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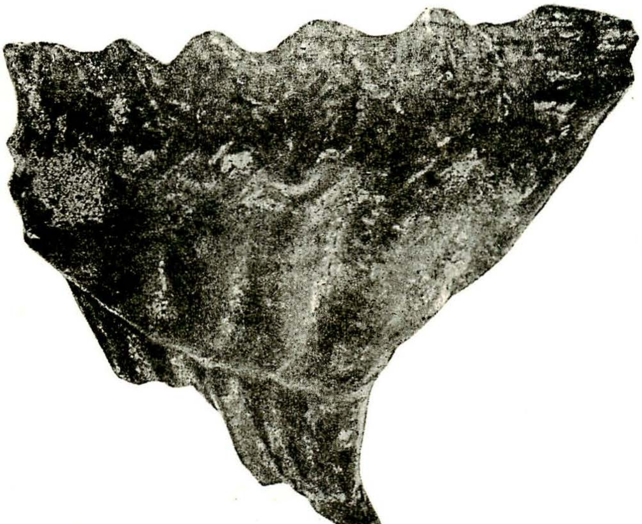

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591. ONTOGENY OF THREE *CEDARIA* ZONE TRILOBITES FROM UPPER CAMBRIAN, MONTANA*

CHUNG-HUNG HU

Department of Biology, Nanyang University, Singapore**

モンタナ州上部カンブリア系の *Cedaria* 帯産三葉虫三種の個体発生： 北米モンタナ州マディソンカウンティの上部カンブリア系 *Cedaria* 帯に属するピルグリム層の淡灰色石灰岩には多数の三葉虫や腕足貝（無関節類）が含まれている。これらのうち三葉虫の 3 種，すなわち *Syspacheilus dunoirensis, Nixonella montanensis, Baltagnostus beltensis* について，その個体発生を調べた結果，第一の種は *Coosella convexa* や *Crepicephalus deadwoodensis* および *Tricrepicephalus blountensis* などの発生に類似する点があり，第二種は同様に，*Kingstonia ara* および *Komaspidella laevis* に，また第三の種はに，*Kormagnostus simplex* に，それぞれ似ていることが判明した。したがって，これらの各組は系統的ないしは分類学的に近縁関係をもつものと解釈できる。なお，*Syspacheilus dunoirensis* については，その雌雄異型をも記載した。 胡 忠 恒

Introduction

The purpose of the present study is to illustrate the ontogenetic development of *Syspacheilus dunoirensis* (MILLER), *Nixonella montanensis* LOCHMAN, *Baltagnostus beltensis* LOCHMAN, and the sexual dimorphism of *Syspacheilus dunoirensis* (MILLER). The ontogenetic development of the first two species is well known, but is incompletely known for the last one. Both the ontogenetic separation and the sexual determination of the trilobites are based on the schemes in the author's earlier works (HU, 1964, 1968a, 1970, etc.).

The materials were collected from west-side, South-Boulder Creek, Madison County, Montana, and are light gray colored, medium crystalline limestone, containing an abundance of trilobite fragments, inarticulate brachiopods, and a few intraformational pebbles. The geologic positions of the materials belong to the Pilgrim formation, *Cedaria* zone, Upper Cambrian.

The ontogenetic metamorphosis of *Syspacheilus dunoirensis* is very similar to those of *Coosella convexa* TASCH (HU, 1968b), *Crepicephalus deadwoodensis* HU (1968a), and *Tricrepicephalus blountensis* RESSER (unpublished material); that of *Nixonella montanensis* LOCHMAN is close to *Kingstonia ara* (WALCOTT) (HU, 1968b), *Komaspidella laevis* RASETTI (HU, 1970); and that of *Baltagnostus beltensis* LOCHMAN to *Kormagnostus simplex* RESSER (HU, 1968a). All members within the same group possibly have close phylogenetic relationship, and belong to a same genetic hierarchy.

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** Present adress: Earth Science Department, Cheng Kung University, Tainan, Taiwan, Republic of China.

his supervision, thanks also go to Dr. Anne JOHNSON, Nanyang University, for reading over the present manuscript. The figured specimens are all stored in the Geology Museum, University of Cincinnati, Ohio (U. C. M.). The financial expenses of the present study were supported by Miss Nancy NUN Science Research Foundation, Nanyang University.

Systematic description

Family Crepicephaliidae KOBAYASHI, 1935

Genus *Syspacheilus* RESSER, 1938

Syspacheilus dunoirensis (MILLER)

Pl. 29, figs. 1–34, and Text-fig. 3a–k.

Blountia dunoirensis MILLER, 1936, p. 27, pl. 8, figs. 25, 26.

Syspacheilus dunoirensis (MILLER) : LOCHMAN & DUNCAN, 1944, p. 131–132, pl. 11, figs. 44, 45; PALMER, 1954, p. 734, pl. 78, fig. 9; DELAND & SHAW, 1957, p. 561, pl. 64,

Syspacheilus dunoirensis var. (MILLER) : LOCHMAN & HU, 1961, p. 135, pl. 26, figs. 26, 37–39.

Syspacheilus occidens LOCHMAN, 1950, p. 342, pl. 50, figs. 25, 26.

Syspacheilus praecedens var. *elongatus* LOCHMAN & HU, 1961, p. 136, pl. 27, figs. 19–28, 30.

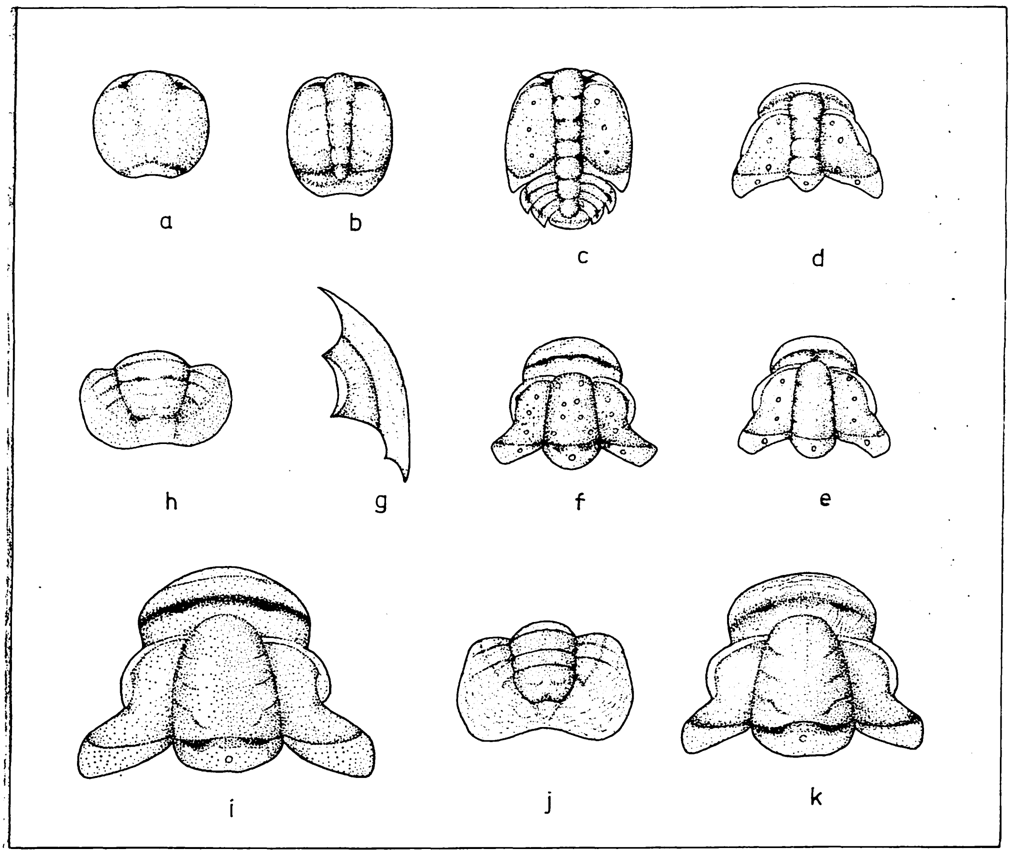
Coosella vagrans LOCHMAN & HU, 1961, pl. 26, figs. 49–54.

Diagnosis: Cranidium trapezoidal; anterior border broad, convex; glabella conical; preglabellar field medium wide; occipital ring crescentic, bearing a tiny median tubercle. Fixigena less than one-half the width of glabella; posterior border same width as the occipital ring. Librigena subtrapezoidal having a rather small genal spine; ocular platform the same width as lateral border. Pygidium broadly kidney shaped, convex with two axial rings; marginal border broad and flat. Outer skeletal surface granulated, and inner surface punctured; a pair of elongated pits on the anterior furrow, and irregular concentric ridges along pygidial margin.

Remarks: LOCHMAN & HU (1961) reported that there are four distinct species within the present genus: they are *Syspacheilus typicalis* RESSER, 1938, *S. praecedens* LOCHMAN & HU, 1961, *S. camurus* LOCHMAN, 1940, and *S. dunoirensis* (MILLER, 1936). The first two species have broader flat preglabellar fields and in the last two, they are narrow and steeply slope downward. Furthermore, *S. dunoirensis* and *S. praecedens* have slender glabella, whereas those of the other two are broader. The materials which I have studied could be segregated into two different morphologic groups. The first group conforms with " *S. dunoirensis* " and the second to "*S. praecedens*". These bimodal traits are here interpreted as the presence of sexual dimorphism within the same species population and are found in the same ecological habitats. The first group is presumably the female and the second the male. If this postulation is acceptable then the *S. typicalis* and *S. camurus* are possibly another example of the different sexual representatives of the same species.

The early ontogenetic development of the both sexes are indistinguishable: all immature forms have the same morphologic characteristics, but in their late stages the cranidium is gradually differentiated into two forms; one group with slender glabella, flat preglabellar field, and broader pygidial margin, and the other has broader glabellar, tilted preglabellar field, and narrow pygidial margin.

Coosella vagrans LOCHMAN & HU, 1961



Text-fig. 1. *Syspacheilus dunoirensis* (MILLER).

a, Anaprotaspis, ×50; b, Metaprotaspis, ×50; c, Paraprotaspis, ×32; d, Early meraspid cranidium, ×20; e, f, Two late meraspid cranidia, ×9, ×8; g, Librigena, ×5; h, k, A male pygidium and a cranidium, ×4, ×4; i, j, A female cranidium and a pygidium, ×6, ×20. (all drawings were made from photographs.)

has no distinct characters by which it can be separated from *S. dunoirensis* except the "*C. vagrans*" has the cranidium slightly flattened. This feature is possibly due to compaction of the deposits or to individual variation, but has no specific significance.

Syspacheilus dunoirensis (MILLER), "male"

Pl. 29, figs. 14, 21, 23, 25–29, 31 and Text-fig. 1h, k.

Description: The cranidium is trapezoidal in outline, highly convex; glabella conical, short and broad, and with rounded anterior margin; the preglabellar field is of medium width, slopes downward from the anterior glabellar, and inclined about 45 degrees; the anterior furrow is deep and broad, possessing a pair of elongate pits laterally; the anterior border is narrow crescentic, convex, arching forwardly; the occipital ring is convex both vertically and posteriorly, bearing a small median node; the broad and deeply impressed occipital furrow curves forward on the axial line (sag.), and deepens both posteriorly and laterally with a pair of elongate pits. The fixigena is narrow, about one-half the width of the glabella, medium width, convex; the medium sized palpebral lobe is sickle-shape, situated on the mid-line of the glabella (tr.), and well delimited by palpebral furrow; the palpebral lobe is indistinct, which extends to the antero-lateral margin of the glabella from the anterior palpebral lobe, and arches forward; the facial suture is opisthoparian, its anterior branch is slightly divergent and convex, and the posterior one divergent-straight, and convex.

The subtrapezoidal librigena is convex and has the ocular platform narrowed; the large ocular ring is connected to both anterior and posterior free margins; the lateral furrow is shallow, and narrower than the lateral border; the lateral border is horizontal, convex, possesses a rather small genal spine; posterior librigenal border absent; the genal angle or the posterior free margin curves into the genal spine to form a broad rounded angle and a short broad base indentation.

Pygidium is lenticular or kidney-shaped, convex, occupied by a broad and short axial lobe; the axis is divided into one or two convex rings and a broad terminal portion by shallow ring furrows; the posterior axis is slightly elevated and moderately convex, and separated from the terminal portion by an indistinct furrow; the pleural lobe is narrow, convex, slopes downward from the shallow dorsal furrow, marked with one or two shallow pleural furrows; the broad margin is delimited by the shallow inner marginal furrow, and with shallow posterior embedding.

The exoskeleton of the animal is covered by medium-sized granules, parallel ridges marked along the outer margin of the anterior border, faint and radial ridges on the preglabellar field, and a longitudinal ridge is marked along the central cranidial axis.

Figured specimens: Male form: Cranidia, U. C. M. 40279m, v, x, c′; Librigenae, U. C. M. 40279 n, s; Pygidia, U. C. M. 40279t, y, z, a′.

Syspacheilus dunoirensis (MILLER), "female"

Pl. 29, figs. 16–19, 22, 24, 30, 33, 34, and Text-fig. 1 i, j.

Comparison: The female form differs from the male in having the deeper and narrower anterior furrow; steeper preglabellar field; narrower pygidial axis; broader pygidial margin, and deeply marked posterior marginal embayment. The sexual ratio is 217.

Figured specimens: Female form: Cranidia, U. M. C. 40279o, p, w, d′; Librigena, U. M. C. 40279e′; Pygidia, U. M. C. 40279r, u, b′.

Syspacheilus dunoirensis (MILLER), ontogeny

Anaprotaspid stage (Pl. 29, fig. 1, and Text-fig. 1a).—The shield is rounded, moderately convex, about 0.30 mm in length (sag.); the axial lobe is convex, slightly above the pleural region, without any distinct dorsal furrow; the posterior margin is flat and slightly curved inward.

Only a single specimen is assigned to

the present stage. The shield surface is characterized without any special feature. Its anterior margin may be marked by a pair of frontal pits and the posterior marked by an elevated occipital node; these suggest the orientation of the shield.

Metaprotaspid stage (Pl. 29, fig. 2, and Text-fig. 1b).—The shield is rounded-oval in outline, convex, about 0.30-0.35 mm in length (sag.); the axial lobe is expanded forward from the posterior end to the anterior margin; the dorsal and the ring furrows are only recognizable on the larger specimens, otherwise indistinct; the pleural lobe is rather broad, about twice as wide as the axis (tr.); the anterior pits are elongate, and well impressed; the posterior shield is surrounded by a flat and slightly down sloping margin, without indication of the segmentation, except for a rounded occipital ring and border furrow.

The present stage differs from the anaprotaspis in having the well developed axial furrow and both of the axial and pleural lobes.

Paraprotaspid stage (Pl. 29, figs. 3-5, and Text-fig. 1c).—The shield is oval, consists of the cephalon and the protopygidium and is about 0.40-0.55 mm in length (sag.); the distinctly differentiated axial lobe is cylindrical, expanded slightly forward, without a well developed axial ring, except for the occipital one; the dorsal furrow is irregularly marked, which suggests the presence of the axial ring and ring furrows; a pair of short eye-brow ridges extend laterally from the sides of the frontal lobe, they are well delimited by paired anterior pits, and palpebral ridges; the pleural lobe is broad, about one and one-half the width of the axis, convex; the posterior shield or the protopygidium is convex, surrounded by broad flat margin, and divided into two or three segments; the protopygidial axis and the pleural lobes are well differentiated into axial rings and pleural bands by furrows. The surface of the shield is faintly granulated, and four pairs of coarser grains are marked on the fixigena and the fixigenal borders.

The present stage is characterized by the cylindrical glabella, narrower pleural lobes, and the presence of the protopygidium.

Early meraspid stage (Pl. 29, figs. 6-9 and Text-fig. 1d).—The cranidium is trapezoidal in outline, convex, about 0.65-0.70 mm in length (sag.), with well developed facial sutures; the glabella is cylindrical, or slightly expanded both anteriorly and posteriorly from the central line (tr.); the four rounded and recognizable axial rings are indistinctly divided, and the first ring is impressed by a pair of elongate pits laterally; the occipital ring is narrow, convex, curving posteriorly bearing a minute median node, and distinctly separated by a narrow occipital furrow; the anterior border is very narrow, horizontal, convex, arching forward, well delimited by a deep furrow. The fixigena is broader than the glabella (tr.), triangular, moderately convex; the palpebral ridge is situated in front of the mid-line of the glabella (tr.), narrow, elevated, well separated from the fixigena by palpebral furrow, and connected to both of the anterior pleural ridge and the glabellar margins; the posterior border is well impressed by broad border furrow, convex, elevated, about one and one-half width of the occipital ring. The facial suture is the proparian type, with its anterior branch short and convex, and the posterior one divergent laterally and convex. The skeletal surface is faintly granulated, four pairs of coarse granules on the fixigenae and the fixigenal border.

The distinct characters of the present stage are that the glabella becomes cylindrical or oblongus, without distinct glabellar furrow, occipital ring broadly convex, well separated from the glabella by occipital furrow, facial suture proparial, well defined.

Late meraspid stage (Pl. 29, figs. 10-13, and Text-fig. 1 e, f).—The trapezoidal cranidium is convex, about 0.80 to 1.65 mm long (sag.); the glabella is subquadrate or oblongus, marked without distinct glabellar furrow; the occipital ring is crescentic, convex both vertically and posteriorly, bearing a minute median tubercle; the preglabellar field is narrower than the anterior border, convex, tilted slightly anteriorly; the frontal furrow is deep and broad, having a pair of elongate pits laterally; the fixigena is the same width as the glabella or slightly narrower, convex, with a pair of medium-sized palpebral lobes situated on the mid-line of the glabella (tr.); the palpebral furrow is narrow and distinct. The posterior fixigena is subtriangular, convex, with posterior fixigena well demarked by a broad furrow, convex, about the same width as the occipital ring (sag.); the facial suture is opisthoparian, its anterior branch slightly divergent-convex, and the posterior one is divergent-straight.

The skeletal surface is covered by faint granules, four pairs of coarse granules are regularly marked on the glabella and three pairs on the fixigena.

The present stage differs from the previous one in that the preglabellar field appears, the glabella becomes oblongus, the palpebral lobe is situated on the mid-length of the glabella, the fixigena narrower, and opisthoparian facial suture present.

Remarks: The morphogenesis of the present species is very closely similar to those of *Crepicephalus deadwoodensis* HU (HU, 1968a), *Coosella convexa* TASCH (HU, 1968b), *Tricrepicephalus blountensis* RESSER (unpublished material). All of the features have parallel development during their growth stages, especially in the shape of their glabella, and the four pairs of coarse granules are indistinguishable within the four species in the immature forms. It is doubtless these four species are the member of the same family, and with close phylogenetic relationship.

Figured specimens: Anaprotaspis, U. C. M. 40279; Metaprotaspis, U. C. M. 40279a; Paraprotaspides, U.C.M. 40279b-d; Early meraspides, U. C. M. 40279e-h; Late meraspides, U. C. M. 40279 i-l.

Family Pagodiidae KOBAYASHI, 1935

Genus *Nixonella* LOCHMAN, 1944

Synonym: Genus *Nixonella* LOCHMAN, 1944 (type species, *Nixonella montanensis* LOCHMAN).

Genus *Torridella* LOCHMAN & HU, 1962 (type species, *Torridella migranta* LOCHMAN & HU).

