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The fossil on the cover is Unuma (Spinunuma) echinatus ICHIKAWA and YAO, a Middle Jurassic multisegmented radiolaria from Unuma, Gifu Prefecture, central Japan (photo by A. YAO, × 260).

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816. SOME INOCERAMIDS (BIVALVIA) FROM THE CENOMANIAN (CRETACEOUS) OF JAPAN—I NEW OR LITTLE KNOWN FOUR SPECIES FROM HOKKAIDO AND KYUSHU*

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Abstract. In a series of papers in 3 parts some new and little known inoceramid species from the Cenomanian of Japan are to be described. In this part we describe the following four species including three new ones. (1) Birostrina sp. nov., which belongs to the group of B. concentrica but has a radial groove on the posterior part and ribs of moderate intensity in the late growth-stage. It is represented by a number of specimens from the Middle Cenomanian of the Mifune (central Kyushu), Mikasa (central Hokkaido) and Kotanbetsu (northwestern Hokkaido) areas. (2) Inocermus sp. nov., which is allied to I. comancheanus but has a subrectangular outline with less convex valves and weaker subcostae. Its holotype came from the Lower Cenomanian of the Mikasa area. (3) I. heinzi Sornay, which is represented by several specimens from the Upper Cenomanian and/or lowest part of the Lower Turonian of the Saku area (northwestern Hokkaido). They are very similar to the holotype from Madagascar. (4) Mytiloides sp. nov., which has a larger beak angle and more convex anterior margin than M. submytiloides and is characterized by regular concentric ribs combined with fine concentric lirae. Its holotype came from the Zone of Euomphaloceras septemseriatum (Upper Cenomanian) of the Mikasa area.

Introduction

Through the field works in various areas of Japan to cooperate in the IGCP Project No. 58 Mid-Cretaceous Events (MCE) (1975–1982) and also in the Regional Working Group for the Subcommission on Cretaceous Stratigraphy of the IUGS (1976–1984), we have obtained a great amount of mega-fossils which may be useful for biostratigraphic and other aims. The major parts of the collections are those of ammonites and inoceramid bivalves and some of them have been and would be evaluated in improving the taxonomy and biostratigraphic zonation and correlation.

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In a series of papers entitled at the heading, we are going to describe some species of the Inoceramidae from the Cenomanian of Japan, which have been recorded only preliminarily or left untouched for full description. As the persons concerned with the cooperative study vary case by case, the results are to be published successively in three parts by different authorships.

For some reasons, some species from the Cenomanian of Japan are represented by a small number of specimens. This is probably due to our collection failure and indeed unfavourable for getting an adequate conception of a species. It would be, however, better to describe them at this moment than to leave them unrecorded for a long time, so that someone may obtain a satisfactory sample of population in future to revise the present definition. In Part I we describe four species of which three belong to such category. The material of this study is the specimens from the Mikasa, Saku and Kotanbetsu areas of Hokkaido, but one of the species depends also on those from the Mifune area of Kyushu which were once treated by Tamura and Matsumura (1974).

The repositories of the described or mentioned specimens are as follows with abbreviation in parentheses:

Geological Collections, Kyushu University, Fukuoka (GK)

Geological Collections, Faculty of Education, Kumamoto University, Kumamoto (KE)

Institute of Geology and Palaeontology, Tohoku University, Sendai (IGPS)

University Museum, University of Tokyo, Tokyo (UMUT)

Systematic descriptions

Family Inoceramidae Zittel, 1881

As to the authorship of this family we follow Vokes' (1980) indication.

Kauffman (*in* Kauffman *et al.*, 1977 and elsewhere) commented that the current taxonomy of this family at generic level based primarily on external characters should be revised on the ground of more important interior features, but has not yet given fully his scheme of classification nor his description of generic diagnosis, except for a few genera, *e.g. Mytiloides.* At present, we have no competent idea of our own scheme of overall taxonomy and have to depend on the existing concepts of Dobrov and Pavlova (1959), Cox (1969), Seitz (1961, 1965, 1967, 1970), Sornay (1966), Dhondt (1983) *etc.*, as well as Kauffman (*op. cit*; 1977), with some modification.

For the terms to describe morphological characters we follow primarily those defined by Nagao and Matsumoto (1939), which have been used by Noda (1983, 1984 *etc.*) and Matsumoto and Noda (1985) with some modification. Readers may refer to Efremova (1978) to compare them with other authors'.

The symbols (or letters) to abbreviate the dimensions and angles in the tables of measurements in this paper are as follows:

h=height, l=length, H=maximum linear dimension from beak to posteroventral extremity, L=ditto perpendicular to H, s=length of hinge line (previously indicated as HL), b= breadth (previously indicated as th or T), α =anterior hinge angle (angle between hinge line and anterodorsal margin), β =angle of umbonal inflation, γ =posterior hinge angle (angle between hinge line and posterior margin), ζ =obliquity (angle between axis of growth and hinge line); L=left valve, R=right valve

The terms to describe the concentric ornamentation vary between authors and also in accordance with the characters. In this paper we use the following terms:

concentric lines or lirae: fine markings on the surface of shell, which are not impressed on the internal mould, except in the case of the composite internal mould concentric rings: fine concentric elevations of the third order, which may correspond to the concentric lines or lirae but are somewhat more elevated than them and may be discernible even on the internal mould concentric subcostae or riblets (minor ribs): concentric elevations of the second order, well recognized even on the internal mould, being larger (*i.e.* thicker and higher) than the concentric rings but somewhat smaller (narrower and lower) than and often branched from or intercalated between the concentric elevation of the first order

concentric ribs or ridges (major ribs): concentric elevations of the first order. When they are broad but low or weak the term concentric undulations may be employed. concentric depressions: concentric furrow along the constricted or geniculated part of the shell in the case when the shell shows an abrupt change in convexity.

Radial or divergent ornaments do not occur in the described species, except for a *radial sulcus* or groove in a species.

Radial markings which reflect the interior shell morphology may appear on some well preserved specimens, but they should not be treated as ornamentation.

Genus Birostrina J. Sowerby, 1821

Type species:—Inoceramus sulcatus Parkinson, 1819.

Diagnosis:—Shell small, inequivalve, with narrow and prominent left umbo and prosogyrous beak; hinge line short, without or with very narrow posterodorsal auricle; surface ornamented with fine concentric lirae and with or without concentric ribs, riblets and/or radial folds.

Remarks:—Presence of the radial folds is not a generic criterion and the genus is best represented by *Inoceramus concentricus* Parkinson, 1919. Although the group of *I. concentricus* was taken too much comprehensively by Nagao and Matsumoto (1939), *Birostrina* evidently ranges up to the Cenomanian in the North Pacific region.

Birostrina tamurai sp. nov.

Pl. 81, Figs. 1–6; Pl. 82, Figs. 1–3; Pl. 83, Figs. 1–3; Pl. 85, Figs. 4–5

1974. Inoceramus concentricus costatus Nagao

et Matsumoto; Tamura and Matsumura, p. 49, pl. 1, figs. 1-5.

- 1976. Inoceramus concentricus nipponicus Nagao et Matsumoto; Noda and Matsumoto, pl. Cr-31, fig. 2.
- 1976. Inoceramus concentricus costatus Nagao et Matsumoto; Noda and Matsumoto, pl. Cr-31, fig. 3.
- 1977. Birostrina n. sp., Kauffman, p. 175.

Material:-Holotype, KE 1976 (Pl. 81, Fig. 1), composite internal mould of left valve from loc. 4 (Yaseto, Mifune area, Kyushu) of Tamura and Matsumura (1974). Paratypes, KE 1977 from loc. 1 (Omine), KE 1978 from loc. 5 (Okadake Playground), KE 1979 from loc. 2 (Asanoyabu) and KE 1706 from loc. 3 (Subayashi) of the Mifune area; also GK. H 10164 and H 10165 both valves, GK. H 10166, small left valve, and others (GK. H 10167-H 10169) from loc. Ik 2021a, Pombets gorge, Mikasa district (coll. M. Noda and T. Matsumoto); GK. H 10082, H 10157-H 10159 from loc. R 100 and GK. H 10153-H 10156, H 10160-H 10162 from loc. R 101 of the Kotanbetsu area (coll. T. Matsumoto and H. Okada).

