed apical archeopyle and basically intratabular precingular processes.

Slide NG 7—5 (8AIV), x 1250.

°: in interference contrast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from the Middle to Late Eocene sediments in southern Kutch in India.

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Explanation of Plate 74

Fig. 1. *Homotryblium pallidum* Davey and Williams 1966
a: apical surface showing the epicystal archeopyle. b: antapical surface showing postcingular and antapical processes, c: optical cross section of the taeniate process.
Slide NG 5—1 (6GI), 1a, 1b x 500, 1c x 1250.

Fig. 2. *Homotryblium* sp. cf. *H. oceanicum* Eaton 1976
a°: upper focus of ventral surface showing precingular and postcingular processes, b°: lower focus of ventral surface. c°: optical cross section of dorso-ventral view.
Slide NG 1—1 (5WIV), x 500.

Figs. 3—7. *Homotryblium plectilum* Drugg and Loeblich 1967
3a: oblique apical surface showing the epicystal archeopyle, 3b: optical cross section of polar view, 3c: oblique antapical surface.
Slide NG 5—4 (6cIV), x 500.
4: lateral view showing taeniate and polytubular processes.
Slide NG 49—5 (3rII), x 540.
5: oblique apical surface showing the epicystal archeopyle.
Slide NG 5—4 (5NIII), x 500.
6: oblique apical surface showing the epicystal archeopyle.
Slide 5—4 (7oII), x 500.
7: polytubular process.
Slide NG 5—4 (9cII), x 1250.

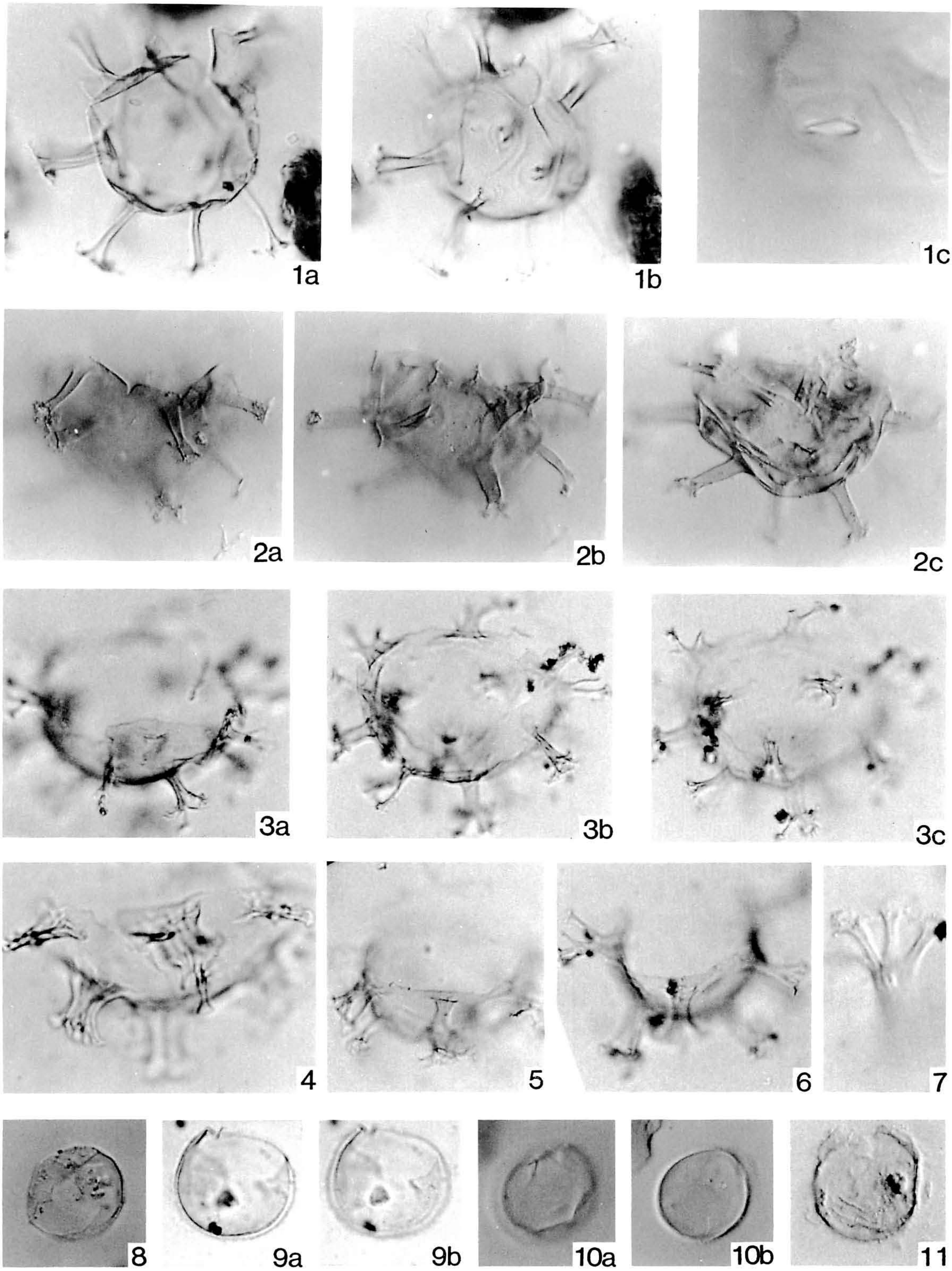
Fig. 8. *Baticasphaera explanata* (Bujak 1980) comb. nov.
apical surface showing the apical archeopyle.
Slide NG 5—3 (3hII), x 500.