Remarks: The present genus is a common member within the *Cedaria* zone, Upper Cambrian. Its appearance is similar to *Genevievella* LOCHMAN, 1936, both have no preglabellar field, a simple anterior border, and conical glabella, except the *Nixonella* has the gonatoparian facial suture and the later one the proparian. The holotype of the *N. montanensis* LOCHMAN (1944, pl. 13, figs. 29, 30) is a small cranidium, about 2.0 mm in length (sag.), with the broad anterior border and oblong glabella. It is possibly not a well developed mature specimen. The associated pygidium of *N. montanensis* (LOCHMAN, 1944, pl. 13, fig. 28) consists of two segments, transverse, semicircular in outline, about 1.0 mm in length (sag.), is a meraspid pygidium, and possibly belongs to cedaroid (*Paracedaria* ?).

A genus *Torridella* proposed by LOCHMAN & HU (1962) has the type species *T. migranta* about 3.0 mm in length (sag.) (pl. 6, fig. 8; holotype), with the similar characteristics as " *N. montanensis* " except its glabella is conical and anterior border is narrower. It is presumably a mature specimen. The pygidium of " *T. migranta* " is roundly triangular in outline, convex, consists of more than six axial rings. Since these features are distinctly different from any other species within the same faunal assemblage, this is possibly the correct association. These facts here permit to state that the genera " *Torridella* " and "*Nixonella*" are synonymous, however the type species of "*Nixonella montanensis*" has a semicircular pygidium and that of "*Torridella migranta*" has conical glabella as described above, but the former was due to the misassociation and the latter one was the mature specimens in the full grown stage. Therefore, these two forms have no foundation for the genetic separation.

Nixonella montanensis LOCHMAN

Pl. 30, figs. 1–21, and Text-fig. 2a–k.

Nixonella montanensis LOCHMAN, 1944, p. 105, pl. 13, figs. 23, 27, 29–31 only (not fig. 28) : LOCHMAN & HU, 1962, p. 16, pl. 5, figs. 48, 50–52 only (not fig. 49).
Nixonella cf. *montanensis* LOCHMAN, 1944, p. 106, pl. 27, fig. 29.
Torridella migranta LOCHMAN & HU, 1964, p. 17, pl. 6, figs. 7–18.

Diagnosis: Cranidium trpezoidal, convex; glabella conical, three pairs of glabellar furrows; no preglabellar field; anterior border narrow crescentic; fixigena about one-half width of the glabella, triangular, and palpebral lobe small; gonatoparian facial suture present. Librigena narrow, crescentic without distinct marginal furrow and genal spine. Pygidium regular triangular, convex; six axial rings; axis narrower than the pleural lobe, and not extends to the full length of the pygidium.

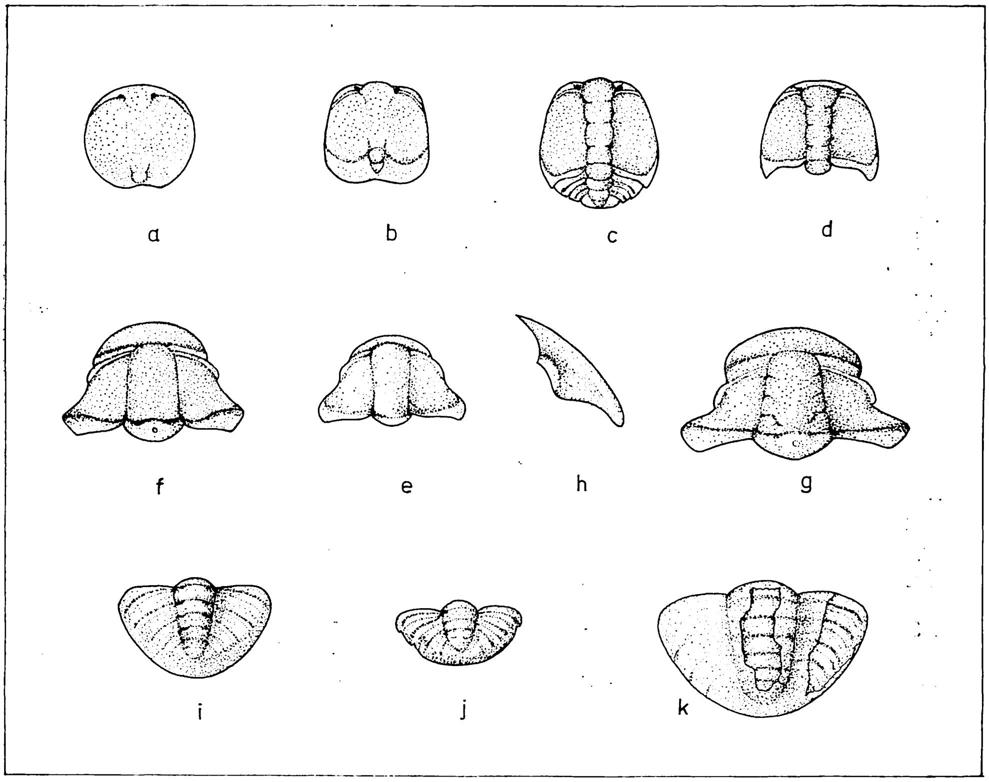
Description: The regular trapezoidal cranidium is convex, has a conical glabella marked by three pairs of shallow glabellar furrows; the first pair of glabellar furrows is faint and short, the second is medium-sized, and the third one is the largest and deeply marked, and obliquely directed to the occipital furrow from the posterior palpebral lobe; preglabella field absent; the anterior border is horizontally convex, narrow, arching anteriorly and well delimited by the frontal furrow; the occipital ring is crescentic, convex, arches posteriorly and bears a minute median tubercle; the narrow occipital furrow arches slightly forward on the mid-line, and is demarked with a pair of elongate pits laterally; the dorsal furrow is deep and broad. The fixigena is nearly triangular, convex, about one-half the width of the glabella; the small palpebral lobe is located in front of the mid-line of the glabella (tr.), and the palpebral ridge is distinct; the convex posterior fixigenal border is about the same width as occipital ring (tr.), well defined by a broad and shallow border furrow; the anterior branch of the facial suture is slightly divergent-convex, and the posterior one divergent-straight laterally.

The librigena is narrow, elongate, without genal spine; the lateral furrow and the border are about the same width, and indistinctly demarked; the narrow ocular platform is flat, with the posterior area broader than the anterior margin; the small oval ocular ring is located forward from the mid-line of librigena (tr.), convex, and elevated above the ocular paltform.

Pygidium is triangular in outline, without marginal spine, and convex along the rounded margin; the axial lobe is slenderly conical, tapering posteriorly, divided by 6 or 7 narrow, convex axial rings by indistinct furrows; the pleural lobe is slightly broader than the axis, delimited by a broad and deep dorsal furrow, and has rather faintly impressed pleural furrows; the marginal border is broader posteriorly from the facet angles, and demarked by a rather indistinct inner marginal furrow.

The animal exoskeleton is covered by faint granules, and inner surface with the furrows deeply marked.

Figured specimens: Cranidia, U. C. M. 40280, 40280 a-c; Librigena, U. C. M. 40280t; Pygidia, U. C. M. 40280p-s.



Text-figure 2. *Nixonella montanensis* LOCHMAN.

a, Anaprotaspis, ×32; b, Metaprotaspis, ×38; c, Paraprotaspis, ×33; d, Early meraspid cranidium, ×28; e, f, Two late meraspid cranidia, ×15, ×12; h, Librigena, ×11; g, Adult cranidium, ×7; i, A meraspid pygidium, ×20; j, k, Two adult pygidia, showing both the inner and outer skeletal surface, ×5, ×9. (all drawings were made from photographs).

Nixonella montanensis LOCHMAN, ontogeny

Anaprotaspid stage (Pl. 30, fig. 14, and Text-fig. 2a).—The shield is rounded, convex, and about 0.25 mm in length (sag.); the axial and the pleural lobes are incompletely differentiated; the anterior axis is deeply impressed by a pair of frontal pits on the sides of the small frontal lobe, and its posterior axis is ended into a small rounded node; a pair of short superciloid ridges extend postero-laterally from the margin of the frontal lobe, which are well delimited by anterior pits and border furrows; the pleural lobe is rather broad, convex, and slightly above the narrow axis; no inner marginal furrow is marked. The shield surface is faintly granulated.

Two or three specimens are assigned to the present stage but are mostly incomplete. The figured specimen here suggests the axial region is narrow, depressed, and with a few coarse grains. These coarse grains are possibly the limestone matrix.

Metaprotaspid stage (Pl. 30, fig. 15, and Text-fig. 2b).—The shield is about 0.40 mm in length (sag.), round or oval in outline, and has the axial and pleural lobes which are faintly demarked by dorsal furrows; the axis is rather narrow, cylindrical, with the frontal lobe slightly expanded forwardly; no axial ring or ring furrow is visible; the posterior end of the axis or the occipital ring is convex, and well defined by furrows; the pleural lobe is broad about twice as wide as the axis, convex, slightly above the axis; the posterior margin of the shield is surrounded by a narrow flat band, which is broad laterally and narrower to the posterior axis to form a shallow embedding. The skeletal surface is covered by fine granules.

The present stage is characterized by the well differentiated axial and the pleural lobes, and the well depressed dorsal furrows.

Paraprotaspid stage (Pl. 30, figs. 11-13, and Text-fig. 2c).—The shield is oval, divided into a cranidium and a small protopygidium, all about 0.50-0.65 mm in length (sag.), convex, with the axial and pleural lobes well differentiated; the axial lobe is cylindrical, expanded slightly forward, with the axial rings indistinctly marked; the broadly rounded frontal lobe is well delimited by a pair of distinct anterior pits, and by short superciloid ridges; behind the superciloid ridges is a pair of faint elevated palpebral ridges which arch forward and are well delimited by furrows; the occipital ring is well defined by furrows, convex, and transverse-oval. The fixigena or the pleural lobe is about one and one-half the width of the glabella, convex, with the posterior border curving inward; the posterior border furrow is well defined, and its extreme lateral end is turned forward before it reaches the marginal border; the protopygidium is subtriangular, convex, divided into two to three thoracic segments, and all are freely articulated. The surface of the exoskeleton is covered by faint granules.

The present stage is characterized by a protopygidium, axial and pleural lobes being well differentiated, and the distinct posterior fixigenal border present.

Early meraspid stage (Pl. 30, figs. 7-10, and Text-fig. 2d).—The cranidium is trapezoidal, with posterior border broader than the anterior one (tr.), convex, about 0.55 to 0.80 mm in length (sag.); the glabella is long, cylindrical, with the anterior margin slightly expanded forwardly, and four indistinctly divided glabellar segments are visible; the anterior segment is the largest, and those of the followings—2nd, 3rd, and 4th—are about equal in size; a narrow and elevated anterior border appears along the anterior margin; the anterior pits are visible on the small specimens, but becomes shallower or absent on the larger ones; the palpebral lobe is well elevated and separated from the anterior border by a narrow transverse area; the occipital ring is deeply delimited by an occipital furrow, convex, arches posteriorly. The fixigena is about the same width as the glabella; the posterior lateral fixigena is convex, slopes downward both rearly and laterally from the deeply impressed dorsal furrow, with narrow posterior border deeply separated by the furrow, and about one and one-half width of the occipital ring. The skeletal surface is faintly granulated.

The present stage differs from the previous one in that the anterior border appears, anterior pits are shallower or absent, palpebral ridge is separated from the anterior border and the facial suture is turned onto the dorsal surface to show the proparian type.

Late meraspid stage (Pl. 30, figs. 3-5, and Text-fig. 2e, f).—The cranidium is convex, trapezoidal in outline, about 1.0 to 1.5 mm long (sag.); the oblongus glabella is rounded anteriorly, and without distinct glabellar furrows; no preglabellar field; the anterior border is rather broad and convex, crescentic, and delimited by a deep and broad anterior furrow; the occipital ring is convex, mid-line broader than the sides, delimited by a deep occipital ring and bearing a minute median tubercle; the fixigena is slightly narrower than the glabella, convex, below the glabella; a pair of small narrow palpebral lobes are situated in front of the mid-line of the glabella (tr.); they are elevated and distinctly delimited by the palpebral furrow; the palpebral ridge is faint, but traceable, it is connected to both of the palpebral lobe and the antero-lateral glabellar margin; the broad posterior fixigena is convex, downward sloping, and has the narrow border well delimited by broad and deep border furrows; the postero-lateral fixigenal border is elevated from the border furrow, and about the same width as the occipital ring (tr.). The skeletal surface is faintly granulated.

During the present period, the glabella is developed from the cylindrical to oblongus shape, the anterior border increases the width, the fixigena becomes narrower, and the palpebral lobe is located nearly on the mid-line of the glabella (tr.).

Remarks: The ontogenetic development of the present species is similar to those of cedariods, but in comparing the same sized skeletons, the glabella is broader, and without any median expansion. The morphogenesis of the present species is also similar to those of *Kingstonia ara* (WALCOTT) (HU, 1968a) and *Komaspidella laevis* RASETTI (HU, 1970). Thus, these three species might represent the members of the same family, and with close phylogenetic relationship.

Figured specimens: Anaprotaspis, U. C. M. 40280m; Metaprotaspis, U. C. M. 40280n; Paraprotaspides, U.C.M. 40280j-l; Early meraspides, U.C.M. 40280f-i; Late meraspides, U.C.M. 40280c-e.

Family Spinagnostidae HOWELL, 1935

Genus *Baltagnostus* LOCHMAN, 1940

Baltagnostus beltensis LOCHMAN

Pl. 30, figs. 22-35, and Text-fig. 3a-e.

Baltagnostus beltensis LOCHMAN in LOCHMAN & DUNCAN, 1944, p. 138, pl. 12, figs. 3–5.

Baltagnostus wyomingensis LOCHMAN & HU, 1960, p. 822, pl. 99, figs. 1–4.

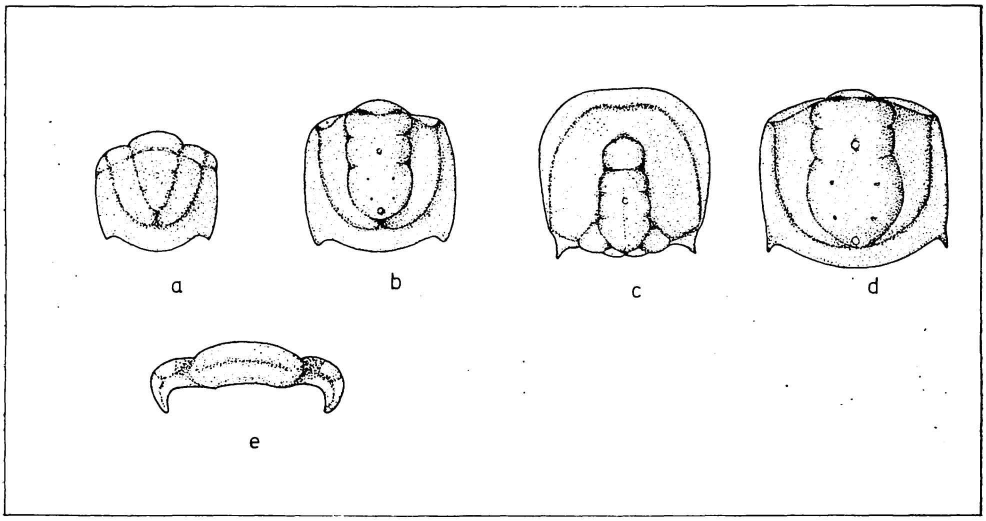
Cf. *Baltagnostus wyomingensis* LOCHMAN & HU, 1960, p. 822, pl. 99, fig. 32.

Diagnosis: Cranidium quadrate or rounded, convex; axial lobe or glabella narrower than the pleural lobe; preglabellar field narrower than the pleural lobe, no central furrow; first axial ring round, and the following ones indistinct; anterior furrow broad, convex. Thoracic segment narrow; axial lobe broad; pleural lobe about one-half width of the axis. Pygidium quadrate or rounded, convex; three axial rings; terminal segment broadly expanded; posterior border convex; posterior furrow broad and concave.

Description: The cranidium is nearly quadrate or roundly quadrate in outline, convex; glabella conical, convex, above the pleural lobes, well defined by dorsal furrows; the first glabellar segment or the frontal lobe is rounded, convex, and isolated by furrows; the 2nd to 4th glabellar segments are indistinctly differentiated, and connected by a narrow and elongated longitudinal ridge; a small but distinct node is located on the central portion of the third axial segment; the occipital ring is rather narrow, convex below the posterior glabella, and connected with a pair of triangular nodes laterally; the preglabellar field is slightly narrower than the pleural lobe, convex, downwardly sloping from the anterior glabella, marked without longitudinal median furrow; the anterior furrow is deep and broad, concave, and has a median notch toward the preglabellar field; the anterior border is broad, convex, and decreases in width postero-laterally; the pleural fixigenal border is narrow, delimited by a distinct border furrow, about one-half width of the occipital ring, and associated by a pair of short posteriorly directed spines at its extreme lateral corners. The thoracic segment is convex; axial lobe very broad and convex, and lenticular with the half ring furrow indistinctly marked; the pleural lobe is short, about one-half width as the axis (tr.), and curves strongly posteriorly; the pleural furrow is deep and marked along the center of the pleural lobe.

Pygidium is rounded or roundly quadrate, convex, occupied with a large and broad axial lobe, and delimited by narrow and faint dorsal furrows; the axial rings are indistinctly divided by ring furrows; the first axial ring is narrow, the second is medium sized, ornamented by a small median tubercle, and the third one is the largest, roundly expanded posteriorly, and marked by two pairs of rounded pits on equal distances; on the nearly posterior axial margin a tiny median node is marked, which is surrounded by well depressed furrow; the pleural lobe is about one-half width of the axis, convex, slopes downward, and decreases in width posteriorly; the posterior border is convex, increases in width posteriorly, and is defined by a broad deep border furrow; a pair of short broad based spines extends rearly from the postero-lateral margin. The exoskeleton is covered by faint granules.

Remarks: The present species represents more than 30 cranidia and pygidia. The materials consist also of a few of *Kormagnostus* sp. specimens, but all are poorly preserved. The cranidium of *Baltagnostus beltensis* is quite different from that of *Kormagnostus* sp. and it is impossible to misidentify. The pygidium of both species closely resemble each other, and are almost indistin-



Text-fig. 3. *Baltagnostus beltensis* LOCHMAN.

a, Early meraspid pygidium, ×28; b, Late meraspid pygidium, ×12; c, d, An adult cranidium and a pygidium, ×7; e, A thoracic segment, ×8. (all drawings were made from photographs).

Explanation of Plate 29

Figs. 1–34. *Syspacheilus dunoirensis* (MILLER).

1. An anaprotaspis, notice the indistinctly developed axis. ×50, U. C. M. 40279.
2. A metaprotaspis, showing the well differentiated axial and pleural lobes. ×50, U. C. M. 40279a.

3–5. Three paraprotaspides, showing the presence of their protopygidia. 3, ×36, U. C. M. 40279b; 4, ×36, U. C. M. 40279c; 5, ×45, U. C. M. 40279d.

6–9. Four early meraspid shields, showing the presence of their anterior border and protopygidia. 6, ×30, U. C. M. 40279e; 7, ×32, U. C. M. 40279f; 8, ×25, U. C. M. 40279g; 9, ×20, U. C. M. 40279h.

10–13. A few late meraspid cranidia, showing the glabella iucreases the width from cylindrical to oblong and the surface covered with large and small granules. 10, ×19, U. C. M. 40279i; 11, ×12, U. C. M. 40279j; 12, ×18, U. C. M. 40279k; 13, ×12, U. C. M. 40279l.