Diagnosis:—Rather small, inequivalve, asymmetrically ovoid shell of the group of *Birostrina* concentrica, characterized by the presence of a radial sulcus on the posterior part and the development of rather irregular concentric ribs and riblets in late growth stage in addition to finer concentric lirae or rings.

Description:—The holotype (Pl. 81, Fig. 1) is small and probably not a full-grown individual, but it does show diagnostic characters. Tamura and Matsumura (1974, pl. 1, figs. 1a— 1b) have carefully given two figures in somewhat different views, which clearly show the posterior radial sulcus and the details of the posterodorsal part as well as other features, although the authors did not mention these two characters in the text. KE 1979 (Tamura and Matsumura, 1974, pl. 1, fig. 5; this paper Pl. 81, Fig. 3) is somewhat larger than the holotype but deficient in the anteroventral and posteroventral portions. KE 1977 (Tamura and Matsumura, 1974, pl. 1, fig. 2; this paper Pl. 85, Figs. 4—5) is also incomplete but the largest of the Mifune specimens, attaining to about 75 mm in H in a restored outline. GK. H 10164 (Pl. 81, Fig. 6; Pl. 82, Fig. 1) from Mikasa and GK. H 10153 (Pl. 82, Fig. 2) from Kotanbetsu may represent the normal size of this species. The right valve of the former is badly eroded, but this deficiency is supplemented by another specimen, GK. H 10165 (Pl. 81, Fig. 5; Pl. 82, Fig. 3) from Mikasa, which however, is somewhat distorted. GK. 10154 from Kotanbetsu has both valves and more right valves are preserved in the Kotanbetsu sample (e.g. GK. H 10155-10157, H 10159-10161). Shell layer is partly preserved in some Kotanbetsu specimens.

On the basis of a considerable number of these specimens the specific characters are well recognized. Evidently the left valve is more convex than the right, having a fairly inflated, prominent but narrow umbonal part whose beak is considerably curved inward and forward, exceeding the hinge line.

The hinge line is nearly as long as or slightly longer than a half of shell length, forming an angle (α) of about 80° with the anterior margin and that (γ) of about 140° with the posterior margin. The axis of growth extends towards the posteroventral extremity nearly straightly or obliquely with a forward gently concave curvature, forming an angle (ζ) of about 40° to 50° with the hinge-line. The anterior margin is gently concave below the umbo and broadly convex in the lower part towards the anteroventral edge, where it is bent to the asymmetrically rounded ventral margin, which passes to the gently arcuate posterior margin. The narrow posterodorsal edge is somewhat flattened.

A radial sulcus runs on the posterior part of the disk near the margin of the umbonal inflation in the left valve, extending towards the posteroventral part, where the ribs may show slight sinuosity on crossing the shallow sulcus. A faint, corresponding sulcus is discernible on some right valve specimens, *e.g.* GK. H 10154 and H 10155.

The shell is ornamented with numerous concentric lirae or rings and rather irregularly developed concentric ribs and riblets. The lirae or rings are distinct on the young part (e.g. up to 25 mm in H in the holotype) as fine and dense markings on the shell surface and sometimes even on the internal mould, some of which may be somewhat stronger than others. Major ribs and branched or intercalated minor ribs are developed in late growth stages with rather irregular intensity and distance, being combined with the finer rings on the interspaces. Major ribs extend to the posterior part. whereas minor ribs or riblets and rings on the main part of the disk fade away as they approach the zone of radial sulcus. Some of the

Explanation of Plate 81

Figs. 1–6. Birostrina tamurai sp. nov. Page 411

- 1. Holotype, KE 1976 (LV), from Mifune; lateral (a), anterior (b), posterior (c) and dorsal (d) views, × 1.2.
- 2. Replica of holotype in the lighting somewhat different from 1a to show the posterior sulcus, \times 1.
- 3. KE 1979 (LV) from Mifune, lateral view, \times 1.
- 4. GK. H 10166 (LV), from Mikasa; lateral (a), anterior (b) and posterior (c) views, \times 1.
- 5. GK. H 10165 (BV) from Mikasa; left (a) and right (b) lateral, anterior (c) and posterior (d) views, \times 1.
- 6. GK. H 10164, left lateral view in the disposition a little different form Pl. 82, Fig. 1a, \times 1.1.

BV: both valves, LV: left valve, RV: right valve.

Photos. (Pls. 81-85) by M. Noda.



Specimens	h	1	l/h	н	L	L/H	b	b/h	S	s/l	α	β	γ	δ
KE 1976 (L)	34.5	26.0	.75	37.0	26.7	.72	14.0	.41	18.0	.61	80 [°]	60°	140°	50°
GK. H 10164 (L)	59.6	36.7	.62	62.5	38.0	.61	27.0	.45	19.0	.52	80°	55°	130°	56°
GK. H 10164 (R)	52.8	36.7	.70	56.8	38.0	.67	-	_	19.0	.52			130°	56°
GK. H 10153 (L)	-	_	-	48.4	34.2	.71	18.5	_			_	55°		_
GK. H 10157 (R)	40.0	30.8	.77	42.0	31.6	.75	12.0	.30	≥15.4	≧.50	100°	-	137°	50° 65°
GK.H 10083 (L)	50.0	42.0	.84	58.6	37.8	.65	21.4	.42	21.4	.51	90°	55°	145°	50°

Table Measurements of selected specimens.

ribs extended from the main part of the disk reach the narrow, flat, posterodorsal edge with gradual weakening, as seen in the well preserved specimens (*e.g.* holotype and GK. H 10082).

Etymology:—This species is dedicated to Professor Minoru Tamura of Kumamoto University who has contributed much to the palaeontology of the Mesozoic Bivalvia.

Comparison and discussion:-We owe much to Erle G. Kauffman (1977, p. 175) who suggested that the presence of the posterior radial sulcus should be evaluated as a specific character in *Birostrina*. In fact, the sulcus is observable in a number of examined specimens from particular beds of the three areas. In some specimens (*e.g.* GK. H 10082 figured by Noda and Matsumoto, 1976; this paper Pl. 83, Fig. 3) the sulcus is faint.

The lectotype of *Inoceramus concentricus* var. costatus Nagao et Matsumoto, 1939 was designated by Tamura and Matsumura (1974, p. 49) to the one illustrated by Nagao and Matsumoto, 1939, pl. 24, figs. 1a-c, *i.e.* UMUT. MM 6480 [=I-690]. It has no posterior sulcus and is distinguished from *B. tamurai*. It resembles closely *Inoceramus concentricus* var. porrectus Woods (1917, pl. 4, figs. 1a-b), as Nagao and Matsumoto (1939, p. 271) have already pointed out. Kauffman considered it as identical with *B. porrecta* (Woods) from New Zealand. We would defer the conclusion about this point until we could examine more carefully the specimens from New Zealand and Japan.

Kauffman (op. cit.) compared the species represented by Tamura and Matsumura's specimens (that is now called *B. tamurai*) with an undescribed species, "*Birostrina* n. sp. (sulcate)", from the Albian of England. This is interesting, but *B. tamurai* has concentric ribs of moderate intensity in the late growth-stage. The young shell of *B. tamurai* ornamented with fine concentric lirae and rings may be similar to that Albian species, which has not yet been clearly described nor illustrated. The sulcus may be the same kind of radial plication as those of *B. sulcata* (Parkinson, 1819) and *B. subsulcata* (Wiltshire, 1879) (see Woods, 1911).

Occurrence:—The type locality is Yaseto, Toyono-mura, Shimomashiki-gun, Kumamoto Prefecture (central Kyushu). This and other nearby localities are recorded by Tamura and Matsumura (1974). They are all in the lithic sandstone of the Lower Formation of the Mifune Group. Eucalycoceras sp. cf. E. spathi (Collignon) is recorded to occur in the same formation (Matsumoto in Tamura and Matsumura, 1974). On the evidence of this ammonite and other associated fossils (Tamura, 1979) the Lower Mifune is assigned to the Middle Cenomanian.