Fig. 9. *Baticasphaera micropapillata* Stover 1977
a: optical cross section, b: oblique apical view showing the apical archeopyle.
Slide NG 49—1 (8DIV), x 670.

Fig. 10. *Kallosphaeridium* sp.
a°: lateral view showing the attached operculum, b°: optical cross section of lateral view.
Slide NG 21—2 (1kIII), x 500.

Fig. 11. *Caligodinium* sp. cf. *C. amiculum* Drugg 1970
lateral view showing the hyaline and adhesive material.
Slide NAG 25—4 (1JIII), x 500.

°: in interference contrast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インドネシア中部ジャワ島ナングーラン層からの渦鞭毛藻シスト：インドネシア中部ジャワ島ジョクジャカルタ西方に分布する古第三系ナングーラン層より渦鞭毛藻類ゴニオラックス目に属する9属13種（うち4新種）を記載した。それらは，セラチウム系列の *Glaphyrocysta circularis* sp. nov., *G. dentata* sp. nov. とゴニオラックス系列の *Exochosphaeridium reticulatum* sp. nov. および *E. brevispinosum* sp. nov. である。　松岡数充

Addendum:

After this manuscript had been accepted, *Chytroeisphaeridea explanata* Bujak was replaced in the genus *Baticasphaera* on the basis of its apical archeopyle by Islam (1983). Therefore, this species should be described under the following name; *Baticasphaera explanata* (Bujak) Islam, 1983.

Reference;

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Trans. Proc. Palaeont. Soc. Japan, N.S., No. 134, pp. 388—392, pls. 75, July 30, 1984

781. PRIMITIVE FUSULINACEA FROM DANGYOKEI OF TAISHAKU (STUDIES OF THE STRATIGRAPHY AND THE MICROFOSSIL FAUNAS OF THE CARBONIFEROUS AND PERMIAN TAISHAKU LIMESTONE IN WEST JAPAN, No. 5)*

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Abstract. This is the fifth of the serial papers on the stratigraphy and the microfossil faunas of the Carboniferous and Permian Taishaku Limestone in Hiroshima Prefecture of western Japan, which treats of the primitive fusulinacean faunas in the type section of the Dangyokei Formation and its overlying limestone beds belonging to the Eimyoji Formation at Dangyokei in the Taishaku area.

Introduction

No fusulinacean faunas have been reported from the stratotype of the Dangyokei Formation (Yokoyama, 1957; Hase et al., 1974; Sada, 1975a, 1977) and its overlying lower part of the Eimyoji Formation at Dangyokei in the Taishaku Limestone upland located in Tojo-cho of Jinseki-gun, Hiroshima Prefecture, western Japan. However, recently we newly discovered the *Eostaffella* fauna in the Dangyokei Formation and *Millerella-Eostaffella* fauna in the basal part of the Eimyoji Formation at Dangyokei. This discovery is worthy of note for the biostratigraphic zonation and correlation of the Dangyokei Formation called by Yokoyama (1957). In this paper the faunas are discussed and *Eostaffella kanmerai* (Igo), which is representative species of the faunas, is described.

