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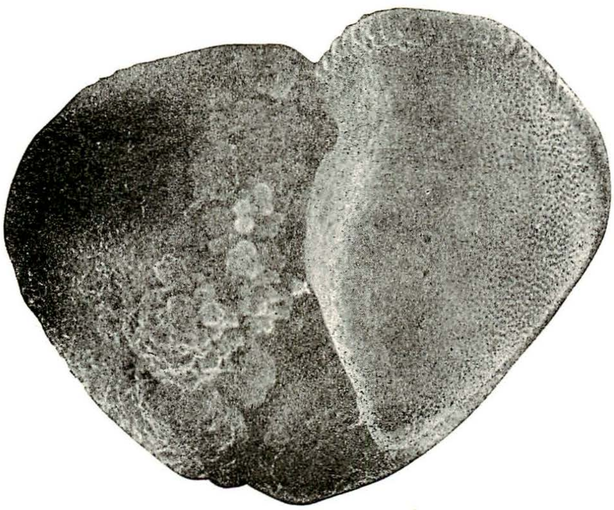

日本古生物学会

Palaeontological Society of Japan
June 30th, 1970

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Fossils on the cover is *Globorotalia truncatulinoides* (D'ORBIGNY, 1839).
The photograph was taken on a scanning electron microscope, JEOL-JSM-2, ×100.

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565. THE ONTOGENIES OF *PONUMIA OBSCURA* (LOCHMAN), N. G., AND OF *HOUSIA CANADENSIS* (WALCOTT) (TRILOBITA) FROM THE UPPER CAMBRIAN OF THE BIG HORN MOUNTAINS, WYOMONG

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北米ワイオミング州の上部カンブリア系産三葉虫 *Ponumia obscura* (LOCHMAN) および *Housia canadensis* (WALCOTT) の個体発生：ビッグホーン山地の *Elvinia* 帯から産した *Ponumia obscura* (LOCHMAN) および *Housia canadensis* (WALCOTT) の生長変化を記載した。前者は *Bynumiella ? obscura* LOCHMAN に基づいて樹てられた新属で，anaprotaspid 段階から late meraspid 段階までの個体発生がよく追跡される。後者については paraprotaspid 段階が不明であるが，尾板については全ての発達段階がよく保存されており，従来良好な分類基準と考えられていた自由頰の刺，尾板と胸節との連接部などの形態，尾板の尾針の有無などは，生涯を通じて著しく変化するものであることが判明した。胡　忠　恒

Introduction

The present study describes the ontogeny of *Bynumiella* ? *obscura* LOCHMAN, (which is assigned to a new genus, *Ponumia*) and the ontogeny of *Housia canadensis* (WALCOTT). The materials for this study were collected from the *Elvinia* zone in the Franconian, Upper Cambrian, Flathead Formation of the Big Horn Mountains in north-central Wyoming during the summer session of 1968 at the University of Illinois Geology Summer Field Camp. The Flathead Formation lithology from which the trilobites were collected is a friable, light-green, micaceous shale containing some small intraformational limestone pebbles. Only three species of trilobites were available : *Housia canadensis* (WALCOTT), *Ponumia obscura* (LOCHMAN), and *Pseudagnostus communis* (HALL and WHITFIELD).

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The collected material for the ontogenetic study of *Ponumia obscura* (LOCHMAN) is very complete, showing the continual growth sequence from very early protaspid to the adult form ; however, *Housia canadensis* is only incompletely represented in the author's collection, its paraprotaspids being unknown. The later stages of *H. canadensis* are beautifully preserved, and the pygidium is represented at all subsequent growth stages. At immature stages these species are distinguished by the narrower axial lobe or glabella and the broader fixigenae of *H. canadensis*.

It has been necessary to infer the specific assignments and associations of the trilobite fragments — the librigenae, hypostomata, and pygidia —, because these parts are disarticulated from the cranidia and thraxes.

The terminology employed here for the ontogenetic sequences is that based on the morphologic changes of the cranidium: Anaprotaspid, metaprotaspid, paraprotaspid, early meraspid, and late meraspid stages. The author has employed these terms previously (HU, 1968a, b).

Acknowledgments

The author wishes to thank Dr. K. E. CASTER, Department of Geology, University of Cincinnati, for his supervision. Thanks are also extended to Dr. F. L. KOUCKY, Department of Geology, University of Cincinnati, who guided me to the collecting sites in the Flathead Formation in the Big Horn Mountains and aided in the collecting. The author deeply appreciates the help of Mr. M. STEPHENS, Division of Geological Sciences, California Institute of Technology, who assisted with the English of the text.

The specimens described in the present study are stored in the Geology Museum, University of Cincinnati, Ohio.

Systematic Paleontology

Family Housiidae HUPÉ, 1953

Genus *Housia* WALCOTT, 1916

Housia canadensis (WALCOTT)

Pl. 27, figs. 1–33, pl. 28, figs. 24, 26, 28–31 and text-fig. 1 and 2.

Ceratopyge canadensis WALCOTT, 1912, p. 233, pl. 36, figs. 13–22.

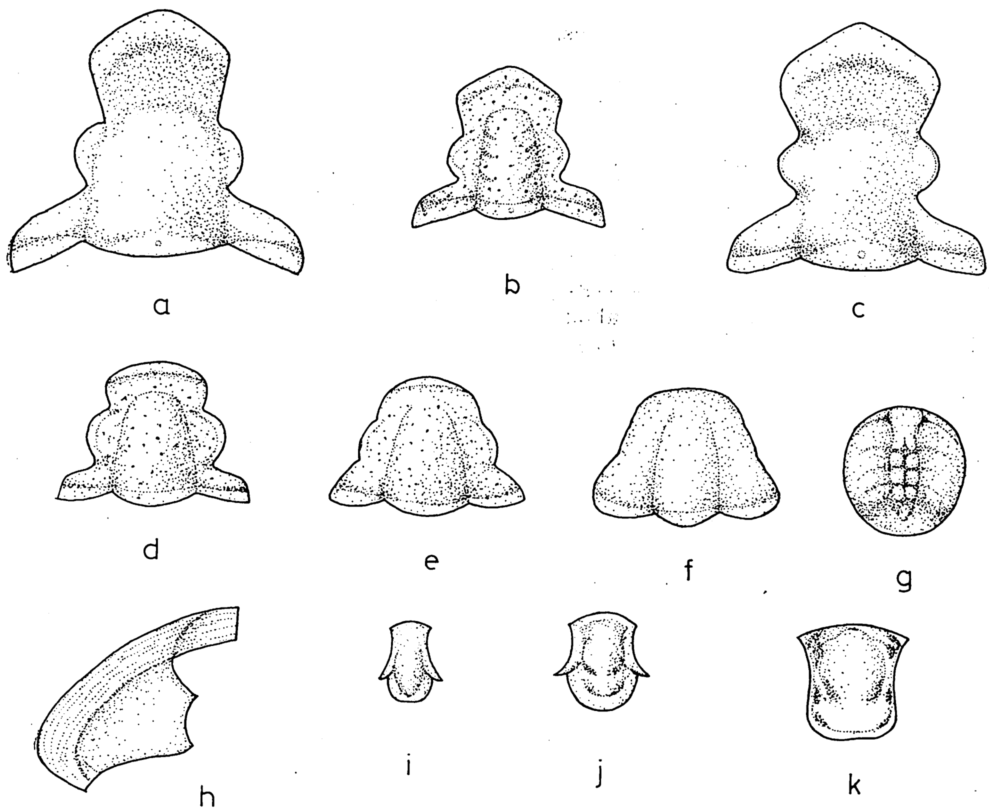
Housia canadensis (WALCOTT), 1925, p. 94, pl. 22, figs. 10, 11; and LOCHMAN, 1964, p. 46, pl. 12, figs. 16–29.

Housiella canadensis (WALCOTT), KOBAYASHI & ICHIKAWA, 1955, p. 66, pl. 11, fig. 12.

Synonomy.—KOBAYASHI and ICHIKAWA (1955) proposed a new genus, *Housiella*, based on *Housia canadensis* (WALCOTT) and attempted to distinguish it from *Housia* by its possession of genal spines, shallow axial furrow along the glabella, and a pair of caudal spines on the pygidium. This distinction was considered trivial by LOCHMAN (1959) and PALMER (1965). It is now known that the genal and caudal spines are absent in the later growth stages; therefore, these structures probably do not have any specific significance for the present species, but further examination is needed.

Material.—The species *Housia canadensis* is represented in the author's collection by more than 15 cranidia, 10 pygidia, 10 librigenae, a few hypostomata, and about 20 immature instars. The largest cranidium measures about 9.0 mm., the largest pygidium, 6.0 mm. in length (sag.). Some of the adult specimens previously prepared by the author and studied by LOCHMAN (1964) are cranidia measuring up to 20 mm. and pygidia, 9.0 mm. long (sag.). This gap in the size sequence may indicate that the largest individuals of the present study are not fully grown forms. The smallest specimens (pl. 27, figs. 11, 12) measure 0.22 mm. in length (sag.). They are shields composed of five axial segments and belong to the early protaspid stage. These protaspides of *Housia canadensis* are differentiated from those of *Ponumia obscura* by their narrower glabella and broader fixigenae. Later stages are discontinuously represented in the collections.

Figured specimens.—
Cranidia, U.C.M. 39744, 39744a-d.
Hypostomata, U.C.M. 39744o-q.
Librigenae, U.C.M. 39744h′-k′.
Pygidia, U.C.M. 39744e′, f′.



Text-fig. 1. A growth series of *Housia canadensis* (WALCOTT).
a–c, three adult cranidia, ×3.5, ×14, ×4; d, e, two late meraspid cranidia, ×20, ×20; f, an early meraspid cranidium, ×30; g, a metaprotaspis, ×60; h, a librigena, ×2; i, j, k, a growth series of the hypostoma, ×60, ×25, ×8. (All drawings were made from photographs.)

Ontogeny

Metaprotaspid stage (pl. 27, figs. 11, 12; text-fig. 1g). — The convex shield is rounded to subrounded in outline and about 0.20–0.25 mm. in length (sag.). Its dorsal furrows distinctly define a fusiform axial lobe, which is divided into five axial rings by distinct transverse furrows. The small frontal lobe (or first axial ring) tapers and is rounded anteriorly. A pair of shallow lateral pits are associated with it. The second to fourth axial rings are each composed of a pair of rounded nodes and are all distinctly delimited by longitudinal and segmental furrows. The occipital ring is small, posteriorly rounded, and distinct. The fixigenae or pleural lobes are equal to or slightly wider than the axial lobe; they are convex and curve ventrally along their margins. No librigenae or protopygidia were observed except for some specimens showing a narrow, unsegmented area along the post-axial margin. The surface is finely granulose.

Only three specimens of the metaprotaspid stage of *H. canadensis* were sorted out from several hundred of *Ponumia obscura*. These instars are correctly identified because both species, *Housia canadensis* and *Ponumia obscura*, are present as adults in the same samples, and *Housia canadensis* is recognized by its narrower axial lobe and broader fixigenae.

Early meraspid stage (pl. 27, figs, 9, 10, 13, 14, 19-24; text-fig. 1f, i, and text-fig. 2a, b).—The convex cranidium is regularly trapezoidal in outline and about 0.50-0.60 mm. in length (sag.). The faintly impressed dorsal furrows delimit a conical glabella with a rounded anterior margin. No glabellar furrows or rings are recognizable. The anterior border is narrow and flat and indistinctly differentiated from the glabella. The occipital ring is a narrow, posteriorly convex crescent which lacks an occipital spine. The narrow fixigenae are each about one-half as wide as the glabella; they slope gradually down from the dorsal furrows. Their palpebral lobes are located in front of the mid-length of the cranidium. The narrow posterior fixigenal border is distinctly delimited by the border furrow. Each librigena is about 1.5 mm. long, convex, and without recognizable lateral furrows (pl. 27, fig. 14). The narrow ocular platform bears the eye-ring far anteriorly, next to the anterior facial suture. The posterior platform is narrow and elongate and projects into a delicate genal spine.

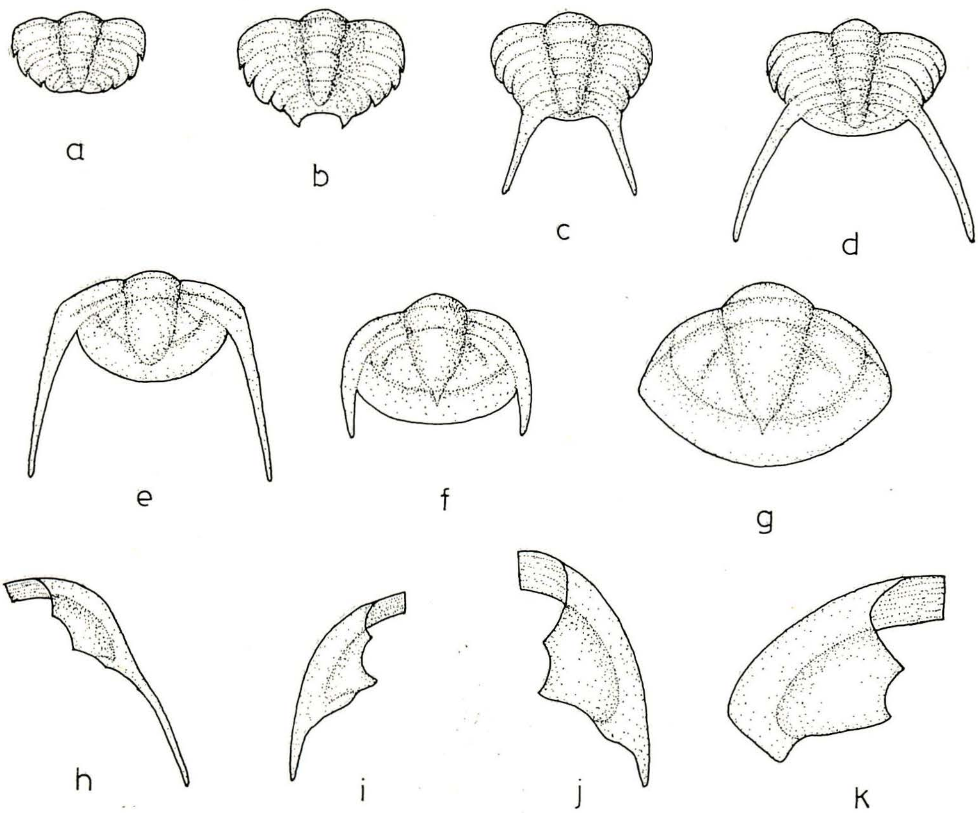
The early meraspid pygidium is semicircular in outline, convex, and about 0.40-0.60 mm. in length. It consists of five to eight segments separated by indistinctly impressed dorsal furrows. The axial lobe is a narrow cone tapering posteriorly. Each pleural lobe is about one and one-half as wide as the axis; their margins slope uniformly. Each pleural segment of the smaller specimens has a pair of blunt spines, but the spines of the larger individuals are indistinct except for the terminal pair, which are long and strong.

The early meraspid hypostome is about 0.27 mm. long, elongate, and arrowhead-shaped. The median body is a narrow cone distinctly delimited by lateral furrows and ending in a sharp point. The anterior margin arches forward with a pair of small lateral wings; the lateral borders are continued by a pair of spines extending postero-laterally from the sides of the median body. The posterior inner marginal border is broad, convex, and U-shaped.

The meraspid cranidia of *H. canadensis* are distinguished from those of *Ponumia obscura* by the absence of the distinct dorsal furrow, narrow occipital ring which lacks an occipital spine, and the narrower posterior fixigenal border. There is a gap in the documentation between the metaprotaspid and the early meraspid stages. The reason for this gap is unknown, but the mode of life may be significant in this connection, since the species *Ponumia obscura* is represented by more abundant immature instars and less numerous adult forms, whilst in *Housia canadensis* adult are more abundant and immature instars less so. The latter species may have been migrant, i. e., had a different reproductive region from the area inhabited by the mature form.

The metamorphosis of the pygidium is very well shown by the material of this growth stage; the smaller forms (pl. 27, figs. 19, 20) show no caudal spines or macrosegment; the medium-sized specimens have a pair of short spines hanging laterally behind the posterior axial lobe, and the larger specimens have large spines extending postero-laterally from the pygidial margin.

The hypostome has a narrow median body and a pair of lateral spines; these spines are reduced in length to absent during the next developmental stages.



Text-fig. 2. A growth sequence of pygidium and librigenae of *Housia canadensis* (WALCOTT).

a, b, two early meraspid pygidia, ×25, ×20; c–f, four late meraspid pygidia, ×20, ×14, ×13, ×8; g, an adult pygidium, ×5; h–j, three meraspid librigenae, ×8, ×8, ×3; k, an adult librigena, ×10. (All drawings were made from photographs.)

Late meraspid stage (pl. 27, figs. 3, 6–8, 16, 25–31; pl. 28, figs. 24, 26, 28–31; text-fig. 1d, e, j, and text-fig. 2c, f, h–j). — The convex cranidium is elongately subtrapezoidal in outline and about 0.90–1.30 mm. in length (sag.). The faintly delimited glabella is conical, tapering forward with a rounded anterior margin; no glabellar furrows are recognizable. The flat preglabellar field is very narrow and delimited by a distinct frontal furrow. The anterior border is narrow and convex and arches forward. The narrow occipital ring is a convex crescent delimited by the distinct occipital furrow. The fixigenae are rather narrow; they bear large palpebral lobes located at the mid-length of the cranidium; each posterior fixigena is narrow and about one-half as wide as the occipital ring. The border is defined by a narrow border furrow. The anterior facial suture is straight or slightly convergent convex, and each posterior fixigena is divergent straight or gently convex along the lateral side. The librigenae are moderately convex and have broad lateral borders and distinct border furrows. The broad doublure is slightly concave, marked by a few parallel ridges, and terminated anteriorly at the median suture and posteriorly extending into the genal spine. The hypostoma is elongate, subquadrate, and convex. It bears a pair of short lateral spines. The median body is oval and distinctly delimited by marginal furrows. The posterior inner border is broad and U-shaped, convex, and faintly defined by the border furrow. The marginal border is narrow and elevated.