Other described specimens came from two places. One is loc. Ik 2021a at Pombets gorge in a tributary of the River Ikushumbets, Mikasa district (central Hokkaido), in the Mikasa Sandstone between the layers rich in trigonians. *Calycoceras* cf. *C. asiaticum* (Jimbo) occurs fragmentarily at loc. Ik 2021b in a trigonian bed. For the route map and stratigraphic section see Matsumoto (1965, figs. 3 and 5). The other is locs. R 100 and R 101, on road side of Highway 239, about 800 m linearly west of Kiritachi Pass, Kotanbetsu area (northwestern Hokkaido), from calcareous nodules in the mudstone of the Middle Yezo Group. *Caly*- coceras sp. of newboldi group was found from loc. R 100. For the map and stratigraphic section of this route see Matsumoto and Okada (1973, figs. 7-8).

To sum up, the known age of *Birostrina* tamurai is Middle Cenomanian. The fossils occur separately in the Mifune area but in groups often with both valves conjugated in the Mikasa and Kotanbetsu areas.

Inoceramus takahashii sp. nov. Pl. 84, Figs. 1a-c

Holotype:-GK. H. 10145, both valves, collected by Takemi Takahashi from the upper reaches of the 8th branch of the Kami-ichi-nosawa, a tributary to the River Ikushumbetsu, Mikasa district, central Hokkaido. Outer and inner shell layers preserved on the umbonal part; inner shell layer attached on some contiguous part; the rest main part of left valve and some portions of right valve internal mould.

Specific characters:—Shell subequivalve; the umbo of left valve slightly more projecting and incurved than the right. Valve gently convex in the main part, but for somewhat more inflated umbonal part. Posterior part flattened, passing gradually from the main part of the disk, except the umbonal part, where there is a faint auricular depression. Anterior side steep, with concave anterodorsal part.

Shell subrounded rectangular in rough outline, nearly as high as broad in early stage and higher

than long later. Hinge plate fairly thick; hinge line moderately long, somewhat more than half of shell-length. Anterior hinge angle (α) about 105° and angle of umbonal inflation (β) 85°. Anterior margin nearly straight, with very gently arcuate curvature towards rounded anteroventral edge; ventral margin rather broadly and asymmetrically rounded, passing gradually to gently arcuate posterior margin. Posterior hinge angle (γ) from 120° (in young stage) to 140° (later). Axis of growth runs along the central line of flank, forming angle (δ) of about 65° with the hinge line.

Shell in the main growth-stage ornamented with numerous, fairly dense, rather weak concentric subcostae, which become very weak in the last stage. Major ribs of the first order scarcely developed, except for the indistinct ones in the early middle grwoth-stage, but the occurrence of comparatively more distinct subcostae at periodic intervals associated with somewhat deeper interspaces may imply incipient or hidden major ribs. Fine concentric lirae of the third order discernible on the surface of the outer shell layer which is preserved on the umbonal part of the holotype.

Etymology:—This species is dedicated to Mr. Takemi Takahashi of Mikasa, who is one of the most eminent naturalists in collecting scientifically valuable fossils from Hokkaido.

Remarks:-The holotype itself is fairly good, but no more specimen has been obtained from the same bed and the extent of variation is un-

Specimen	h	1	l/h	Н	L	L/H	b	b/h	S	s/l	α	β	γ	δ
GK. H 10145	92.0	71.0	.77	102.0	72.0	.71	24.0	.26	41.0	.58	105°	85°	140°	65°

Measurements of holotype (left valve).

Explanation of Plate 82

Figs. 1-3. Birostrina tamurai sp. nov. Page 411 1. GK. H 10164 (BV) from Mikasa; left lateral (a), right lateral (b), anterior (c),

posterior (d) and dorsal (e) views, \times 1.

- 2. GK. H 10153 (LV) from Kotanbetsu; lateral (a), anterior (b), posterior (c) and dorsal (d) views, × 1.
- 3. GK. H 10165 (BV) from Mikasa; anterior view in the lighting somewhat different from Pl. 81, Fig. 5d, × 1.



known at present. There are, however, some specimens from other areas within Hokkaido, which are comparable but not quite identical with the holotype. They will be described in Part 3.

Comparison:-This species is somewhat similar to Inoceramus comancheanus Cragin, 1895 from the Albian of Texas. By courtesy of Dr. W. A. Cobban, there are plaster casts (GK. H 9194 and H 9195) of the two syntypes (USNM. 32686 A, B) (for their and other illustrations see Hill, 1901 and Reeside, 1923) from the Duck Creek Limestone. Furthermore, Pergament (1964) described an example from the Albian of Kamchatka under Inoceramus cf. I. comancheanus and then Eigenheer and Sornay (1974) another example from the basal Cenomanian of Montlaux (Alpes-de-Provence, France) under Inoceramus aff. I. comancheanus. Our species differs from them in having more subrectangular outline, with larger umbonal angle (β) and more broadly rounded ventral margin and weaker and denser concentric subcostae. Especially, the concentric ribs are distinctly stronger in the late growthstage of I. comancheanus. In the two syntypes (left and right valves) of that species the main part of the flank is more convex and slopes down less gradually to the posterior flat part, with a very faint, incipient, radial sulcus between the two parts. The specimen from the basal Cenomanian of Montlaux, mentioned above, is more compressed than the American types and is similar to ours in that respect, but is extended more obliquely and has more irregular and stronger ribs than the holotype of our species. Anyhow, that French species is not either identical with ours.

I. takahashii is somewhat similar to I. prefragilis Stephenson, 1953 (see also Kauffman et al., 1977), from the Middle Cenomanian of Texas and Oklahoma, in the general outline and ornamentation, but the latter has a more convex main part of the flank, more distinct auricular sulcus or break, and finer but more distinct concentric subcostae.

The specimens described long ago by Etheridge (1872) from the "Marathon Formation" of

Queensland (Australia) under *I. multiplicatus* Stoliczka var. *elongatus* Etheridge, *I. pernoides* Etheridge and *I.* sp. aff. *I. problematicus* d'Orbigny seem to be allied to *I. comancheanus*. The third one is especially similar to *I. takahashii* in the shell-form but different in having more distinct concentric subcostae on its younger half and stronger concentric ribs on its later half. The age of the Marathon Formation was considered as Cenomanian by Etheridge but must be Albian in the light of recent knowledge about the Cretaceous stratigraphy of Australia (Ludbrook, 1978).

To sum up, the described specimen found by T. Takahashi represents a new species belonging to the group of *I. comancheanus*.

Occurrence:—In a calcareous nodule derived from the sandstone referable to the lower part of the Mikasa Formation in the upper reaches of the 8th branch (Hachi-no-sawa in Japanese) of the Kami-ichi-no-sawa, a tributary of the River Ikushumbets. As *Sharpeiceras* sp. was obtained by T. Takahashi form a nearby locality, the sandstone is most probably referred to the Lower Cenomanian.

Inoceramus heinzi Sornay, 1965

Pl. 83, Figs. 4a-d; Pl. 85, Figs. 2-3b

1933. Inaequiceramus inaequivalvis (Schlüter); Heinz p. 246, pl. 18, fig. 1.

1965. Inoceramus heinzi Sornay, p. 7, pl. B, fig. 4.

Material:-GK. H 10148, internal (Pl. 83, Fig. 4) and external moulds of left valve from loc. T 5046 B; GK. H 10149 (Pl. 85, Fig. 2), left valve, with shell attached on the main part, from loc. T 5046 A; GK. H 10150, internal (Pl. 85, Fig. 3) and external moulds of right valve from loc. T 5045 B; poorly preserved GK. H 10151, from loc. T 5046 B (*I.* cf. *I. heinzi*); all collected by T. Matsumoto.

Description:-Shell medium-sized, inequivalve and inequilateral. Beak of left valve projected considerably beyond hinge and curved remarkably inward and forward, as seen in GK. H 10148. Valve moderately convex in the umbonal part, inclined abrupty forward to the almost vertical and somewhat concave anterior side and gently towards the flattened posterodorsal wing like part. Convexity along the growth-axis gradually decreased towards ventral margin.