The field work was financed by the grants from the Japanese Government Ministry of Education.

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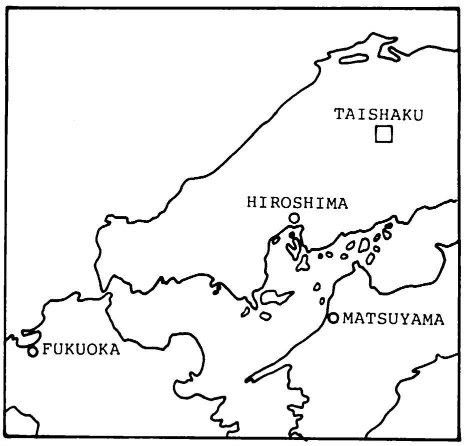


Text-fig. 1 Location of the Taishaku Limestone in Hiroshima Prefecture, western Japan.

Stratigraphy and discussion of faunas

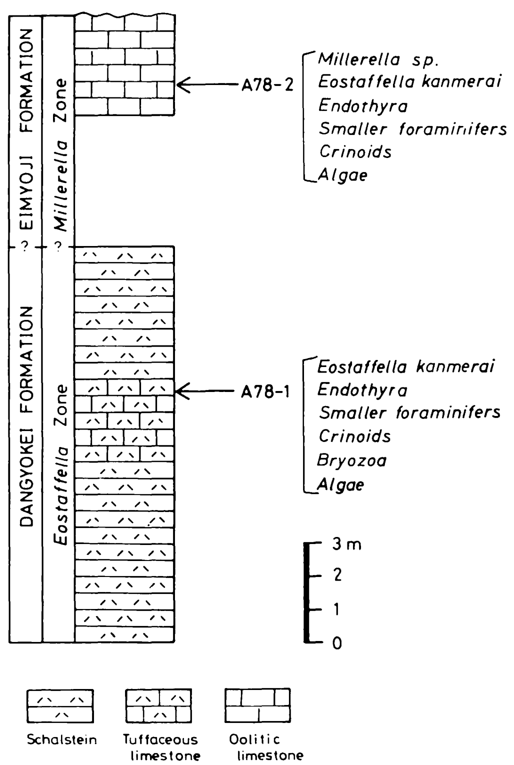
The Carboniferous of the Taishaku Limestone in the central part of this upland is divided into the Dangyokei Formation and the Eimyoji Formation (Yokoyama, 1957; Okimura, 1966; Hase et al., 1974; Sada, 1975a, 1977). Regarding the fossils from Dangyokei, in 1944 Huji-

Text-fig. 2. Map showing the fossil locality at Dangyokei in the Taishaku Limestone area, Hiroshima Prefecture. (Fossil locality plotted on Geographical Survey Institute of Japan topographical map "Taishakukyo" of scale 1:25000.)

moto reported a species of Carboniferous coral, *Nagatophyllum* sp., from Dangyokei and thought it to be of Viséan age. After that, Yokoyama (1957) described *Lithostrotionella taishakuensis* Yokoyama, *Clisiophyllum ofukuensis* (Ozawa) and *C. awa* Minato from the type section of the Dangyokei Formation and entertained the opinion that the coral fauna might be of the Bashkirian. The stratotype of the Dangyokei Formation is composed of schalsteins (basaltic lava, tuff and hyaloclastite) and an about 3 m thick tuffaceous limestone lens which is made of the crinoidal biosparrudite. The overlying Eimyoji Formation consists of oolitic massive limestone at Dangyokei.

The limestone lens at the type section (Loc. A78–1) of the Dangyokei Formation contains *Eostaffella kanmerai* (Igo), *Endothyra*, smaller foraminifers, crinoids and algae. On the other hand, the oolitic massive limestone (Loc. A78–2) of the lower part of the Eimyoji Formation is characterized by *Millerella* sp., *Eostaffella kanmerai* (Igo), *Endothyra*, smaller foraminifers, crinoids and algae.