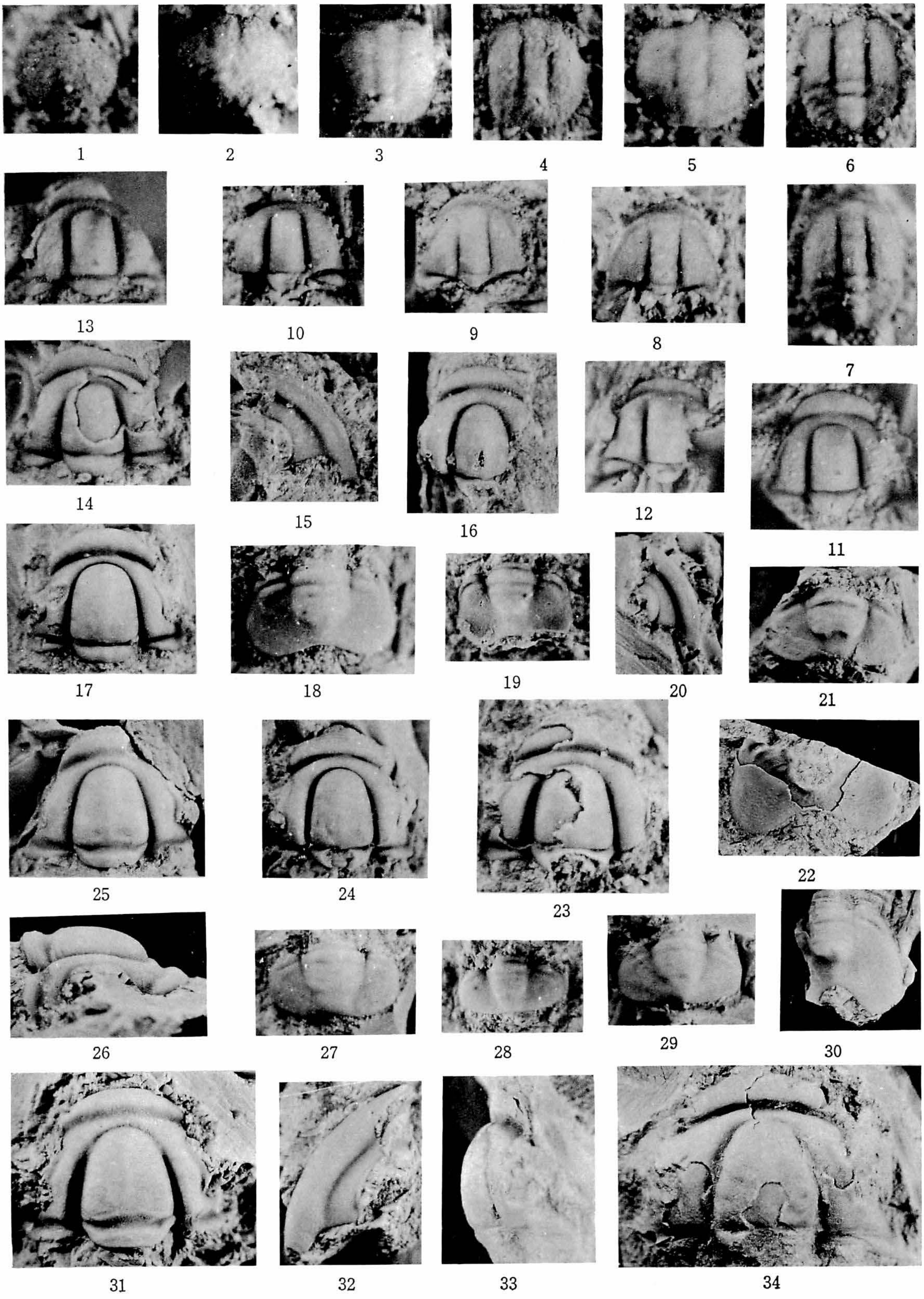
14, 23, 25, 26, 31. Four different sized male cranidia. 14, ×8, U. C. M. 40279m; 23, ×8, U. C. M. 40279v; 25, ×5, U. C. M. 40279x; 26, 31, profile and dorsal views of a cranidium, ×4, U. C. M. 40279c′.

15, 20, 32. The librigenae; male, 15, ×6, U. C. M. 40279n; 20, ×5, U. C. M. 40279s; female, 32, ×5, U. C. M. 40279e′.

18, 19, 22, 30. Four different sized female pygidia. 18, ×9, U. C. M. 40279q; 19, ×8, U. C. M. 40279r; 22, ×2, U. C. M. 40279u; 30, ×3, U. C. M. 40279b′.

16, 17, 24, 33, 34. Four different sized female cranidia. 16, ×8, U. C. M. 40279o; 17, ×6, U. C. M. 40279p; 24, ×6, U. C. M. 40279w; 33, 34, top and side views of a cranidium, ×2, U. C. M. 40279d′.

21, 27–29. Four different sized male pygidia. 21, ×4, U. C. M. 40279t; 27, ×5, U. C. M. 40279y; 28, ×8, U. C. M. 40279z; 29, ×6, U. C. M. 40279a′.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guishable. However, the present species has a slightly narrower pygidial axis and the posterior axial lobe slightly touches the border furrow, whereas the axis of *Kormagnostus* sp. is broader and running into the border furrow.

Both *Baltagnostus wyomingensis* LOCHMAN & HU and Cf. *B. wyomingensis* LOCHMAN & HU reported from Wyoming have the conical pygidial axis and are apparently the immature forms of *B. beltensis.*

Baltagnostus beltensis LOCHMAN, ontogeny

The material which I have studied contains the smallest cranidium about 1.1 mm in length and the largest one reaching to 4.0 mm (sag.), showing the continuous size variation within the limits of these scales, but morphologically they are almost without differentiation. Therefore, the cranidium gives no valuable criterion for dividing up the growth stages of the animal. The present assignations of the growth stages are based merely on the pygidium.

Early meraspid stage (Pl. 30, figs. 27–29, 31, and Text-fig. 3a).—The pygidial shield is rounded, convex, about 0.9-1.3 mm in length (sag.); the axis is conical, narrow posteriorly, and bearing an indistinct axial ring; a tiny median tubercle is borne on the second axial ring; the dorsal furrow is deep and distinct; the pleural lobe is narrower than the axis, convex, slopes downward, its posterior end is parenthetic, and holds the posterior axis; the convex posterior border increases the width posteriorly, and is well delimited by the border furrow; a pair of short spines extends posteriorly from the lateral margin. The animal skeleton is covered by faint granules. Some small pygidia are associated with thoracic segment.

Late meraspid stage (Pl. 30, figs. 30, 34, and Text-fig. 3b).—The pygidial shield is quadrate, or rounded, convex, about 1.5 to 2.5 mm in length (sag.); the axis is oblongus, consists of three indistinctly divided axial rings, but of the 1st and 2nd segments are about the same size, and the last one is the largest; the last axial segment is rounded, convex, and marked by two pairs of granules on the central surface, and a small one at the posterior median line; the pleural lobe is about-one-half the width of the axis, decreases in width from the posterior lateral margin to the posterior median furrow; the posterior border furrow is broad, convex, the posterior border is convex with a rear median notch directed to the axial terminal portion, and a pair of short marginal spines is directed rearly from the lateral margin.

The present stage differs from the early one in that the axial lobe is subquadrate, terminal segment increases in width, posterior median furrow is nearly invisible, and the pleural lobe decreases in width.

Remarks: The present species has its ontogenetic characteristics very similar to that of *Kormagnostus simplex* RESSER (HU, 1968a), except the cranidium is completely different in adult and immature morphology. The similarity of the pygidial development possibly indicates the close phylogenetic relationship between the two species, since the pygidial variations are the main taxonomic criteria for this group—the Agnostida.

PALMER (1955) divided the ontogenetic metamorphosis of *Pseudagnostus communis* (HALL & WHITFIELD) into immature and early mature stages earlier than adult form. These two stages are correlated to the present ontogenetic divisions.

Figured specimens: Cranidia, U. C. M. 40281, 40281 a-d; Thoracic segment, U. C. M. 40281k; Pygidia, U.C.M. 40281j, m; Early meraspid pygidia, U. C. M. 40281e-g, i; Late meraspid pygidia, U. C. M. 40281h, l.

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Explanation of Plate 30

Figs. 1-21. *Nixouella montanensis* LOCHMAN.

1-3, 16. Three different sized cranidia, showing the broad glabella. 1, ×7, U. C. M. 40280; 2, ×8, U. C. M. 40280a; 3, ×7, U. C. M. 40280b; 16, ×8, U. C. M. 40280c.

4-6. Three late meraspid cranidia, showing the oblong glabella. 4, ×14, U. C. M. 40280c; 5, ×12, U. C. M. 40280d; 6, ×15, U. C. M. 40280e.

7-10. Four early meraspid cranidia, showing the cylindrical glabella and the narrow anterior border. 7, ×20, U. C. M. 40280f; 8, ×25, U. C. M. 40280g; 9, ×28, U. C. M. 40280h; 10, ×27, U. C. M. 40280i.

11-13. Three paraprotaspides, showing the slightly expanded glabella and the presence of the protopygidium. 11, ×36, U. C. M. 40280j; 12, ×45, U. C. M. 40280k; 13, ×33, U. C. M. 40280l.

14. An anaprotaspis, showing the indistinctly differentiated axial and pleural lobes. ×32, U. C. M. 40280m.

15. A metaprotaspis, showing the indistinctly developed axis. ×38, U. C. M. 40280n.

17, 19. Two adult pygidia. 17, ×5, U. C. M. 40280p; 19, ×9, U. C. M. 40280r.

18, 20. Two immature pygidia. 18, ×9, U. C. M. 40280q; 20, ×20, U. C. M. 40280s.

21. A nearly complete librigena. ×11, U. C. M. 40280t.

Figs. 22-35. *Baltagnostus beltensis* LOCHMAN.

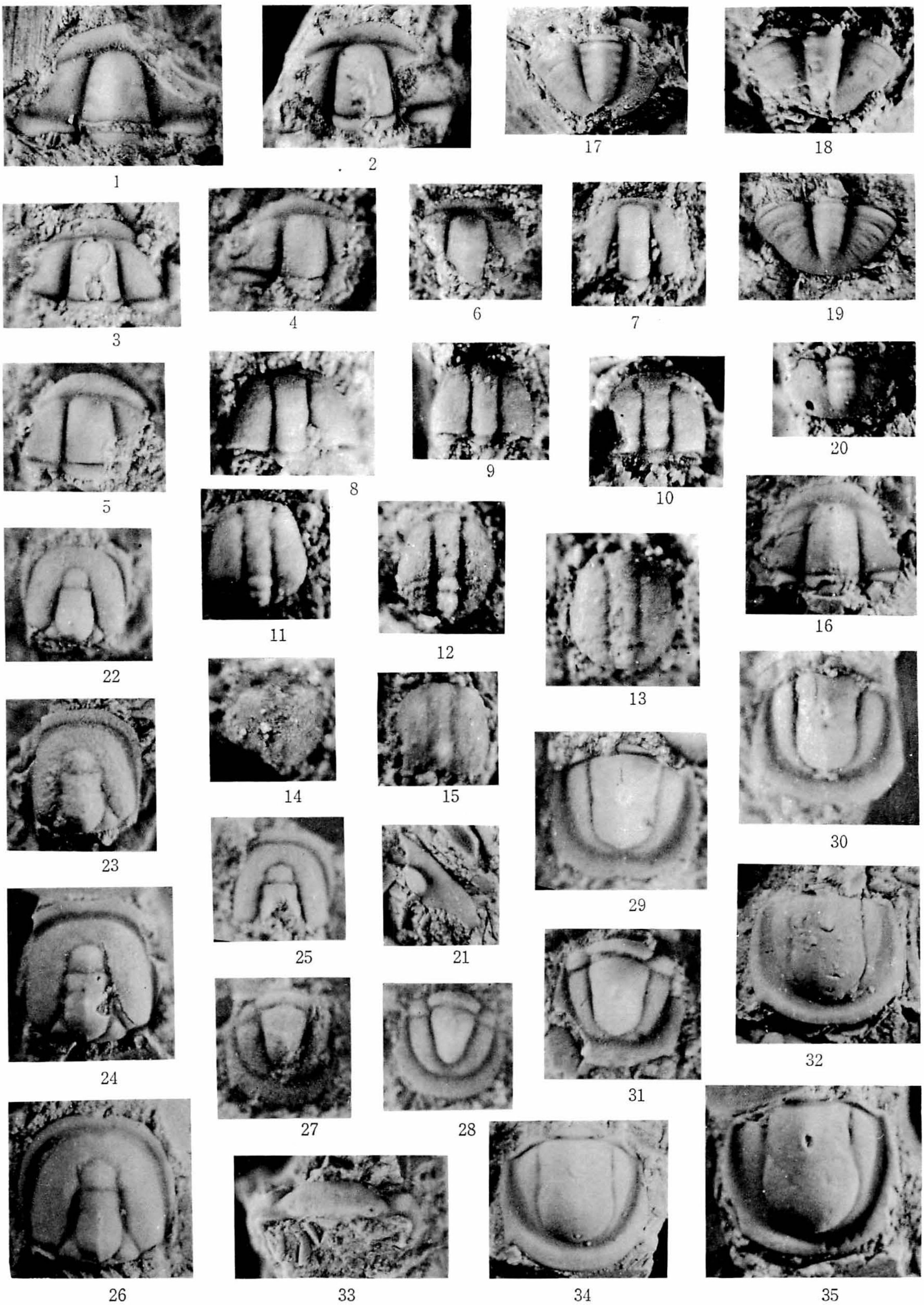
22-26. Five different sized cranidia, showing the stabilized morphogenesis within the series. 22, ×14, U. C. M. 40281; 23, ×8, U. C. M. 40281a; 24, ×9, U. C. M. 40281b; 25, ×17, U. C. M. 40281c; 26, ×7, U. C. M. 40281d.

27-29, 31. Four early meraspid pygidia, notice the conical axis. 27, ×24, U. C. M. 40281e; 28, ×25, U. C. M. 40281f; 29, ×17, U. C. M. 40281g; 31, ×21, U. C. M. 40281i.

30, 34. Two late meraspid pygidia, showing the cylindrical axis. 30, ×12, U. C. M. 40281h; 34, ×7, U. C. M. 40281l.

32, 35. Two adult pygidia, showing the slightly forwardly tapered axial lobe. 32, ×6, U. C. M. 40281j; 35, ×7, U. C. M. 40281m.

33. A complete thoracic segment. ×8, U. C. M. 40281k.



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592. ON THE *LEPIDOLINA* ZONE DISCOVERED FROM THE SHIMA PENINSULA, SOUTHWEST JAPAN*

NOBUO YAMAGIWA

Institute of Geoscience, Osaka Kyoike University

and

YUKIYASU SAKA

Institute of Earth Science, School of Education, Waseda University

志摩半島より発見された *Lepidolina* 帯について：筆者等は最近志摩半島の秩父累帯中帯に位置する鳥羽市砥谷海岸北崖の砂岩中から個体として産出する *Lepidolina kumaensis* をはじめとする *Lepidolina multiseptata multiseptata—L. kumaensis* 化石群を発見した。この砂岩中には *Yabeina* aff. *globosa* も共存している。筆者等はこれらの化石を記載すると共に，*Lepidolina* 化石群と *Yabeina* 化石群の関係についても論じた。なお，これらの化石を産する地層は従来砥谷層群（時代未詳古生界）にいれていたが，このたびの研究で，同層群からきりはなし，あらたに鳥羽層群と命名する。山 際 延 夫・坂 幸 恭

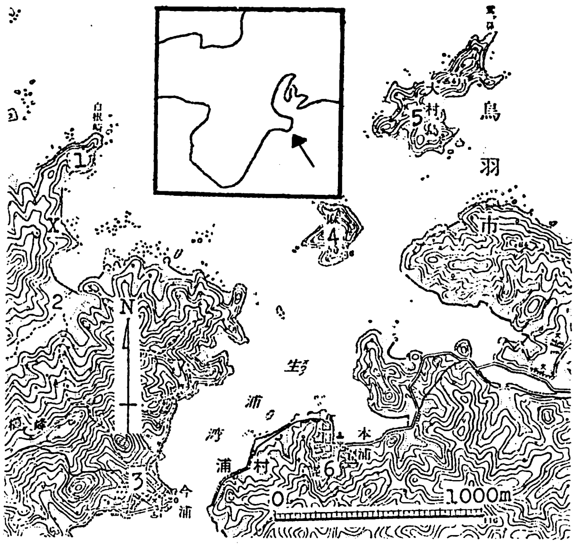
Geological summary

Previously the writers (1967) reported explanatorily on the geology and geological structure of the Chichibu terrain in the eastern part of the Shima peninsula, Kinki District. In this part of the peninsula, the Chichibu terrain is divided into the northern, middle and southern sub-belts as is that of Shikoku. Each sub-belt trends NE-SW to NNE-SSW, and is separated from each other by marked faults. Of these sub-belts, the northern one alone consists exclusively of the Palaeozoic Chichibu complex, while the other two are intercalated with narrow slices of the Mesozoic sediments between longitudinal faults, and form, as a whole, the so-called sandwich structure. The northern boundary fault of the middle sub-belt is called the Arashima-Gokasho tectonic line (YAMAGIWA, 1957), which is easily traced owing to serpentinite intruding along its whole extension. Some authors regard this tectonic line as an eastern equivalent of the Kurosegawa zone (ICHIKAWA et al., 1956) elucidated in Shikoku (e.g., HAMADA, 1963). Several lenticular bodies of serpentinite crop out sporadically along the southern marginal fault, too.

In the middle sub-belt the Jurassic and the Cretaceous strata are distributed along with the Chichibu complex. The former, trapped in a narrow strip, is correlated with the Upper Jurassic Imaura group which occupies the northern

* Received March 6, 1971; read January 25, 1969 at Tokyo and November 22, 1970 at Hiroshima.

marginal part of the southern sub-belt. The latter, named the Matsuo group, is distributed separately in three narrow zones. Its age is verified palaeontologically to be of the lower Cretaceous, Kôchian epoch.

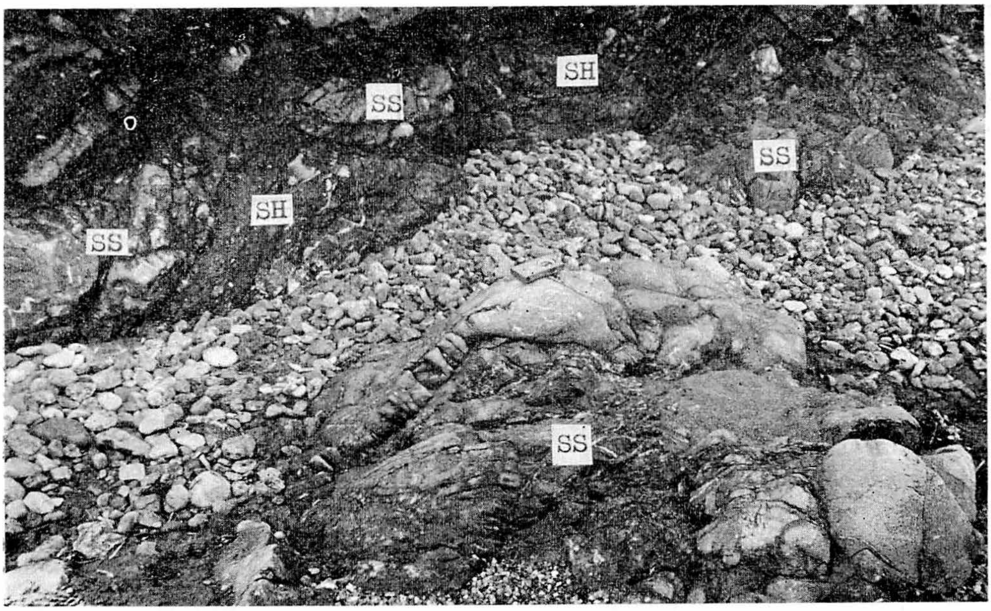


Text-fig. 1. Map showing fossil locality.
Fossil locality....X
1....Shiranezaki, 2....Toya, 3....Imaura,
4....Ogurajima, 5....Ômurajima, 6....Motoura.