Outline suboval, extending obliquely towards the posteroventral extremity, with axis of growth forming angle (δ) of about 50° with hinge line; beak anterior, hinge line slightly shorter than a half of shell length, forming angle (α) of 75– 80° with anterior margin and that (γ) of 145° to 150° with the posterior margin; anterior margin broadly arcuate with gentle anterodorsal concavity; ventral margin asymmetrically rounded, passing gradually to gently convex, arcuate posterior margin.

Shell ornamented with rather low concentric major ribs or undulations and also concentric rings, the latter of which may not be impressed on internal mould but well discernible on shell surface or external mould. Posterior muscle impression is observable slightly behind the midline in GK. H 10150.

Comparison and discussion:—The described specimens are very similar to the holotype illustrated by Heinz (1933, pl. 18, fig. 1) and also by Sornay (1965, pl. B, fig. 4) of *I. heinzi* Sornay from Madagascar.

The specimens (no. 534 A, B) from Ankomaka, drawn by Sornay (1965, fig. 3), have somewhat larger anterior hinge angle, longer hinge line and larger ratio of L/H than our described specimens and also than the holotype. The specimens IGPS. 22709 and UMUT. MM 6492 [=GT. I-710] from pebbles of the River Obirashibe, described under *Inoceramus* sp. indet. (sp. nov.?) by Nagao and Matsumoto (1939, p. 280, pl. 27, fig. 1 and pl. 28, fig. 1), are somewhat similar to this Sornay's form, as Kauffman (1977, p. 176) has pointed out, but they are larger, "broader" and flatter. Probably they represent a distinct species, but we have not yet been successful to decide the stratigraphic position of this peculiar form.

Occurrence:--Loc. T 5046 A, B, Saku-gakkono-sawa, lower part of Member II c (clayey mudstone); also loc. T 5045 B, close to T 5046, uppermost part of Member II b (fine-grained sandy siltstone), Saku area, Teshio Mountains (see route map of Matsumoto and Okada, 1973). The main part of II b, lower than loc. T 5045, is referred to the Middle Cenomanian on the evidence of ammonites, Desmoceras (Pseudouhligella) japonicum Yabe, Calycoceras spinosum (Kossmat), C. cf. C. bathyomphalum (Kossmat) and Euomphaloceras asura Matsumoto et Muramoto [= ?E. multicostatum (Basse)], and the main part of II c, higher than loc. T 5046, is referred to the Lower Turonian on the evidence of Mytiloides mytiloides (Mantell), Fagesia cf. F. rudra (Stoliczka) and F. thevestensis

Specimens	h	1	l/h	Н	L	L/H	b	b/h	s	s/l	α	β	γ	δ
GK. H 10148	70	65	.93	78	52	.67	19	.27	32.0	.49	85°	65°	145°	50°
GK. H 10150	47	42	.89	55	42	.76	12	.26	19.5	.46	90°	-	150°	50°

Measurements of described specimens.

Explanation of Plate 83

Figs. 1–3. Birostrina tamurai sp. nov Page 411
1. GK. H 10155 (RV) from Kotanbetsu; lateral view, x 1.
2. GK. H 10158 (LV) from Kotanbetsu; lateral (a) and posterior (b) views, \times 1.
3. GK. H 10082 (LV) from Kotanbetsu; lateral (a), anterior (b), posterior (c) and
dorsal (d) views, \times 1.
Fig. 4. Inoceramus heinzi Sornay Page 415
GK. H 10148 (LV) from Saku; lateral (a), dorsal (b), posterior (c) and anterior (d)
views, $\times 1$.



Pervinquière. Therefore, the beds exposed at locs. T 5045 and T 5046 are probably referable to the Upper Cenomanian and/or lowest part of Lower Turonian.

Genus Mytiloides Brongniart, 1822

Type species:—Ostracites labiatus Schlotheim, 1813.

Remarks:—For generic diagnosis and distinction from *Inoceramus* Sowerby, 1814 readers may refer to Kauffman *et al.*, 1977 and Keller, 1982, whom we follow.

Mytiloides mikasaensis sp. nov.

Pl. 85, Figs. 1a-c

Holotype:-GK. H 10045, composite internal mould of right valve, with test attached partly, collected by Tatsuo Muramoto from loc. Ik 1038 on the right bank of the River Ikushumbets, Mikasa district, central Hokkaido.

Specific characters:—Valve gently convex from beak to ventral margin and also from front to rear, inclined fairly steeply on anterior side and gently to posteior, passing to rather narrow flat wing. Hinge plate thin. Hinge line rather short, a little more than a third of shell length. Beak nearly but not exactly at the anterior end of hinge line, suberect, projecting slightly.

Shell extended obliquely towards the posteroventral extremity, with H fairly longer than L and with axis of growth convexly curved forward, showing angle (δ) of 45° to 35° with hinge line. Anterior hinge angle (α) and angle of umbonal inflation (β) large. Anterior margin convex, with forward arcuate anteroventral margin, passing gradually to broadly and asymmetrically curved ventral margin, and then curved rather abruptly at the posteroventral extremity to gently arcuate, long, posterior margin. Posterior hinge angle (γ) very large in late growth-stage.

Shell ornamented with regular concentric

ribs, which are of moderate intensity in the middle growth-stage and gradually weakened later; surface with fine and regular concentric lirae, which may be somewhat prominent on the summit of concentric ribs.

Test very thin. Faint radial striae, which may be tracks of mantle retractor muscles, discernible on the main part of internal mould, but for a narrow zone along the growth axis, which may be posterior adductor muscle insertion area.

Remarks:—Fragmentary shells with regular concentric ribs are contained in the calcareous nodule together with the holotype, but they are too incomplete to show the entire outline.

Comparison:—This species is distinguished from Mytiloides submytiloides (Seitz, 1935) (Holotype; Seitz, 1935, p. 444, pl. 37, fig. 1, text-fig. 8a), from the Upper Cenomanian and lowest Turonian of Europe and North America (Wiedmann and Kauffman, 1985), in its larger anterior hinge angle (α) and larger umbonal angle (β) more convex and forward projecting anterior margin, and more regular concentric ribbing combined with finer and more regular concentric lirae.

M. mikasaensis is similar in shell-form to *M. goppelnensis* (Badillet et Sornay, 1980) (Keller, 1982), from the Lower Turonian of Europe and North America, especially to the form described under *M. goppelnensis tourtenayensis* (Badillet et Sornay, 1980) from France, but the former has less arcuate growth-axis and more regular and less crowded concentric ribs combined more regularly with finer lirae.

For some reasons, Seitz (1935), Kauffman (in Kauffman et al., 1977 and other papers) and Tröger (1981) seem to have misunderstood Inoceramus opalensis Böse, 1923 in the original sense, which is represented by Böse (1923, pl. 13, figs. 1–3) and never so oblique as the so-called M. opalensis by them. This has been revised by Badillet and Sornay (1980), to whose opinion we are quite agreeable. W. A. Cobban

Measurements of holotype.

			_		-			• •						
Specimen	h	1	l/h	Н	L	L/H	b	b/h	s	s/l	α	β	γ	δ
GK. H 10045	41.0	51.0	1.24	51.8	37.6	.73	11.0	.27	19.0	.37	140°	130°	155°	45°-35°

(1983, personal communication) told us that examples of correctly identified *M. opalensis* occur near the boundary of Lower and Middle Turonian, *i.e.* near the boundary of *Mammites nodosoides* Zone and *Collignoniceras woollgari* Zone.

Mytiloides modeliaensis (Sornay, 1981), from the Lower Turonian of Colombia and North America, is similar to *M. mikasaensis* with respect to the shell-form, especially to the convex anterior margin, but the former has on the average less oblique growth-axis and more crowded and sharper concentric ribs.

Occurrence:—Loc. Ik 1038, right bank of the main stream of the River Ikushumbets, Zone of Euomphaloceras septemseriatum, Upper Cenomanian of the Mikasa district, central Hokkaido (see Matsumoto, 1965, figs. 2 and 4 for the location of Ik 1038).

Summary

As a summary the species described in this paper are listed below with indication of their known age and area.