The *Eostaffella kanmerai* fauna of the Dangyokei Formation is quite similar to the Chesterian *Eostaffella kanmerai* fauna (Sada, 1969) in limestones cropping out along the Tojo River near the town of Tojo, and also to the Chesterian *Eostaffella* faunas described by Kanmera (1952) from the Kakisako Formation in Kyushu and by Igo (1957) from the Ichinotani Formation in Gifu Prefecture. Furthermore the fauna can be correlated with the Russian



Text-fig. 3. Columnar section of the lower part of the Taishaku Limestone exposed on the south side of the Taishaku Gorge in the Taishaku area, Hiroshima Prefecture.

Eostaffella faunas (Rosovskaya, 1963; Aisenberg et al., 1960) and North American *Eostaffella* faunas (Zeller, 1953; Anisgard and Campau, 1963; Sada and Danner, 1973). The *Millerella* sp. fauna of the Eimyoji Formation resembles in specific composition the early Pennsylvanian *Millerella* faunas in Japan (Igo, 1957; Sada, 1964, 1975b, 1975c, 1980) and North America.

Description

Family Ozawainellidae Thompson and Foster, 1942

Genus *Eostaffella* Rauser-Chernoussova, 1948

Eostaffella kanmerai (Igo)

Pl. 75, Figs. 1—8

Millerella kanmerai Igo, 1957, p. 175—177, pl. 1, figs. 20—26, pl. 2, fig. 14.
Eostaffella kanmerai, Sada, 1964, p. 230—231, pl. 21, figs. 8, 16—17; 1967, p. 144—145, pl. 2, figs. 1—10; 1969, p. 120—121, pl. 12, figs. 1—13, pl. 13, figs. 1—2; Sada and Danner, 1974, p. 259—266, pl. 37, figs. 1–3, 5, 18—19; Sada, 1975c, p. 35—36, pl. 8, figs. 1—5; 1980, p. 68—69, pl. 1, figs. 1—5, 11—13.

Material studied.—Description is based on 5 illustrated specimens (Rg. No. UHA78—2Aa, UHA78—2Ac, UHA78—2A13, UHA78—1w, and UHA78—1A and many other unillustrated specimens from Loc. A78—1 and A78—2.

Descriptive remarks.—The shells are discoidal in shape, having the subangular to the broadly rounded periphery and the umbilicated poles. The shells of the four to five volutions are 172 to 280 μ in length and 571 to 704 μ in width. The form ratios range from 0.30 to 0.40. The outer volutions are involute. The diameters of the whorls of the 2nd to the 5th volution are 129—138, 244—266, 394—430 and 649—707 μ, respectively. The spirotheca consists of a tectum and inner and outer tectoria. The thickness of

Table 1. Measurements of *Eostaffella kanmerai* (Igo)

Specimens		UHA78-2Aa	UHA78-2Ac	UHA78-2A13	UHA78-1w	UHA78-1A
Pl., fig.		1,1	1,4	1,2	1,7	1,8
Length		0.285	0.236	0.295	0.306	0.286
Width		0.707	0.649	0.682	0.656	0.730
Form ratio		0.40	0.36	0.43	0.47	0.39
Diameter of	Vol.					
whorl	1	—	—			
	2	0.138	0.129			
	3	0.266	0.244			
	4	0.430	0.394			
	5	0.707	0.649			
Thickness of	0	—	—			
spirotheca	1	—	0.014			
	2	0.021	0.016			
	3	0.012	0.019			
	4	0.022	0.015			
	5	0.028	0.023			

Measurements in mm.

the spirotheca of the 1st to the 5th volution is 14, 16—21, 12—19, 15—22 and 23—28 μ, respectively.

The symmetrical chomata are low. The present species is very poor in preservation because of the secondary mineralization. In the shell shape, the number of volution and the internal biocharacteristics, the species, however, resembles closely *Eostaffella kanmerai* described by Igo (1957) from the Ichinotani Formation in Gifu Prefecture, by Sada (1967, 1969, 1975c, 1980) from many places in western Japan and by Sada and Danner (1974) from British Columbia in Canada.