The late meraspid pyridium is ankylosed with one or a few of the thoracic segments and varies from 0.9 to 2.0 mm. in length; some of the small specimens possess two to five thoracic segments in front of the stout macrosegment, and the pygidium is small. In the larger forms the macrosegment is reduced in length, and the pygidium increases in width. The axial lobe is narrow, conical, and convex. It consists of various numbers of axial rings. The pleural lobe is broader than the axis. The pygidium increases in its number of segments, but the segmental furrow become obsolete during later growth periods.

The morphological changes of the late meraspid stage are the initial appearance of the preglabellar field, the reduction in width of the fixigenae, the increase in relative size of the hypostomal median body, and the decrease in relative length of the lateral spines. The pygidium increases in size, but the number of the anterior macrosegmental thoracic segments becomes less distinct. The librigenae show a reduction in the length of the genal spines.

Figured specimens.—
- Metaprotaspides, U.C.M. 39744k, j.
- Early meraspides,
  - Cranidia, U.C.M. 39744i, h.
  - Librigena, U.C.M. 39744m.
  - Hypostoma, U.C.M. 39744l.
  - Pygidia, U.C.M. 39744p–v.
- Late Meraspides,
  - Cranidia, U.C.M. 39744e–g.
  - Librigena, U.C.M. 39744g′, l′.
  - Hypostoma, U.C.M. 39744n.
  - Pygidia, U.C.M. 39744w–z, a′–d′.

Family undetermined

Genus *Ponumia* HU, new genus

Type-species.—*Bynumiella? obscura* LOCHMAN.

Diagnosis. — Cranidium subtriangular to elliptical in outline; glabella narrow, subtriangular, with narrowly rounded anterior end; glabellar furrows indistinct, occipital ring convex, crescentic, bearing medium-sized occipital spine; preglabellar field rather narrow, sloping ventrally toward the anterior border furrow; anterior border furrow almost obsolete, very narrow anterior border; fixigenae sloping ventrally, convex, bearing small palpebral lobes; posterior fixigenae of same width as occipital ring (sag.). Librigenae unknown. Pygidium subtriangular in outline, convex, with three large axial rings and a small, triangular terminal portion; convex pleural lobes of same width as axial ring, which bears three or four pairs of pleural furrows and interpleural grooves.

Description.—Convex cranidium broadly subtriangular in outline, delimited by distinct dorsal furrows. Convex glabella narrowly conical with a narrow and rounded anterior margin; glabellar furrows indistinct, except for the last pair, which are faintly impressed. Convex crescentic occipital ring distinctly separated by narrow occipital furrow; ring bears a medium-sized spine. Brim narrow, i. e., about one-third the length of glabella (sag.). Flat brim slopes slightly ventrally and has faintly impressed frontal furrow; anterior border very narrowly triangular with a median point projecting anteriorly. Fixigenae broadly triangular, convex, with small palpebral lobes slightly elevated and located next to anterior glabellar margin (tr.); palpebral ridge indistinct; posterior fixigenae broadly triangular, convex, distinctly impressed by rear furrow; convex marginal border of medium width (sag.) and about the same width as occipital ring (tr.). Anterior branch of facial suture running convergent convex, short, narrowly cutting anterior fixigenae; posterior facial suture divergent immediately behind palpebral lobes but strongly convex laterally with broad posterior fixigenae.

Pygidium broadly subtriangular in outline but with posterior marginal medially recessed. Axial lobe conical, tapering posteriorly and bearing three or four convex axial rings and deep ring furrow; terminal portion narrowly triangular, faintly marked by a pair of lateral furrows. Convex pleural lobe equal to or slightly narrower in width than axial lobe; pleural lobes sloping ventrally from dorsal furrow and marked by three or four pairs of pleural furrows and interpleural grooves; pleural bands run directly from dorsal furrow to posterior lateral margin. No border or border furrow is distinguishable.

The librigena and hypostome are unknown. The skeletal surface is smooth or finely granulose.

Comparison.—The new genus *Ponumia* is very similar to the genus *Aphelotoxon* PALMER (1960, 1965): Both possess a conical glabella, small palpebral lobes and narrow fixigenae; but *Ponumia* differs in having the palpebral lobes located anteriorly and in having a preglabellar field. The pygidium of *Ponumia* also resembles that of *Aphelotoxon* (*A. limbata* PALMER, 1965, p. 79, 80; pl. 19, figs. 6, 11) and resembles the pygidium of the genus *Cliffia* WILSON (*Cliffia wilsoni* LOCHMAN, 1964, p. 47, pl. 11, figs. 18–20), but differs in being slightly broader.

The genus *Ponumia* is differentiated from *Bynumiella* RESSER (1942) by the presence of the frontal furrow, narrower glabella, broader posterior fixigenae, and presence of the occipital spine. WILSON (1951) reported that the genus *Bynumiella* occurs in the Trempealeuan with the genera *Illaenurus* and *Rasettia*. PALMER (1965) re-examined the types of *Bynumiella* (*B. typicalis* RESSER) and synonymized it with the genus *Cleandia* ROSS (1951). Nevertheless, both of these forms, i. e., *Bynumiella* and *Clelandia*, are much younger than the new genus *Ponumia*.

The family of the new genus *Ponumia* is still undetermined, but *Aphelotoxon*, *Cliffia*, and *Ponumia* may belong to the same taxonomic group.

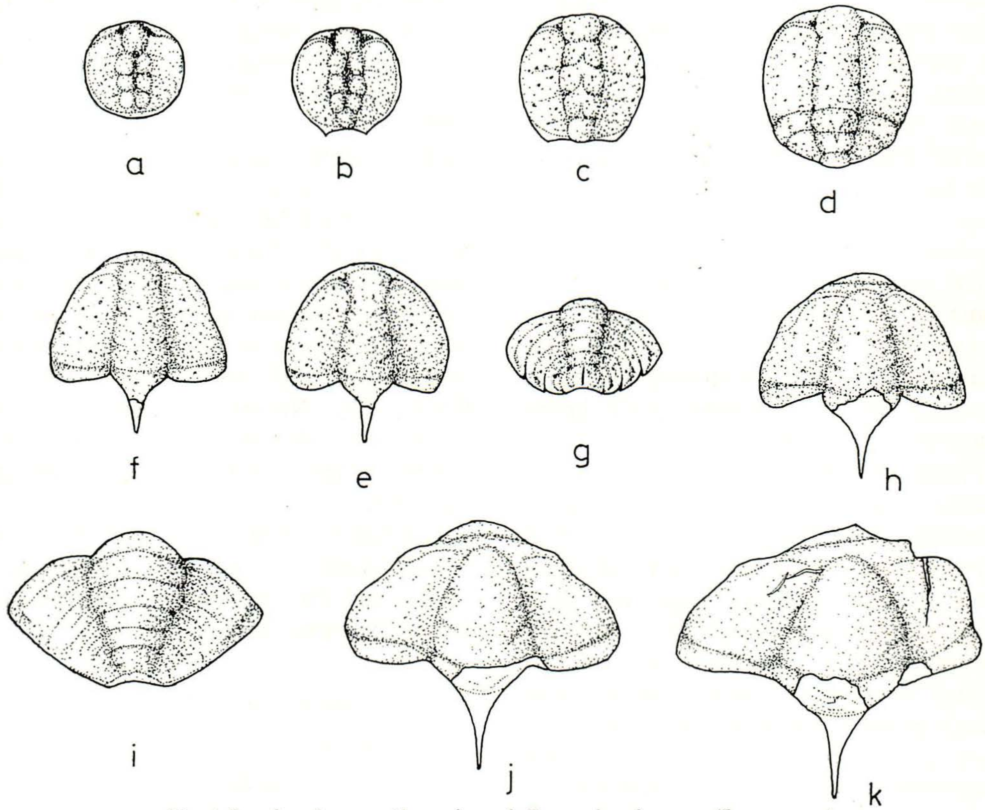
Ponumia obscura (LOCHMAN)

Pl. 28, figs. 1–25, 27, 32–35;
text-fig. 3a–k.

Bynumiella ? obscura LOCHMAN, Pl. 19, figs. 21–24, p. 46.

Material.—This species is represented in the author's collections by more than two hundred immature specimens, 15 adult cranidia, and several pygidia. The specimens were slightly compacted and deformed due to preservation in a shale matrix. LOCHMAN (1964) has associated two small pygidia with the cranidium of the present species; both pygidia measure less than 1.0 mm. in length (sag.). They quite possibly represent the earlier immature pygidia of *Housia canadensis* (WALCOTT), because they have distinct segments (pl. 27, figs. 19–22). The cranidium of the present species comforms exactly to those found in the Williston Basin (LOCHMAN, 1965). The largest cranidium is about 2.0 mm., and pygidium, 1.5 mm. in length. Apparently this is the small, not especially common, but widely distributed trilobite of the *Elvinia* zone.

Figured specimens.—
Plesiotypes
Cranidia, U.C.M. 39745s, t, w.
Pygidia, U.C.M. 39745y, z, a′, b′.



Text-fig. 3. A growth series of *Ponumia obscura* (LOCHMAN).

a, an anaprotaspis, ×60; b, c, twp metaprotaspides, ×60; d, a paraprotaspis, ×43; e, f, two early meraspid cranidia, ×34, ×30; g, a meraspid pygidium, ×24; h, a late meraspid cranidium, ×30; i, an adult pygidium, ×13; j, k, two adult cranidia, ×22, ×12. (All drawings were made from the photographs.)

Ontogeny

Anaprotaspid stage (Pl. 28, figs. 1, 2; text-fig. 3a).—The shield is about 0.20–0.24 mm. in length, rounded and convex with well-defined axial and pleural lobes. The axial lobe is elongate fusiform, divided into four segments, of which the first segment or frontal lobe is small and delimited by a pair of distinct lateral pits; the second to fourth segments are each composed of two nodes, which are all distinctly defined by dorsal, longitudinal, and segmental furrows. The convex pleural lobes are of the same width as the axis; two or three pairs of pleural furrows are faintly marked laterally from the axial segmental furrows. The librigena and pygidium are unknown. The skeletal surface is minutely granulose.

Mataprotaspid stage (pl. 28, figs. 3-6, 8-12; text-fig. 3b, c).—The shield is about 0.25-0.30 mm. in length (sag.), rounded to subrounded in outline, and moderately convex with distinctly differentiated axial pleural lobes. The smallest instars show the fusiform axis, which is composed of five axial segments. The first segment, or frontal lobe is small, rounded anteriorly, and faintly delimited by a pair of lateral pits. The second to fourth segments are each composed of a pair of rounded nodes and separated by broad, deeply impressed long furrows; the last, or occipital, segment is small and rounded and located near the posterior margin of the shield. The pleural lobe is convex, gently and uniformly sloping ventrally along the margin. The pleural or fixigenal furrows are shown by certain well-preserved specimens (pl. 28, figs. 9-10). The larger instars of the metaprotaspid stage are elongate, with or without a longitudinal central axial furrow; generally the axial nodes are fused in pairs to form three complete transverse rings. The skeletal surface is covered by minute granules. No librigena or pygidium is seen.

Paraprotaspid stage (pl. 28, figs. 7, 13-17; text-fig. 3d).—The skeleton is subrounded convex, and distinctly divided into cranidial and pygidial shields. The length of the skeleton varies from 0.35-0.55 mm. (sag.). The dorsal furrow is distinct. The glabella is narrow, cylindrical or gently tapering anteriorly with a slightly expanded frontal lobe; glabellar rings are faintly delimited by furrows. The first glabellar segment or frontal lobe is expanded forward and continues with a pair of eye-brow ridges laterally from its antero-lateral corners. The second glabellar segment is slightly smaller than the following ones, which are transversely oval. The occipital ring is distinctly marked off from the glabella by a deep furrow. The ring is transversely oval and possibly bears a minute occipital spine. The fixigenae are about the same width as the glabella and bear very fine palpebral ridges located at the antero-lateral margins, which indicate the initial appearance of the narrow, elongate librigenae. The posterior fixigenal border is convexly elevated and defined by a distinct border furrow. The small protopygidium is subtriangular, convex, and slopes ventrally from the posterior cranidial margin; it shows none to two segments. The surface of the skeleton is convered by fine minute granules, and possibly by few coarser ones.

Early meraspid stage (pl. 28, figs. 15-19, 22, 23; text-fig. 3e, f).—The convex cranidium is nearly regular trapezoidal in outline and has its anterior border arching forward uniformly. It is about 0.50-0.70 mm. long (sag.). The dorsal furrow is distinctly impressed. The glabella is cylindrical, tapering gently forward, slightly expanded anteriorly; the glabellar furrows are incomplete, deeply impressed laterally and shallow across the central axis. The narrow anterior border appears along the anterior glabellar margin from which it is separated by the frontal furrow. The anterior of the glabella is elevated and arches forward. The occipital ring is narrow, convex, and delimited by the deep occipital furrow; the occipital ring bears a minute median spine directed posteriorly. The convex fixigenae are slightly wider than, or of the same width as the glabella. The palpebral lobes are located at the antero-lateral margin of the fixigenae. The narrow palpebral lobes are elevated and well-defined by the palpebral furrows. Their anterior ends are continuous with the eye-ridges, which run directly to the antero-lateral corners of the glabella. The posterior fixigenae are about the same width as the occipital ring and have the border furrow deeply marked. The border is elevated; the lateral margin is rounded and steeply sloping ventrally; it suggests the proparial suture. The anterior facial suture is short and convergent-convex, and the posterior one is long and divergent-convex from the posterior ends of the palpebral lobes. The cranidial surface is covered by minute granules and sparsely with coarse ones.

Late meraspid stage (pl. 28, figs. 18, 27, 32; text-fig. 3g, h).—The convex cranidium varies from 0.70–0.95 mm. in length (sag.) and is triangular in outline. The

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Explanation of Plate 27

Figures 1–33. *Housia canadensis* (WALCOTT).

1–5. Five cranidia, notice the variation in the facial suture, size of palpebral lobe, and presence or absence of glabellar furrows.
1, 3.5 U.C.M. 39744; 2, ×13, U.C.M. 39744a; 3, ×14, U.C.M. 39744b; 4, ×4, U.C.M. 39744c; 5, ×8.3, U.C.M. 39744d.

6–8. Three late meraspid cranidia.
6, ×17, U.C.M. 39744e; 7, ×20, U.C.M. 39744f; 8, ×20, U.C.M. 39744g.

9, 10. Two early meraspid cranidia.
9, ×30, U.C.M. 39744h; 10, ×30, U.C.M. 39744i.

11, 12. Two metaprotaspides.
11, ×60, U.C.M. 39744j; 12, ×60, U.C.M. 39744k.

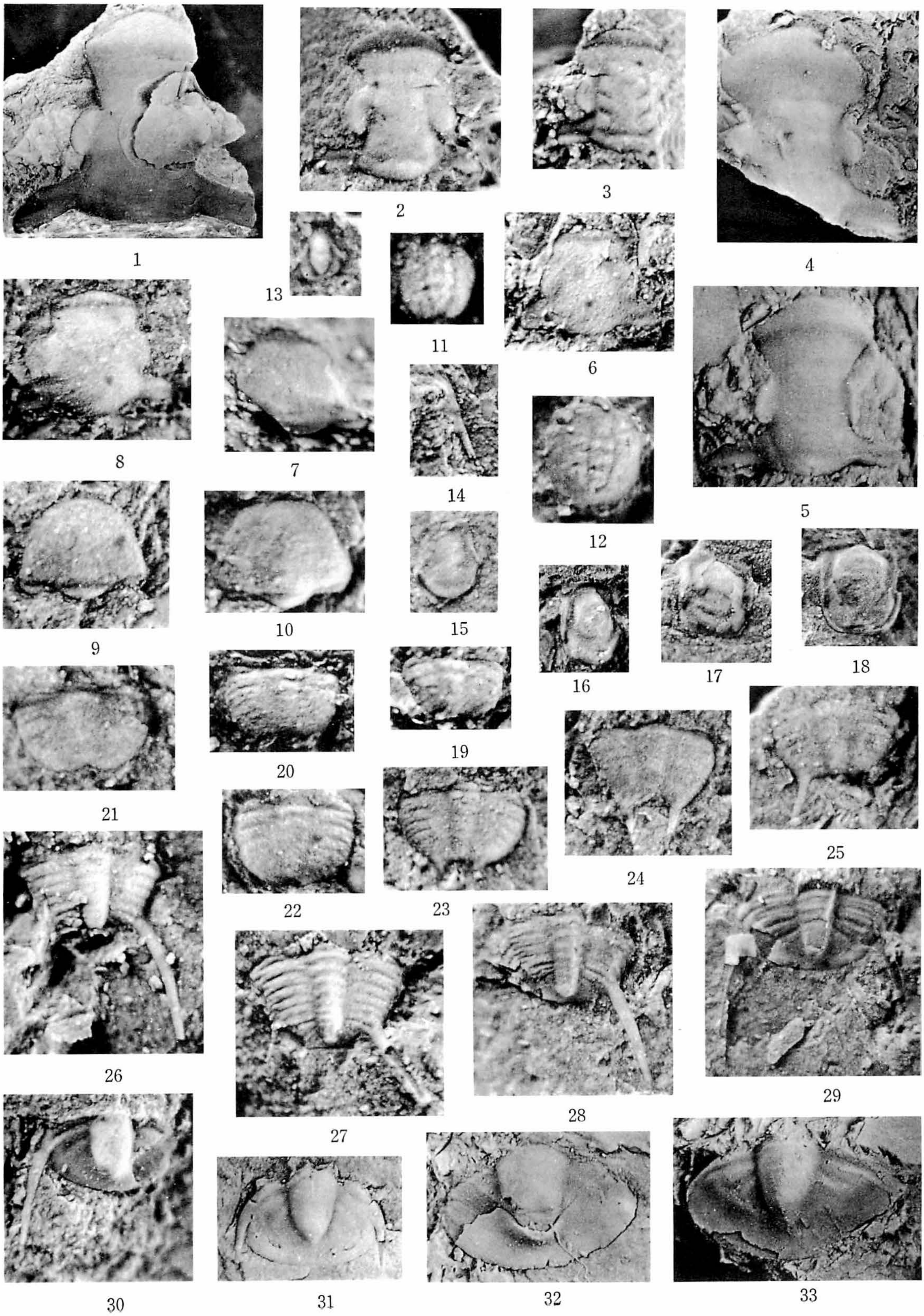
14. An early meraspid librigena.
×12, U.C.M. 39744m.