- Birostrina tamurai sp. nov., Middle Cenomanian of the Mifune (central Kyushu), Mikasa (central Hokkaido) and Kotanbetsu (northwestern Hokkaido) areas
- Inoceramus takahashii sp. nov., Lower Cenomanian of the Mikasa area
- Inoceramus heinzi Sornay, Upper Cenomanian and (?) Lower Turonian of the Saku area (northwestern Hokkaido)
- Mytiloides mikasaensis sp. nov., Upper Cenomanian of the Mikasa area.

We hope that more examples of these species would be found from other localities in the future, so that their biostratigraphic and biogeographic implications may become clearer.

Acknowledgements

We wish to thank Professors Minoru Tamura and Hakuyu Okada and Messrs. Takemi Takahashi, Tatsuo Muramoto and Kikuwo Muramoto for their kind help to this study, including the supply of valuable specimens. Thanks are extended to Professors Itaru Hayami of the University of Tokyo and Tamio Kotaka of Tohoku University, who gave us facilities to study there some type specimens in their charge, and also to Drs. W. A. Cobban, E. G. Kauffman and Jacques Sornay who gave us good suggestions.

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Explanation of Plate 84



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Explanation of Plate 85

Fig. 1. Mytiloides mikasaensis sp. nov I	Page 412
Holotype, GK. H 10045 (RV), from Mikasa; lateral (a), anterior (b) and postero-	
dorsal views, $ imes$ 1. Fragmentary left valve is attached on the opposite side.	
Figs. 2–3. Inoceramus heinzi Sornay H	Page 415
2. GK. H 10149 (LV) from Saku; lateral view, × 1.	
3. GK. H 10150 (RV) from Saku; lateral (a) and anterior (b) views, \times 1.	
Figs. 4–5. Birostrina cf. B. tamurai sp. nov.	Page 411
4. KE 1977 (LV), incomplete, secondarily compressed, large example (internal	
mould), x 1.	
5. Rubber-cast from the external mould (posteroventral portion) of KE 1977, \times 1.	

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本邦白亜系セノマニアン階産イノセラムス-I. 北海道と九州産のよく知られていなかった 4種:本邦のセノマニアンからは、まだよく究明されていなかった種がかなりあるので、それ らを逐次記載していく。この論文では次の4種を記載した。(1) Birostrina tamurai sp. nov.; 以前に Inoceramus concentricus costatus Nagao et Matsumoto と呼ばれていたものの 一部で、B. concentrica 群に属するが、殻の後部に放射状の溝があり、成長後期に肋が発達 する。九州の御船層群下部層と北海道幾春別及び古丹別のセノマニアン中部産。(2) Inoceramus takahashii sp. nov.; I. comancheanus 群に属するが、殻の輪郭が準長方形で、膨ら みが弱く、亜肋も弱い。幾春別のセノマニアン下部産、(3) I. heinzi Sornay; マダガスカ ル原産のものに同定できる。天塩佐久のセノマニアン・チューロニアン境付近産。(4) Mytiloides mikasaensis sp. nov., M. submytiloides (Seitz) よりも殻頂角が大きく、前縁 が前方に凸の線を描く輪郭で、規則正しい同心肋に加えて細かい同心条線が殻表面を覆うこと で識別される。幾春別のセノマニアン上部の Euomphaloceras septemseriatum 帯に産する。 Trans. Proc. Palaeont. Soc. Japan, N.S., No. 143, pp. 422-434, pl. 86, September 30, 1986

817. LEPIDOLINA COLUMBIANA (PERMIAN FUSULINID) FROM BRITISH COLUMBIA, CANADA*

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Abstract. Nine species of Yabeina have been reported from British Columbia. On the basis of statistical study of specimens collected from Marble Canyon and Upper Hat Creek, it is concluded that our specimens as well as specimens of the nine species of "Yabeina" (Y. columbiana, Y. minuta, Y. obesa, Y. dawsoni, Y. gracilis, Y. dunbari, Y. cylindrica, Y. ampla and Y. parvula) belong to one species which should be referred to the genus Lepidolina. They are described under the species L. columbiana (Dawson).

Introduction

It has been suggested that Middle Permian fusulinids of the Cordilleran region including British Columbia, Oregon and California resemble Tethyan fusulinids unlike those of the Mid-Continent, North America (Dunbar, 1932, Thompson and Wheeler, 1942, Ross, 1967 and others). With this suggestion in mind, one of us (Goto) visited the Marble Canyon region during his stay in British Columbia in 1980 and collected limestone samples containing many specimens of "Yabeina" columbiana. Recently Ishii and others (1985) reexamined distribution of neoschwagerinids in the Tethys. According to them, *Neoschwagerina* and *Yabeina* are distributed all over the Tethys, while distribution of *Colania* and *Lepidolina* is restricted to East Asia including Southeast Asia, China and Japan, which forms the Paleopacific biogeographic province in Middle Permian time.

Our paleontological restudy of "Yabeina" columbiana from British Columbia has revealed that this species does not belong to the genus Yabeina, but is assignable to the genus Lepidolina. In this paper we intend to present a result of our study on species of the genus Yabeina described from Marble Canyon, British Columbia on the basis of specimens collected by Goto.

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Historical reviews:—According to Duffell and McTaggart (1951), the study of fusulinids of the Marble Canyon limestone, British Columbia was started in 1872 by Selwyn. In 1877 Dawson revisited Selwyn's original locality in Marble Canyon and on the basis of the fusulinids, assigned a Carboniferous age to the Marble Canyon limestone. Dawson (1879) described *Loftusia columbiana* from Marble Canyon. Although *Loftusia* Brady is originally based on a Tertiary species, Dawson concluded that *L. columbiana* was a Carboniferous form rather than Cretaceous or Eocene because of the accompanying fusulinids.

Dunbar (1932) restudied Dawson's thin sections of specimens of Loftusia columbiana and described the species under the genus Neoschwagerina. He pointed out that the limestone at Marble Canyon is Permian in age. Based on a study of well oriented section of Loftusia columbiana Dawson, Thompson and Wheeler (1942) pointed out that this species should be referred to the genus Yabeina Deprat. They also described Yabeina minuta, Schwagerina pavilioensis var. acris, Nankinella? and Staffella in addition to Yabeina columbiana from samples of talus in Marble Canyon. Thompson, Wheeler and Danner (1950) redescribed Y. columbiana and Y. minuta associated with Yabeina ? n. sp. Schwagerina acris, S. andersoni ? and Codonofusiella duffeli from the Marble Canyon region. Skinner and Wilde (1966) described seven new species of the genus Yabeina listed below in addition to Y. columbiana, Y. minuta, Schwagerina canadensis and Chusenella spicata from the same locality of Marble Canyon material. The seven species of the genus Yabeina are Yabeina obesa, Y. dawsoni, Y. gracilis, Y. dunbari, Y. cylindrica, Y. ampla and Y. parvula.

Acknowledgement:—We wish to express our thanks to Dr. Raymond C. Douglass of U.S. Geological Survey, Prof. Wilbert R. Danner of University of British Columbia, Canada and Prof. Koichiro Ichikawa of Osaka City University for their kind advice.

Geological setting

Geological mapping of the area including the Marble Canyon region, British Columbia was made by Duffell and McTaggart (1951). Trettin (1980) described Permian Cache Creek Group of the Marble Range. According to them the Marble Canyon Formation is a constituent of Cache Creek Group. The Marble Canyon Formation is composed of the massive and mostly recrystallized limestone with intercalations of volcanic rocks, argillites and cherty quartzites, typically exposed in the Marble Canyon and Pavilion Mountains (Text-fig. 1). In the western limit of the distribution of the limestone in Pavilion Mountain, strata are dipping mainly to the west and southwest at about 60 degrees, but near the eastern boundary, dips are to the west at about only 20 degrees. Though the repetition of strata resulting from minor folding and faulting is conspicuous, it is probable that the limestone has a thickness of about 1800 m. The Marble Canyon Formation is flanked on both sides by chert, argillite, greenstone, minor limestone, quartzite and their metamorphic equivalents, which are constituents of the Cache Creek Group. The Marble Canyon Formation yields Permian foraminifers, crinoids, blastoids, corals and brachiopods, and this formation has been assigned to the Guadalupian Formations of the other regions by many investigators (Duffel and McTaggart, 1951 and Trettin, 1980).

Our samples were collected from the following two localities (Text-fig. 1).