The Chichibu complex constituting the middle sub-belt is known as the Horikiri, the Aonomine and the Toya groups. The Horikiri group, correlated with the Middle Carboniferous system is exposed as small lenses along the southern boundary fault. The Aonomine group constitutes two zones covering the widest area in the middle sub-belt. Several fusulinid fossils found from it indicate its age to be the Middle to Upper Permian period*. On the other hand, no useful fossils had been gained from the Toya group which is bounded both on the northern and the southern sides by the Matsuo group up to the time when the writers previously described the geology of this district. The writers, on this account, presumed the age of the Toya group to be the Permian period, judging from its lithofacies and geological situation.

Recently, the writers discovered the *Lepidolina multiseptata multiseptata*—*L. kumaensis* fauna from the strata which they had previously included in the Toya group. The strata in question are exposed in the sea-cliff on the Toya coast facing to the east and constitute the southeasternmost part of the "Toya group" on the geological map. These fusulinid-bearing strata are bounded both on the north and the south by longitudinal faults and form a small block which measures no more than 35 m in width (namely in the direction perpendicular to the general strike). On the south, they are in contact with the alternation of sandstone and shale, subordinate constituent of the Lower Cretaceous Matsuo group; on the north, in contact with the semi-schist belonging to the Toya group barren of fossils. Along the northern boundary fault, serpentinite intrudes, as is usually observed along the longitudinal faults demarcating each group within the middle sub-belt. Here in this paper, the writers, laying stress on the occurrence of this small block, and regarding it as separate from the fossil-free Toya group, propose to call it the Toba group. The writers have

* *Neoschwagerina sakaguchii* and *N. fujimotoi* were discovered from the lower part of the Aonomine group (YAMAGIWA, 1956; YAMAGIWA and SAKA, 1967), and *Yabeina katoi*, *Y. packardi shimensis* and *Y. omurensis* from the upper part (YAMAGIWA, 1956; YAMAGIWA and ISHII, 1958; YAMAGIWA and SAKA, 1967).



Text-fig. 2. The outcrop of the Toba group at Toya, Toba City, Mie Prefecture. The fossils were collected from sandstone lenses contained in the contorted shale. SS....Sandstone, SH....Shale.

confirmed the occurrence of this group in no other places than along the Toya coast, and conclude that it was squeezed out as a lenticular body along the fault which forms the boundary between the Toya group and the Matsuo group.

The Toba group consists mainly of sandstone and shale, with subordinate tuff, chert and limestone. Each stratum is so much disturbed that the abovementioned rocks except shale are torn off into irregular-shaped fragments of various sizes scattered in the contorted shale, thus showing a cataclastic conglomeratic aspects. Sandstone, frequently penetrated by calcite veins, is composed mainly of quartz- and feldspar-grains cemented by the matrix of argillaceous material. Besides occasional patches of shale, small amounts of fragments of chert, limestone igneous and metamorphic rocks are also contained. The mineral composition corresponds to that of low rank greywacke according to KRYNINE's classification. Under a microscope, grains, irregular in shape and in size, are mostly in plane-contact, rarely in suture-contact. Some quartz-grains show wavy extinction. Igneous rocks occurring as fragments in sandstone are acidic andesite and diabase, all having suffered alteration. Metamorphic rocks contained are crystalline schists of low metamorphic grade*.

Tuff is altered too, and is andesitic in texture and composition. Chert is green in colour.

Each stratum of the Toba group forms a homoclinal structure, striking N50°-70°E and either dipping steeply to the

* These metamorphic and igneous rocks will be described in detail in future after a close examination.

north or standing vertically.

Fusulinid fossils were found not from limestone which, occurring as small lenses, is crystalline and white in colour, but from small sandstone lenses contained in the contorted shale. Examination of about eighty thin sections revealed the following fossils:

Lepidolina kumaensis
Lepidolina multiseptata gigantea
Lepidolina multiseptata multiseptata
Yabeina columbiana
Yabeina aff. *globosa*
Metadoliolina gravitesta
Pachyphloia sp. indet.

Though the outer volutions of these fossils are partly broken, they are never rounded to such a degree as would be expected in case they had been transported to some distance. The writers conclude, on this account, that they are allochthonous fossils in the strict sense but not derived ones.

Geological age

The faunal assemblage of the above mentioned fossils except *Yabeina* aff. *globosa* is closely similar to that known from the Kuma formation in Kyushu (KANMERA, 1953, 1954), the Mizukoshi formation in Kyushu (YANAGIDA, 1958), the Maizuru group in Kinki (NOGAMI, 1958), the Haigyu formation in Shikoku (SUYARI, 1962) and the Iwaizaki limestone in Kitakami (CHOI, 1970a), so that the age of the Toba group is undoubtedly referred to the Upper Permian. Only disparity recognized between the Toba group and the others is that *Yabeina* aff. *globosa*, which has never been reported to occur in the latter, co-exists with other fusulinids in the Toba group, and that only the Toba group is intercalated with chert and tuff.

KANMERA (1953, 1954) divided the Upper Permian system (*Yabeina* zone) of Japan into the upper and lower sections: According to him, the lower one, characterized by the *Yabeina globosa* fauna, is represented by the *Yabeina* zone of Akasaka limestone in the Mino belt, and the upper one, characterized by the *Lepidolina toriyamai* fauna, is represented by the Kuma formation (*Lepidolina toriyamai* zone) cited above. On the other hand, HANZAWA and MURATA (1963) expressed an exactly opposite view, that is, the *Lepidolina* fauna corresponds to the *Neoschwagerina* zone which underlies the *Yabeina* zone represented by the *Yabeina globosa* fauna. YABE (1964b, 1965, 1966) and TORIYAMA (1967) regarded the *Yabeina globosa* zone represented by the Akasaka limestone as contemporaneous with the *Lepidolina toriyamai* zone represented by the Kuma formation plus the *Yabeina shiraiwensis* zone represented by the Akiyoshi limestone in Chugoku. TORIYAMA, taking note of the components of these faunal assemblages and of variance of the lithofacies, proposed the name " Kinshozan facies " for the sequence containing the *Yabeina globosa* fauna, and the " Kuma facies " for that containing the *Lepidolina toriyamai* fauna. He further advocated that the *Yabeina* zone in Japan, represented by the Kuma facies should be renamed *Yabeina shiraiwensis—Lepidolina toriyamai* zone.

Recently, OZAWA (1970) expressed a new opinion concerning the Upper Permian biofacies of Japan. According to him, the Verbeekinoidea fauna known from the Upper Permian system consists of two groups, the *Yabeina globosa* fauna and the *Lepidolina multiseptata* fauna. *Yabeina globosa*, *Y. pachardi*, *Neoschwagerina katoi*, *N. minoensis*, etc. are typical of the *Yabeina globosa* fauna. The

Lepidolina multiseptata fauna is subdivided into the *Lepidolina multiseptata shiraiwensis—Colania douvillei* fauna of the lower horizon and the *Lepidolina multiseptata multiseptata—Lepidolina kumaensis* fauna of the upper horizon. The former, represented by *Lepidolina multiseptata shiraiwensis, Colania douvillei,* etc. is considered as contemporaneous with the *Yabeina globosa* fauna. *Lepidolina kumaensis, L. multiseptata multiseptata,* etc. are representative of the latter, which, he insisted, is the most evolved type of Verbeekinoidea. Here, what the writers should pay special attention to is that, according to OZAWA, no cases are known where the *Yabeina globosa* co-exists with the *Lepidolina multiseptata* fauna.

Several problems are left unsolved on the biostratigraphy and biofacies of the Upper Permian *Yabeina* zone in Japan, as the writers have reviewed above.

The *Lepidolina*-bearing fauna that the writers lately found from the Toba group is exactly alike that from the Kuma formation in Kyushu with respect to its faunal assemblage, and is considered to correspond to the *Lepidolina multiseptata multiseptata—Lepidolina kumaensis* zone of OZAWA. Occurrence of *Yabeina* aff. *globosa* in this fauna is worthy to note, because, as OZAWA already pointed out, there has ever been known no parallel case on record where *Yabeina globosa* occurs in the *Lepidolina multiseptata* fauna. The fact that *Yabeina* aff. *globosa* co-exists with the members of the *Lepidolina multiseptata* fauna in the Toba group may contribute to the interpretation of the Upper Permian stratigraphy and biofacies in Japan. Also, it is interesting that, as already stated, the Toba group, consisting mainly of sandstone and mudstone with minor amounts of chert and tuff, shows some lithological difference from the Kuma formation and other stratigraphic units characterized by the *Lepidolina multiseptata multiseptata—Lepidolina kumaensis* fauna.

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Systematic description

Order Foraminiferida

Suborder Fusulinina VON MÖLLER, 1878

Superfamily Verbeekinoidea STAFF and WEDEKIND, 1910

Family Neoschwagerinidae DUNBAR and CONDRA, 1928

Subfamily Lepidolininae MIKLUKHO-MAKLAY, 1958

Genus *Lepidolina* LEE, 1933

Lepidolina multiseptata gigantea (GUBLER)

Plate 31, fig. 1

1935. *Neoschwagerina megaspherica* var. *gigantea* GUBLER, *Mem. Soc. Géol. France, Nov. Ser.*, T. 11, Fasc. 4, pp. 116–118, pl. 3, figs. 6, 8, 10?.
1935. *Neoschwagerina douvillei* GUBLER, *Ibid.*, pp. 111–113, pl. 7, figs. 7, 8, pl. 8, fig. 6; pl. 6, fig. 2?; pl. 7, fig. 10?; pl. 8, fig. 10?.
1954. *Yabeina gubleri* KANMERA, *Mem. Fac. Sci. Kyushu Univ., Ser. D*, vol. 4, no. 1, pp. 19–21, pl. 4, figs. 1–13.
1958. *Yabeina gubleri*: NOGAMI, *Mem. Coll. Sci. Univ. Kyoto, Ser. B*, vol. 25, no. 2, pp. 103–104, pl. 1, figs. 5–6.
1960. *Yabeina gubleri*: CHISAKA, *Jour. Coll. Art. Sci. Chiba Univ.*, vol. 3, no. 2, pp. 250–251, pl. 6, figs. 1–4; pl. 7, figs. 1–6; pl. 8, figs. 1–5.
1964. *Yabeina multiseptata gigantea*: ISHII and NOGAMI, *Jour. Geosci. Osaka City Univ.*, vol. 8, Art. 2, pp. 20–22, pl. 6, figs. 1–4.

Description:—Shell is large, elongate fusiform with inflated central part; their lateral slopes gently concave. Inner two volutions are spherical or subspherical, and the third to fifth are inflated fusiform. Beyond the 6th volution shell form resembles its mature shape. Several outer volutions are missing. The specimen illustrated as fig. 1 on Plate 31 is 9.2 mm in length and 3.5 mm in width, giving a form ratio of 2.6. Proloculus is large; with outside diameter of 0.45 to 0.65 mm. Spirotheca is thin, composed of a tectum and a thin keriotheca with fine alveoli, measuring 0.005 to 0.01 mm. The heights of the first to the 11th volution of the above mentioned specimen are 0.10, 0.10, 0.12, 0.12, 0.12, 0.10, 0.15, 0.16, 0.19, 0.18 and 0.17 mm, respectively. Axial septula and primary transverse septula present throughout shell and slender. Primary transverse septula come into contact with the top of parachomata. Secondary transverse septula were first 2nd volution: and one septulum developed between adjacent primary ones, but beyond the fourth volution one to two ones are generally present; they are of generally bar-like shape, but in rare cases pendant shaped.

Remarks:—The distinct characters of the present specimens are their large proloculus, very thin spirotheca and elongate fusiform with inflated central part. The features mentioned above pratically agree with those of *Lepidolina multiseptata gigantea* (GUBLER, 1935; KANMERA, 1954; NOGAMI, 1958; CHISAKA, 1960; ISHII & NOGAMI, 1964) from the Upper Permian of Japan and Cambodia. The present form closely resembles *L. kumaensis* KANMERA (KONISHI, 1952; KANMERA, 1954; YANAGIDA, 1958; NOGAMI, 1958; CHISAKA, 1960; SUYARI, 1962; HASEGAWA, 1965; CHOI, 1970a; YAMAGIWA & SAKA, in this paper) and *L. multiseptata multiseptata* (DEPRAT, 1912, 1914; OZAWA, 1922; COLANI, 1924; GUBLER, 1935; THOMPSON, 1948; SKINNER & WILD, 1954; ISHII & NOGAMI, 1964; SADA & YOKOYAMA, 1966; YAMAGIWA & SAKA, in this paper) in its large proloculus, very thin spirotheca and other important characters. However, the former one can be distinguished from the latter, having elongate fusiform with inflated central part.

ISHII and NOGAMI (1964) described this species under the generic name of *Yabeina* and then they divided it into three subspecies, namely *Y. multiseptata multiseptata*, *Y. multiseptata gigantea* and *Y. multiseptata shiraiwensis*. Very recently, OZAWA (1970) discussed the difference between *Yabeina* and *Lepidolina*. According to him, *Lepidolina* is distinguished from *Yabeina* by having larger proloculus in the megalospheric generation, larger, elongate shell of the microspheric generation and the essential difference in the thickness and shape of septa and septula. In the above respects, this subspecies should be referred to *Lepidolina*. The present specimens are megalospheric form.

Occurence:—The present specimens occur from the Toba group at Toya, Toba City, Mie Prefecture, Southwest Japan. The present form is associated with *Lepidolina kumaensis*, *L. multiseptata multiseptata*, *Yabeina columbiana*, *Yabeina* aff. *globosa*, *Metadoliolina gravitesta* and *Pachyphloia* sp. indet.

Repository:—It is deposited in the collection of the Institute of Geoscience, Osaka Kyoiku University. Reg. nos. 71001, 71002, 71003.

Lepidolina multiseptata multiseptata (DEPRAT)

Plate 31, fig. 2

1912. *Neoschwagerina (Sumatrina) multiseptata*, DEPRAT, *Mém. Serv. Géol. Indochine*, vol. 1, fasc. 3, pp. 53-55, pl. 3, figs. 2-8.
1914. *Neoschwagerina (Sumatrina) multiseptata*, DEPRAT, *Ibid.*, vol. 3, fasc. 1, pp. 34-35, pl. 5, figs. 7-11.
1922. *Neoschwagerina (Yabeina) hayasakai*, OZAWA, *Geol. Soc. Tokyo, Jour.*, vol. 29, no. 348, pp. 369-370, pl. 4, fig. 2.
1924. *Neoschwagerina multiseptata*: COLANI, *Mém. Serv. Géol. Indochine*, vol. 11, fasc. 1, pp. 154-155, pl. 15, fig. 1; pl. 24, figs. 12-13; pl. 25, figs. 1-8, 10-12, 14-15; pl. 26, figs. 1-2, 4, 6-18.
1935. *Neoschwagerina multiseptata*: GUBLER, *Mém. Soc. Géol. France, Nov. Ser.* T. 11, fasc. 4, pp. 119-123, pl. 3, fig. 5; pl. 6, figs. 1, 3, 8-10; pl. 7, fig. 5.
1935. *Neoschwagerina megasphaerica*, GUBLER, *Ibid.*, pp. 114-116, pl. 7, fig. 3; pl. 6, fig. 4.
1948. *Neoschwagerina multiseptata*: THOMPSON, *Protozoa, Art. 1, Univ. Kansas*, pp. 66-67, pl. 20, figs. 5-6; pl. 22, figs. 1-5.
1954. *Lepidolina multiseptata*: SKINNER and WILD, *Jour. Paleont.*, vol. 28, no. 4, pp. 449-450, pl. 52, figs. 1-5.
1954. *Yabeina yasubaensis*, KANMERA, *Mem. Fac. Sci. Kyushu Univ., Ser. D*, vol. 4, no. 1, pp. 18-19, pl. 2, figs. 10-13; pl. 5, figs. 14-19.
1964. *Yabeina multiseptata multiseptata*: ISHII and NOGAMI, *Jour. Geosci. Osaka City Univ.*, vol. 8, Art. 2, pp. 17-20, pl. 3, figs. 1-3; pl. 4, figs. 1-3; pl. 5, figs. 1-4.
1966. *Yabeina multiseptata multiseptata*: SADA and YOKOYAMA, *Trans. Proc. Paleont. Soc. Japan, N. S.*, no. 63, pp. 304-307, pl. 33, figs. 4-5, 7-8.

Description:—Shell is medium, inflated fusiform. Inner two or three volutions are spherical or subspherical, and beyond 5th volution shell form resembles its mature shape. A few outer volutions are missing. Shell at 11th volution in our typical specimen (Plate 31, fig. 2) is 6.0 mm in length and 3.6 mm in width; form ratio about 1.7. Proloculus is large and spherical. Its outside diameter is 0.45 to 0.65 mm. The heights of the first to the 11th volution are 0.13, 0.13, 0.14, 0.12, 0.14, 0.15, 0.17, 0.18, 0.19, 0.20 and 0.17 mm, respectively. Spirotheca is very thin, composed of a tectum and a keriotheca with very fine alveoli. Thickness of spirotheca is 0.01 mm in outer volutions. Septa, axial septula and primary transverse septula present throughout shell and slender. Secondary transverse septula first appear in the second volution. One septulum occurs between adjacent primary ones in inner volutions and one or two septula occur in outer volutions. Parachomata come into contact with the top of primary transverse septula near the center of chamber.

Remarks:—The present subspecies closely resembles *Lepidolina multiseptata shiraiwensis* (OZAWA, 1925; FUJIMOTO, 1936; TORIYAMA, 1942, 1958; CHEN, 1956; MORIKAWA, 1956, 1958; NOGAMI, 1958, 1961; CHISAKA, 1960, 1962; ISHII & NOGAMI, 1961, 1962; SADA & YOKOYAMA, 1966; CHOI, 1970) in many important respects, but differs from the latter in having larger proloculus and thinner spirotheca. It is similar to *L. multiseptata gigantea* (GUBLER, 1935; KANMERA, 1954; NOGAMI, 1958; CHISAKA, 1960; ISHII & NOGAMI, 1964; YAMAGIWA & SAKA, in this paper). However, the former one differs from the latter, having inflated fusiform in shape. The present specimens are megalospheric form.

Occurrence:—These specimens found in the Toba group at Toya, Toba City, Mie Prefecture, Southwest Japan; the associated fossils are *Lepidolina kumaensis, L. multiseptata gigantea, Yabeina columbiana, Y.* aff. *globosa, Metadoliolina gravitesta* and *Pachyphloia* sp. indet.

Repository:—The present form is deposited in the collection of the Institute of Geoscience, Osaka Kyoiku University. Reg. nos. 71004, 71005, 71006, 71007.