13, 15–18. A growth sequence of the hypostoma, showing the absence of the lateral spine and expansion of the median body during each successive growth stages.
13, ×60, U.C.M. 39744l; 15, ×25, U.C.M. 39744n; 16, ×12, U.C.M. 39744o; 17, ×10, U.C.M. 39744p; 18, ×8, U.C.M. 39744q.

19–24. A growth series of the early meraspid pygidium showing the presence of the caudal spine.
19, ×25, U.C.M. 39744r; 20, ×25, U.C.M. 39744s; 21, ×26, U.C.M. 39744t; 22, ×25, U.C.M. 39744u; 23, ×20, U.C.M. 39744v; 24, ×20, U.C.M. 39744w.

25–31. A growth series of the late meraspid pygidium, notice the expansion of the macrosegment, and obsolescence of the thoracic segments during its successive growth periods.
25, ×20, U.C.M. 39744x; 26, ×15, U.C.M. 39744y; 27, ×15, U.C.M. 39744z; 28, ×14, U.C.M. 39744a′; 29, ×14, U.C.M. 39744b′; 30, ×13, U.C.M. 39744c′; 31, ×8, U.C.M. 39744d′.

32, 33. Two adult pygidia, showing the ankylosis of the macrosegment.
32, ×6, U.C.M. 39744e′; 33, ×5, U.C.M. 39744f′.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dorsal furrows are distinctly marked. The conical glabella is faintly impressed by two pairs of recognizable glabellar furrows, which are very faint. The narrow preglabellar field appears in front of the anterior glabellar margin, which slopes downwards to the indistinct frontal furrow. The anterior border is narrow, elevated, obtuse, median lobe pointing anteriorly. The convex crescentic occipital ring is separated by a deep occipital furrow; the ring bears a median spine. The broad, subtriangular fixigenae are convex, sloping ventrally from the dorsal furrow. The narrow palpebral lobes are located on the fixigenae antero-laterally behind the transverse line of the anterior glabellar margin. The posterior fixigenal border is broad, elevated, and delimited by deep border furrows. The pygidium is transversely triangular in outline, gently convex, with an elevated axial lobe. It consists of three axial rings and a rounded terminal portion. Each pleural lobe is broader than the axis; each pleural segment ends is a short, broad spine. The posterior margin is medially recessed and the pleural segments are concentrically arranged around the terminal portion of the axis. The skeletal surface is faintly granulose and bears coarser granules more sparsely distributed. The larger specimens show the palpebral lobes located in front of the transverse line of the anterior glabellar margin; this indicate that the eye position moved forward during the late meraspid period.

Figured specimens.—
Anaprotaspides, U.C.M. 39745, 39745a.
Metaprotaspides, U.C.M. 39745b-e, g-k.
Paraprotaspides, U.C.M. 39745f, l, m, o, p.
Early meraspid cranidia, U.C.M. 39745n, r, u, v.
Late meraspid cranidia, U.C.M. 39745q, x.

References Cited

HU, C.H. (1968a): Note on the ontogeny and sexual dimorphism of Upper Cambrian trilobites of the *Welleraspis* faunule from Pennsylvania. *Jour. Nanyang University*, vol. 2, p. 321-357.

—— (1968b): Ontogeny and sexual dimorphism of Lower Paleozoic trilobites. *Unpublished Ph. D. dissertation*, University of Cincinnati, Ohio. (accepted for Paleontographica Americana.)

KOBAYASHI, T. & ICHIKAWA, T. (1955): Discovery of *Proceratopyge* in the *Chuangia* zone in Manchuria, with a note on the Ceratopygidae. *Trans. Proc. Palaeont. Soc. Japan, N.S.*, no. 19, p. 65-72.

LOCHMAN, C. (1959): Treatise on Invertebrate Paleontology, part 0, Arthropoda 1. *Geol. Soc. America*, p. 260.

—— (1964): Upper Cambrian faunas from the subsurface Deadwood Formation, Williston Basin, Montana. *Jour. Paleontology*, vol. 38, p. 33-60.

PALMER, A.R. (1960): Trilobites of the Upper Cambrian Dunderberg Shale, Eureka district, Nevada. *Geol. Survey, Prof. Paper*, 334-c, p. 53-109.

—— (1965): Trilobites of the Late Cambrian peterocephalid biomere in the Great Basin, United States. *Geol. Survey, Prof. Paper*, 492, p. 101.

WALCOTT, C.D. (1925): Cambrian and Lower Ozarkian trilobites. *Smith. Misc. Coll.*, vol. 75, p. 53-60.

WILSON, J.L. (1951): Franconian trilobites of central Appalachians. *Jour. Paleontology*, vol. 2, p. 617-654.

Explanation of Plate 28

Figures 1–23, 25, 27, 32–35. *Ponumia obscura* (LOCHMAN).

1, 2. Two anaprotaspid shields notice the faint impression of the cephalic segmental furrows.
1, ×60, U.C.M. 39745; 2, ×60, U.C.M. 39745a.

3–6, 8–12. A growth sequence of the metaprotaspid shields, showing the absence of the central axial furrow, and the combination of the axial rings.
3, ×60, U.C.M. 39745b; 4, ×60, U.C.M. 39745c; 5, ×60, U.C.M. 39745d; 6, ×53, U.C.M. 39745e; 8, ×53, U.C.M. 39745g; 9, ×53, U.C.M. 39745h; 10, ×53, U.C.M. 39745i; 11, ×53, U.C.M. 39745j; 12, ×53, U.C.M. 39745k.

7, 13, 14, 16, 17. A growth series of paraprotaspides, notice the presence of the protopygidium.
7, ×43, U.C.M. 39745f; 13, ×40, U.C.M. 39745l; 14, ×43, U.C.M. 39745m; 16, ×43, U.C.M. 39745o; 17, ×40, U.C.M. 39745p.

15, 19, 22, 23. Four early meraspid cranidia.
15, ×34, U.C.M. 39745n; 19, ×30, U.C.M. 39745r; 22, ×30, U.C.M. 39745u; 23, ×30, U.C.M. 39745v.

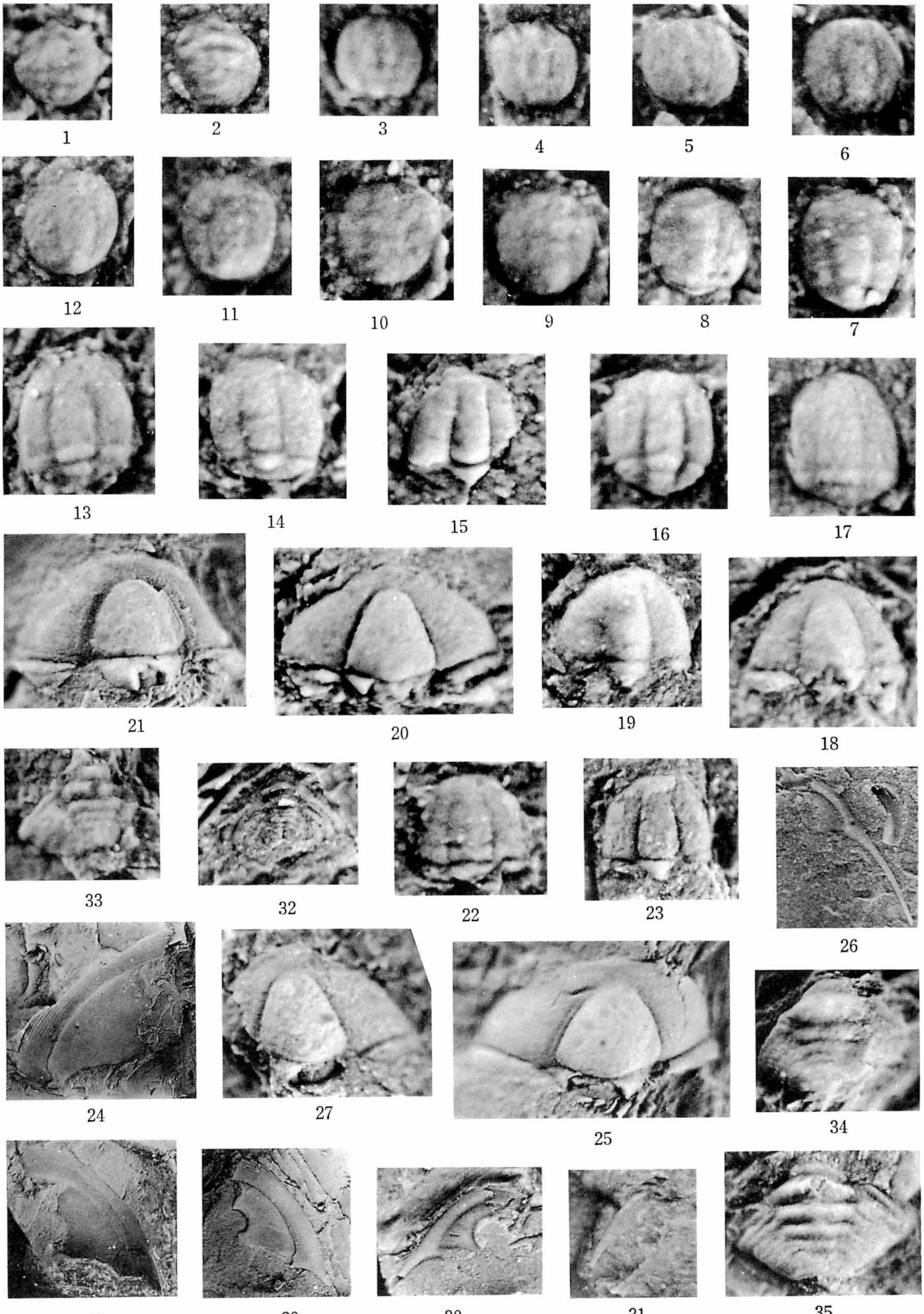
18, 27. Two late meraspid cranidia.
18, ×30, U.C.M. 39745q; 27, ×30, U.C.M. 39745x.

20, 21, 25. Three slightly deformed cranidia.
20, ×22, U.C.M. 39745s; 21, ×13, U.C.M. 39745t; 25, ×12, U.C.M. 39745w.

32–35. A growth series of the pygidium, notice the differentiation of the pygidial segments from the terminal portion.
32, ×24, U.C.M. 39745z; 33, ×24, U.C.M. 39745a′; 34, ×18, U.C.M. 39745b′; 35, ×13, U.C.M. 39745y.

Figures 24, 26, 28–31. *Housia canadensis* (WALCOTT).

A growth sequence of the librigena, notice the obsolescence of the genal spine during its successive growth periods.
24, ×3.4, U.C.M. 39744g′; 26, ×8, U.C.M. 39744h′; 28, ×3, U.C.M. 39744i′; 29, ×4, U.C.M. 39744j′; 30, ×8, U.C.M. 39744k′; 31, ×10, U.C.M. 39744l′.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21 20 19 18
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Trans. Proc. Palaent. Soc. Japan, N. S., No. 73, pp. 265-275, pls. 29, 30, June 30, 1970

566. SOME PALYNOMORPHS FROM THE UPPER CRETACEOUS SEDIMENTS OF HOKKAIDO

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北海道上部白亜紀堆積物からの若干の花粉：北海道東部の西別産上部白亜紀の花粉・胞子の中から形態的に著しい特徴をもつ Loranthaceae の花粉 2 種，Proteaceae の花粉 1 種，所属不明の *Aquilapollenites* 花粉 2 種，*Mancicorpus* 花粉 1 種，? *Sporopollis* 花粉 1 種および函渕層群産のこれまでシベリヤのみから知られていた *Orbiculapollis globosus* について記載し，層位学的ならびに植物地理学的分布について興味ある事実が判明したので述べる。　高橋　清

Introduction

In 1964, the author described many spores and pollen grains from the Upper Cretaceous Hakobuchi Group. Later, he (1965), in reporting some spores and pollen grains from the Upper Cretaceous sediments from boring cores at Nishibetsu, eastern Hokkaido, emphasized that the pollen assemblages must be studied carefully for a stratigraphic standard. However, the zonation of the Upper Cretaceous pollen assemblages in the Nemuro and Kushiro regions has not yet been established.

In this paper, the author describes in detail some remarkable pollen grains which were first reported by him in 1965, and compares these with the same or similar pollen grains from both the circum-Pacific region and Siberia. In addition, he redescribes here the Siberian species, *Orbiculapollis globosus* CHLONOVA, which in 1964 he reported as *Trivestibulopollenites* sp. from the Upper Cretaceous Hakobuchi Group, Yubari coalfield.

The author wishes to thank Professor Dr. Tatsuro MATSUMOTO, Department of Geology, Kyushu University, for his kind assistance in getting the samples analyzed, and for valuable suggestions on the stratigraphic relations and geologic age; and Dr. AZUMA, Sapporo Mining Office, Petroleum Exploitation Corporation, for kindly supplying the boring cores. Thanks are also due to Professor Dr. Glenn E. ROUSE, Department of Botany, University of British Columbia, Canada, for his valuable advice in the determination of some of the species, and for reading the manuscript.

Materials and Methods

Five core samples from the boring SK 1 were palynologically analyzed. The sedimentary rocks analyzed and their depth are as follows:

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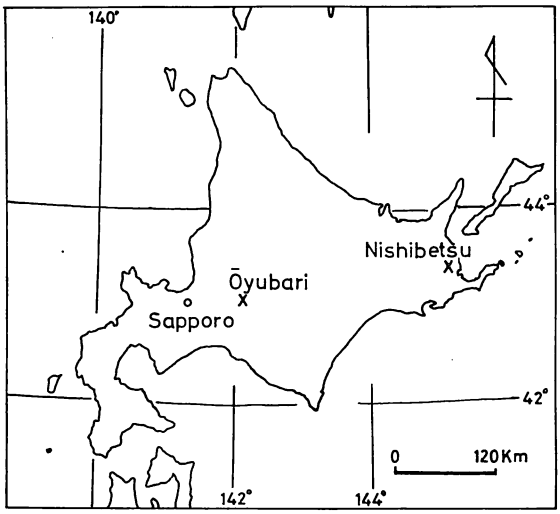
Depth from surface	Rock type
901.5 m	greenish gray shale
917.1 m	gray shale
933.0 m	dark gray shale
983.0 m	light greenish shale
1007.0 m	dark gray shale

The samples were crushed in an iron mortar. After macerating with dilute HCl during one to several days the fine materials only were gathered by stiring the precipitate, and excluding coarse fragments. The fine fractions were then rinsed repeatedly with water. Finally, concentrated HF was used for dissolving minerals that were not dissolved by HCl, mainly silica. The organic residue containing microfossils was mounted in glycerine jelly on slides and sealed with a mixture of solid paraffin and Canada balsam for microscopic studies.



Text-fig. 1. Map showing the localities of the Upper Cretaceous palynomorphs of Hokkaido.

Spores, pollen grains, and other microfossils

The author could find some palynomorphs from four samples, excepting the sample of dark gray shale at 933.0 m in depth. Unfortunately, the palynomorphs were not well preserved, and in some cases, morphological details were difficult to determine. The palynomorphs obtained from the various samples are as follows:

(A) Boring No. SK 1, 901.5 m in depth.

Spores:

Stereisporites pseudostereoides TAKAHASHI, *Laevigatosporites senonicus* TAKAHASHI, *Laevigatosporites* ? sp., *Deltoidospora psilostoma* ROUSE

Pollen grains:

Inaperturopollenites pseudodubius TAKAHASHI, *Inaperturopollenites magnus* (R. POT.) THOMSON & PFLUG, *Cycadopites* sp., *Graminites* sp., *Monocolpopollenites* sp., *Monocolpopollenites* ? sp., *Alnipollenites eminens* TAKAHASHI, *Ulmipollenites* sp., *Tricolporopollenites* *castaneoides* TAKAHASHI, *Tricolpopollenites ? reticulatus* TAKAHASHI, *Tricolporopollenites minor* TAKAHASHI, *Ilexpollenites clavatus* TAKAHASHI, *Ilexpollenites excellens* TAKAHASHI, *Tricolporopollenites meinohamensis* TAKAHASHI, subsp. *rotundus* TAKAHASHI, *Tricolporopollenites* spp., ? *Cranwellia striata* (COUPER) SRIVASTAVA.

(B) Boring No. SK 1, 917.1 m in depth.

Spore:

Laevigatosporites senonicus TAKAHASHI

Pollen grains:

Betulaepollenites minutulus TAKAHASHI, *Alnipollenites eminens* TAKAHASHI, *Tricolporopollenites* spp.

Hystrichosphere:

Leiosphaeridia n. sp. (no description)

(C) Boring No. SK 1, 983.0 m in depth.

Spores:

Laevigatosporites senonicus TAKAHASHI, *Laevigatosporites dehiscens* TAKAHASHI, *Laevigatosporites* sp., ? *Cicatricososporites* sp.