Loc. 1, Marble Canyon: Talus on the north shore of the Pavilion Lake. Massive recrystallized limestone. Type locality of "Yabeina" columbiana (Dawson). Sample obtained from Loc. 1 are grayish limestone, containing fossils of fusulinids, smaller foraminifers and algae. The preservation of these fossils is generally poor, because of recrystallization of limestone owing to regional metamorphism.

Loc. 2, Upper Hat Creek: About 30 km south of Loc. 1. Bedded limestone, partly recrystallized. Samples obtained from Loc. 2 are dark



Text-fig. 1. Geological sketch map of the Marble Canyon region. Loc. 1: Marble Canyon, Loc. 2: Upper Hat Creek, 1: Pavilion beds, 2: western belt of Cache Creek Group, 3: central belt of Cache Creek Group (Marble Canyon Formation), 4: eastern belt of Cache Creek Group. (after Trettin, 1980)

gray limestone showing micritic texture. Only fusulinids are found as fossils. This locality is newly found by Goto.

Morphologic variation

Before going over the systematic paleontology, some results of morphological analysis of yabeinid specimens from two localities are presented in order to examine the scope of specific variation.

Morphometry of the specimens from Marble Canyon and Upper Hat Creek is carried out with respect to the following shell characters such as form ratio, diameter of proloculus, thickness of spirotheca and first appearance of secondary transverse septula.

First, the comparison of individuals treated this time with those of species of Yabeina and Lepidolina described previously is made with reference to the form ratio and the diameter of proloculus (Text-fig. 2). The individuals treated this time and those of nine species of Yabeina described by Skinner and Wilde from the same region are recognized to be situated on the intermediate position between Lepidolina multiseptata from East Asia (cf. Ozawa, 1975), and the Yabeina group including Y. globosa, Y. packardi, Y. kaizensis, Y. igoi, Y. katoi, etc. In Text-fig. 2, measured values of proloculus of the present specimens and those of nine species of Yabeina mentioned already are overlapping with that of Lepidolina asiatica but are not overlapping with that of most of



Text-fig. 2. Diameter of proloculus against form ratio for present specimens from Upper Hat Creek (open circle) and Marble Canyon (solid circle). Variation ranges of species of Lepidolina and Yabeina are shown as vertical bars and squares. 1: "Yabeina" columbiana, 2: "Y." minuta, 3: "Y." obesa, 4: "Y." dawsoni, 5: "Y." gracilis, 6: "Y." dunbari, 7: "Y." cylindrica, 8: "Y." ampla, 9: "Y." parvula, 10: Y. cascadensis, 11: Y. decora, 12: Y. fusiformis, 13: Y. packardi, 14: Y. kaizensis, being indicated by symbol of black triangle, 15: Y. igoi, 16: Y. inouyei, 17: Y. katoi, 18: Y. globosa, 19: Lepidolina multiseptata multiseptata, 20: L. m. shiraiwensis, 21: L. asiatica, 22: L. japonica. Variation range of the species of Yabeina (s. str.) falls within the part below the broken line.





Text-fig. 3. Comparison of spirotheca, primary and secondary transverse septula among Lepidolina multiseptata multiseptata, L. columbiana and Yabeina globosa. a: L. m. multiseptata, topotype, loc. Phnom Bak, Sisophon, Cambodia (coll. Ishii), b: L. columbiana, KU 3002, enlarged part of pl. fig. 2, loc. Marble Canyon, British Columbia (coll. Goto), c: Y. globosa, topotype, loc. Mameishi limestone, Akasaka, Gifu Prefecture, Japan (coll. Ishii). the Yabeina group. This text-figure shows that some specimens, which were referred to "Yabeina" columbiana and "Y." ampla by Skinner and Wilde, are below 100 microns in diameter of proloculus. However, there is a possibility that thin sections of these specimens were not cut through the center of proloculus. Since diameter of proloculus of representative species of Yabeina such as Yabeina globosa, Y. cascadensis, Y. decora, Y. fusiformis, Y. packardi, Y. kaizensis, Y. igoi, Y. inouyei and Y. katoi is mostly below 100 microns, we regard the genus Yabeina as fusulinids having the prolocular diameter of less than 100 microns.

Secondarily, the present specimens and those of nine species of "Yabeina" from Marble Canyon have the generic character of Lepidolina that secondary transverse septula are thin bar and occasionally pendant club-shape in cross section (Text-fig. 3). In view of these differences,



Text-fig. 4. Frequency distribution curves of form ratio for the present specimens from Marble Canyon and Upper Hat Creek. n: measured individual number, m: mean value.

we described that present specimens and those of nine species by Skinner and Wilde belong to the genus *Lepidolina*.

Next, the frequency distribution curves for magnitude of form ratio of the specimens from Marble Canyon and Upper Hat Creek show a bell shape (Text-fig. 4). The bell shape in the frequency distribution curves of specimens from Marble Canyon and Upper Hat Creek may be attributed to that the specimens come from a population. Most of the specimens have a form ratio of 1.5 to 2.0. The specimens of "Yabeina" columbiana described by Skinner and Wilde (1966) are within this range of form ratio (Textfig. 4).

Incidentally several morphologic characters including form ratio, diameter of proloculus, thickness of spirotheca, first appearance of secondary transverse septula are said to change phylogenetically in the subfamily Neoschwagerininae (Ozawa, 1970). For example, the more advanced species of the genus Lepidolina which is included in the Neoschwagerininae have larger form ratio, larger proloculus, thinner spirotheca and the earlier appearance in ontogeny of secondary transverse septula. In addition, the magnitude of form ratio also changes according to change of environment such as the change in speed of water current and in wave action. It seems that species of Eopolydiexodina and Monodiexodina having larger form ratio are found in limestone of higher energy environment such as sparite, while the species of Yabeing and Verbeeking having smaller form ratio are observed in limestone of low energy environment such as micrite. The larger value of form ratio in the Marble Canyon specimens is larger than that of Upper Hat Creek. In view of resembling lithology of limestone in the two localities, the above mentioned feature may reflect the phyletic increase in form ratio.

The specimens from both localities are compared with one another by plotting thickness of spirotheca and volution number on which secondary transverse septula first appears (Textfigs. 5, 6). On these two text-figures, present specimens and those of nine species of "Yabethickness of spirotheca, in microns



Text-fig. 5. Variaton in thickness of spirotheca of the present specimens (lower figure) in comparison with that of various species of *Lepidolina* and *Yabeina* (upper figure). For numbers 1 to 21 see Text-fig. 2. The measurement values for the present specimens fall within the range between the dotted lines of the upper figure.

ina" are still situated between the Yabeina species group and the Lepidolina species group.

Finally, we made an investigation about allometry on which the half length and the radius vector were adopted as two parameters. If the two characters of each individual have the relation of allometry, the following formula is expected between values of these characters



Text-fig. 6. Stage of the first appearance of secondary transverse septula of the present specimens (lower figure) in comparison with that of various species of *Lepidolina* and *Yabeina* (upper figure). For numbers 1 to 22 see Text-fig. 2. The measurement values for the present specimens fall within the range between the dotted lines of the upper figure.

(x, y). $Y = bX^a$, where, a is a relative growth coefficient and b is a initial growth index. The formula $Y = bX^a$ is transformed to log $Y = a \log X + \log b$. The latter formula is expected to be linear line having the inclination of a.

Text-figs. 7 and 8 show the respective mean

first appearance of secondary transverse septula



Text-fig. 7. Growth curves of the present specimens from Marble Canyon. Line A is a mean curve of specimens whose form ratio are within 1.0 to 1.5, and so forth.



Text-fig. 8. Growth curves of the present specimens from Upper Hat Creek. For line A to E see Text-fig. 7.

values which were calculated for all individuals classified by range of form ratio in each locality.

Table 1. Relative growth coefficients (a) for the present specimens, Lepidolina multiseptata multiseptata, L. m. shiraiwensis, L. asiatica (after Ozawa, 1975) and Yabeina globosa (after Hanzawa and Murata, 1963).