Lepidolina kumaensis KANMERA

Plate 31, fig. 3

1952. cfr. *Sumatrina annae*, KONISHI, *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 5, pp. 159-161, pl. 14, figs. 2-5, 7.
1954. *Lepidolina kumaensis*, KANMERA, *Mem. Fac. Sci. Kyushu Univ., Ser. D*, vol. 4, no. 1, pp. 22-24, pl. 5, figs. 1-13.
1954. *Lepidolina toriyamai*, KANMERA, *Ibid.*, pp. 24-26, pl. 6, figs. 1-19.
1958. *Lepidolina* cfr. *toriyamai*: YANAGIDA, *Jour. Geol. Soc. Japan*, vol. 64, no. 752, p. 228, text-fig. 2.
1958. *Lepidolina kumaensis*: NOGAMI, *Mem. Coll. Sci. Univ. Kyoto, Ser. B*, vol. 25, no. 2, pp. 104-105, pl. 2, figs. 8-9.
1958. *Lepidolina toriyamai*: NOGAMI, *Ibid.*, pp. 105-106, pl. 1, figs. 1-2.
1958. *Lepidolina toriyamai maizuruensis*, NOGAMI, *Ibid.*, p. 106, pl. 2, figs. 1-5.
1960. *Yabeina proboscis*: CHISAKA, *Jour. Coll. Art. Sci. Chiba Univ.*, vol. 3, no. 2, pp. 252-253, pl. 9, figs. 1-3.
1962. *Lepidolina kumaensis*: SUYARI, *Jour. Gakugei Tokushima Univ.*, vol. 12, pp. 38-39, pl. 12, figs. 2-4.
1965. *Lepidolina kumaensis*: HASEGAWA, *Chikyu Kagaku*, no. 76, pp. 27-32, pl. 1, fig. 1-5, pl. 2.
1970. *Lepidolina kumaensis*: CHOI, *Jour. Fac. Sci. Hokkaido Univ., Ser. 4*, vol. 14, no. 3, pp. 321-324, pl. 5, figs. 1-9, pl. 6, fig. 1.

Description:—Shell is moderately large, elongate subcylindrical form. A few outer volutions are crushed away. Inner two volutions are spherical or subspherical, and beyond the 4th volution shell form resembles its mature shape. Mature specimen (Plate 31, fig. 3) having 10 volutions is 6.2 mm in length and 2.1 mm in width: with form ratio of about 3.0. Proloculus is large, spherical in shape; its outside diameter about 0.3 mm. The heights of the first to the 10th volution of the above mentioned one are 0.05, 0.06, 0.05, 0.07, 0.09, 0.10, 0.12, 0.10, 0.11 and 0.12 mm, respectively. Spirotheca is very thin, composed of a tectum and a extremely very finely alveolar keriotheca, but partly of a single layer. Thickness of the spirotheca never exceeds 0.01 mm in the whole volutions. Primary transverse septula occur throughout shell. Secondary transverse septula appear first in the third and two (sometimes three) of them developed between adjacent primary transverse septula in the 6th to the outer volutions. They are pendant or thin bar-like shaped. Parachomata occur throughout shell, and they come into contact with the top of primary transverse septula near the center of chamber.

Remarks:—The present specimen is characterized by its large proloculus, elongate subcylindrical fusiform in shape and very thin spirotheca. These features practically agree with those of *Lepidolina kumaensis* KANMERA from the Kuma formation (KANMERA, 1954) and other Upper Permian in Japan (NOGAMI, 1958; YANAGIDA, 1958; SUYARI, 1962; HASEGAWA, 1965; CHOI, 1970). It is closely similar to *L. multiseptata gigantea* (GUBLER, 1935; KANMERA, 1954; NOGAMI, 1958; CHISAKA, 1960; ISHII & NOGAMI, 1964; YAMAGIWA & SAKA, in this paper) in many important characters. The former is, however, different from the latter in having elongate subcylindrical fusiform in shape. It is a megalospheric specimen.

Occurrence:—A specimen was obtained from the Toba group at Toya, Toba City, Mie Prefecture, Southwest Japan. It is associated with *Lepidolina multiseptata gigantea*, *L. multiseptata multiseptata*, *Yabeina columbiana*, *Y.* aff. *globosa*, *Metadoliolina gravitesta* and *Pachyphloia* sp. indet.

Repository:—It is deposited in the collection of the Institute of Geoscience, Osaka Kyoiku University. Reg. no. 71008.

Subfamily Neoschwagerininae DUNBAR and CONDRA, 1928

Genus *Yabeina* DEPRAT, 1914

Yabeina columbiana (DAWSON)

Plate 31, fig. 4

1879. *Loftusia columbiana*, DAWSON, *Qaurt. Jour. Geol. Soc. London*, vol. 35, pp. 69–75, pl. 6, figs. 1–7.
1942. *Yabeina columbiana*: THOMPSON and WHEELER, *Jour. Paleontology*, vol. 16, no. 6, pp. 708–710, pl. 106, fig. 5; pl. 107, fig. 5; pl. 108, fig. 1; pl. 109, figs. 1–4.
1950. *Yabeina columbiana*: THOMPSON, WHEELER and DANNER, *Contribution from the Cushman Foundation for Foraminifera Research*, vol. 1, pls. 3–4, pl. 61, pl. 8, figs. 1–3.
1954. *Yabeina columbiana*: KANMERA, *Mem. Fac. Sci. Kyushu Univ., Ser. D*, vol. 4, no. 1, pp. 16–18, pl. 3, figs. 1–7.
1958. *Yabeina columbiana*: NOGAMI, *Mem. Coll. Sci. Univ. Kyoto, Ser. B*, vol. 24, pp. 101–102, pl. 1, figs. 9–10.
1960. *Yabeina columbiana*: CHISAKA, *Jour. Coll. Art. Sci. Chiba Univ.*, vol. 3, no. 2, p. 249–251, pl. 7, fig. 3.

Description:—Shell is medium in size, inflated fusiform. Several outer volutions are missing. A specimen (Plate 31, fig. 4) of 11 volutions is 4.7 mm in length and 3.1 mm in width; form ratio 1.5. Proloculus is small, spherical in shape; its outside diameter is 0.14 mm. The heights of the first to the 11th volution of the above mentioned one are 0.05, 0.07, 0.07, 0.11, 0.14, 0.14, 0.17, 0.15, 0.16, 0.16 and 0.17 mm, respectively. Spirotheca is thin, composed of a tectum and a thin keriotheca with fine alveoli. Thickness of the spirotheca is 0.01 to 0.015 mm in outer volutions. Primary transverse septula are present throughout shell. Secondary transverse one first appear in the fourth volution, and there is one secondary transverse one in most cases between adjacent primary transverse ones. They are rather irregular in shape. Parachomata extend to the top of the primary transverse one near the center of the chamber.

Remarks:—The present specimen is closely allied to *Yabeina columbiana* (DAWSON) described and illustrated from the Upper Permian of Japan (KANMERA, 1954; NOGAMI, 1958; CHISAKA, 1960) and British Columbia (THOMPSON & WHEELER, 1942; THOMPSON, WHEELER & DANNER, 1950) in having small proloculus, inflated fusiform, relatively thin spirotheca and other important respects. It resembles *Yabeina globosa* (YABE, 1906; OZAWA, 1927; FUJIMOTO, 1936; MORIKAWA & SUZUKI, 1961; SUYARI, 1962). However, the former one can be distinguished from the latter by its larger proloculus, thinner spirotheca and more loosely coiled inner voluions.

Occurrence:—A specimen was obtained from the Toba group at Toba, Toba City, Mie Prefecture, Southwest Japan. It is associated with *Lepidolina kumaensis*, *L. multiseptata gigantea*, *L. multiseptata multiseptata*, *Yabeina* aff. *globosa*, *Metadoliolina gravitesta* and *Pachyphloia* sp. indet.

Repository:—It is deposited in the collection of the Institute of Geoscience, Osaka Kyoiku University. Reg. no. 71009.

Yabeina aff. *globosa* (YABE)

Plate 32, figs. 1-6

1906. *Neoschwagerina globosa*, YABE, *Jour. Coll. Sci. Imp. Univ. Tokyo*, vol. 21, no. 5, p. 4, fig. 4, pl. 2, fig. 1.

1927. *Neoschwagerina globosa*: OZAWA, *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2*, vol. 2, pp. 159-160, pl. 42, figs. 1-2, 4, 6.

1936. *Yabeina globosa*: FUJIMOTO, *Sci. Rept. Tokyo Bunrika Daigaku, Sec. C*, vol. 1, pp. 119-120, pl. 24, fig. 25, figs. 1-4.

1961. *Yabeina globosa*: MORIKAWA and SUZUKI, *Sci. Rept. Saitama Univ., Ser. B*, vol. 4, no. 1, pp. 67-68, pl. 10, fig. 2, pl. 21, fig. 1.

1962. *Yabeina globosa*: SUYARI, *Jour. Gakugei, Tokushima Univ., Nat. Sci.*, vol. 12, pp. 37-38, pl. 12, fig. 1.

Description:—Shell is medium and fusiform; with bluntly pointed poles, straight axis of coiling. Lateral slopes of mature shell are nearly straight and slightly convex. Several outer volutions are missing. Inner three volutions are spherical or subspherical, and beyond the 3rd volution shell form resembles its mature stage. The specimen illustrated as fig. 1 on Plate 32 is 3.9 mm in length and 2.7 mm in width, with form ratio of 1.4. Proloculus is small, spherical or subspherical in shape, with outside diameter of 0.02 to 0.04 mm. The heights of the first to the 12th volution of the above mentioned specimen are 0.04, 0.03, 0.045, 0.07, 0.10, 0.10, 0.105, 0.14, 0.15, 0.17, 0.20 and 0.15 mm, respectively. Spirotheca is rather thin, composed of a tectum and a keriotheca with very fine alveoli, measuring about 0.02 to 0.03 mm in later stage. Septal count is difficult because of numerous axial septula. Axial septula first appear in the 6th volution. Primary transverse septula present throughout shell. Secondary transverse septula first appear in the 6th or 7th volution; there is one septulum between two adjacent primary transverse ones, but in rare cases the two occur in outer volutions. Parachomata occur throughout shell; they come into contact with the top of the primary transverse septula near the center of chamber.

Remarks:—The present form is closely

similar to *Yabeina globosa* (YABE, 1906; OZAWA, 1927; FUJIMOTO, 1936; MORIKAWA & SUZUKI, 1961; SUYARI, 1962) in having small proloculus, inflated fusiform in shape, rather thin spirotheca and other characters. However, the former one is represented by the specimens whose several outer volutions are missing, so the detailed characters can not be determined with accuracy. It resembles closely *Yabeina* sp. indet. described and illustrated from the Tsuiji group (Upper Permian) in the southern sub-belt of the Chichibu terrain in Shima Peninsula by YAMAGIWA (1969) in many improtant characters. The latter one may belong to *Yabeina globosa*.

Occurrence:—The present specimens occurred from the Toba group at Toya, Toba City, Mie Prefecture, Southwest Japan. The associated fossils are *Lepidolina kumaensis*, *L. multiseptata gigantea*, *L. multiseptata multiseptata*, *Yabeina columbiana*, *Metadoliolina gravitesta* and *Pachyphloia* sp. indet..

Repository:—They are deposited in the collection of Geoscience, Osaka Kyoiku University. Reg. nos. 71010, 71011, 71012, 71013, 71014, 71015.

Family Verbeekinidae STAFF and WEDEKIND, 1910

Subfamily Misellininae MIKLUKHO-MAKLAY, 1958

Genus *Metadoliolina* ISHII and NOGAMI, 1961

Metadoliolina gravitesta (KANMERA)

Plate 31, figs. 5–6

1954. *Pseudodoliolina pseudolepida gravitesta*, KANMERA, *Mem. Fac. Sci., Kyushu Univ., Ser. D*, vol. 4, no. 1, pp. 12–14, pl. 2, figs. 1–6.
1954. *Pseudodoliolina* n. sp. ?, KANMERA, *Ibid.*, pp. 14–15, pl. 2, figs. 7–8.
1954. *Verbeekina?* n. sp., KANMERA, *Ibid.*, pp. 15–16, pl. 2, fig. 9.
1960. *Pseudodoliolina pseudolepida gravitesta*: CHISAKA, *Jour. Coll. Art. Sci. Chiba Univ.*, vol. 3, no. 2, p. 246, pl. 4, figs. 1–6.
1961. *Metadoliolina gravitesta*: ISHII and NOGAMI, *Trans. Proc. Palaeont. Soc. Japan*, *N. S.*, no. 44, pp. 163–164, pl. 25, figs. 1–4.

Description:—Shell is medium, elongate ellipsoidal and broadly rounded polar regions. Inner three volutions are spherical or subspherical, and beyond the fourth volution shell form resembles its mature stage. A specimen of 10 volutions is 4.7 mm in length and 1.9 mm in width; form ratio about 2.6. Perhaps a few outer volutions are missing. Proloculus is small, spherical, and its outside diameter is 0.20 mm. The heights of the first to the 10th volution are 0.05, 0.04, 0.07, 0.07, 0.08, 0.09, 0.12, 0.13, 0.14 and 0.16 mm, respectively. Spirotheca is rather thick, composed of a thin tectum and a thin keriotheca with very fine alveoli. In outer volutions, the upper surface of the tectum is coated with a more or less discontinuous layer of dense material which is continuous with parachomata. Thickness of the spirotheca in the fourth to the 10th volution are 0.01, 0.01, 0.007, 0.10, 0.01, 0.015 and 0.02 mm, respectively. Parachomata are well developed, and heights of them are a half of the heights of the chamber; they are massive.

Remarks:—This form is represented by an axial section and another transverse section alone. It is referable to *Metadoliolina gravitesta* (KANMERA, 1954; CHISAKA, 1960; ISHII & NOGAMI, 1961) from the Upper Permian in Japan. The two ones are closely similar to each other in having relatively thick spirotheca, elongate ellipsoidal form in shaps, small proloculus, tightly coiling in inner volutions and other important characters.

Occurrence:—The present specimens have been obtained from the Toba group at Toya, Toba City, Mie Prefecture, Southwest Japan. It is associated with *Lepidolina kumaensis*, *L. multiseptata gigantea*, *L. multiseptata multiseptata*, *Yabeina columbiana*, *Y.* aff. *globosa* and *Pachyphloia* sp. indet..

Repository:—The present ones are deposited in the collection of the Institute of Geoscience, Osaka Kyoiku University. Reg. nos. 71016, 71017.

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Explanation of Plate 31

Fig. 1. *Lepidolina multiseptata gigantea* (GUBLER).
Axial section.... ×15

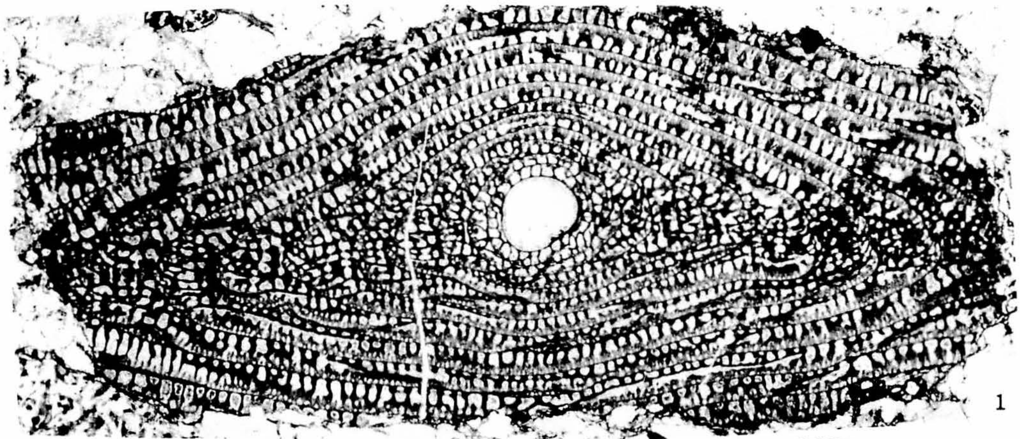
Fig. 2. *Lepidolina multiseptata multiseptata* (DEPRAT).
Axial section.... ×15

Fig. 3. *Lepidolina kumaensis* KANMERA.
Axial section.... ×15

Fig. 4. *Yabeina columbiana* (DAWSON).
Axial section.... ×15

Figs. 5-6. *Metadoliolina gravitesta* (KANMERA).
5. Transverse section.... ×20
6. Axial section.... ×20

Fig. 7. *Pachyphloia* sp. indet.
Transverse section?.... ×40



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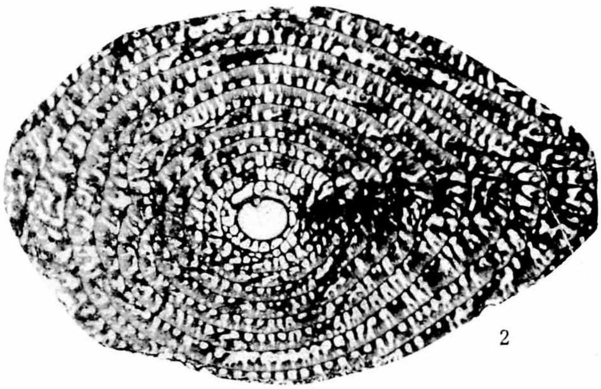

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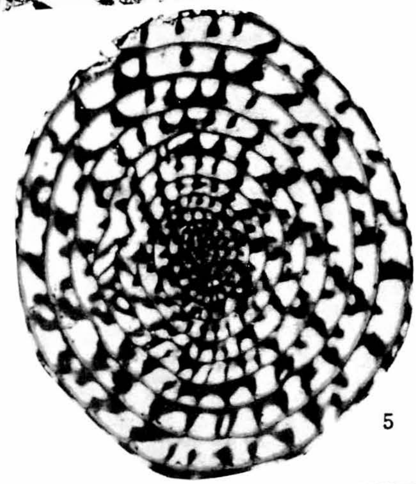

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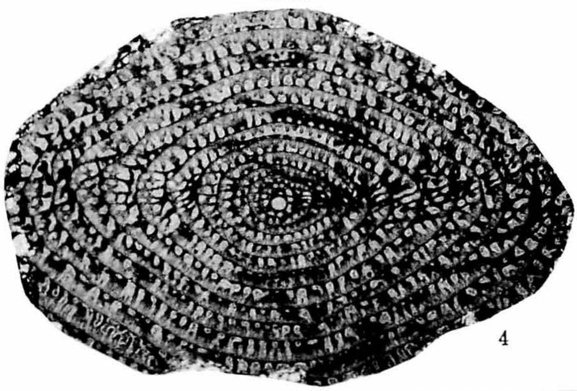