Pollen grains:

Inaperturopollenites pseudodubius TAKAHASHI, *Inaperturopollenites* sp., ? *Sequoiapollenites* sp., *Betulaepollenites minutulus* TAKAHASHI, *Alnipollenites eminens* TAKAHASHI, *Triporopollenites* sp., *Tricolporopollenites* sp., *Cranwellia striata* (COUPER) SRIVASTAVA, *Polyporopollenites* spp., *Aquilapollenites parvus* n. sp., ? *Sporopollis* sp.

Hystrichospheres:

Leiosphaeridia n. sp. (no description), *Leiosphaeridia* sp., *Baltisphaeridium* spp., *Hystrichosphaeridium* sp., *Hystrichosphaeridium* n. sp. (no description), "*Spinidinium*" sp.

(D) Boring No. SK 1, 1007.0 m in depth.

Spores:

Stereisporites limbatus TAKAHASHI, *Lygodiumsporites* ? sp., ? *Cicatricososporites* sp., *Laevigatosporites probatus* TAKAHASHI, *Laevigatosporites dehiscens* TAKAHASHI, *Laevigatosporites senonicus* TAKAHASHI, *Punctatosporites* sp., *Apiculatisporis* cf. *inouei* TAKAHASHI, *Lycopodiumsporites* sp., *Echinatisporites* sp., ? *Biretisporites* cf. *minus* TAKAHASHI, *Biretisporites* sp., ? *Reticulisporites* sp.

Pollen grains:

Inaperturopollenites pseudodubius TAKAHASHI, *Pityosporites* sp., *Inaperturopollenites magnus* (R. POT.) THOMSON & PFLUG, ? *Phyllocladidites* sp., *Alnipollenites eminens* TAKAHASHI, *Proteacidites thalmanni* ANDERSON, *Tricolporopollenites* cf. *microreticulatus* TAKAHASHI, *Cranwellia* cf. *rumseyensis* SRIVASTAVA, *Tricolporopollenites* spp., *Aquilapollenites parvus* n. sp., *Mancicorpus* sp., *Aquilapollenites* cf. *mirabilis* SRIVASTAVA.

Hystrichospheres:

Cymatiosphaera globulosa TAKAHASHI, *Hystrichosphaera* sp., *Micrhystridium* cf. *asagaiense* TAKAHASHI, *Micrhystridium* spp., *Leiosphaeridia* n. sp. (no description), ? *Leiosphaeridia* sp.

The sample yielding the Siberian pollen species, *Orbiculapollis globosus* CHLONOVA, is from the Fukaushi sandstone member of the Hakobuchi Group close to the Ōyubari dam, Yūbari coal-field. The following palynomorphs were found:

Spores:

Gleicheniidites marginatus TAKAHASHI, *Concavisporites* sp., *Stereisporites pseudostereoides* TAKAHASHI, *Corrugatisporites yubariensis* TAKAHASHI, *Baculatisporites* cf. *validus* TAKAHASHI, *Neoraistrickia* sp., *Tuberculatisporites* sp., ? *Tuberculatisporites* sp., ? *Biretisporites minus* TAKAHASHI, *Laevigatosporites prominens* TAKAHASHI, ? *Laevigatosporites probatus* TAKAHASHI, *Laevigatosporites dehiscens* TAKAHASHI, *Laevigatosporites senonicus* TAKAHASHI, *Polypodiisporites repandus* TAKAHASHI, *Polypodiisporites invisus* TAKAHASHI, *Punctatisporites* sp.

Pollen grains:

Inaperturopollenites pseudodubius TAKAHASHI, ? *Inaperturopollenites falsus* TAKAHASHI, *Inaperturopollenites* sp., *Momipites* sp., *Betulaepollenites minutulus* TAKAHASHI, *Betulaepollenites* sp., *Orbiculapollis globosus* CHLONOVA, *Alnipollenites eminens* TAKAHASHI, *Polyporopollenites punctatus* TAKA-

HASHI, *Polyporopollenites* sp., *Ulmipollenites* sp., *Graminidites microapertus* TAKAHASHI, *Monocolpopollenites shiyuparoensis* TAKAHASHI, *Tricolpopollenites* cf. *ditis* TAKAHASHI, *Tricolpopollenites* spp., *Rhoipites* ? *minutireticulatus* TAKAHASHI, *Tricolporopollenites* cf. *minor* TAKAHASHI, *Aquilapollenites quadrinus* TAKAHASHI, ? *Pistillipollenites* sp.

The sediments obtained from the boring cores at Nishibetsu contain some common species with those from the upper members of the Hakobuchi Group, that is, *Stereisporites pseudostereoides* TAKAHASHI, *Laevigatosporites senonicus* TAKAHASHI, *Laevigatosporites dehiscens* TAKAHASHI, *Inaperturopollenites pseudodubius* TAKAHASHI, *Alnipollenites eminens* TAKAHASHI, *Inaperturopollenites magnus* (R. POT.) THOMSON & PFLUG, and *Betulaepollenites minutulus* TAKAHASHI.

Stereisporites pseudostereoides TAKAHASHI, *Laevigatosporites senonicus* TAKAHASHI, and *Inaperturopollenites magnus* (R. PAT.) THOMSON & PFLUG occur in the Hakobuchi Group, and *Betulaepollenites minutulus* TAKAHASHI only in upper horizon of the Hakobuchi Group. The others range from Upper Cretaceous to Paleogene.

The genus *Cranwellia* occurs only in the circum-Pacific regions and Siberia, and is fairly characteristic of the Upper Cretaceous and Paleogene. *Cranwellia striata* (COUPER) SRIVASTAVA appears more often in the Maastrichtian of western Canada and Siberia than in the Paleogene. *Cranwellia rumseyensis* SRIVASTAVA is known only in the Edmonton Formation of Alberta, Canada. *Proteacidites thalmanni* ANDERSON has been reported from the Maastrichtian of many regions, including New Mexico, California, Montana, and Amur (Siberia). Many localities containing *Orbiculapollis globosus* CHLONOVA are known in Siberia. One specimen was reported as "cf. *Orbiculapollis globosus* CHLONOVA" by S. K. SRIVASTAVA (1968) from the Edmonton Formation, Alberta, Canada. The genus *Sporopollis*, belonging to the Normapolles group, was proposed by H. D. PFLUG in 1953 and is known in the Upper Cretaceous of Europe. K. R. NEWMAN (1965) described *Sporopollis laqueaeformis* WEYLAND & GREIFELD from the Mancos shale, Mesaverde, Iles, and Williams Fork Formations. Species of *Aquilapollenites* are very interesting and important because of their stratigraphic distribution. Most of *Aquilapollenites* species appear in the Upper Cretaceous, especially in the Maastrichtian of Alaska, western Canada, northwestern America (USA), Japan, and Siberia. They also occur, but apparently in much reduced numbers in Southeastern Asia including South India, equatorial regions of Africa, Scotland etc.

All slides are kept in the Department of Geology, Kyushu University.

Description of palynomorphs

Family Loranthaceae

Genus *Cranwellia* SRIVASTAVA, 1966

Type species: *Cranwellia striata* (COUPER) SRIVASTAVA

Cranwellia striata (COUPER) SRIVASTAVA

Pl. 29, figs. 1a, b.

1953. *Elytranthe striatus* COUPER, *New Zealand Geol. Surv. Paleont. Bull.* 22, p. 51, pl. 6, fig. 85.

1957. *Elytranthe striatus*, G. E. ROUSE. *Canadian J. Bot.*, 35, p. 369, pl. 3, fig. 64.

1960. *Triptycha striata* CHLONOVA, *Tr. Inst. Geol. Geophys., Sibirsk, Otd. Akad.*

Nauk, SSSR, 3, p. 74, pl. 10, fig. 36.
1961. ? *Elytranthe striatus*, A. F. CHLONOVA, *Tr. Inst. Geol. Geophys., Sibirsk, Otd, Akad. Nauk, SSSR*, 7, p. 90–91, pl. 16, figs. 123, 124.
1965. *Elytranthe striatus*, G. M. BRATZEVA. *Geol. Inst. Akad. Nauk, SSSR*, 129, p. 37, pl. 22, figs. 1–6.
1966. *Cranwellia striata* (COUPER) SRIVASTAVA, *Pollen et spores*, 8, 3, p. 537–538, pl. 11, figs. 1, 4.

Description: Isopolar, tricolporate pollen, colpi breaking until halfway to the poles. Grain triangular with somewhat rounded apices, sides concave in polar view. Exine thin, finely granular, granules arranged in a linear pattern giving a striate appearance, striations meeting at right angles to the colpi. Equatorial diameter 31.6μ, distance from the pole to the sides 11.5 to 12.5μ.

Occurrence: Light-greenish shale from the boring No. SK 1, 983.0 m in depth, at Nishibetsu, eastern Hokkaido; Upper Cretaceous—Maastrichtian ?

Remarks: In 1966, S. K. SRIVASTAVA proposed a new organ-genus *Cranwellia* instead of the genus *Elytranthe*. The present species *Cranwellia striata* occurs sometimes in Paleogene and Upper Cretaceous sediments of the circum-Pacific regions and Siberia.

Distribution: The following localities and ages yielding this species are known:

New Zealand:
Waimumu-Otamita Rd., Mataura valley, Southland; Oligocene—Landonian.
Canada:
Southern Alberta; Oldman Formation, Upper Cretaceous—Santonian.
Scollard, Alberta; Upper Edmonton member of the Edmonton Formation, Upper Cretaceous—Maastrichtian.
USSR:
Siberia, right bank of the river Sym, 5 km up the mouth of the river Doguldo, 300–500 m above Brusovo Yar; Danian—Lower Paleogene.
Catchment areas of the rivers Sym, Taz, and Vakh, wells at Tolka; Upper Cretaceous.
Amur; Upper Cretaceous—Maastrichtian.
Northwestern, western, and eastern areas of the west Siberian lowland; Senonian—Paleocene.

Cranwellia cf. *rumseyensis* SRIVASTAVA

Pl. 29, figs. 2a, b.

1966. *Cranwellia rumseyensis* SRIVASTAVA, *Pollen et spores*, 8, 3, p. 538, pl. 11, figs. 3, 7.

Description: Isopolar, tricolpate (?) pollen, colpi reaching halfway to the poles. Equatorial contour triangular, with slightly convex sides. Exine granulate, with granules arranged striae. Striae very fine, running at right angles to each colpus. Equatorial diameter of the present specimen 21μ.

Occurrence: Dark gray shale from the boring No. SK 1, 1007.0 m in depth, at Nishibetsu, eastern Hokkaido; Upper Cretaceous—Maastrichtian ?

Remarks: The present specimen is very similar to the Canadian species *Cranwellia rumseyensis* SRIVASTAVA from the Edmonton Formation. The author reports here the present specimen as *Cranwellia* cf. *rumseyensis*, in spite of it being impossible to determine exactly whether this specimen is tricolpate or not.

Family Proteaceae

Genus *Proteacidites* COOKSON, 1950

Type species: *Proteacidites adenanthoides* COOKSON

Proteacidites thalmanni ANDERSON

Pl. 29, fig. 5.

1960. *Proteacidites thalmanni* ANDERSON, *New Mexico Bureau of Mines Mineral Res., Mem.*, 6, p. 21, pl. 2, figs. 1-4; pl. 10, figs. 9-13.
1965. *Proteacidites thalmanni*, G. M. BRATZEVA. *Geol. Inst. Akad. Nauk, SSSR*, 129, p. 33-34, pl. 19, figs. 1, 2, 5, 6.
1967. *Proteacidites thalmanni*, W. S. DRUGG. *Palaeontographica*, 120, Abt. B, p. 58, pl. 8, fig. 38.
1969. *Proteacidites thalmanni*, N. J. NORTON and J. W. HALL. *Palaeontographica*, 125, Abt. B, p. 38, pl. 5, fig. 10.

Description: Triporate pollen grain; slightly elongate-triangular with straight or convex sides in polar view and with rounded corners; pores large and circular; pore canals (?) widening slightly inward, about 6 to 7μ in depth, 12.6 to 14μ in diameter. Exine about 1.5μ thick. Exine surface reticulate, lumina of irregular shape, 0.7 to 1.4μ in diameter. Size of pollen grain about 40μ.

Occurrence: Dark gray shale from the boring No. SK 1, 1007.0 m in depth, at Nishibetsu, eastern Hokkaido.

Remarks: The present specimen is very similar to the specimens from the Kirtland shale and Lewis shale of New Mexico, especially the figures 3 and 4 from the Kirtland shale and the figure 13 from the Lewis shale.

Distribution: The Upper Cretaceous species, *Proteacidites thalmanni* ANDERSON, apparently occurs only in the circum-Pacific regions of the northern hemisphere and Siberia. The localities occurred are as follows:

USA:

New Mexico: Kirtland shale and Lewis shale; Uppermost Cretaceous.

California: Upper Moreno Formation, Marca shale and Dos Palos shale; Maastrichtian and Danian.

Montana: Hell Creek Formation; Maastrichtian.

USSR;

Amur: Zeya—Bureya depression, Tsagaiansk Formation; Masstrichtian.

Pollen—Incertae Sedis

Genus *Orbiculapollis* CHLONOVA, 1961

Type species: *Orbiculapollis globosus* CHLONOVA

Orbiculapollis globosus CHLONOVA

Pl. 29, figs. 3, 4a-c.

1960. *Triporina globosa* CHLONOVA, *Tr. Inst. Geol. Geophys., Sibirsk, Otd. Akad. Nauk, SSSR*, 3, p. 74-75, pl. 10, fig. 37.
1961. *Orbiculapollis globosus* CHLONOVA, *Tr. Inst. Geol. Geophys., Sibirsk, Otd. Akad. Nauk, SSSR*, 7, p. 88, pl. 15, fig. 115.
1961. *Triporina globosa*, N. MTCHEDLISHVILI in SAMOILOVITCH & MTCHEDLISHVILI. *Tr. Vses. Neft. Nauch.-Issl. Geologorazved. Inst. (VNIGRI)*, 177, p. 244-246, pl. 80, figs. 2a-c, 3a, b.
1965. *Orbiculapollis globosus*, G. M. BRATZEVA. *Geol. Inst., Akad. Nauk, SSSR*, 129, p. 10-11, pl. 1, figs. 1, 2, 4, 5.

Description: Isopolar. Triporate pollen. Equatorial contour roundish triangular, with convex sides. Equatorial diameter about 26μ. Three germinal apparata with strongly projected apices, 4μ long, 8.5μ broad on the base. Exine thin, smooth, about 0.5μ thick.

Occurrence: Light-greenish fine sandstone (sample G) of the Fukaushi sandstone member, Upper Hakobuchi Group, collected near by Oyubari dam, Yubari coal-field, Hokkaido.

Remarks: In 1964, the author reported the present specimen as *Trivestibulopollenites* sp., but he describes revisionally here it as *Orbiculapollis globosus* CHLONOVA. The form-genus *Orbiculapollis* was proposed by A. F. CHLONOVA in 1961. Hitherto, the pollen grains of

Orbiculapollis have been found in Siberia, Alaska, and western Canada (Alberta), but *Orbiculapollis globosus* is known only from Siberia. The present specimen described in this paper is the first reported in Japan.

Distribution: *Orbiculapollis globosus* shows the following distribution in Siberia.

USSR:
- Siberia: Amur; Maastrichtian.
  - Eastern area of west Siberia lowland; Senonian—Danian.
  - Eastern area of central Ural; Upper Paleocene.
  - Tazovsk peninsula; Lower Eocene.

Genus *Sporopollis* PFLUG, 1953

Type species: *Sporopollis documentum* PFLUG

? *Sporopollis* sp.

Pl. 29, figs. 6a, b.

Pollen grain triporate, oblate. Equatorial contour triangular, sides weakly convex to concave, pores somewhat protruding at corners. Equatorial diameter 20μ. Exine smooth; sexine thickened at pores forming annuli. Triradiate marks on each polar surface. Tori conspicuous, about 3μ in breadth.

Occurrence: Light-greenish shale from the boring No. SK 1, 983.0 m in depth, at Nishibetsu, eastern Hokkaido; Upper Cretaceous—Maastrichtian?

Remarks: Only one specimen was found from the Upper Cretaceous sediments at Nishibetsu, eastern Hokkaido. The present relatively poorly preserved specimen is similar to the German Upper Cretaceous species *Sporopollis peneserta* PFLUG (1953, p. 93, pl. 19, figs. 5-6). Additional specimens will have to be discovered before the exact status can be determined.

Genus *Aquilapollenites* ROUSE emend. FUNKHOUSER restr. SRIVASTAVA, 1968

Type species: *Aquilapollenites quadrilobus* ROUSE

Aquilapollenites parvus n. sp.

Pl. 30, figs. 1a-c; 2a, b.

Holotype Dimensions: Polar axis 29μ; equatorial axis 11μ; distance from center of polar axis to the apices of equatorial protrusions 19μ; breadth of equatorial protrusion 12μ.

Holotype Preparation: Slide No. GK-V 4050; Pl. 30, figs. 1a-c.

Description: Isopolar to subisopolar; polar protrusions on the proximal and distal polar region well developed, rounded; three wing-like equatorial protrusions meridional, long, size larger than polar protrusions, broader at the base than apex; tricolpate, colpi short, meridional across the apices of equatorial protrusions. Sexine tectate and punctate, becoming echinate on equatorial protrusions; thickness at poles about 0.8 to 1.3μ. Sexine thickens meridionally at the contact of polar and equatorial protrusions, up to 1.8 to 2μ, and becomes thin at the apices of equatorial protrusions. Spinules, accuminate with broad base, distributed densely in apical and middle regions of equatorial protrusions, tips of spinules on equatorial protrusions directed proximally toward the polar axis; breadth of spinules at base somewhat less than 1μ, length about 1μ.