Occurrence.—*Eostaffella kanmerai* (Igo) is associated with *Endothyra* and smaller foraminifers at Loc. A78—2.

Geological age.—Chesterian to early Pennsylvanian.

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Columbia, Canada and northwestern Washington, U.S.A. *Ibid.*, no. 93, p. 249—265, pls. 35—37.

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帝釈断魚渓産の微小紡錘虫（石炭・二畳系帝釈石灰岩の層序と微化石動物群についての研究，No. 5）： 帝釈石灰岩層群最下部の断魚渓層の stratotype から *Eostaffella kanmerai* (Igo) を，その上位に重なる永明寺層最下部より *E. kanmerai* (Igo) と *Millerella* sp. をそれぞれ識別した。断魚渓層の stratotype にはこれまで紡錘虫類がまったく認められていなかったので，今回のこの新知見は同 stratotype の時代決定にさいしてきわめて重要な意義をもつものである。時代決定に最も重要である *Eostaffella kanmerai* (Igo) をここに記載して報告し，断魚渓層の stratotype の微化石群集を Chesterian の *Eostaffella* 群集（猪郷，1957；勘米良，1952；佐田，1969；Rosovskaya, 1963；Zeller, 1953；Sada and Danner, 1973）に対比する。

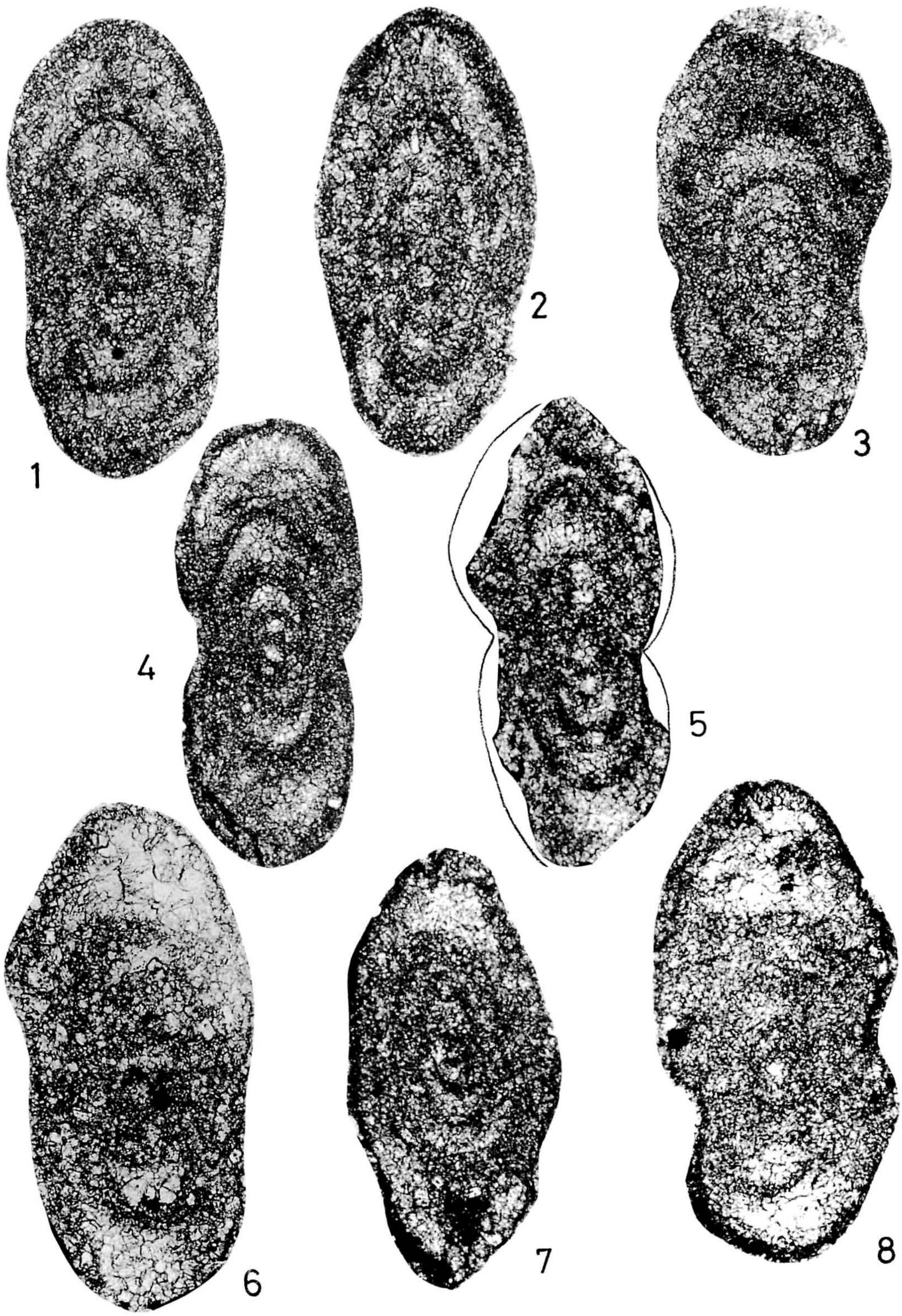
佐田公好・野村和芳・於保幸正

Explanation of Plate 75

All ×100

Figs. 1—8. *Eostaffella kanmerai* (Igo)

1—8. Axial sections. Rg. No. UHA78—2Aa, UHA78—2A13, UHA78—2A8, UHA78—2Ac, UHA78—1n, UHA78—1—3, UHA78—1w and UHA78—1A, respectively.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個　人　講　演

琵琶湖底 1,400 m 深層掘削試料に基づく過去約150万年間の古植生・古気候（予報）……………………………藤　則雄・堀江正治

Larix remains from Pleistocene strata of North-east Japan, with special reference to the distribution of *Larix* in the later half of the Last Glacial age ....Suzuki, Keiji

中部九州後期新生代の化石植物群，その1 阿蘇野地域………………長谷義隆・岩内明子