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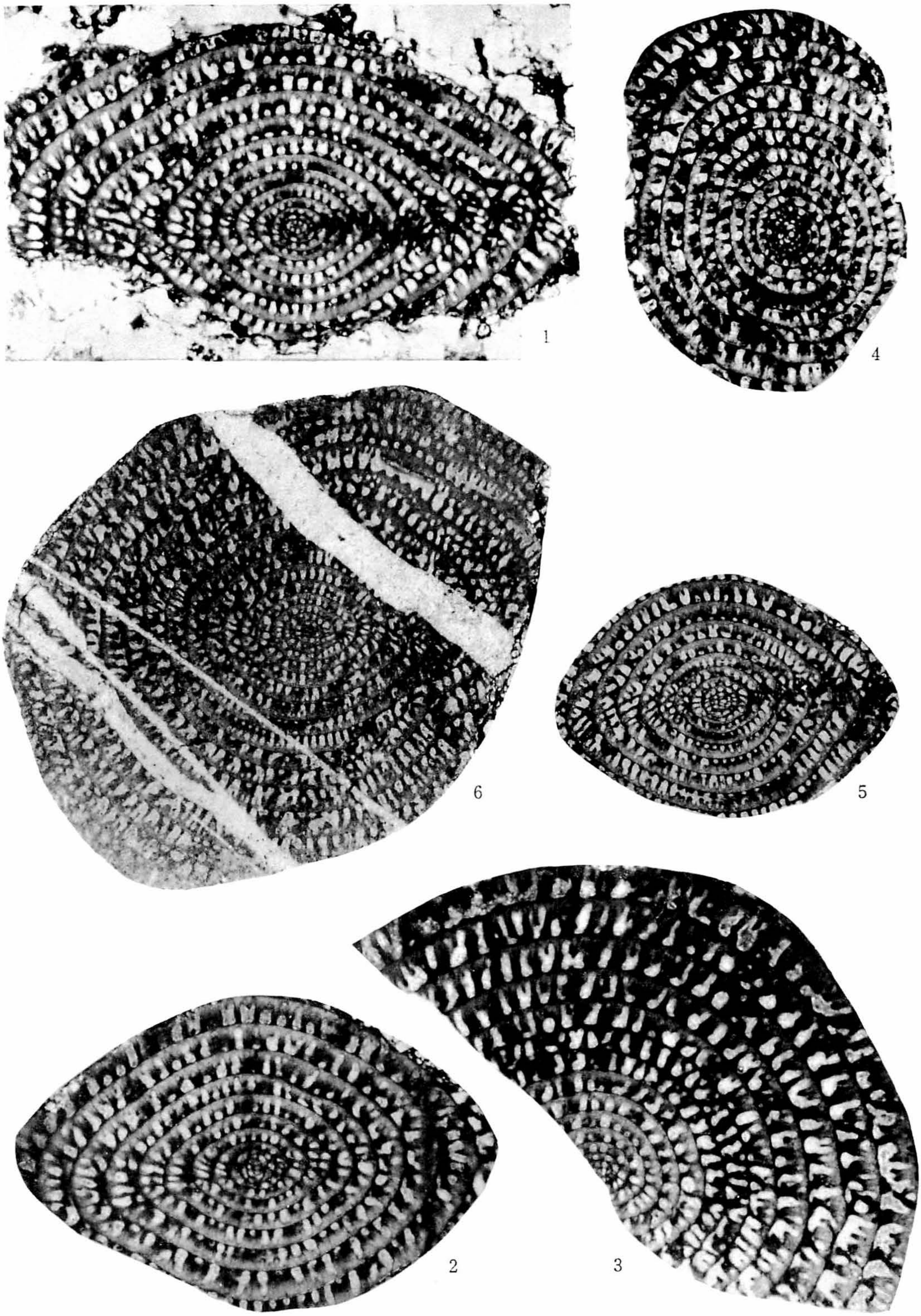
Imaura	今 浦	Shiranezaki	白根崎
Motoura	本 浦	Toba	鳥 羽
Ogurajima	麻倉島	Toya	砥 谷
Ômurajima	大村島		

Explanation of Plate 32

Figs. 1–6. *Yabeina* aff. *globosa* (YABE).
1. Axial section.... ×20
2. Axial section.... ×20
3. Tangential section (somewhat oblique).... ×24
4. Sagittal section.... ×20
5. Tangential section.... ×15
6. Tangential section (somewhat oblique).... ×15



Trans. Proc. Palaeont. Soc. Japan, N. S., No. 85, pp. 275-279, pl. 33, April 20, 1972

593. THE TRIASSIC BRYOZOA FROM KUSAKA, SAKAWA BASIN, SHIKOKU, JAPAN

SUMIO SAKAGAMI

Department of Geology, Faculty of Education, Ehime University, Matsuyama, Japan

四国佐川盆地日下産三畳紀こけ虫：かつて小林貞一博士が佐川盆地日下（柏井）から発見し，*Ceriopora* sp. として報告（未記載）した標本（薄片6枚）について検討した結果，それが *Pseudobatostomella* 属の新種であることが判明したので，*Pseudobatostomella kobayashii* SAKAGAMI と命名して記載報告する。

三畳紀のこけ虫は，1963年 FLÜGEL によって総括されたが，その後，カナダの Ellesmere 島とソビエトの数地から 11 種が記載報告されている。この論文では FLÜGEL (1963) 以後のこれらの三畳紀こけ虫について総括し，あわせて北海道日高層群中から杉山敏郎博士によって記載されたこけ虫（*Batostomella* 属として未定 3 種）のうち 1 種が *Pseudob. kobayashii* に酷似することから，日高産こけ虫の地質時代は二畳紀ではなく三畳紀であることが暗示されるので再検討を要することを述べる。　坂 上 澄 夫

Introduction and acknowledgements

Some 25 years ago, Dr. Teiichi KOBAYASHI discovered a small bryozoan fauna in a sandstone of the *Oxytoma-Mytilus* beds of the Upper Triassic Kochigatani series at Kusaka in the eastern part of the Sakawa basin, Shikoku island, Japan. They were identified by him with *Ceriopora* sp. and reported in 1948 and 1949, but without description.

Recently, Dr. KOBAYASHI sent me the "*Ceriopora*" bearing thin sections for study and the present article is a result of the examination.

Before going into the description, I would like to express my sincere thanks to Dr. Teiichi KOBAYASHI, Professor Emeritus of the University of Tokyo for his kindness in giving me the opportunity for study of the present materials. I am also deeply indebted to Professor Kotora HATAI of the Tohoku University for kindly reading the manuscript and for his constant encouragement.

Received March 6, 1971; read October 22, 1971 at Fukuoka.

Description of species

Pseudobatostomella kobayashii SAKAGAMI, n. sp.

Plate 33, figs. 1-6.

1948. *Ceriopora* sp., KOBAYASHI, p. 176.
1949. *Ceriopora* sp., KOBAYASHI, p. 137.

Six thin sections of fragmentary zoaria were examined. Zoaria probably incrusting in some parts, but consisting of cylindrical stem, about 2.5 to 3.0 mm in diameter. Zooecial tubes subangularly oval in tangential section, their shorter diameter usually ranging from

0.200 to 0.250 mm, 0.150 mm in minimum diameter, and nearly straight or somewhat curved outward from the inner region. Zooecial wall very thin in very short distance of immature region, and gradually thickened to mature region. Mesoecia rare, usually circular, their diameter ranging from 0.040 to 0.100 mm. Well developed acanthoecia surrounded by concentric fibrous tissue, ranging from 0.040 to 0.080 mm in outer diameter, less than 0.010 mm in inner (pore) diameter, irregularly arranged in wall and in some cases disposed at wall margin where zooecial tubes angularly shaped. Diaphragms very thin, at intervals of 0.25 to 0.45 mm.

Remarks:—The present species seems to be near to *Pseudobatostomella jakutica* (LAZUTKINA) (1963) from the Lower Triassic (Induan) of Siberia and *Pseudobatostomella morbosa* MOROZOVA (1969) from the Upper Triassic (Carno-Noric) of the southeastern part of Pamir in their general appearances, but the present new species can be distinguished from the latter two by the larger diameters of the zooecial tubes.

The present form also resembles "*Batostomella*"? (2) which SUGIYAMA (1941) described in association with two other forms of "*Batostomella*": *B.* (1) and *B.* (3) from the upper course of the Motourakawa, Mitsuishi-gun, Hidaka province in Hokkaido, Japan in the diameter of the zooecial tube and other essential characters except for the presentation of diaphragms. In SUGIYAMA's description, however, it was stated that the diaphragm is probably absent, but his illustrations show that there are two diaphragms in a zooecial tube. Although SUGIYAMA's original specimens should be reexamined, there is a high possibility that "*Batostomella*"? (2) is identical with the present species.

The specific name is dedicated to Dr. Teiichi KOBAYASHI who collected the present materials.

Occurrence and geological age:—According to KOBAYASHI and ICHIKAWA (1950), the Upper Triassic Kochigatani series distributed in the Sakawa basin can be divided into three divisions, each characterized by fossil zones as shown in Table 1.

The lower division of the series consists mainly of hard, massive sandstone intercalated with conglomeratic sandstone and conglomerate and is characterized by the *Oxytoma-Mytilus* fauna. KOBAYASHI (1949) discriminated from that division a large number of pelecypods, one brachiopod, bryozoans and ammonites. Among them the pelecypod fauna was studied in detail by KOBAYASHI and ICHIKAWA (1950) and the geological age was considered to be Early Carnic by them.

The present materials were collected

Table 1.

Upper Division	*Entomonotis* Beds	*tenuicostata-zabaikalica* Bed	Late Noric
		ochotica-densistriata Bed	
	Myoconcha Beds		Late Carnic or Early Noric
Middle Division	*Halobia-Tosapecten* Beds	*Tosapecten* Beds	Middle Carnic
		Halobia Beds	
Lower Division	*Oxytoma-Mytilus* Beds		Early Carnic

by KOBAYASHI from a sandstone of the *Oxytoma-Mytilus* beds at Kashiwai of Kusaka-mura, the Sakawa basin of Kochi Prefecture.

Repository and Specimen No.—The specimens are preserved in the collection of the Department of Geology, Faculty of Education, Ehime University. Reg. Nos. 1001 (holotype), 1002, 1003, 1004, 1005 and 1006 (paratypes).

Brief note on the Triassic Bryozoa of the world

In the Triassic system, bryozoan remains are extremely rare in the world. FLÜGEL (1963) revised the Triassic Bryozoa known by that time and recognized 13 species in 4 genera of Cyclostomata and 9 species in 7 genera of Trepostomata aside from some indeterminable species. Subsequently, however, 10 species of Bryozoa were newly added by FRITZ (1961), LAZUTKINA (1963) and MOROZOVA (1965, 1970).

FRITZ (1961) described and illustrated *Arcticopora christiei* FRITZ from Lake Hazen, northeastern Ellesmere island in Canada and the geological age was stated by BOLTON (1961) as "... There is, therefore, little doubt that the bryozoan bed is Triassic, not Permian.... The bryozoan bed is thus not younger than Lower Triassic (early Upper Scythian age)".

LAZUTKINA (1963) described one bryozoan species, *Pseudobatostomella jakutica* (LAZUTKINA) under the generic name of *Batostomella* from the Lower Triassic (Induan) of Jakutii in Siberia, USSR.

MOROZOVA (1965) reported *Polypora darashamensis* NIKIFOROVA without description from the Lower Triassic (lower part of the Induan stage) of Zakavkas (Trans-Caucusia). Though one indeterminable species of *Polypora* (?) was described from the early Upper Triassic (upper Carnic) of Hungary by VINASSA DE REGNY (1901), it is of doubtful material as mentioned by FLÜGEL (1963) and MOROZOVA (1965).

Recently, MOROZOVA (1969) described from the Triassic in USSR, *Paralioclema abnorme* MOROZOVA (Carnic, northwestern part of Caucusus), *Paralioclema formosum* MOROZOVA (Noric, northwestern part of Caucusus), *Paralioclema dagysi* MOROZOVA (Carnic, northwestern part of Caucusus), *Paralioclema amurense* MOROZOVA (Anisic, Primorsk), *Pseudobatostomella sparsa* MOROZOVA (Anisic, northwestern part of Caucusus), *Pseudobatostomella debilis* MOROZOVA (Carno-Ladinic, Primorsk) and *Pseudobatostomella morbosa* MOROZOVA (Carno-Noric, Pamir).

Table 2 shows the chronological ranges of the Triassic bryozoan species reported and/or described after the revision by FLÜGEL (1963).

It is noted that all of the bryozoans shown in the table comprise the so-called "relic" from the Paleozoic era except for *Arcticopora christiei*, a genus that was newly established for the species by FRITZ (1961).

FLÜGEL (1963) mentioned that "Although any Lower Triassic (Scythic) bryozoans have not been described, *Fenestella* and *Stenopora* type bryozoans have been reported from the *Glyptophiceras-Ophiceras* bed (lower Scythic) of east Greenland by TRÜMPY (1960). They are expecting to be described by an American student." After the revision of FLÜGEL, however, three Scythic bryozoans were added from Ellesmere island, Siberia and Trans-Caucusia.

The present article is the first description of the Triassic Bryozoa in Japan. However, bryozoan remains but with some doubt have recently been recognized

Table 2.

	Scy.	Ani.	Lad.	Car.	Nor.	Rha.
Paralioclema amurense MOROZOVA		—				
Paral. abnorme MOROZOVA				—		
Paral. dagysi MOROZOVA				—		
Paral. formosum MOROZOVA					—	
Pseudobatostomella jakutica LAZUTKINA	—					
Pseudob. sparsa MOROZOVA		—				
Pseudob. debilis MOROZOVA			—	—		
Pseudob. kobayashii SAKAGAMI, n. sp.				—		
Pseudob. morbosa MOROZOVA				—	—	
Arcticopora christiei FRITZ	—					
Polypora darashamensis NIKIFOROVA	—					

in the lower member of the Triassic Nakijin Formation distributed in Okinawajima, Ryukyu by ISHIBASHI (1969), but no detailed study has been made. On the other hand, about 30 years ago, SUGIYAMA (1941) described 3 indeterminable species of "*Batostomella*" (one of them with a question mark) from four localities of the so-called Hidaka group distributed in central Hokkaido and he considered the geological age of the four localities to be the same because one of the three "*Batostomella*" (1) was mutual at the four localities. However, FUKADA (1949) pointed out that the brachiopod fauna from one of SUGIYAMA's bryozoan localities (Iwabenosawa, Simukappu-mura), although not the same locality of "*Batostomella*"? (2) but yielded "*Batostomella*" (1), is Triassic rather than Permian in age. "*Batostomella*"? (2) from the Hidaka group seems to be almost identical with *Pseudobatostomella kobayashii*, n. sp. described here. Under such circumstances the three forms of "*Batostomella*" recorded by SUGIYAMA should be reexamined, but unfortunately the depository of the bryozoan specimens studied by him is uncertain.

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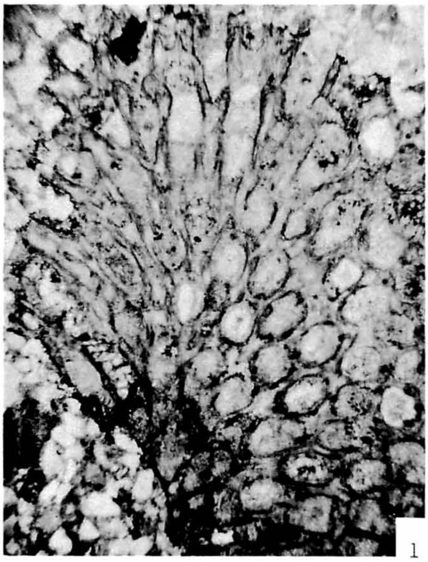
Explanation of Plate 33

Figs. 1-6. *Pseudobatostomella kobayashii* SAKAGAMI, n. sp.

1, 2. Longitudinal sections of paratype (No. 1002) and holotype (No. 1001), respectively, ×20. 3, 4. Enlarged parts of Fig. 2, ×60. 5, 6. Enlarged parts of tangential sections of paratype (No. 1002) and holotype (No. 1001), respectively, ×60.

Photo by SAKAGAMI.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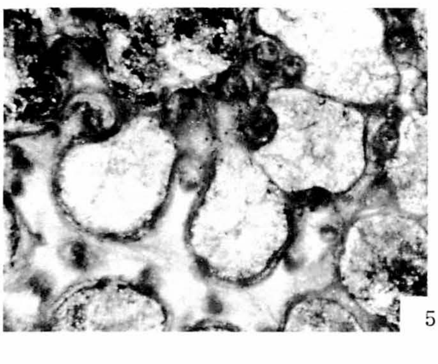
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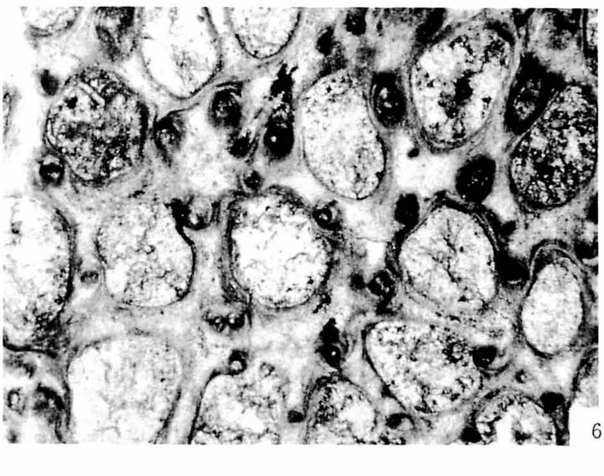
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Iwabenosawa	イワベの沢	Okinawa-jima	沖縄島
Kashiwai	柏井	Ryukyu	琉球
Kusaka	日下	Sakawa basin	佐川盆地
Mitsuishi-gun	三石郡	Simukappu-mura	占冠村

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594. SOME BAJOCIAN AMMONITES FROM KITAKAMI, NORTHEAST JAPAN

TADASHI SATO

Geological Institute, Faculty of Science, University of Tokyo

北上山地より産したバジョシアン菊石について： 日本のバジョシアンは菊石化石の産出が比較的稀で，ジュラ系の他の部分ほど精密な分帯ができなかった。最近北上山地で採集された標本と，今まで記載されずに残されていた標本を検討した結果，唐桑地区の綱木坂層および牡鹿半島の月ノ浦層がかなりくわしい分帯の対象となることがわかった。

綱木坂層は全体で１帯として取り扱うことができ，ヨーロッパ標準の *Otoites sauzei* 帯に対比される。また月ノ浦層は，少なくとも前網の含菊石層に関する限り，*Otoites sauzei*～*Stephanoceras humphriesianum* 帯の一部分に対比される。

この小菊石群は，全体として北米大陸北西部の同時期の菊石群と強い近縁関係にあるが，属のレベルでは，西南太平洋の菊石群とも共通なものがある。　佐　藤　　正

Bajocian, as adopted in the recommendation of the Subcommission of Jurassic of IGC, at the Luxembourg Symposium in 1962, is represented best by a fraction of the Jurassic column in the south Kitakami region in Japan. Its correlation is based on the poorly known ammonite faunules (SATO, 1962; TAKAHASHI, 1969), besides some lamellibranch faunas (HAYAMI, 1961).

The faunules comprise some characteristic Bajocian species, but many are more or less crushed and remained undescribed.

Better preserved specimens of the ammonites are recently collected by F. TAKIZAWA of the Geological Survey and CHIKARAISHI of the Nihon University, from the Ojika Peninsula. These collections comprise some new forms not described yet, and offer more solid basis of the correlation. Bajocian, or more precisely, a zone which should fall in the range from *Otoites sauzei* zone to *Stephanoceras humphriesianum* zone is strongly suggested by these materials.

In this occasion, old but undescribed specimens of ammonoids collected from the corresponding formations and stored in the University of Tokyo are described and figured. These are in favour of attributing the age of the formation to *Otoites sauzei* zone, in addition to previously described *Stephanoceras* sp. cf. *S. plicatissimum* (QUENSTEDT) and *Sonninia* sp. cf. *S. corrugata* (SOWERBY).

The Bajocian is one of the best represented stage of Jurassic in the eastern and southern parts of the circum-pacific, including western Australia. The Bajocian ammonite faunas have, however, regional particularities by different composition in each area, though interconnection among neighbouring areas is easily recognized by the occurrence of certain common genera. Since only a small number of species have been hith-

* Received March 12, 1971; read June 27, 1970 at Mito.

erto reported from Japanese Bajocian, it will be useful from the standpoint of palaeogeography and correlation to give notes here on the newly found faunules.

The ammonites of the Japanese Jurassic are generally quite poorly preserved. The test is usually lost, and the casts are twisted by the later tectonic deformation. This is particularly true for the Kitakami Jurassic, where specimens sufficiently well preserved for full systematic description are rarely found up to the present.

The newly discovered specimens represent Bajocian families of Sonninidae, Otoitidae, Stephanoceratidae and probably Strigoceratidae. The combination of these families are reported widely from the Pacific. The common elements are recognized between Japan and these countries. Among these, the south Alaskan fauna is the most closely related to the Japanese one, as in the case of Toarcian and Aalenian (SATO, 1962a).

I am much indebted to Mr. TAKIZAWA and Mr. CHIKARAISHI for kind permission of studying their materials, and to Prof. HATAI for granting me to refer to the collection of the Tohoku University. Thanks are also due to Dr. TAKAHASHI for his critical discussion and to Prof. WESTERMANN for his critical examination of the present materials.

Systematic descriptions

Genus *Pelekodites* BUCKMAN, 1923

Pelekodites (*Spatulites*) *spatians* (BUCKMAN)

Pl. 34, fig. 1a, b.