Size Range: Polar axis 24.5 to 29μ; equatorial axis 9 to 11μ; distance from the center of polar axis to the tips of equatorial protrusions 13 to 19μ; breadth of equatorial protrusions 9.4 to 12μ.

Illustrated specimen: Slide No. GK-V 4057; Pl. 30, figs. 2a, b.

Occurrence: Light-greenish shale from the boring No. SK 1, 983.0 m in depth, at Nishibetsu, eastern Hokkaido; Upper Cretaceous—Maastrichtian ?

Remarks: The present species is very similar to *Aquilapollenites matsumotoi* TAKAHASHI (1964, p. 252-253, pl. 38, figs. 1a, b; 3a, b.) from the Hakobuchi Group of the Yubari coal-field. However, *A. parvus* has a smaller body, punctate sexine, and a thicker sexine in the apical regions of polar protrusions than *A. matsumotoi.*

Aquilapollenites cf. *mirabilis* SRIVASTAVA

Pl. 30, figs. 3a, b.

1968. *Aquilapollenites mirabilis* SRIVASTAVA, *Pollen et spores*, 10, 3, p. 680-682, pl. 4, figs. 3-8.

Description: Subisopolar. Three apical projections on the equator of pollen body, and proximal and distal polar projections becoming pollen body; equatorial projections short, spatulate; one pole more flattend than the other, poles rounded. Tricolpate, colpi meridional across equatorial projections, long, narrow, reaching polar regions. Sexine bastionate on body, reticulate, lumina 1.1 to 2.7μ, muri 0.7μ broad, 2.1μ high in equatorial region, 1.3μ high at poles. Basal portion of equatorial projections striae, striae start from the base of equatorial projections and fan out over the projection. Broader apices of the equatorial projections reticulate (?), lumina about 0.8μ.

Polar axis 40μ; equatorial axis $18,6\mu$; length of equatorial projection 11.8 to 12.5μ; breadth of equatorial projection 10.5μ at the base, 4.5μ at the apex.

Occurrence: Dark gray shale from the boring No. SK 1, 1007.0 m in depth, at Nishibetsu, eastern Hokkaido; Upper Cretaceous—Maastrichtian ?

Remarks: This Japanese specimen resembles the Canadian species *Aquilapollenites mirabilis* SRIVASTAVA (1968, p. 680-681, pl. 4, figs. 3-8) from the Edmonton Formation in many characteristics. The author has found only one specimen of this species. The present specimen also resembles *Aquilapollenites medeis* SRIVASTAVA (1968, p. 678-679, pl. 3, fig. 6; pl. 4, figs. 1, 2) from the base of the Edmonton Formation in outline and bastionate sexine, but differs from *A. medeis* in the form and ornamentation of the equatorial projection.

Explanation of Plate 29

(All figures magnified $\times 1400$ unless otherwise mentioned)

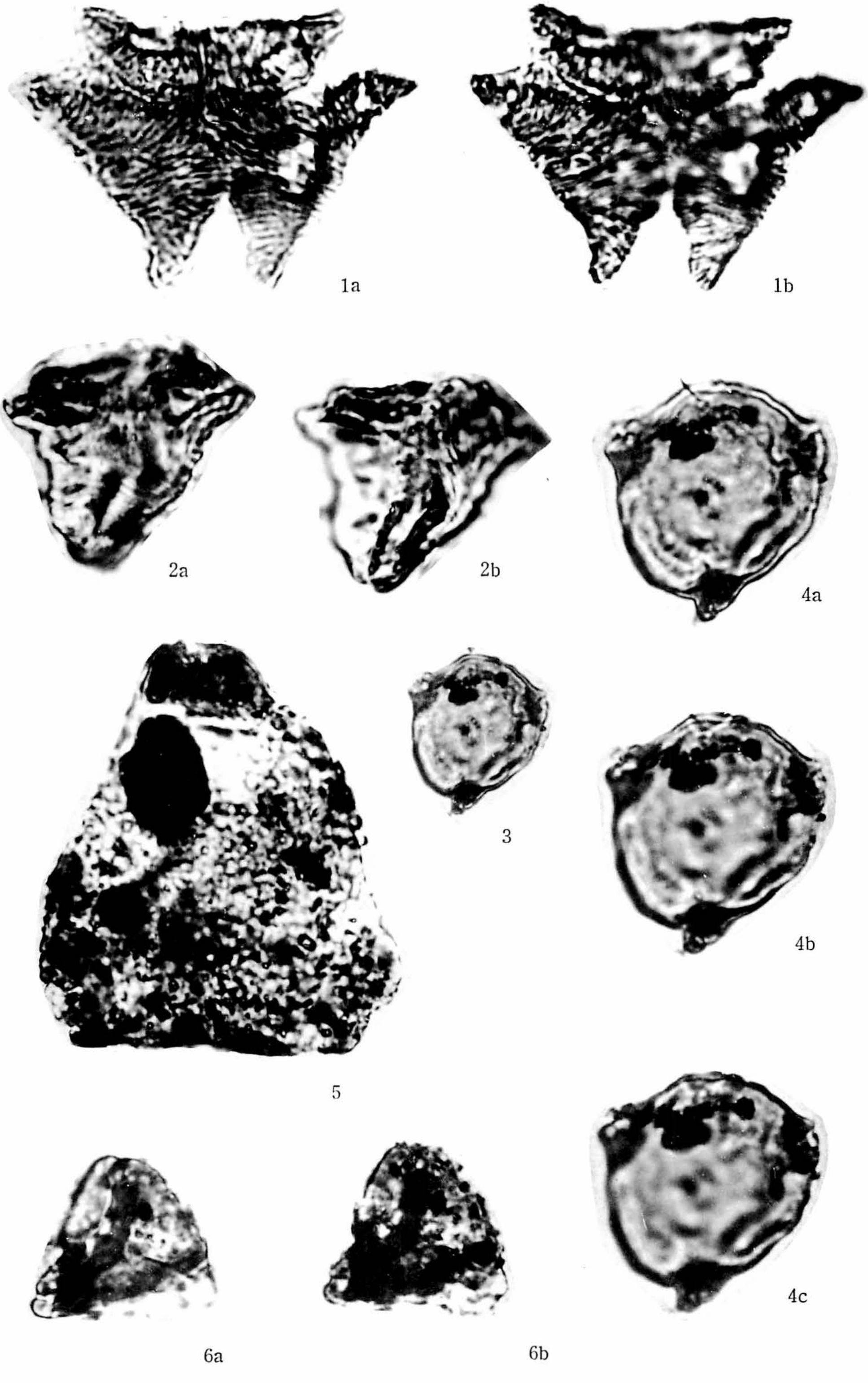
Figs. 1a, b. *Cranwellia striata* (COUPER) SRIVASTAVA
Figs. 1a, 1b, in different foci to show the exine ornamentation pattern; slide GK-V 4042.

Figs. 2a, b. *Cranwellia* cf. *rumseyensis* SRIVASTAVA
Figs. 2a, 2b, in different foci to show the exine ornamentation pattern; slide GK-V 4079.

Figs. 3, 4a-c. *Orbiculapollis globosus* CHLONOVA
Fig. 3, $\times 833$; figs. 4a-c, in different foci. Slide GK-V 3212.

Fig. 5. *Proteacidites thalmanni* ANDERSON
Slide GK-V 4065.

Figs. 6a, b. ? *Sporopollis* sp.
Slide GK-V 4051.


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

Genus *Mancicorpus* MTCHEDLISHVILI emend. SRIVASTAVA, 1968

Type species: *Mancicorpus anchoriforme* MTCHEDLISHVILI, in SAMOILOVICH & MTCHEDLISHVILI

Mancicorpus sp.

Pl. 30, figs. 4a, b.

Heteropolar pollen. Three wing-like equatorial projections and one polar projection developed on the distal (?) pole; a very small projection present on the other pole. The developed polar projection relatively long, the apical region somewhat conical, the polar area of smaller polar projection round. Equatorial projections well developed, long, meridional, broader at the base than at the apex; apices of equatorial projections truncate. Tricolpate, colpi meridional across the apices of equatorial projections. Sexine smooth, baculate; bacula distributed sporadically on the apical areas of equatorial projections.

Polar axis 32μ; equatorial axis 13μ; distance from the center of polar axis to the tips of equatorial projections about 28μ; breadth of apical region of equatorial projections 12.5μ.

Occurrence: Dark gray shale from the boring No. SK 1, 1007.0 m in depth, at Nishibetsu, eastern Hokkaido; Upper Cretaceous—Maastrichtian ?

Remarks: The author has found only one specimen of *Mancicorpus* pollen grain, which he cannot assign to a species.

References

ANDERSON, R. Y. (1960): Cretaceous-Tertiary palynology, eastern side of the San Juan basin, New Mexico. *New Mexico Bureau of Mines and Min. Res. Mem.*, 6, (Catalog fossil spores and pollen, vol. 23).

BANERJEE, D. and MISRA, C. M. (1968): Cretaceous microflora from south India. *Seminar volume on "Cretaceous-Tertiary Formations of South India" Mem.*, 2, 99–104.

BELSKY, C. Y., BOLTENHAGEN, E. and POTONIÉ, R. (1965): Sporae dispersae der oberen Kreide von Gabun, Äquatoriales Afrika. *Paläont. Z.*, 39, 1/2, 72–83.

БРАТЧЕВА, Г.М. (1965): Пыльца и споры Маастрихтских Отложений Дальнего Востока. Тру. Геол. инст. Акад. Наук. СССР. 129, 1–42, Таб. 1–42.

BRATZEVA, G. M. (1967): The problem of the Tsagaiansk flora with regard to spore- and -pollen analytical data. *Rev. Palaeobotan. Palynol*, 2, 119–126.

COUPER, R. A. (1953): Upper Mesozoic and Cainozoic spores and pollen grains from New Zealand. *New Zealand Geol. Surv. Paleont. Bull.*, 22, 1–77.

DRUGG, W. S. (1967): Palynology of the Upper Moreno Formation (late Cretaceous-Paleocene) Escarpado Canyon, California. *Palaeontographica*, B, 120, 1–71.

FUNKHOUSER, J. W. (1961): Pollen of the genus *Aquilapollenites*. *Micropaleontology*, 7, 2, 193–198, pls. 1–2.

MARTIN, A. R. H. (1968): *Aquilapollenites* in the British Isles. *Palaeontology*, 11, 4, 549–553, pl. 106.

MULLER, Jan (1968): Palynology of the Pedawan and Plateau Sandstone Formations (Cretaceous-Eocene) in Sarawak, Malaysia. *Micropaleontology*, 14, 1, 1–37.

NEWMAN, K. R. (1964): Palynologic correlations of late Cretaceous and Paleocene Formations, northwestern Colorado. *Palynology oil exploration—Soc. Econ. Paleont. Miner. A Div.Amer. Assoc. Petrol. Geol. Spec. Publ.* 11, 169–180.

—— (1965): Upper Cretaceous-Paleocene guide palynomorphs from northwestern Colorado. *Univ. Colorado studies, Ser. Earth Sci.*, 2, 1–21.

NORTON, N. J. (1965): Three new species of *Aquilapollenites* from the Hell Creek

Formation, Garfield county, Montana (1). *Pollen et spores*, 7, 1, 135-143, pls. 1-4.

NORTON, N. J. and HALL, J. W. (1967) : Guide sporomorphae in the Upper Cretaceous-Lower Tertiary of eastern Montana (U.S.A.). *Rev. Palaeobotan. Palynol.*, 2, 99-110.

—— and —— (1969) : Palynology of the Upper Cretaceous and Lower Tertiary in the type locality of the Hell Creek Formation, Montana, U.S.A. *Palaeontographica*, B, 125, 1-64, pls. 1-8.

PFLUG, H. D. (1953) : Zur Entstehung und Entwicklung des angiospermiden Pollens in der Erdgeschichte. *Palaeontographica*, B, 95, 60-171, pls. 15-25.

POTONIÉ, R. (1956-66) : Synopsis der Gattungen der Sporae dispersae. I. *Beih. zum Geol. Jahrbuch, Heft* 23 (1956) ; II. *Heft* 31 (1958) ; III. *Heft* 39 (1960) ; IV. *Heft* 72 (1966).

ROUSE, G. E. (1957) : The application of a new nomenclatural approach to Upper Cretaceous plant microfossils from western Canada. *Canadian J. Bot.*, 35, 349-375, pls. 1-3.

САМОЙЛОБИЧ, С. Р. (edit.) (1961) : Пылца и Споры Западной Сибири, Тру. Всес. Нефт. Нау.-Иссле. Геологораз. Инст. (Бнигри). Бьпу. 177.

SAMOILOVICH, S. R. (1967) : Tentative botanico-geographical subdivision of northern Asia in late Cretaceous time. *Rev. Palaeobotan. Palynol.*, 2, 127-139.

SATO, S. (1961) : Pollen analysis of carbonaceous matter from the Hakobuchi Group in the Enbetsu district, northern Hokkaido, Japan. Palynological study on Cretaceous sediments (I). *J. Fac. Sci. Hokkaido Univ., Ser.* 4, 11, 1, 77-93, pls. 1-2.

SRIVASTAVA, S. K. (1966) : Upper Cretaceous microflora (Maastrichtian) from Scollard, Alberta, Canada. *Pollen et spores*, 8, 3, 497-552.

—— (1967) : Palynology of Late Cretaceous Mammal beds, Scollard, Alberta (Canada). *Palaeogeogr., Palaeoclimat., Palaeoecol.*, 3, 133-150.

—— (1968) : Angiosperm microflora of the Edmonton Formation. *Thesis Dr. Ph. Univ. of Alberta.*

—— (1968) : Reticulate species of *Aquilapollenites* and emendation of genus *Mancicorpus* Mtchedlishvili. *Pollen et spores*, 10, 3, 665-699, pls. 1-7.

—— (1968) : Eight species of *Mancicorpus* from the Edmonton Formation (Maastrichtian), Alberta, Canada. *Canadian J. Bot.*, 46, 12, 1485-1490, pls. 1-2.

—— (1969) : New spinulose *Aquilapollenites* spp. from the Edmonton Formation (Maestrichtian), Alberta, Canada. *Canadian J. Earth Sci.*, 6, 1, 133-144, pls. 1-8.

STANLEY, E. A. (1961) : The fossil pollen genus *Aquilapollenites*. *Pollen et spores*, 3, 2, 329-352, pls. 1-8.

—— (1965) : Upper Cretaceous and Paleocene plant microfossils and Paleocene Dinoflagellates and Hystrichosphaerids from northwestern South Dakota. *Bull. Amer Paleont.*, 49, 222, 179-384.

—— (1967) : Cretaceous pollen and spore assemblages from northern Alaska. *Rev.*

Explanation of Plate 30

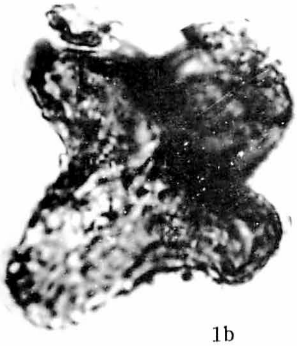
(All figures magnified $\times 1400$)

Figs. 1a-c, 2a, b. *Aquilapollenites parvus* n. sp.
Figs. 1a-c: Holotype; slide GK-V 4050; figs. 2a, b: Paratype; slide GK-V 4057.

Figs. 3a, b. *Aquilapollenites* cf. *mirabilis* SRIVASTAVA
Figs. 3a, 3b, in different foci; slide GK-V 4066.

Figs. 4a, b. *Mancicorpus* sp.
Figs. 4a, 4b, in different foci; slide GK-V 4063.


1a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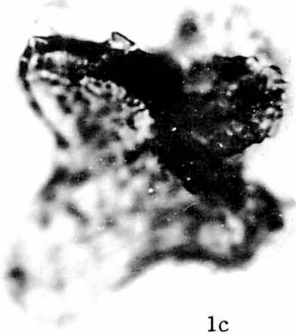
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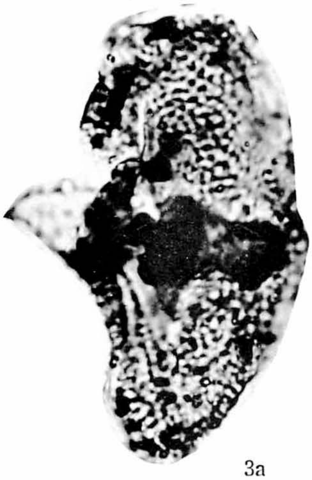
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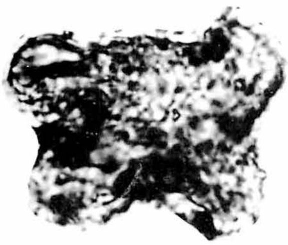
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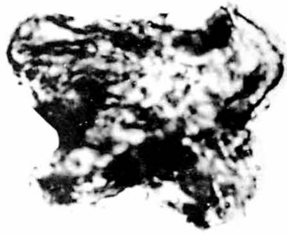
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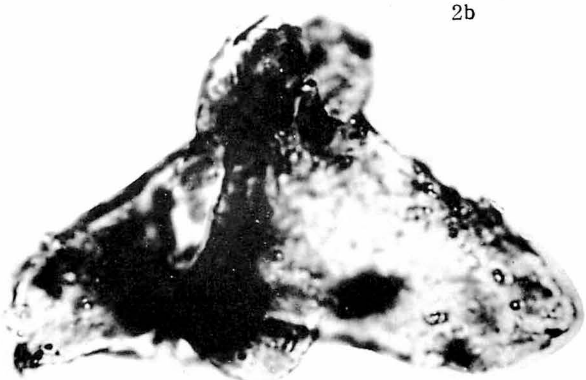
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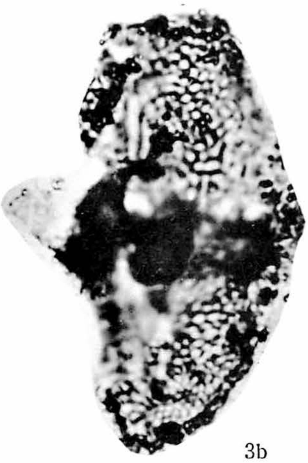
3b


4b

Palaeobotan. Palynol., 1, 229–234.