	Form ratio	а
	1.0 - 1.5	1.02
	1.5 - 2.0	0.82
Marble Canyon	2.0 - 2.5	0.76
	2.5 - 3.0	0.79
	3.0-3.5	0.69
	0.5-1.0	0.99
	1.0 - 1.5	0.76
Upper Hat Creek	1.5 - 2.0	0.85
	2.0 - 2.5	0.85
	2.5 - 3.0	0.79
Lepidolina m. mul	tiseptata	0.63
L. m. shiraiwensis		0.77
L. asiatica		0.82
Yabeina globosa		0.98

Table 1 demonstrates the relative growth coefficients — that is inclination of a — of the respectively classified groups, which is led by applying method of least squares. As seen from Table 1, all the individuals from Marble Canyon and Upper Hat Creek are within the range of about 0.7 to 1.0. It suggests that these two groups would belong to the same species. Moreover, they differ from those of *Lepidolina m. multiseptata*, while they are difficult to be distinguished from *L. asiatica, L. m. shiraiwensis* and *Yabeina globosa* by the relative growth coefficient only. However, they can be distinguished from specimens of the latter two species on basis of prolocular diameter.

In conclusion, all specimens from Marble Canyon and Upper Hat Creek treated this time as well as those of nine species of "Yabeina" described by Skinner and Wilde are regarded to belong to the same species. They belong undoubtedly to the genus Lepidolina and not to Yabeina. They are described under the species Lepidolina columbiana (Dawson).

Table 2.	Measurement of	Lepidolina co	olumbiana	(Dawson)
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vn	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
hl	0.18	0.30	0.40	0.50	0.65	0.85	1.00	1.20	1.45	1.68	1.91	2.18	2.53		
rv	0.25	0.35	0.41	0.50	0.64	0.79	1.00	1.15	1.45	1.65	1.88	2.13			
fr	0.72	0.85	0.97	1.00	1.00	1.08	1.00	1.04	1.00	1.02	1.02	1.02			

Thickness of spirotheca: 30 microns Diameter of proloculus: 250 microns First appearance of sts: 5th volution

vn: volution number, hl: half length (mm), rv: radius vector (mm), fr: form ratio, sts: secondary transverse septula. Note: Thickness of spirotheca is measured at 10th volution on all specimens.

vn	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
hl	0.28	0.34	0.45	0.66	0.91	1.20	1.65	2.00	2.40	2.79					
rv	0.20	0.30	0.40	0.50	0.65	0.85	1.05	1.20	1.43	1.65					
fr	1.38	1.13	1.11	1.31	1.39	1.41	1.57	1.67	1.68	1.69					

Thickness of spirotheca: 12 microns Diameter of proloculus: 302 microns First appearance of sts: 4th volution

	KU 30)03, fr	om M	arble (Canyo	n, Pl.	86, Fi	g. 3.							
vn	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
hl	0.29	0.48	0.65	0.83	1.20	1.50	1.85	2.40	2.83	3.15	3.50	3.80			
rv	0.24	0.33	0.40	0.45	0.53	0.60	0.69	0.80	0.98	1.23	1.43				
fr	1.19	1.46	1.63	1.83	2.29	2.50	2.68	3.00	2.90	2.57	2.45				
	Lengt Thick Diame	h: 7.4 ness o eter of	0 mm, f spirc ? prolo	, width otheca oculus:	n: 3.10 : 28 m 320 r) mm icrons nicron	s								

First appearance of sts: 6th volution

	KU 3(004, fr	om M	arble (Canyo	n, Pl.	86, Fi	g. 4.							
vn	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
hl	0.26	0.42	0.65	0.95	1.20	1.58	1.95	2.53 _.	2.95	3.60	4.37	4.93			_
rv	0.15	0.29	0.33	0.43	0.50	0.65	0.81	0.96	1.13	1.30	1.50	1.66			
fr	1.79	1.45	2.00	2.24	2.40	2.42	2.41	2.63	2.62	2.77	2.91	2.97			
	T	1 10	-	• 141											

Length: 10.5mm, width: 3.60 mm Thickness of spirotheca: 25 microns Diameter of proloculus: 250 microns First appearance of sts: 6th volution

	KU 3005, from Marble Canyon, Pl. 86, Fig. 5.														
vn	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
hl	0.12	0.29	0.49	0.83	1.10	1.35	1.63	1.80	2.36	2.65	3.30	3.60	3.93		
rv	0.10	0.19	0.23	0.28	0.35	0.44	0.49	0.58	0.65	0.77	0.91	1.02	1.20		
fr	1.20	1.53	2.16	3.00	3.14	3.10	3.36	3.13	3.62	3.44	3.65	3.53	3.28		
	•														

Length: 7.30 mm, width: 2.57 mm Thickness of spirotheca: 15 microns Diameter of proloculus: 123 microns First appearance of sts: 6th volution

	KU 3006, from Upper Hat Creek, Pl. 86, Fig. 6.														
vn	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
hl	0.10	0.19	0.28	0.35	0.52	0.62	0.80	0.97	1.09	1.20	1.30	1.43	1.53		
rv	0.13	0.20	0.35	0.45	0.59	0.82	0.95	1.15	1.25	1.45	1.58	1.75	1.90		
fr	0.77	0.93	0.79	0.78	0.88	0.75	0.84	0.84	0.87	0.83	0.83	0.81	0.80		

Length: 3.10 mm, width: 4.00 mm Thickness of spirotheca: 28 microns Diameter of proloculus: 121 microns First appearance of sts: 6th volution

	KU 3007, from Upper Hat Creek, Pl. 86, Fig. 7.														
vn	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
hl	0.07	0.19	0.25	0.34	0.43	0.58	0.74	0.94	1.20	1.45	1.70	1.98	2.25	2.53	2.80
rv	0.09	0.16	0.25	0.29	0.45	0.57	0.70	0.90	1.03	1.35	1.66	1.90	2.15	2.41	2.80
fr	0.78	1.23	1.00	1.16	0.96	1.02	1.05	1.04	1.17	1.07	1.02	1.04	1.05	1.05	1.04

Length: 5.60? mm, width: 5.35 mm Thickness of spirotheca: 26 microns Diameter of proloculus: 144 microns First appearance of sts: 8th volution

	KU 3008, from Upper Hat Creek, Pl. 86, Fig. 8.														
vn	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
hl	0.25	0.35	0.54	0.85	1.15	1.35	1.60	1.85	2.15	2.45	2.75	3.28			
rv	0.16	0.27	0.38	0.48	0.60	0.70	0.85	101	1.16	1.32	1.47	1.66			
fr	1.56	1.30	1.43	1.79	1.92	1.93	1.88	1.84	1.85	1.86	1.86	1.98			
	Length: 6.67 mm, width: 3.10 mm Thickness of spirotheca: 25 microns Diameter of proloculus: 260 microns First appearance of sts: 8th volution														

KU 3009, from Upper Hat Creek, Pl. 86, Fig. 9.															
vn	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
hl	0.17	0.30	0.43	0.60	0.85	1.10	1.39	1.98	2.32	2.55	3.00				
rv	0.15	0.19	0.23	0.30	0.40	0.51	0.66	0.80	0.95	1.10	1.23	1.45			
fr	1.13	1.58	1.87	2.00	2.13	2.17	2.10	2.47	2.44	2.32	2.44				
								_							

Length: 6.20 mm, width: 2.60 mm Thickness of spirotheca: 20 microns Diameter of proloculus: 200 microns First appearance of sts: 8th volution

	KU 3010, from Upper Hat Creek, Pl. 86, Fig. 10.														
vn	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
hl	0.28	0.40	0.61	0.95	1.17	1.61	1.94	2.50	3.00	3.55	3. 9 5	4.40	5.00		
rv	0.15	0.23	0.31	0.43	0.55	0.60	0.83	0.98	1.10	1.25	1.45	1.60	1.76		
fr	1.83	1.78	1.97	2.21	2.12	2.68	2.35	2.65	2.73	2.84	2.72	2.75	2.85		
	Length: 10.00? mm, width: 3.65 mm Thickness of spirotheca: 21 microns Diameter of proloculus: 214 microns														

Systematic paleontology

First appearance of sts: 7th volution

Family Verbeekinidae Staff and Wedekind, 1910

Subfamily Neoschwagerininae Dunbar and Condra, 1928

Genus Lepidolina Lee, 1933

Lepidolina columbiana (Dawson)

Pl. 86, Figs. 1-10.