1928. *Spatulites spatians* BUCKMAN, Type Ammonites, pl. 765.
1969. *Pelekodites* (*Spatulites* ?) n. sp. aff. *P. spatians* (BUCKMAN), WESTERMANN, pl. 32, fig. 4a, b.
1969. *Sonninia* sp., TAKAHASHI, pl. 18, fig. 7, 9, non fig. 3 and ? pl. 19, fig. 7.
?1969. *Hosoureites* cf. *ikianus* (YOKOYAMA), TAKAHASHI, pl. 19, fig. 8.

Material:—A single specimen preserved to the end of the whorl, but the test was completely removed. Collection HAYAMI.

Description:—The whorls become elliptical due to the compression acted obliquely to the axis of coiling. Diameter measured along the longer axis is about 55 mm and that of the shorter axis about 30 mm. Thus the maximum diameter would be of the order of 40 mm or more. The umbilical diameter is about 20 mm along the longer axis, thus occupies about 36% of the diameter.

This is a small form with spatulate lappets. The ventral aspect is not clearly visible but on the internal mould is observable well differentiated low hollow keel as a trace of narrow flat belt surrounding probably fastigate venter. The whorl section can not be confirmed correctly because of flattening, but is likely to be rather elongated oval. The volution is rather evolute. Umbilical wall is steeply inclined, with rounder border. Costation is generally falcoid, rather rursiradiate, terminating at the ventral edge without forward projection, irregularly fasciculate in inner whorls but bundled by umbilical bullae on the last whorl. Ribs become abruptly weakened on the last quarter of the last whorl, where somewhat sinuous striae substitute the ribs.

Suture line is simple, characterized by slender lobes.

Remarks:—This species resembles superficially inner whorls of certain Witchellids. Especially fasciculate and flexiradiate costation is a common character of the two.

BUCKMAN's genera, created mostly on the basis of single species, are not generically separable from *Pelekodites* which has the page priority among others. WESTERMANN (1969, p. 116) further advanced and regards this group of minute sonninids as male equivalent of *Witchellia laeviuscula—W. sutneri* 'plexus'. He tentatively admitted *Spatulites* as a subgenus of *Pelekodites*, in taking its stronger costation than that of *Pelekodites* in consideration.

The present specimen is conspecific with BUCKMAN's *spatians*, in general appearance, except more prominent umbilical bullae which bundle irregularly two or three flexiradiate costae. However, the specimens can be attributed to the BUCKMAN's species, because slight differences of costation would be better considered as intraspecific variation rather than specific.

TAKAHASHI's '*Graphoceras*' sp. A, and '*Sonninia*' sp. A are arbitrary. His pl. 18, fig. 7 and fig. 9 (and probably pl. 19, fig. 8) are probably conspecific with this, though too much fragmentary to be determined specifically, except pl. 18, fig. 9, which has the same fasciculate strong ribs as in the present specimen. His '*Sonninia*' sp. A (pl. 18, fig. 3) should be excluded from this species, and compared to *Sonninia* sp. cf. *S. corrugata* (SATO, 1962a, pl. 9, figs. 3, 4).

Occurrence:—West of Tsunakizaka, Tsunakizaka Formation. Associated with *Strigoceras* sp. which will be described below.

Pelekodites sp. cf. *P. pelekus* BUCKMAN, 1923

Pl. 34, fig. 2a, b.

1962a. *Sonninia* sp., SATO, pl. 9, fig. 2 (5405302).

1969. *Sonninia* sp., TAKAHASHI, pl. 17, fig. 6, 7 and ? fig. 8; ? pl. 18, fig. 4.

Material:—Two crushed specimens from black mudstone stored in University of Tokyo. 43IIR-5111, collection YAMASHITA, 5405302, collection AKIYAMA.

Description:—Exact measurements are impossible because of deformation. Specimen 43IIR-5111 which preserves lappets is about 35 mm in maximum diameter along the longer axis, and about 20 mm along the shorter axis of the deformed elliptical whorls. Thus the diameter measured just behind the aperture is likely to be of the order of 30 mm. The umbilical diameter is about 15 mm along the longer axis, occupying about 43% of the diameter.

Small shell of rather evolute volution, with spatulate lateral lappets. Whorls are likely to be slightly depressed, with broadly convex and keeled venter. Plicate costation is appreciably rursiradiate, irregularly fasciculate and finally smooth and striated on the last quarter of the last whorl.

Remarks:—*Pelekodites spatians*, described above, is different by its smaller conch, more markedly rursiradiate costation, and weaker umbilical bullae, though not totally absent.

This form is in close affinity with the English *Pelekodites pelekus* BUCKMAN, which was only figured but not described. The unfavorable state of preservation of the present form does not permit decisive identification. '*Nannoceras nannomorphum*' BUCKMAN, 1923, is another species closely related, but this is not specifically separable from *pelekus* (WESTERMANN, 1969, p. 116).

TAKAHASHI's '*Sonninia*' sp. A, in which 8 specimens are grouped, comprises largely divergent forms. His pl.

17, figs. 6 and 7, and possibly fig. 8 as well as pl. 18, fig. 4 might be conspecific with the present one. From Wide Bay of Alaska Peninsula, WESTERMANN reported *Pelekodites* cf. *P. pelekus* (1969, pl. 32, figs. 1-2) which is also closely related and cannot be distinguished from the present form even specifically.

Occurrence:—Specimen 43IIR-5111 from the west of Yobaijitoge, 5405302 from Tsunakizaka. Both from Tsunakizaka Formation.

Genus *Otoites* MASCKE, 1907

Otoites sp.

Pl. 34, fig. 10.

Material:—An external mould of the last half volution found in a boulder.

Description:—Though fragmentary, the specimen shows rather involute coiling, crater-like umbilicus with well defined and steeply inclined umbilical wall. Stout and straight primary ribs are on the umbilical wall, terminated by minute rounded tubercles from which two or three secondary ribs are branched off. On the last part of the preserved whorl, however, only two secondary ribs are bifurcated. Costation as a whole is generally rectiradiate, but on the last whorl it becomes slightly geniculated with rursiradiate primaries.

Remarks:—The general appearance, especially costation, is strongly suggestive of *Otoites contractus* group. Ribbing appears in the present specimen somewhat finer than the group of *contractus* (SOWERBY), as in *Otoites delicatus* BUCKMAN (1919, Type Ammonites, pl. 142). But this might be resulted from the lateral deformation and it will be reasonable that the specific determination is not given until better specimen is available.

Occurrence:—Procured from a boulder at the Locality 54044, south of Tsunakizaka.

Genus *Normannites* MUNIER-CHALMAS, 1892

Normannites (*Itinsaites*) sp. cf. *N.* (*I.*) *itinsae* (MCLEARN)

Pl. 34, figs. 3-9.

1969. *Otoites* sp., TAKAHASHI, pl. 9, figs. 2-5.

Material:—Some thirteen fragmentary specimens which represent various developmental stages.

Description:—All the specimens are deformed to some extent, obliquely or perpendicularly to the coiling axis, so that the original shell form is difficult to be confirmed. For the same reason, it is not quite certain that all the specimens belong to a single species, even if each specimen presumbably represents different developmental stage.

Coiling is rather evolute; a specimen (Pl. 34, fig. 5b) representing inner three volutions shows open and shallow umbilicus. Overlapping of the whorl by next one is confined to about outer one third of the whorl height, and the umbilical suture lies approximately on the line connecting the points of bifurcation of ribs on the covered whorl.

Whorl section is likely to be depressed oval with broad and gently convex venter. A figured specimen (Pl. 34, fig. 8b) presents depressed *Teloceras*-like whorl section. But as the impression of the ventral region of the preceding whorl, left on the dorsum, is abnormally narrow and roof-shaped, this figure is not original but deformed.

Short lateral lappets are present (Pl.

34, fig. 4).

Primary ribs of high relief are long, widely spaced, rectiradiate (slightly prorsiradiate in smaller whorls), and two or more secondaries are bifurcated at the lower one third of the whorl height. The latter are finer and more densely spaced, intercalated frequently by free ribs. Minute but clearly differentiated tubercles are superimposed on the branching points.

Remarks:—The possibility that this species belongs to the Stephanoceratidae is excluded because of the presence of lateral lappets. Furthermore, long primary ribs and small secondary lateral lobe which is observable in some specimens, are the characteristics favorable to place them in *Normannites*, instead of *Otoites*. But there are some involute *Normannites* superficially indistinguishable from *Otoites*, and the demarcation between the two genera is not always easy, as ARKELL stated (1954, p. 568).

Among various *Normannites* species, Canadian *Itinsaites* would be comparable directly to this form by its sharp, high, and long primary ribs. *Itinsaites itinsae* known from Queen Charlotte Island (McLEARN, 1929, pl. xv, fig. 2-3) and also Cook Inlet of Alaska (IMLAY, 1964, pl. 14, fig. 3-8, 13) resembles this species in general appearance.

TAKAHASHI segregated four independent but monotypical species within his *Otoites*, based mostly on the different ribbing styles. However, even in a single specimen of the present collection, ribbing is divergent from bifurcating to fasciculating. It seems that until better specimens will be procured, all is better referred to one species.

The largest specimen, more than 4 cm in whorl thickness (Text-fig. 1), shows dense and fine ribbing. This specimen is too much depressed to be determined with confidence. But as the umbilical wall is partly observable, and reveals the *Normannites* type umbilical aspect, it is here tentatively retained in the present species.

Text-fig. 1. Ventro-lateral view of the obliquely deformed whorl of *Normannites* (*Itinsaites*) sp. Loc. H67, Maeami. Collection TAKIZAWA.

Occurrence:—All the specimens are discovered from a seam of poorly sorted silty sandstone, together with lamellibranch and belemnite shell fragments, in the state of fossil bank. Judging from the lithology of the mother rock, *Stephanoceras* sp., which will be described below is associated with this species. H67 (TAKIZAWA), Maeami coast, Ojika Peninsula.

Genus *Stephanoceras* WAAGEN, 1869

Stephanoceras sp.

Pl. 34, fig. 11.

1956. *Stephanoceras* sp. cf. *S. plicatissimum* (QUENSTEDT), SATO, p. 169, pl. 13, figs. 1-3, text-figs. 2-5.

Material:—A single specimen procured from black sandy shale at Maeami. Collection CHIKARAISHI, his specimen number 730123.

Description:—The whorls are laterally deformed and the volution becomes somewhat elliptical; longer axis measures approximately about 90 mm, while the shorter axis about 65 mm.

A part of the living chamber is preserved as an internal mould, but the internal whorls are completely destroyed, but left impression, in somewhat obscure manner, as an outer cast. The volution seems very evolute. The umbilicus is open and shallow and occupies about 1/2 of the diameter. Whorl section is rounded and as high as thick.

Ribbing is composed of stout primary ribs and dense, rectiradiate and generally trifurcate secondaries. The secondaries are branched off from the minute but prominent tubercles at the inner one third of the whorl height. Intercalatories are frequently inserted. Ribs are continuous on the venter without any interruption or bending.

The suture line is not observable.

Remarks:—This planulate ammonite is comparable to the species described previously from the Tsunakizaka shale of the Karakuwa region as *Stephanoceras* sp. cf. *plicatissimum* (QUENSTEDT); this Karakuwa form is characterized by rather well individualized long primary ribs. This difference might be caused by more advanced degree of deformation than in the present specimens. In fact, the ribs appearing along the longer axis of the deformation ellipse look like longer and sharper than those along the shorter axis, as seen in the Karakuwa specimen (SATO, 1956, pl. 13, fig. 1). In an accompanying specimen (Ditto, pl. 13, fig. 3) shorter primaries are observable on the last part of the preserved whorl.

No comparable species is yet known among various stephanoceratids reported from New Guinea, Sula Island, or from West coast of North America including South Alaska and British Columbia, where the fauna of comparative age is widely developed.

Occurrence:—Maeami, collection CHIKARAISHI. Judged from the lithology, this fossil might be collected from the same locality as TAKIZAWA's H67. Tsukinoura Formation after TAKIZAWA.

Genus *Strigoceras* QUENSTEDT, 1886

Strigoceras sp. cf. *S. languidum* (BUCKMAN)

Pl. 34, figs. 12, 13.

1969. *Graphoceras* sp., TAKAHASHI, pl. 19, figs. 2, 3, 4 and ? 5.

Material:—Two outer casts of flatly compressed and laterally deformed shells, collection HAYAMI.

Description:—The maximum measurable diameter is 40 mm but 20 mm when measured along the direction perpendicular to the former, thus the shell is more or less deformed laterally. The umbilical diameter is about 4 mm along the longer axis of the deformation ellipse of the whorl.

Small shell with well differentiated ventral keel and involute coiling. Because of the flattening by tectonic deformation, the exact whorl section is not observable, but it is most likely to be an oxycone. The inner half of the flank is probably concave. The umbilical margin is sharply defined and the weak spiral ridge is formed at the middle height of the flank.

The venter is not clearly observable but it is likely to be fastigate.

The costation is characterized by the falcoid ribs which are much more accentuated on the outer half of the flank than on the inner half.

The suture line is not visible.

Remarks:—Various oxycone Strigoceratids are splitted into independent genera by BUCKMAN. But these are certainly not separable in generic level and better put into the same genus *Strigoceras*, as did ARKELL (1957). *Strigites strigifer* (BUCKMAN, 1924, Type Ammonites, pl. 469A) and '*Varistrigites*' *compressus* (BUCKMAN, pl. 468) are, among others, closely related to the present species, judged by their characteristic ornamentation. But a form reported from South Alaska by IMLAY under the name of *Strigoceras* cf. *S. languidum* (BUCKMAN) (IMLAY, 1964, pl. 23, fig. 4) is the most resembling species known in the circumpacific region.

This small oxycone is apparently comparable to *Graphoceras* of Upper Toarcian-Aalenian age, especially to the group of *G. concavum* with rather rectiradiate ribbing. TAKAHASHI's '*Graphoceras*' sp. B (1969, pl. 19, fig. 4) is judged to be conspecific with the present species. Although *Graphoceras* is not easily separable from this genus when it is imperfectly preserved, the latter should be distinguished by its ribbing which is not strongly rursiradiate in comparison with that of the former and is rather irregularly branched, its complex suture-line, its very involute coiling. These criteria are clearly visible in the present specimens. Therefore, the materials now in question are concerned with *Strigoceras*. TAKAHASHI's other two specimens (pl. 19, fig. 3 and fig. 5) are too fragmentary to be attributed to the present species.

Occurrence:—West of Tsunakizaka. Collection HAYAMI. Collected from the same slab of black shale as *Pelekodites* (*Spatulites*) *spatians*.

Discussion on the occurrence of ammonites

Tsunakizaka Formation:

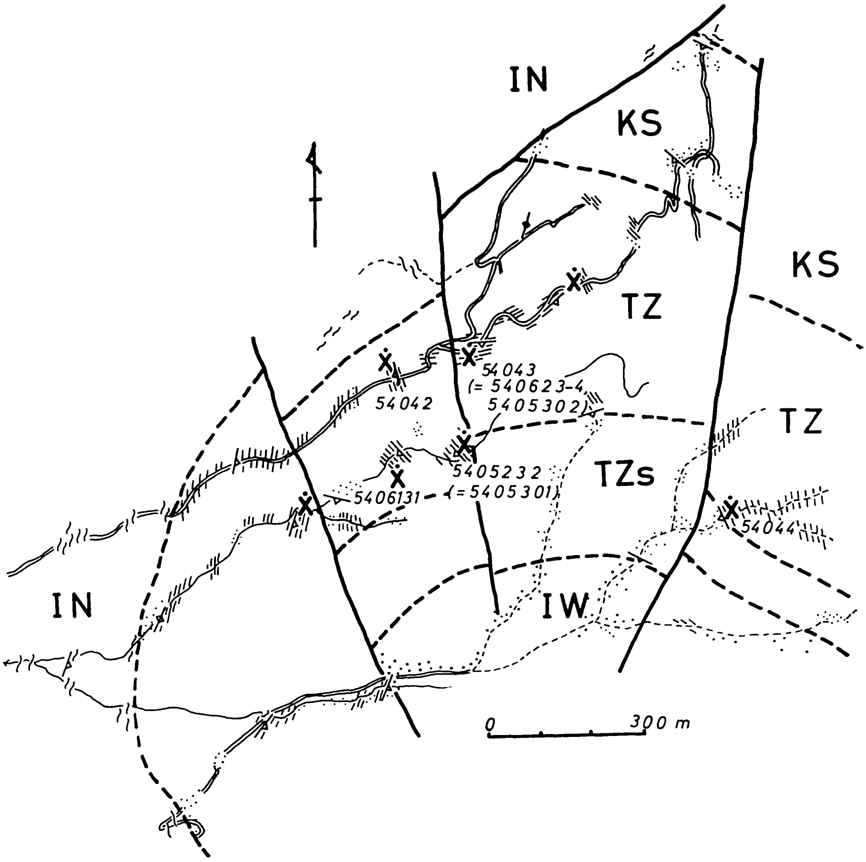
1. Tsunakizaka

This locality is not a pinpoint locality, but some ten different localities scattered around the site called Tsunakizaka are designated under this name. All the specimens procured there occur in the black shale named Tsunakizaka Formation, which is overlain by argillaceous sandstone and underlain by granule sandstone, both barren of ammonite.

A specimen of *Pelekodites* cf. *pelekus* (BUCKMAN) (figured formerly under the name of *Sonninia* sp. indet., SATO, 1962, pl. 9, fig. 2) was discovered from Loc. 5405302, together with *Sonninia* sp. (SATO, 1962a, pl. 9, fig. 3) and fragmentary *Strigoceras*-like shell (yet unfigured) and also *Stephanoceras* sp. (unfigured). From another important locality, 5405232, *Stephanoceras* sp. cf. *S. plicatissimum* (QUENSTEDT) (SATO, 1956, pl. 13, fig. 1) and also *Spatulites spatians* BUCKMAN which still retains striated last whorl were collected (Collection AKIYAMA, Kesen-numa High School).

Stephanoceras cf. *S. plicatissimum* (QU.) (SATO, 1956, pl. 13, fig. 3) was collected at the locality 54044, which is correlated to the top of the black shale formation, but accompanies no other species. *Otoites* sp. described here was unfortunately collected from the river float, thus bears no stratigraphical significance.

Pelekodites, *Sonninia* and *Stephanoceras*



Text-fig. 2. Locality map around Tsunakizaka.
IN : Inai Group, KS : Kosaba Formation, TZ : Tsunakizaka Formation, TZs : Sandstone overlying Tsunakizaka Formation, IW : Ishiwaritoge Formation.

are, therefore, completely coexistant stratigraphically. Discrimination of different fossil horizons is impossible in this locality.

2. Yobaijitoge

This locality is situated about 1 km north of the pass of the Higashi-hama road. The fossiliferous shale is exposed along the trail crossing the mountain range. *Stephanoceras* cf. *S. plicatissimum* (QUENSTEDT) (SATO, 1956, pl. 13, fig. 2) and *Pelekodites* cf. *P. pelekus* BUCKMAN (specimen 43IIR-5111) are discovered from this locality but independently. The stratigraphical relation between the two species is not clear.

The formation from which above mentioned species were collected is about 350 m thick and composed of monotonous black shale. ONUKI (1969, p. 113) cited three different fossil horizons within this formation: this zonation was based on unpublished data of TAKAHASHI, who eventually discriminated two horizons (TAKAHASHI, 1969, p. 33), instead of three.

As discussed above, the Tsunakizaka Formation can not be splitted into zones from the faunal view point. Therefore, TAKAHASHI's result appears to be based on arbitrary splitting of the fauna into two different lots. In fact, the Tsunakizaka Formation constitutes a single zone.