TABBERT, R. L. (1966): Upper Cretaceous pollen and spores from the Ivishak River Country, Arctic Alaska. *Abst. 2nd Intern. Conf. Palynol., Utrecht.*

TAKAHASHI, Kiyoshi (1964): Sporen und Pollen der oberkretazeischen Hakobuchi-Schichtengruppe, Hokkaido. *Mem. Fac. Sci., Kyushu Univ., Ser. D*, 14, 3, 159–271, pls. 23–44.

—— (1965): Mikrofossilien der Oberkreide von Nishibetsu, Hokkaido. (in Japanese with German abstract). *Bull. Fac. Lib. Arts, Nagasaki Univ., Natural Sci.*, 5, 7–20, pls. 1–2.

—— (1965): Spore and pollen assemblages of the Upper Cretaceous Hakobuchi Group in Hokkaido, Japan. *The Palaeobotanist*, 13, 1, 82–84.

—— (1967): Upper Cretaceous and Lower Paleogene microfloras of Japan. *Rev. Palaeobotan. Palynol.*, 5, 227–234.

—— (1967): Pollen- und Sporenfloren der Oberkreide und des Unterpaläogens in der Provinz *Aquilapollenites* und ihre stratigraphische Untersuchung. (in Japanese with German abstract). *Jubilee Publ. Comm. Prof. Sasa, Dr. Sci., Sixtieth Birthday.* 303–315.

ХЛОНОВА, А.Ф. (1960): Видовои Состав Пыльчы и спор в отложениях Верхнего Мела Чулымо-Енисейской Впадины. Тру. Инст. Геолог. и Геофиз. Акад. Маук СССР, Сибир. Отдел. Вып. 3, 1–104, pls. 1–10.

—— (1961): Споры и Пыльча Верхней Половины Верхнего Мела Восточной Части Западно-Сибирской Низменности. Тру. Инст. Геолог. и Геофиз. Акад. Наук, СССР, Сибир. Отае. Вып. 7, 1–138, pls. 1–17.

ЗАКЛИНСКАЯ, Е.А. (1963): Пыльча Покры-Тосемянных и ее Значение Для обоснования Стратиграфии Верхнего Мела и Палеорена. Тру. Геолог. Инст. Акад. Наук, СССР. Вып. 74, 1–256, pls. 1–44.

Habobuchi 函渕　　Nishibetsu 西別　　Ôyubari 大夕張

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 77, pp. 276-289, pl. 31, June 10, 1970

567. FOSSIL MOLLUSCS FROM TESHIMA, SHÔDO-GUN, KAGAWA PREFECTURE, SOUTHWEST JAPAN

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西南日本香川県小豆郡豊島産貝化石について： 香川県小豆郡土庄町豊島に発達する中新世初期豊島層産貝化石群を検討した結果, 新種 4 を含み二枚貝 9 種, 巻貝 10 種を識別した。この豊島貝化石群は瀬戸内地域において中新世の古地理, 地史等の解明に重要なものである。貝化石に基づき豊島層の地質時代を決定し Arcid-Potamid fauna よりは新しく，また豊島貝化石群は中新世初期における中国・四国地方の相対的隆起・沈降の地質学的背景を物語るものとして意義が多い。　斎藤　実, 坂東裕司, 野田浩司。

Introduction

Since SATO (1932) discovered and reported the occurrence of marine shells of *Pectunculus* sp., *Arca* sp., *Tapes* sp. and *Yoldia* sp. from Teshima Island, Tonosho-cho, Shôdo-gun, Kagawa Prefecture, there was no record of molluscan fossils from the Island. Recently, SAITO (1962), SAITO *et al.* (1962) and FURUICHI *et al.* (1969) recorded some Miocene marine molluscan fossils from the islands of Shôdo-shima and Teshima both of which are located the northside of Shikoku, an area from where no Miocene marine sediments had been known to be distributed. The occurrence of mollusca of Miocene age from the islands in the Setouchi Sea is considered to be important for interpretation of the history of the paleo-Setouchi (Setonai-Kai).

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Stratigraphic Occurrence of the Teshima Fauna

The Teshima fauna as it may be called comprises 9 species of Pelecypoda and 10 species of Gastropoda as shown in Table 1, among which 11 species including 4 new species were determined to specific level. The Teshima fauna listed in Table 1 is from the Teshima Formation of yellowish gray tuffaceous coarse grained arkosic sandstone. This fossiliferous stratigraphic unit is shown below according to the classification of FURUICHI *et al.* (1969).

Holocene	Alluvial deposits	Unconsolidated sand, gravel, clay
	.... Unconformity	
	Terrace deposits	Gravel, sand, clay
	.... Unconformity	
Pliocene	Sanuki group Upper	Sanukitic andesite
	Sanuki group Lower	Black brecciated tuff, *Fagus* sp., *Liquidambar* sp.
	.... Unconformity	
Miocene	Karato Formation ±20 m.	Dark green tuffaceous siltstone, fine to medium grained sandstone, *Turritella* sp.
	.... Conformity	
	Ieura Formation ±30 m.	Whitish gray medium grained sandstone, granular sandstone, conglomerate, Gastropoda gen. et sp. indet.
	.... Conformity	
	Teshima Formation 20–80 m.	Dark yellowish gray tuffaceous medium to coarse grained sandstone, Teshima Fauna Medium to coarse grained sandstone, siltstone, *Cinnamomum lanceolatum*, *Metasequoia* sp. Cobble to boulder conglomerate
	.... Unconformity	
Cretaceous	Basement: Granitic Rocks	

The Teshima Formation lies upon the Cretaceous biotite-granodiorite with unconformity and commences with basal conglomerate. It is distributed mainly in the central part of Teshima Island surrounding Mt. Dan (339.8 m above sea level). The formation is composed mainly of yellowish gray, medium to coarse grained sandstone, siltstone and conglomerate in the order from the upper to lower and is covered by the Ieura Formation with conformity. The molluscan fossils from above the coarse grained sandstone mentioned above occurred in a crowded assemblage. Some of the fossils still retain the original shell materials, whereas many occurred as molds or casts. The valves are mostly isolated ones and those with intact valves are rare.

Table 1. Fossils from the Teshima Formation, Teshima Island.

Saccella sp., few
Glycymeris sp., common
Lucinoma sp., rare
Venericardia (*Cyclocardia*) *siogamensis* NOMURA, common
Cardita minoensis ITOIGAWA, rare
Vasticardium teshimaense SAITO, BANDO and NODA, n. sp., few
Vasticardium sp., few
Gomphina sp., few
Tapes nagahamaensis SAITO, BANDO and NODA, n. sp., abundant
Astraea furuichii SAITO, BANDO and NODA, n. sp., rare
Turritella sp., few
Epitonium sp. 1, rare
Epitonium sp. 2, rare
Calyptraea hataii SAITO, BANDO and NODA, n. sp., rare
Calyptraea sp., rare
Crepidula isimotoi OTUKA, few
Euspira meisensis (MAKIYAMA), rare
Musashia cf. *yanagidaniensis* (ARAKI), rare
Terebra sp., rare

The fossil localities and the distribution of the formation are shown in the geological map (Fig. 1). The fossils described in the present article are preserved in the collection of the Institute of Geology and Paleontology, Faculty of Science, Tohoku University (abbreviated IGPS coll. cat. no.).

Geological age of the Teshima Fauna

Based upon the fossil marine molluscs listed in Table 1, the geological age of the Teshima Formation may be considered to be early Middle Miocene. The following species are considered to be important for determination of the geological age.

Venericardia (*Cyclocardia*) *siogamensis* NOMURA, first described from the Miocene Ajiri Formation in Miyagi Prefecture in 1935, is known to occur from the following formations; Suenomatsuyama Formation (CHINZEI, 1958, pl. 7, fig. 3), Shimonagaya sandstone and Kusakizawa alternation (MIZUNO, 1965, p. 431, pl. 1, fig. 12), both in Iwate Prefecture; Miocene sandstone of Tajima in Okayama Prefecture (OTUKA, 1941, p. 23, text-figs. 2-3); Manzaemonyama Formation (KOTAKA and NODA, 1967, pl. 2, fig. 9), Fukaura Formation (MIZUNO, 1964, p. 612, pl. 1, fig. 14), both in Aomori Prefecture; Honya Formation (KAMADA, 1962, p. 85-86, pl. 7, fig. 23, pl. 8, figs. 1a-1b), Nakayama Formation (KAMADA, 1962, p. 85-86), Kokozura Formation (KAMADA, 1962, p. 85-86, pl. 7, figs. 10a-10b, 12-19), Numanouchi Formation (KAMADA, 1962, p. 85-86, pl. 7, figs. 20, 22) all in Fukushima Prefecture; Taira Member of the Kanagase Formation in Miyagi Prefecture (MASUDA and TAKEZAWA, 1965, pl. 1, fig. 14); Kaisekizan Formation in Mie Prefecture (ARAKI, 1960, p. 88-89, pl. 6, figs. 5-6).

Cardita minoensis ITOIGAWA (1960) is known only from the type locality of Shukunohora Sandstone of the Oidawara Formation in Gifu Prefecture, an unit which is characterized by the *Glycymeris-Miogypsina* assemblage according to ITOIGAWA (1960).

Crepidula isimotoi OTUKA (1934) has been recorded from the Kadonosawa Formation in Iwate Prefecture, Isomatsu Formation in Aomori Prefecture (IWAI, 1969) and Tomikusa Group in Nagano Prefecture (TANAKA, 1967). The Kadonosawa Formation has yielded *Anadara ninohensis* (OTUKA), *Anadara ogawai* (MAKIYAMA), *Ostrea gravitesta* YOKOYAMA, *Chlamys nisataiensis* OTUKA, *Felaniella ferruginata* (MAKIYAMA), *Dosinia nomurai* OTUKA, *Batillaria yamanarii* MAKIYAMA, *Nassarius simizui* OTUKA etc. The Isomatsu Formation was first

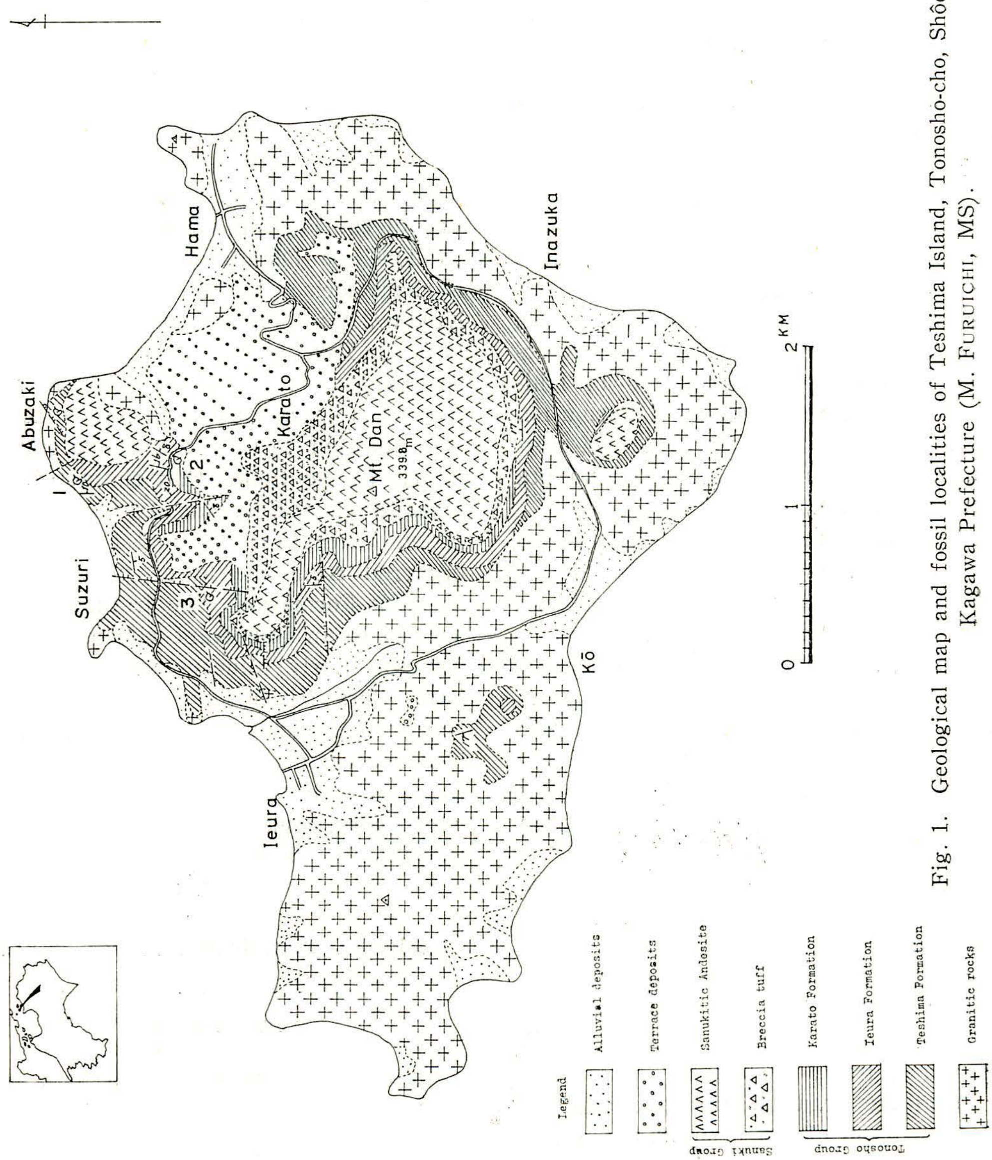

Fig. 1. Geological map and fossil localities of Teshima Island, Tonosho-cho, Shôdo-gun, Kagawa Prefecture (M. FURUICHI, MS).

considered to be Oligocene by KOTAKA (1955). *Modiolus tugaruana* KOTAKA, *Nanaochlamys notoensis* (YOKOYAMA), *Pitar itoi* (MAKIYAMA), *Felaniella ferruginata* (MAKIYAMA), *Nipponomarcia nakamurai* (IKEBE), *Siratoria siratoriensis* (OTUKA), *Batillaria tateiwai* MAKIYAMA, *Vicaryella tyosenica otukai* (NOMURA) etc. were recorded from the Isomatsu Formation by MIZUNO (1965).

Euspira meisensis (MAKIYAMA) originally from the Heiroku Formation in Korea, occurs from the Kadonosawa Formation in Iwate Prefecture, Shobara Formation in Hiroshima Prefecture, Kaisekizan Formation in Mie Prefecture, Honya Formation in Fukushima Prefecture, Higashi-Innai Formation in Ishikawa Prefecture, Kurosedani Formation in Toyama Prefecture, Tanozawa Formation in Aomori Prefecture and Nukuta Formation in Nagano Prefecture.

Musashia yanagidaniensis (ARAKI, 1959) according to SHIKAMA (1967) is distributed in the type area of the Kaisekizan Formation in Mie Prefecture.

Among the indetermined species shown in Table 1, the under-mentioned ones are of considerable chronostratigraphic value.

Saccella sp. (pl. 31, fig. 8) resembles *Saccella nidatoriensis* (OTUKA, 1934) from the Kadonosawa Formation in Iwate Prefecture. *Turritella* sp. (pl. 31, figs. 12-13) is allied to *Turritella oyasio* IDA (1952) from the Kurosedani Formation in Toyama Prefecture. *Epitonium* sp. 1 (pl. 31, fig. 14) is close to *Epitonium yabei* NOMURA (1936) from the Kurosawa Formation in Iwate Prefecture.

From the data mentioned above, the marine fauna of the Teshima Formation is considered to be early Middle Miocene in geological age and can be correlated with the Kaisekizan Formation, and the Shobara Formation of the Bihoku Group in the Kinki and Chugoku areas respectively. Moreover, as stated by SAITO (1962) the formation based upon its stratigraphic position and marine molluscan fauna can be correlated with the Fujiwara Group in the Nara basin and with the Tsuzuki Group in the Kyoto basin. In broad sense, the Teshima fauna corresponds to that of Nishikurosawa in Northern Japan. The Teshima fauna is very similar to and can be correlated with those found in the Shikai Formation of the Tonosho Group developed in Shôdo-shima Island. The Shikai fauna is characterized by *Glycymeris* cf. *crassa* KURODA, *Cardium* sp., *Callista* sp., *Siratoria* sp., *Turritella oyasio* IDA, *Calyptraea* sp., *Euspira meisensis* (MAKIYAMA) and *Nassarius* sp. according to SAITO (1962).

In addition to the data above stated, it may be mentioned that characteristic plant fossils as *Cinnamomum lanceolatum* HEER, *Metasequoia* sp. and *Quercus* sp. occurred from the lower part of the Teshima Formation. The first mentioned species is an important element and a common Early Miocene species of the Utto Flora (HUZIOKA, 1963a, 1963b) in Northern Honshu, Japan. This flora-bearing formation is succeeded upwards by the Nishikurosawa marine fauna, which corresponds as already stated, to the Teshima fauna.

Geological Significance of Occurrence of Miocene Teshima Fauna from Teshima

As already discussed by KASAMA and FUJITA (1957) and the Cenozoic Research Group of Southwest Japan (1960), Southwest Japan can be classified into four provinces, each of which have their own characteristic back-ground in the historical development of their respective sedimentary basins, geological structures, volcanic activities, and paleontological evidences (TAI, 1959). Based upon the Teshima fauna, the characteristics of the biostratigraphy and historical geology of the paleo-Setouchi province can be described as mentioned below.