Miocene plants from the Koura Formation in Shimane Prefecture ....Onoe, Toru

長野県小川層産植物化石群について ….尾崎公彦

北半球におけるフウ属（マンサク科）の分布変遷……………………………植村和彦

北海道古第三系の *Alangium* 属葉化石の再検討……………………………棚井敏雅

岩手県種市層産出の木生シダ *Tempskya* について……………………………西田治文

相馬中村層群栃窪層の植物化石……………………木村達明・辻井正則・滝本秀夫

Dipteridaceae from the Upper Triassic Mine Group in Yamaguchi Prefecture, Japan (3) .... Naito, Gentaro

北海道夕張地域の上部白亜系の浮遊性有孔虫（予報）……………………………海保邦夫

相模湾の堆積物中に含まれる海綿骨片と現生海綿の有する骨片の対比 ……………井上雅夫

高知市鴻ノ森山の中期古生代放散虫化石 ..古谷裕・吉倉紳一・浜本厚美・森山稔里・山口理佐

東京都五日市町柏原付近の秋川流域より産する二畳紀 *Spumellaria* ……指田勝男・遠西敬二

Upper Triassic spicular Radiolaria .... Nishimura, Harumi

Triassic Radiolaria from the Kamiaso area, Gifu Prefecture. Part I Anisian .... Nishimura, Harumi

Lower Triassic conodonts from the Kamiaso area, Gifu Prefecture .... Sato, Yoshitsugu and Igo, Hisaharu

長野県木曾福島町周辺の三畳系ージュラ系，その1. ラディニアンーカーニアン境界付近のコノドント生層序 ……………………風間　敏

二枚貝マルスダレガイ科 (Veneridae) の殻構造について ……………………………島本昌憲

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1. 和文会員名簿（本年末刊行予定）を完全なものにするため，さきにお送りした名簿原稿（はがき）をまだお送りいただいていない方は至急お願いします（6月末現在回収率60%）。
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おわびと訂正

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Errata for No. 133

Plates 59 and 60 [Matsumoto, Takahashi, Obata and Futakami: Cretaceous nautiloids from Hokkaido—IV]
Read Plate 60 *for* Plate 59, and *read* Plate 59 *for* Plate 60.

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