Tsukinoura Formation:

1. Maeami.

This locality is the sea-side exposure near Maeami, in the east coast of the Ojika Peninsula. TAKIZAWA's locality H67 yields both *Stephanoceras* cf. *S. plicatissimum* (QUENSTEDT) and *Normannites* (*Itinsaites*) sp.

These fossils are discovered from a seam of poorly sorted silty sandstone, together with other lamellibranch and belemnite shell fragments. Fossils are more or less crushed and concentrated in a thin seam as a shell bank. It is evident that the shells were transported by current and brought into depositional site altogether.

It is safe to conclude that the species composing the Maeami faunule are completely synchronous and indicate a single age.

Note on the ammonite zone

In Japanese Jurassic, a solitary occurrence of a single individual of fossil ammonites is not rare. The solitary ammonite is important as a time-indicator, but cannot define a zone. As I previously noticed (SATO, 1962a, p. 40), the term 'niveau' was used to denote the stratigraphical horizon dated by this kind of ammonite occurrence, instead of using 'zone' of OPPEL's sens. The veritable zones of ammonites exist in Japanese Jurassic; later I discriminated them from ill-defined 'niveaux' (SATO, 1962b).

The Tsunakizaka Formation is composed of black sandy shale. The lithology is quite homogeneous. There is no evidence of disordering of the bedding, such as slumping structure or turbidite. Therefore the admixture of the fossils of different ages is hardly admitted in this sequence.

As discussed later in detail, the ammonite species discovered from the Tsunakizaka Formation can coexist, as far as judged from hitherto known ranges of every species. Therefore, the whole Tsunakizaka Formation can be defined as a zone.

A zone is a biostratigraphical term, so that the upper and lower limits should be demarcated by lines on the exposure. It is not an abstract concept but objective. Since the ammonites are confined in the black sandy shale sequence, and the sequence cannot be subdivided into smaller units, the formation represents an ammonite zone as a matter of course.

Correlation

All the constituents of the faunules now in question are of Bajocian age. They are known widely around the Pacific.

Tsunakizaka Formation:—The ammonite faunule of this formation is composed of:

Stephanoceras sp. cf. *S. plicatissimum* (QUENSTEDT)
Sonninia sp. cf. *S. corrugata* (J. de C. SOWERBY)
Pelekodites (*Spatulites*) *spatians* (BUCKMAN)
Pelekodites sp. cf. *P. pelekus* BUCKMAN
Otoites sp.
Strigoceras sp. cf. *S. languidum* (BUCKMAN)

Stephanoceras sp. was compared previously to *S. plicatissimum* (QUENSTEDT), but this is open to question. Because the specimens are completely flattened without exception, the identification is even generically difficult. The specimens are characterized apparently by short and bullate primary ribs which are also comparable to those of *Pseudotoites*. Although the exact whorl section is not known in the present specimens, the possibility to belong to this particular Pacific genus can not easily be rejected. *Pseudotoites* cf. *P. argentinus* ARKELL (figured by WESTERMANN from Wide Bay of Alaska Peninsula) resembles superficially this form. Even if this be a *Pseudotoites*, the age which represents the form is not be altered, because both are of early-middle Bajocian age.

Stephanoceras (including *Skirroceras* as subgenus) is a genus prolific in the Pacific Middle Bajocian. It is so far reported from Southern Alaska and New Guinea, but the *Stephanoceras* s. s. is relatively rare. Indisputable *Stephanoceras* s. s. is known only from West Irian (*S.* aff. *S. humphriesianum* (QUENSTEDT)), British Columbia and Chile (for example *S. coamanoi* McLEARN). Numerous *Skirroceras* from South Alaska and Oregon are partly transferred to *Docidoceras* (WESTERMANN, 1970, p. 294), of Lower Bajocian age.

The sonninids reported from Kitakami were compared to *Sonninia corrugata* group, but these might belong to the subgenus *Euhoploceras*. Associated *Pelekodites* is up to now confined to occur in the Northeastern Pacific. This microconchiate ammonite is difficult to be determined unless the aperture is preserved. Some sonninids ever described and of small shell diameter would be of this genus. For example, '*Sonninia subdeltafalcata*' TORNQUIST (Pl. 5, fig. 7) and '*S.*' *bodenbenderi* of the same author (pl. 5, fig. 9) from Espinazito Pass of Argentina might be *Pelekodites*. Thus the distribution of the genus would be far more wide-spread than supposed at present. *Pelekodites* is yet unknown from the western and southwestern Pacific, and now its presence in Japan links paleobiogeographically the northwestern and northeastern parts of the Pacific.

Other sonninids reported from Kitakami offer another link between Japanese and Southwestern Pacific paleobiogeographic provinces. Stephanoceratids and a dubious *Otoites* sp. figured herein corroborate this connection.

Strigoceras is known from South Alaska (IMLAY, 1964) and doubtful one from Supplee area of Oregon (LUPHER, 1941).

As a whole, the Tsunakizaka faunule has a close affinity with those of South Alaska and Western Canada, including Western Interior of the United States, suggested by the common occurrence of *Stephanoceras* (though somewhat doubtful), *Pelekodites*, *Strigoceras* and probable *Sonninia*. Especially *Pelekodites* is comparable between two regions even in specific level.

Chronologically important is the *Otoites*, which attained the climax of prosperity in *Otoites sauzei* zone, although it appeared already in the upper part of *Sonninia sowerbyi* zone. Unfortunately the specimen of *Otoites* sp. was discovered in the river float, but it should be derived from the surrounding Tsunakizaka black shale, as suggested by its lithology.

Among associated genera of the Tsunakizaka faunule, *Stephanoceras* is also an indicator of the *Otoites sauzei* and *Stephanoceras humphriesianum* zones, not that for *Sonninia sowerbyi* zone. The presence of *Sonninia* sp., *Pelekodites* spp., *Strigoceras* sp. in association with *Otoites* and *Stephanoceras* cannot reject the *O.*

sauzei zone age, because these range in whole early and middle Bajocian.

The Tsunakizaka Formation is, therefore, of the *Otoites sauzei* zone age. I previously correlated it with the *Stephanoceras humphriesianum* zone (SATO, 1962b, p. 894), but the new collection of ammonite does not permit to retain this correlation.

TAKAHASHI's K1 horizon (which was correlated with Upper Toarcian—Aalenian) cannot be sustained, because his basis of correlation was on misidentified Aalenian genera. In fact, his '*Grammoceras*' sp. from Yobaijitoge might be *Asthenoceras*, and '*Phymatoceras*' sp. might be *Sonninia* (*Euhoploceras*).

The chronological relation with the Hosoura Formation which is of Upper Toarcian—Aalenian age and is correlated with the Tsunakizaka Formation K1 by TAKAHASHI, remains unsolved from the stratigraphical point of view, because the distribution of the two formation is completely separated.

Tsukinoura Formation:

The collection from Maeami is important for correlation of the formation. This faunule is composed of:

Stephanoceras sp. cf. *S. plicatissimum* (QUENSTEDT)
Normannites (*Itinsaites*) sp.

These are strong indicators for *Stephanoceras humphriesianum* zone. *Normannites* is a wide spread genus, known from South Alaska, Western Canada, probably from Andes, Indonesia and Western Australia, and is known mainly from *Stephanoceras humphriesianum* zone. It ranges, however, into the *Otoites sauzei* zone, as exemplified by the occurrence in South Alaska. The Japanese species resembles *Itinsaites* reported from the Queen Charlotte Island, which is distributed in both *sauzei* and *humphriesianum* zones.

Numerous *Normannites* (sometimes reported as *Otoites*) are found in Indonesia and New Guinea. However, the true *Normannites* is rather rare. *Normannites etheridgei* is an example, and was later redefined as *Stemmatoceras* by WESTERMANN.

The combination of *Stephanoceras* and *Normannites* is known both in *Otoites sauzei* and *Stephanoceras humphriesianum* zones. Therefore, the Tsukinoura Formation is Middle Bajocian age, at least its fossiliferous part.

Conclusion

In Karakuwa district of southern part of Kitakami plateau, the Jurassic sequence commences with the Kosaba sandstone which is succeeded by the Tsunakizaka Formation of *O. sauzei* zone age. The Kosaba sandstone is fossiliferous but barren of ammonites. Its age is naturally before that age, but its position in the zonal scheme remains uncertain.

In Ojika Peninsula of the same plateau, the Tsukinoura Formation is the basal member of the Jurassic and is of the Middle Bajocian age.

The underlying beds in both districts are Triassic; thus the sedimentation did not occur during the period covering from Rhaetian to Aalenian, if the Kosaba sandstone remains within the Bajocian.

From the structural viewpoint, both districts are aligned on the same synclinorium axis, which runs approximately in N-S. The sequences in both regions are not completely identical, but it is very much likely that the Jurassic sequence commenced with the beds of similar age.

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Higashihama	東 浜	Ojika	牡 鹿
Kitakami	北 上	Tsukinoura	月 ノ 浦
Kosaba	小 鯖	Tsunakizaka	綱 木 坂
Maeami	前 網	Yobaijitoge	夜這路峠

Explanation of Plate 34

Fig. 1a, b. *Pelekodites* (*Spatulites*) *spatians* BUCKMAN
1a. Outer cast preserving lateral lappet. 1b. Inner mould, partly preserved suture lines. Tsunakizaka. Collection HAYAMI.

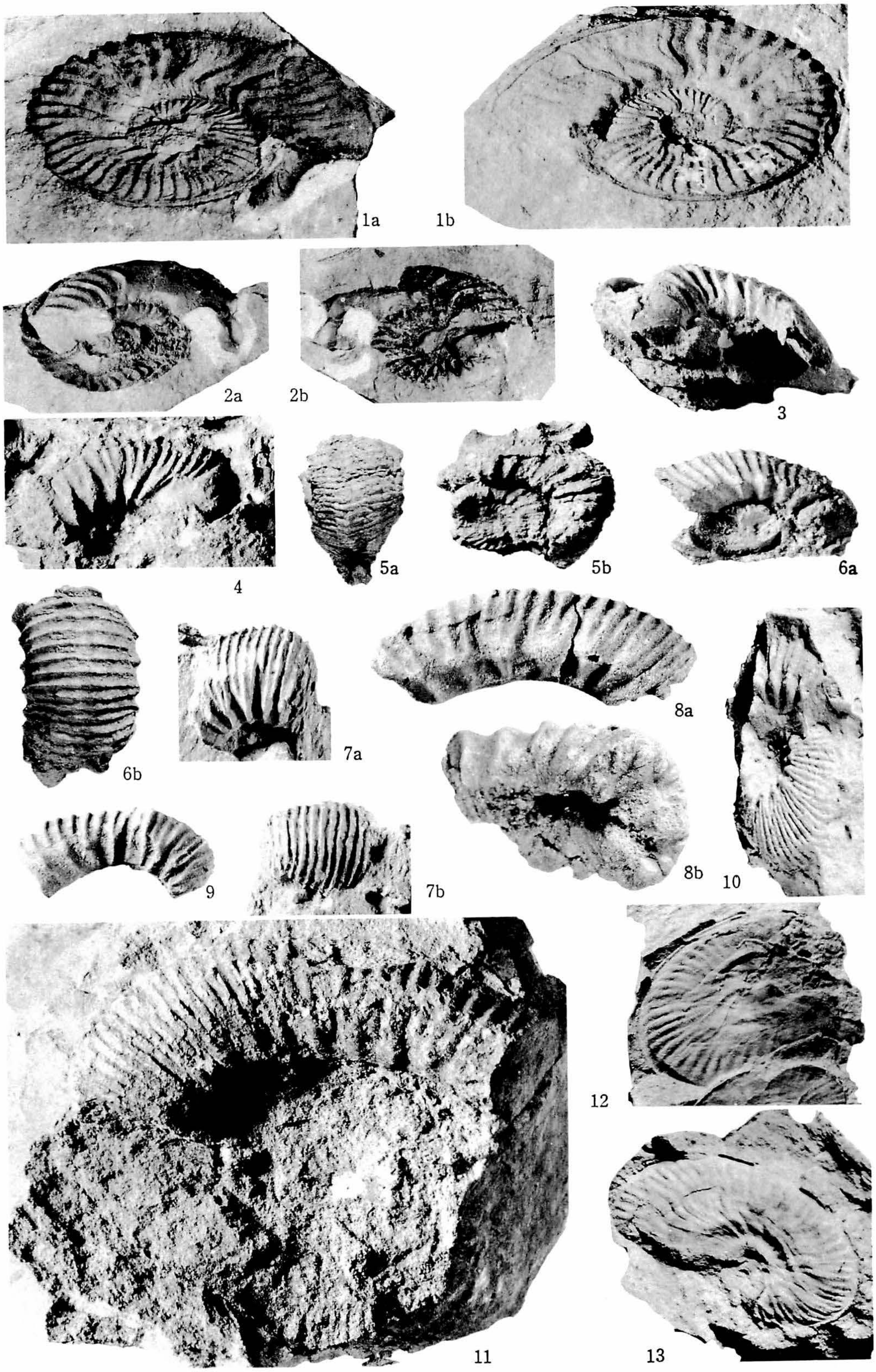
Fig. 2a, b. *Pelekodites* sp. cf. *P. pelekus* BUCKMAN
2a. Partly preserved last whorl, inner mould. Lateral lappet preserved. 2b. Outer cast of the whole whorls. Lateral lappet is preserved. Loc. 43IIR-5111, west of Yobaijitoge, Collection YAMASHITA.

Figs. 3–9. *Normannites* (*Itinsaites*) sp.
3. Inner mould of obliquely deformed last ? whorl. 4. Inner mould of the last part of the living whorl, preserving the wide and short lateral lappet. 5a, b. Inner mould of inner three volutions. a. Lateral view, b. Ventral view. 6a, b. Inner mould of the middle stage of whorls. 7a, b. Inner mould of an obliquely deformed part of non septated whorl. 8a, b. Inner mould of slightly depressed beginning part of last whorl. ×1.5. 9. Inner mould of the whorl showing transition from bifurcating to trifurcating ribbings. All from H67, Maeami Coast. Collection TAKIZAWA.

Fig. 10. *Otoites* sp.
Gypsum model of the outer cast of a part of laterally deformed whorl. Loc. 54044, Tsunakizaka. Collection AKIYAMA.

Fig. 11. *Stephanoceras* sp. cf. *S. plicatissimum* (QUENSTEDT)
Inner mould of the last non septate whorl. Loc. H67, Maeami coast. Collection CHIKARAISHI.

Figs. 12, 13. *Strigoceras* sp. cf. *S. languidum* (BUCKMAN)
Outer casts, from the same slab as *Pelekodites* (*Spatulites*) *spatians* BUCKMAN. Tsunakizaka. Collection HAYAMI.



ISHIBASHI photo.

PROCEEDINGS OF THE PALAEONTOLOGICAL SOCIETY OF JAPAN

日本古生物学会1972年総会・年会は，1972年1月22日（土）・23日（日）の2日間千葉大学教養部を会場として開催された（参加者110名）。

海外学会出席報告

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サンゴ類に関する第1回国際会議 ……浜田隆士
二畳系 ― 三畳系に関する国際会議……鳥山隆三
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シンポジウム「軟体動物化石による日本新生代の年代層位学」

北陸新第三系の貝化石と岩相による層序区分 ‥
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中国地方備北層群および川合・久利累層の貝化石群による一考察……………..岡本和夫
北太平洋地域の新第三紀イタヤガイ科化石群 ‥
…………………………増田孝一郎

新第三系の対比表と貝化石の層位的分布．鎮西清高
総合討論

（世話人 増田孝一郎）

学 会 記 事

◎ 1972年度よりの入会者（1972年1月21日の評議員会で承認）普通会員9名，在外会員2名（順不同，敬称略，以下同様）茨木雅子，井上英二，田沢純一，由井誠二，青島睦治，配川武彦，松川正樹，川上享，小笠原憲四郎，Reiner JORDAN，Tuncer GÜVENC.

◎ 1971年度中に逝去された会員3名。Ralph W. CHANEY，遠藤誠道，久住久吉。

◎ 1972年1月21日の評議員会において，次の諸君の退会が認められた。Anders B. BOHLIN，Raymond C. MOORE，中嶋輝允，加藤国男，佐藤二郎。

◎ 同上評議員会において，次の7名の諸君が特別会員に推薦された。長谷川美行，甲藤次郎，木村達明，野田浩司，沖村雄二，山際延夫，石崎国熙。

◎ 1971年度学会誌論文賞は，増田孝一郎君の "On some *Patinopecten* from North America" に対して贈られた。

◎ 1972年度の学術奨励金は，鎮西清高君（東北日本第三系の貝化石群集の古生態学的研究）に贈られた。

◎ 1972年2月1日より，日本古生物学会の本部事務所を文京区弥生 2-4-16，日本学会事務センター内に移すことになった。

お 知 ら せ

◎ 日本古生物学会特別号 No. 16, "Tertiary molluscan fauna from the Yakataga District and adjacent areas of Southern Araska"（菅野三郎著）が刊行されました。(154 pp., 18 pls.) 定価は 3,500円（郵送・梱包料 300円･，$15 です。但し本会会員は1ケ年間に限り（1972年中）2,800円（郵送・梱包料込み）$12 で頒布いたします。購入御希望の方は 〒812 福岡市箱崎町 九州大学理学部地質学教室内，日本古生物学会特別号編集委員会へ。

地質地理学輯報原稿募集について

現在，地質地理学集報（学術会議出版）はいろいろの事情で今後の出版についての方針がまだ決っておりません。しかし，その如何に拘らず，48年度も若干の論文の掲載は可能の見込みです。（今，Vol. 42 約 200 pages 刷上り予定，印刷中）

従って，下記により皆さんの投稿を御願い致します。

論　　文：欧文原著)原則として日本の研究者が国内で行った成果の発表)

審　　査：集報編集委員会の責任で行う。

掲　　載：審査により最終的に受理された順で，予算の都合によりその号に掲載不可能のときは投稿された方の希望により返却。

別　　刷：現在100部無料，出版方針の変更があれば，それにより減少の可能性。

投稿期限：昭和47年8月末日（Vol. 43）

投 稿 先：東京都文京区本郷　東京大学理学部地質学教室内　地質地理学集報編集委員会
委員長　岩生周一宛

例　会　通　知

	開催地	開催日	講演申込締切日
109 回 例 会	宇都宮大学	1972 年 6 月 3・4 日	1972年 5 月 10 日
110 回 例 会	愛媛大学	1972 年 10 月 28・29 日（予定）	1972年 9 月 20 日
1973年 総会・年会	東北大学	1973 年 1 月 19・20 日（予定）	1972年 12 月 10 日
111 回 例 会	新潟大学（予定）	1973 年 6 月 下 旬	1973年 5 月 20 日

◎ 109回例会（宇都宮大学）には，野外巡検（6月4日）を予定しています。行先は，最近ジュラ紀菊石化石の発見された栃木県芳賀郡益子町付近の鷲ノ子山地周辺です。出発は9時30分（宇都宮大），解散は16時頃（宇都宮駅）の予定で，貸切バスを利用します。（案内者 鈴木陽雄）

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従来総会や例会で開催されてきたシンポジウムを，いっそう充実した有意義なものにするため，常務委員会内にその世話係を常置し，行事委員が当ることになりました。会員諸賢で，こういうシンポジウムを持ちたいという御希望があれば，同志とはかられ，随時シンポジウム代表者より常務委員会行事係宛御申込み下さい。今のところ講演会は年3回ですから，あらかじめ講演会開催日以前に，申込まれたシンポジウムを，委員会で検討し実施したいと思います。なお採択されたシンポジウムには運営費を少額ながら支給することになります。

● 本会誌の出版費の一部は文部省研究成果刊行費による。

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