With the opening of the Miocene age, many areas of Chugoku and Shikoku were submerged and the major marine transgression brought in an Asiatic fauna characterized by the Arcid-Potamid fauna (TSUDA, 1965). This fauna is characterized by *Vicarya japonica* YABE and HATAI, *Vicaryella notoensis* MASUDA, *Batillaria yamanarii* MAKIYAMA, *Anadara kakehataensis* HATAI and NISIYAMA, *Anadara kurosedaniensis* HATAI and NISIYAMA, *Striarca uetsukiensis* HATAI and NISIYAMA, *Ostrea gravitesta* YOKOYAMA and other brackish water dwellers of subtropical regions. These elements distributed to the inner basins such as to the Yoshino Formation in the Tsuyama basin (KAWAI, 1957), Shobara Formation in the Saijo area (YOKOYAMA, 1929) and sporadically to the Lower Bihoku Group in the Miyoshi and Iigoshi basin (IMAMURA, 1966) taken together are included into the Miyoshian stage by TAI (1959).

The Arcid-Potamid fauna (TSUDA, 1965) generally occupies a stratigraphic horizon lower than the *Operculina-Miogypsina* fauna or Pectinid fauna (TSUDA, 1965) of the Setouchi province (KASAMA and HUZITA, 1957; TAI, 1959).

As described in the earlier lines, the Teshima fauna is not represented by the elements of the Arcid-Potamid fauna (TSUDA, 1965) and *Vicarya-Tateiwaia* fauna (KOTAKA, 1958) but is characterized by *Glycymeris*, *Vasticardium*, *Gomphina*, *Turritella*, *Calyptraea* and *Crepidula*. As stated by ITOIGAWA (1969), the molluscan assemblage in the Setouchi areas differs in specific components according to the paleo-environmental condition. Considering from the sedimentary facies that yielded the Teshima fauna, the unconformity between the Teshima Formation and the pre-Tertiary granite may serve to explain the absence of and actually represent the horizon of the Arcid-Potamid fauna or the *Comptoniphyllum-Liquidambar* flora both of which are widely recognized in the Sanin-Hokuriku regions but not in the Setouchi or Nanki regions. This may suggest that the Miyoshian stage of the Setouchi and Nanki provinces is represented by an unconformity in this area and points to upheaval of the Cretaceous granitic area. On the contrary, the Sanin-Hokuriku province was subjected to submergence as may be judged from the sediments and fossils that accumulated on the borderland of the Japan Sea (KATO, 1969; OKAMOTO, 1965).

The view just stated is supported from the absence of the stratigraphic succession of marine sediments with representative molluscan fossils of the Japan Sea borderland in Setouchi-Kinki province.

From the evidence at hand it is inferred that the Teshima fauna lived on a sea bottom of clear water and was fed with rather rapid deposition of coarse grained sand transported from the area of active erosion of the Eocene Kuma Group and/or Cretaceous Izumi sandstone and granitic rocks forming the hinterland in Ehime and Kagawa Prefectures (SAITO, 1962). The provenance of the Miocene sea distributed in Tanabe, Shôdo-shima, a part of Hiroshima (KUSUMI and KATAYAMA, 1962) and Okayama (TAI, 1965; IMAMURA, 1966) was the uplifted area just mentioned. The shallow areas of the warm sea was favourable to the flourishing of *Miogypsina-Operculina*, Pectinid fauna and other sessile forms and open sea dwellers. This particular stage is younger than the Arcid-Potamid faunal stage which is represented by warm, tropical and brackish water dwellers. The different crustal movements that influenced the separated sedimentary basins in the region referred to seem to have been responsible also for the development of the different paleozoological provinces stated above.

Description

Family Veneridae RAFINESQUE, 1815

Subfamily Tapesinae H. and A. ADAMS, 1887

Genus *Tapes* MEGERLE, 1811

Tapes nagahamaensis SAITO, BANDO and NODA, n. sp.

Pl. 31, figs. 1-4, 22

Siratoria sp. (nov. ?), SAITO, 1962, *Mem. Fac. Agr. Kagawa Univ.*, no. 10, pl. 14, figs. 7-11.
Holotype: IGPS coll. cat. no. 78707, *Siratoria* sp. of SAITO, 1962, pl. 14, fig. 7.
Paratype: *Siratoria* sp. of SAITO, 1962, pl. 14, figs. 8-11.

The present species was from the Miocene Shikai Formation and was first illustrated by SAITO (1962) under the name of *Siratoria* sp. without description. Specimens identified with the *Siratoria* sp. of SAITO (1962) cited above were collected from the Teshima Formation in Teshima. After re-examination of the specimens of *Siratoria* sp. of SAITO (1962) preserved in the collection of the Institute of Geology and Paleontology, Faculty of Science, Tohoku University, the writers came to the conclusion that it represents an undescribed species. This species is described below.

Shell rather medium in size, elliptically elongated in form, longer than high. Anterior side shorter than posterior, both dorsal margins straight. Anterodorsal margin narrowly rounded at end, posterior margin narrowly acute and ventral margin broadly rounded. Shell surface sculptured with narrow, slightly elevated, fine radial ribs and interstitial striations crossing concentric growth lines. Beak small, pointed anteriorly.

Length 26.8, Height 16.6 (in mm), Holotype
Length 24.6, Height 14.6 (in mm)
Length 34.0, Height 18.0 (in mm)

Comparison: The present new species resembles *Tapes* (*Amygdala*) *miyamuraensis* ITOIGAWA (1956) from the Miyamura Sandstone of the Tsuzuki Group, Kyoto Prefecture in the dense radial striations on the external surface but differs from the former by the convex dorsal margins and wide anterior and posterior borders. *Siratoria siratoriensis* (OTUKA, 1934) frequently recorded from the Early Miocene sediments of Japan differs from the present new species in having high ovately trigonal form and distinct banded growth lines.

Locality: Locality no. 1.
Formation: Teshima Formation.
Depository: IGPS coll. cat. no. 86743.

Family Carditidae FLEMING, 1820

Genus *Cardita* BRUGUIÈRE, 1792

Cardita minoensis ITOIGAWA, 1960

Pl. 31, fig. 9

Cardita minoensis ITOIGAWA, 1960, *Jour. Earth Sci., Nagoya Univ.*, vol. 8, no. 2, p. 267-268, pl. 1, figs. 9-10.

An imperfect specimen was examined.

The species was originally described from the Shukunohora Sandstone Member of the Oidawara Formation in Gifu Prefecture by ITOIGAWA (1960). According to ITOIGAWA (1960), the external surface is sculptured with 17-18 strong radial ribs. The present specimen is characterized by its larger shell (Length about 30 mm, Height about 18 mm) compared with the original description and strongly elevated, flat-topped radial ribs (exact number unknown because of anterior end being slightly broken but 15 were counted) being wider than its interspaces.

Locality: Locality no. 1.
Formation: Teshima Formation.
Depository: IGPS coll. cat. no. 86744.

Family Cardiidae LAMARCK, 1809

Subfamily Cardiinae LAMARCK, 1809

Genus *Vasticardium* IREDALE, 1927

Vasticardium teshimaense SAITO, BANDO and NODA, n. sp.

Pl. 31, figs. 5-7

Shell rather small in size, swollen, ovately-rounded in form, longer than high. Anterior and posterior dorsal margins nearly straight, ventral margin well rounded. Shell surface sculptured with about 30 narrowly elevated radial ribs. Beaks small, pointed, in-curved, directed forward, nearly touching each other and situated anteriorly.

Length: 22.4 (in mm), Height: 19.1 (in mm), Holotype, left
Length: 25.8 (in mm), Height 20.6 (in mm)

Remarks: The present specimen without the original shell material resembles *Vasticardium ogurai* (OTUKA, 1938) from the Shobara Formation in Okayama Prefecture in shell form and shape of radial ribs but differs in having more radial ribs. *Vasticardium arenicoloides* AKUTSU (1964) from the Kanomatazawa Formation in Tochigi Prefecture is similar to the present species in number of radial ribs but the former is characterized by the higher shell form and more flat-topped radial ribs compared with the present species. Among the Tertiary species of *Vasticardium* recorded in Japan *Vasticardium ogurai* (OTUKA, 1938), *Vast. tochigiensis* HIRAYAMA (1954), *Vast. shimotokuraensis* AKUSTU (1964), *Vast. arenicoloides* AKUTSU (1964) and *Vast. hyuganum* SHUTO (1960) are distributed in the area south of central Japan and range from Early Miocene to Middle Miocene in age.

Locality: Locality no. 1.
Formation: Teshima Formation.
Depository: IGPS coll. cat. no. 86745.

Family Turbinidae RAFINESQUE, 1815

Subfamily Astraeinae DAVIES, 1933

Genus *Astraea* RÖDING, 1798

Astraea furuichii SAITO, BANDO and NODA, n. sp.

Pl. 31, fig. 10

Shell moderate in size, of trochoid form, post nuclear-conch of 6 whorls sculptured with small tubercles in three spiral rows at regular intervals paralleling with distinct sutures. Uppermost spiral tubercular row weaker than others. Tubercles of lower two rows equal to one another in numbers, shape, and size. Tubercles about 20 to 22 in a row on body whorl. Base flat and sharply angular at side of body whorl. Apical angle about 70°.

Height 23 mm (nuclear whorl missing and slightly deformed)
Width 26.0 mm (Holotype)

Remarks: The present new species is named after Mr. Mitsunobu FURUICHI of the Kagawa University in recognition of his studies on the biostratigraphy and tectonic geology of Teshima and Shôdo-shima islands.

Comparison: The present new species resembles the Recent species *Astraea tayloriana* SMITH in its shell form but the latter has smaller and more tubercular structures on the external surface. *Astraea gradata* GRANT and GALE (1931) from the Pliocene of Los Angeles, California resembles the present species in its form and sculpture but has rather stronger tubercles in the spiral rows compared with the present species. Another allied species is *Astraea* sp. of HIRAYAMA (1967) from the Miocene Arakawa Group in Tochigi Prefecture. Unfortunately it is deformed but it resembles the present species in having similar tubercular rows. *Turcica osawanoensis* TSUDA (1959) resembles the present species in the external tubercular rows but differs distinctly in having swollen body base.

Locality: Locality no. 1.

Formation: Teshima Formation.

Depository: IGPS coll. cat. no. 86747 (Holotype).

Family Calyptreidae LAMARCK, 1799

Genus *Calyptraea* LAMARCK, 1799

Calyptraea hataii SAITO, BANDO and NODA, n. sp.

Pl. 31, figs. 15–16

Shell rather small in size, conical in form, ovately rounded in apertural view. A small half volution largely incurved and situated anteriorly and succeeding body whorl swollen, abruptly increasing in size and width. Apex situated anteriorly about at one fourth of shell length. External surface unknown but inner surface rather smooth.

Length: 10.8 mm, Height: 5.0 mm,
Width: 8.6 mm (Holotype).

Comparison and *Remarks:* The present new species is characterized by the position of the apex and apertural form. *Calyptraea tokunagai* HATAI and NISIYAMA (1952) and *Calyptraea aokii* HIRAYAMA (1955) both from the Asagai Formation of the Joban Coal-field, differ from the present new species in the shell form and anterior inclination of the apex.

Locality: Locality no. 1.

Formation: Teshima Formation.

Depository: IGPS coll. cat. no. 86748 (Holotype).

Calyptraea sp.

Pl. 31, figs. 17–18

Several specimens were examined. The specimens are characterized by their high, subcircular, swollen conical form. They lack their original shell materials. *Calyptraea yokoyamai* KURODA (1929) differs from the present species in the subcircular convex shell and high shell form. *Calyptraea tokunagai* HATAI and NISIYAMA (1952) from the Asagai Formation differs from the present species in having slender conical form and in the apex being pointed at the central part of shell.

This may be a new form but the state of preservation of the shell does not permit determination.

Locality: Locality no. 1.

Formation: Teshima Formation.
Depository: IGPS coll. cat. no. 86749.

Genus *Crepidula* LAMARCK, 1799

Crepidula isimotoi OTUKA, 1934

Pl. 31, figs. 19–21, 23

Crepidula isimotoi OTUKA, 1934, *Bull. Earthq. Res., Inst.*, vol. 12, pt. 3, p. 626, pl. 48, figs. 56–61.

A few specimens are at hand. Though the specimens all lack the original shell materials, the characteristics such as ovately elongated body whorl and small incurved coiled beak serve to refer them to the original description of OTUKA (1934), whose specimens are from the Kadonosawa Formation in Iwate Prefecture. Among the recorded Tertiary species of *Crepidula* in Japan, *Crepidula jimboana* YOKOYAMA recorded by NOMURA and HATAI (1936) from the Miocene Tanagura Formation resembles the present species in apical view but differs from the latter in having more rounded and wider apertural view. *Crepidula nidatoriensis* OTUKA (1934) is another species allied to the present one but differs in having narrow apertural view and gradually increases in width posteriorly.

Locality: Locality no. 1.
Formation: Teshima Formation.
Depository: IGPS coll. cat. no. 86750.

Family Naticidae LINNAEUS, 1758

Genus *Euspira* AGASSIZ in SOWERBY, 1859

Euspira meisensis (MAKIYAMA, 1926)

Polinices (Euspira) meisensis MAKIYAMA, 1926, *Coll. Sci., Kyoto Imp. Univ., Ser. B*, vol. 2, no. 3, p. 150–151, pl. 12, fig. 7.

? *Polinices (Euspira) meisensis* MAKIYAMA, OTUKA, 1934, *Bull. Earthq. Res. Inst.*, vol. 12, pt. 3, p. 627, pl. 49, figs. 76–77.

Natica (Euspira) aff. *meisensis* (MAKIYAMA), OTUKA, 1938, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2*, vol. 5, pt. 2, p. 37, pl. 3, figs. 25, 28.

Euspira meisensis (MAKIYAMA), SHIKAMA, 1954, *Sci. Rep., Yokohama Nat. Univ., Sec, 2*, no. 3, pl. 7, figs. 2–3.

Euspira meisensis (MAKIYAMA), ARAKI, 1960, *Bull. Lib. Arts, Dep., Mie Univ., Spec. Vol.*, no. 1, p. 109–110, pl. 9, figs. 11–14.

Euspira meisensis (MAKIYAMA), SAITO, 1962, *Mem. Fac. Agr., Kagawa Univ.*, no. 1, pl. 14, figs. 23–25.

Euspira meisensis (MAKIYAMA), KAMADA, 1962, *Palaeont. Soc. Japan, Spec. Papers*, no. 8, p. 158–159, pl. 18, fig. 23.

Polinices meisensis MAKIYAMA, MASUDA, 1967, *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 65, pl. 1, figs. 24a–b.

Remarks: The present species has been frequently recorded from the Early Miocene age of Southwestern Japan and Korea. The species from the Kadonosawa Formation (OTUKA, 1934) rather resembles *Euspira isensis* ARAKI (1960) originally described from the Miocene Kaisekizan Formation in Mie Prefecture which is characterized by its well swollen body whorl. At present, the species from the Kadonosawa Formation is left with question whether it is *meisensis* or *isensis*. However, according to ARAKI (1960) *Euspira isensis* occurred in association with *Euspira meisensis*. Anyway, the two species cited above should be re-examined.

As already mentioned by ARAKI (1960), *Euspira* and *Polinices* are often difficult to distinguish from one another especially in the case of fossils because in many cases, the preservation of the umbilical characters are not so good. Originally MAKIYAMA (1926) stated that the umbilicus of the species is open moderately and elongate, and he illustrated good specimens. These characters are shown in a cross section of the species from the Higashi-Innai Formation (MASUDA, 1967).

Locality: Locality no. 1.

Formation: Teshima Formation.

Depository: IGPS coll. cat. no. 86751.

Family Fulgoraridae PILSBRY and OLSSON, 1954

Subfamily Fulgorariinae PILSBRY and OLSSON, 1954

Genus *Musashia* SHIKAMA, 1967

Musashia cf. *yanagidaniensis* (ARAKI, 1959)

Pl. 31, fig. 11

Compared with:

Fulgoraria hirasei yanagidaniensis ARAKI, 1959, *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 36, p. 165, pl. 18, fig. 6.

Fulgoraria hirasei yanagidaniensis ARAKI, 1960, *Bull. Lib. Arts, Dep. Mie Univ., Spec. Vol.*, no. 1, p. 104–105, pl. 8, fig. 5.

Musashia (Neopsephaea ?) yanagidaniensis (ARAKI), SHIKAMA, 1967, *Sci. Rep., Yokohama Univ., Sec. 2*, no. 13, p. 115–116, pl. 13, figs. 5–8, text-fig. 20.

An imperfect specimen was examined. The specimen is characterized by the narrowly elevated, 13–14 longitudinal striae on the external body whorl and the ovately rounded aperture. This specimen is comparable with *Fulgoraria hirasei yanagidaniensis* ARAKI (1959) originally described from the Miocene Kaisekizan Formation in Mie Prefecture. ARAKI's (1959) species was re-described in detail by SHIKAMA (1967), who stated that *yanagidaniensis* is characterized by "subsutural band absent and suture rather deep, axial ribs acute and 14 in penultimate whorl." The specimen at hand is imperfect but the characters as preserved agree with the description of SHIKAMA (1967).

Locality: Locality no. 1.

Formation: Teshima Formation.

Depository: IGPS coll. cat. no. 86752.

References Cited

AKUTSU, J. (1964): The geology and paleontology of Shiobara and its vicinity, Tochigi Prefecture. *Sci. Rep., Tohoku Univ., 2nd Ser.*, vol. 35, no. 3, p. 211–293, pls. 57–66, figs. 1–15, tabs. 1–11.

ARAKI, Y. (1959): On some marine Miocene Mollusca from Mie Prefecture, Japan. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 36, p. 161–167, pl. 18.

—— (1960): Geology, paleontology and sedimentary structures (including Problematica) of the Tertiary formation developed in the environs of Tsu City, Mie Prefecture, Japan. *Bull., Lib. Arts Dep., Mie Univ., Spec. Vol.*, no. 1, p. 1–118, pls. 1–11, tabs. 1–6, 1 section, 3 maps.

Cenozoic Research Group of Southwest Japan. (1960): An outline of the Cenozoic history of Southwest Japan, (in Japanese with English abstract). *Earth Science*, nos. 50–51, p. 56–65, figs. 1–2, 1 table.

CHINZEI, K. (1958): A new Pliocene *Venericardia* from the northern end of Iwate Prefecture, Japan. *Venus*, vol. 20, no. 1, p. 119–128, pl. 7, figs. 1–3.

FURUICHI, M., SAITO, M., BANDO, Y. and TANIYAMA, Y. (1969): [Neogene Tertiary around Teshima, Kagawa Prefecture], (in Japanese, abstract only). *Jour. Geol. Soc. Japan*, vol. 75, no. 2, p. 91.

GRANT, U.S. and GALE, R.H. (1931): Catalogue of marine Pliocene and Pleistocene Mollusca of California and adjacent regions. *Mem., San Diego Soc. Nat. Hist.*, vol. 1, p. 1–1036, pls. 1–32, figs. 1–15.

HATAI, K. and NISIYAMA, S. (1952): Check list of Japanese Tertiary marine Mollusca. *Sci. Rep., Tohoku Univ., 2nd Ser., Spec. Vol.*, no. 3, p. 1–464.

HIRAYAMA, K. (1954): Miocene Mollusca from the Arakawa group, Tochigi Prefecture, Japan, Part 1. *Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C.*, vol. 3, no. 18, p. 43-76, pls. 1-15, 1 table.

—— (1955): The Asagai formation and its molluscan fossils in the northern region, Joban coal-field, Fukushima Prefecture, Japan. *Sci. Rep., Tokyo Kyoiku Daigaku, Sec. C.*, vol. 4, no. 29, p. 49-130, pls. 1-5, figs. 1-5, tabs. 1-3.

—— (1967): Miocene Mollusca from the Arakawa group, Tochigi Prefecture, Japan, Part II. *Prof. H. Shibata Mem. Vol.*, p. 389-395, pl. 1.

HUZIOKA, K. (1963a): Tertiary floras of Japan, Miocene Flora 3, The Utto flora of Northern Honshu. *Collal. Assoc. Comm. 80th Ann., Geol. Surv. Japan*, p. 153-258, pls. 28-39, figs. 10-12, tabs. 29-46.

—— (1963b): Aniai flora and Daishima flora, (in Japanese). *Fossils*, no. 5, p. 39-50, tabs. 1-6.

IDA, K. (1952): A study of fossil *Turritella* in Japan. *Rep., Geol. Surv. Japan*, no. 150, p. 1-62, pls. 1-7, figs. 1-24, tabs. 1-4.

IMAMURA, S. (1966): [Discovery of *Miogypsina kotoi* HANZAWA from Nichioji, Tsudaka-machi, Okayama Prefecture and on the geological age of so-called Neogene Tertiary around Okayama City], (in Japanese). *Rep., Geol. Inst., Fac. Sci., Okayama Univ.*, no. 1, p. 1-10, pl. 1.

ITOIGAWA, J. (1956): Molluscan fauna of the Tsuzuki group in Kyoto Prefecture, Japan. *Mem., Coll. Sci., Univ. Kyoto., Ser. B*, vol. 23, no. 2, p. 179-192, pls. 1-3, figs. 1-2.

—— (1960): Paleoecological studies of the Miocene Mizunami group, Central Japan. *Jour., Earth Sci., Nagoya Univ.*, vol. 8, no. 2, p. 246-300, pls. 1-6, figs. 1-5, tabs. 1-2.

—— (1969): Miocene molluscan fauna from the eastern part of the Setouchi region, Japan, (in Japanese). *Fossils*, no. 17, p. 50-55, 1 table.

IWAI, T. (1969): Molluscan biostratigraphy of the Cenozoic deposits in Aomori Prefecture, Northeast Japan, (in Japanese). *Fossils*, no. 18, p. 5-16, tabs. 1-2.

KAMADA, Y. (1962): Tertiary marine Mollusca from the Joban coal-field, Japan. *Palaeont. Soc. Japan, Spec. Papers*, no. 8, p. 1-187, pls. 1-21, figs. 1-3, tabs. 1-2.

KASAMA, T. and HUZITA, K. (1957): Sedimentary province of the Japanese Cenozoic System and its development (1), Characteristics and development of the Setouchi geological province, (in Japanese with English abstract). *Cenozoic Res.*, nos. 24-25, p. 518-526, figs. 1-8.

KATO, G. (1969): Biostratigraphy of the western central part of Shimane Prefecture, (in Japanese with English abstract). *Sci. Rep., Dep. Geol., Kyushu Univ.*, vol. 10, no. 1, p. 31-49, figs. 1-4, tabs. 1-7.

KAWAI, M. (1957): Explanatory text of the geological map of Japan, Scale 1:50,000, Tsuyama-Tobu, (in Japanese with English abstract). *Geol. Surv. Japan*.

KOTAKA, T. (1955): Molluscan fauna from the Oligocene Isomatsu Formation, Aomori Prefecture. *Saito Ho-on Kai Mus. Res. Bull.*, no. 24, p. 23-31, pl. 2.

—— (1958): Faunal consideration of the Neogene invertebrates of Northern Honshu, Japan. *Saito Ho-on Kai, Mus. Res. Bull.*, no. 27, p. 38-44, fig. 1, tabs. 1-3.

—— and NODA, H. (1967): Miocene Mollusca from the Minami-Tsugaru district, Aomori Prefecture, Northeast Japan. *Saito Ho-on Kai, Mus. Res. Bull.*, no. 36, p. 33-47, pls. 1-2, tabs. 1-2.

KURODA, T. (1929): Notes and descriptions of some new and noteworthy species from Tateyama Bay in the report of Mr. T. FUJITA. *Venus*, vol. 1, no. 3, p. 93-97, pl. 3.

KUSUMI, H. and KATAYAMA, S. (1962): Geology of Saijo area, Hiba-gun, Hiroshima Prefecture, (in Japanese with English abstract). *Mem., Fac. Educ., Hiroshima Univ., Ser. 2*, no. 10, p. 59-69, figs. 1-2, 1 map.

MAKIYAMA, J. (1926): Tertiary fossils from North Kankyô-dô, Korea. *Coll. Sci., Kyoto Imp. Univ., Ser. B.*, vol. 2, no. 3, p. 143-160, pls. 12-13.

MASUDA, K. (1967): Molluscan fauna of the

Higashi-Innai formation of Noto Peninsula, Japan, III. *Trans. Proc. Palaeont. Soc. Japan, N.S.*, no. 65, p. 1–18, pls. 1–2.
—— and TAKEZAWA, H. (1965): Remarks on the Miocene molluscs from the Sennan district, Miyagi Prefecture, Northeast Honshu, Japan. *Saito Ho-on Kai, Mus. Res. Bull.*, no. 34, p. 1–14, pls. 1–2.
MIZUNO, A. (1964): A study on the Miocene molluscan fauna of the Kitatsugaru and Nishitsugaru districts, North Honshu. *Bull., Geol. Surv. Japan*, vol. 15, no. 10, p. 595–622, pls. 1–4, figs. 1–3, tabs. 1–16.
—— (1965): Tertiary molluscan fauna from the environs of Hanawa basin, North Honshu, (in Japanese with English abstract). *Bull., Geol. Surv. Japan*, vol. 16, no. 6, p. 31–36, pls. 1–2, fig. 1, tabs. 1–3.
NOMURA, S. (1935): Miocene Mollusca from Shiogama, Northeast Honshu, Japan. *Saito Ho-on Kai, Mus. Res. Bull.*, no. 6, p. 193–234, pls. 16–17, fig. 1.
—— (1936): Three new species of Neogene Mollusca from along the Koromo-gawa, Iwate-ken, Northeast Honshu, Japan. *Saito Ho-on Kai, Mus. Res. Bull.*, no. 13, p. 169–172, pl. 23.
—— and HATAI, K. (1936): Fossils from the Tanagura beds in the vicinity of the Town Tanagura, Hukusima-ken, Northeast Honshn, Japan. *Saito Ho-on Kai, Mus. Res. Bull.*, no. 10, p. 109–155, pls. 13–17.
OKAMOTO, K. (1965): Tertiary formations in the Yuya-wan (bay) district, southwest Japan with references to the Tertiary geologic history. *Jour. Sci., Hiroshima Univ., Ser. C.*, vol. 5, no. 1, p.

Explanation of Plate 31

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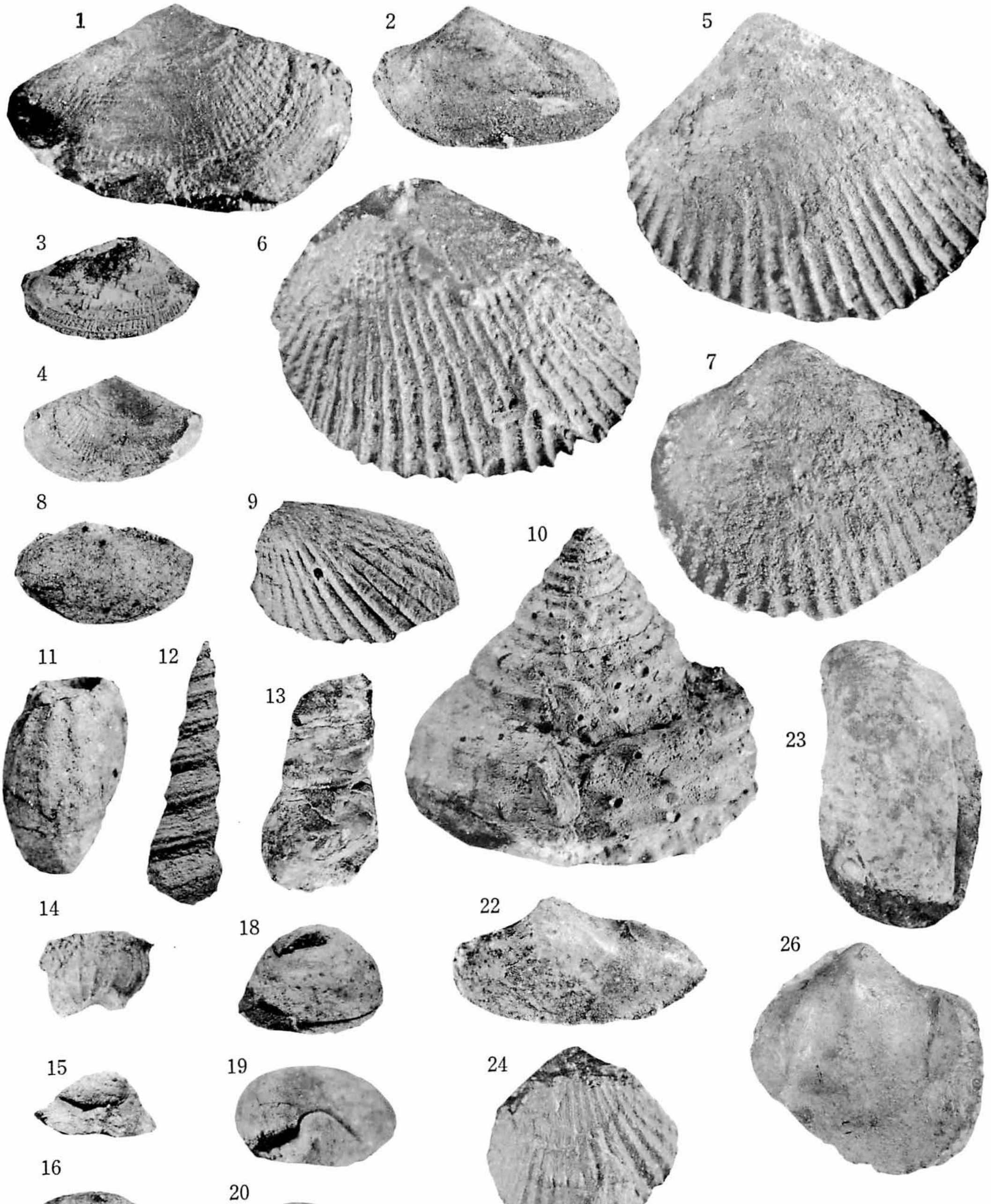

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81–111, pl. 6, figs. 1–3, tabs. 1–2.

OTUKA, Y. (1934): Tertiary structures of the northwestern end of the Kitakami mountainland, Iwate Prefecture, Japan. *Bull., Earthq. Res. Inst.*, vol. 12, pt. 3, p. 566–638, pls. 44–51, fig. 1, tabs. 1–6.

—— (1937): The geologic age of the Tertiary formations near Hamada, Shimane Prefecture, Japan. *Japanese Jour. Geol. Geogr.*, vol. 14, nos. 1–2, p. 23–32, pl. 3.

—— (1938): Mollusca from the Miocene of Tyûgoku, Japan. *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2*, vol. 5, pt. 2, p. 21–45, pls. 1–4, figs. 1–4.

—— (1941): Fossil Mollusca from Tazima, Hyogo Prefecture, Japan. *Japanese Jour. Geol. Geogr.*, vol. 18, nos. 1–2, p. 21–24, figs. 1–5.

SAITO, M. (1962): The geology of Kagawa and northern Ehime Prefectures, Shikoku, Japan. *Mem., Fac. Agr., Kagawa Univ.*, no. 10, p. 1–74, pls. 1–17, figs. 1–5, tabs. 1–6.

SAITO, M., BANDO, Y. and BABA, Y. (1962): Explanatory text of the geological map of Kagawa Prefecture, Scale 1:100,000, (in Japanese). Naiba Chika-Kogyo, K.K., p. 1–75.

SATO, M. (1932): [Miscellaneous notes on the Sanuki district], (in Japanese). *Jour. Geogr.*, vol. 44, no. 520, p. 333–339.

SHIKAMA, T. (1954): On the Tertiary formations of Tomikusa in south Nagano Prefecture, (in Japanese with English abstract). *Sci. Rep., Yokohama Nat. Univ., Sec. 2*, no. 3, p. 71–108, pls. 4–8, figs. 1–3, tabs. 1–16.

—— (1967): System and evolution of Japanese fulgorarid Gastropoda. *Sci. Rep., Yokohama Nat. Univ., Sec. 2*, vol. 13, p. 23–132, pls. 1–17, figs. 1–26, tabs. 1–41.

SHUTO, T. (1960): Cardiids from the Miyazaki group. *Trans. Proc. Palaeont. Soc. Japan, N.S.*, no. 37, p. 209–222, pl. 25, figs. 1–2, tab. 1.

TAI, Y. (1965): On the Miocene sedimentary cycle found out in Kojima bay, Okayama Prefecture, west Japan, (in Japanese with English abstract). *Geol. Rep., Hiroshima Univ.*, no. 14, *Prof. S. Imamura Mem. Vol.*, p. 13–24, figs. 1–11.

—— (1959): Miocene microbiostratigraphy of west Honshu, Japan. *Jour. Sci., Hiroshima Univ., Ser. C.*, vol. 2, no. 4, p. 265–395, pls. 37–43, fig. 1, tabs. 1–33.

TANAKA, K. (1967) *in* TANAKA *edit.*: [Fossils from Anan-machi, Nagano Prefecture, Fossils from the Tomikusa Group] (in Japanese), p. 21–100, pls. 1–15.

TSUDA, K. (1959): New Miocene molluscs from the Kurosedani formation in Toyama Prefecture, Japan. *Jour., Fac. Sci., Niigata Univ., Ser. 2*, vol. 3, no. 2, p. 67–110, pls. 1–7.

—— (1965): Neogene molluscan assemblages in the inner zone of Northeast Japan—with special reference to the Middle Miocene assemblages, (in Japanese). *Fossils*, no. 10, p. 20–23, tabs. 1–2, fig. 1.

YOKOYAMA, M. (1925): Molluscan remains from the uppermost part of the Joban coal-field. *Jour., Coll. Sci., Imp. Univ. Tokyo*, vol. 45, art 5, p. 1–34, pls. 1–6.

—— (1929): Neogene shells from the provinces of Chugoku. *Jour., Fac. Sci., Tokyo Imp. Univ., Sec. 2*, vol. 2, pt. 8, p. 363–368, pl. 70.

Bihoku	備 北
Danzan	壇 山
Ieura	家 浦
Iigoshi	飯 越
Kaisekizan	貝石山
Karato	唐 戸
Miyoshi	三 次
Saijo	西 条
Sanuki	讃 岐
Shikai	四 海
Shobara	庄 原
Shôdo-shima	小豆島
Teshima	豊 島
Tonosho	土 庄
Tsuzuki	綴 喜
Tsuyama	津 山
Utto	打 当

例　会　通　知

	開　催　地	開　催　日	講演申込締切日
105 回　例　会	国立科学博物館	1970 年 9 月 12・13 日	1970 年 7 月 31 日
106 回　例　会	広　島　大　学	1970 年 11 月 22 日	1970 年 10 月 10 日
1971年 総会・年会	東　京　大　学	1971 年 1 月 23・24 日	
107 回　例　会	関　西　地　区	1971 年 6 月	

◎ 105 回例会（国立科学博物館）： コロキウム，海洋微古生物学に関するコロキウム（仮題）（事務連絡者： 氏家 宏　講演申込みは 7 月 10 日まで）。この他，故矢部長克名誉会長の追悼会が予定されている。

◎ 106 回例会（広島大学）： シンポジューム，中国地方新生界の化石群（世話人： 中野光雄）。

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