- Loftusia columbiana Dawson, 1879, p. 69-75, pl. 6, figs. 1-7; Silvestri, 1932, p. 87, pl. 2, figs. 4-7.
- Neoschwagerina columbiana, Dunbar, 1932, p. 46-48, pl. 1, figs. 1-4.
- Yabeina minuta Thompson and Wheeler, 1942,
 p. 707-708, pl. 106, figs. 6-10; Thompson,
 Wheeler and Danner, 1950, p. 62, pl. 8, figs.
 4-7; Ishii and Nogami, 1964, p. 22, pl. 4,
 figs. 4-7; Skinner and Wilde, 1966, p. 309-

311, pl. 34, figs. 3-7; Yang, 1978, p. 120, pl. 34, figs. 1-2.

- Yabeina columbiana, Thompson and Wheeler, 1942, p. 708-710, pl. 106, fig. 5, pl. 107, fig. 5, pl. 108, fig. 1, pl. 109, figs. 1-4; Thompson, Wheeler and Danner, 1950, p. 61, pl. 8, figs. 1-3; Kanmera, 1954, p. 16-18, pl. 3, figs. 1-5, 7, questionable specimens, pl. 3, fig. 6; Nogami, 1958, p. 101-102, pl. 1, figs. 9-10; Chisaka, 1960, p. 249-250, pl. 7, fig. 3, p. 54, fig. 18c; Skinner and Wilde, 1966, p. 47-48, pl. 38, figs. 1-6; Yamagiwa and Saka, 1972, p. 268-269, p. 31, fig. 4; Zang, 1982, questionable specimens, p. 209, pl. 34, figs. 3, 7.
- Yabeina obesa Skinner and Wilde, 1966, p. 50, pl. 40, figs. 1--7.
- Yabeina dawsoni Skinner and Wilde, 1966, p. 50, pl. 41, figs. 1-7.
- Yabeina gracilis Skinner and Wilde, 1966, p. 50-51, pl. 42, figs. 1-9.
- Yabeina dunbari Skinner and Wilde, 1966, p. 51-52, pl. 43, figs. 1-6.
- Yabeina cylindrica Skinner and Wilde, 1966, p. 52, pl. 44, figs. 1-7.
- Yabeina ampla Skinner and Wilde, 1966, p. 52-53, pl. 45, figs. 1-4, pl. 46, fig. 1.
- Yabeina parvula Skinner and Wilde, 1966, p. 53-54, pl. 46, figs. 2-11, pl. 47, figs. 1-2.

Description:—Shell large, inflated fusiform to elongate fusiform in shape, with straight to slightly curving axis of coiling, gently convex to concave lateral slopes. Mature specimens of 11 to 13 volutions or more. 5.0 to 10.0 mm long, and 2.6 to 5.4 mm wide, form ratios of 0.8? to 3.3

Outside diameter of proloculus 100 to 330 microns, mostly 150 to 250 microns. Spirotheca composed of a tectum and a keriotheca with very fine alveoli. Thickness of spirotheca 10 to 30 microns in outer volutions. Septa and primary transverse septula present throughout shell and essentially slender. Axial septula thin, first appear in 4th to 5th volution. Secondary transverse septula first appear in 4th to 8th volution, mostly in 5th to 7th volution, usually one septulum between adjacent primary transverse septula throughout shell, but two septula in most outer volutions. Measurement:-See Table 2.

Remarks:—Morphologic variation within the species is given in detail in the preceding chapter. The present species differs from Lepidolina multiseptata multiseptata and L. m. shiraiwensis in having rather smaller proloculus. Moreover the secondary transverse septula appear in slightly later stage and the thickness of spirotheca is larger in the former than in the latters.

The secondary transverse septula of the present species appear in earlier stage than those of L. asiatica. Although measured values of size of proloculus and form ratio of the present species overlap those of L. asiatica, these values of L. asiatica are concentrated on the end of the morphometrical variation of L. columbiana (Text-fig. 2).

The present species resembles L. japonica (Huzimoto, 1936) in size of proloculus, but the former has generally a smaller form ratio than the latter (Text-fig. 2), so far as Huzimoto's original description of L. japonica is concerned.

Occurrence:—The specimens at hand have been collected from the type locality, Marble Canyon, and from Upper Hat Creek, British Columbia, Canada (Marble Canyon Formation of the Cache Creek Group). They occur together with many specimens of Schwagerina in the two localities, and also with specimens of Colania in Upper Hat Creek.

Materials:-Reg. no. KU 3001, KU 3002, KU 3003, KU 3004 and KU 3005 from Marble Canyon. KU 3006, KU 3007, KU 3008, KU 3009 and KU 3010 form Upper Hat Creek. These materials are collected by H. Goto, and are deposited in Institute of Geosciences, College of Liberal Arts, Kobe University.

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ブリティッシュ コロンビア産 Lepidolina columbiana (ペルム紀紡錘虫): ブリティッシ ュ コロンビア地域から従来,9種の Yabeina 属が報告されている。今回,上記地域のマーブ ル キャニオンとアッパー ハット クリークから Yabeina 属とされた紡錘虫化石を採集し, これまで報告されたものと併せて個体群の形態変異の検討を行った。その結果,従来同地域か ら記載された Yabeina 属は Lepidolina 属であり,かつ同一種に属すると判断した。この種 を Lepidolina columbiana (DAWSON) として記載した。 後藤博弥・丸岡匡孝・石井健一

Explanation of Plate 86

Lepidolina columbiana (Dawson) All figures ×10

Figs. 1, 2, 6, 7. Specimens of inflated fusiform.
1. KU 3001, 2. KU 3002 from Marble Canyon.
6. KU 3006, 7. KU 3007 from Upper Hat Creek.
Figs. 3, 8. Specimens of fusiform.
3. KU 3003 from Marble Canyon.
8. KU 3008 from Upper Hat Creek.
Figs. 4, 5, 9, 10. Specimens of elongate fusiform.
4. KU 3004, 5. KU 3005 from Marble Canyon.

9. KU 3009, 10. KU 3010 from Upper Hat Creek.



818. ON A NEW TEMPSKYA STEM FROM JAPAN*

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Abstract. Tempskya iwatensis sp. nov. was described from the Taneichi district, Iwate Prefecture, Japan. The age of the specimen was dated as Santonian based on marine mollusca. Stratigraphically, this is the youngest Tempskya species known with certainty. The past distribution of Tempskya is plotted on paleogeographic map in relation to the Cretaceous paleoclimate.

Introduction

Tempskya is a genus of leptosporangiate ferns flourished during the Cretaceous and probably becoming extinct by the end of the period. It had a tree habit sometimes attaining a height of up to six meters. Some species are thought to have had a prostrate or vinelike habit with dorsiventral stems. The stem of *Tempskya* is generally described as a "false stem" consisting mainly of a mass of adventitious roots in which are embedded slender rhizomes and petioles of the plant.

A comprehensive reference to the history and taxonomy of *Tempskya* was prepared by Ash and Read (1976). According to them ten species of *Tempskya* have been described up to 1976. This excluded most of the European species described prior to *T. rossica* Kidston et Gwynne-Vaughan (1911), which were too poorly preserved to allow anatomical comparison with later described tempskyas. Nine species, other than *T. rossica*, have been described in North America, chiefly in the Rocky Mountains. One species from Atlantic Coastal Plain (T. whitei Berry) has also been excluded by earlier workers for anatomical comparison because this species is also based on poorly preserved material. Endo (1926) reported a *Tempskya* stem from the Cretaceous of Kii (Wakayama Pref.). His specimen was based on a root mass with no embedded rhizomes. Ogura (1927) reidentified that specimen as part of a fern stem with Cyatheaceous affinity, highly possibly *Cyathocaulis* Ogura.

About 12 years ago Biichi Fukkiri, an amateur rock collector, found a petrified trunk at the seashore of Oh-hama, Yagi, Taneichi Town, Sannohe-Gun, Iwate Prefecture (locality, 40°21' 12"N, 141°45'30"E; Text-fig. 1). The area around the fossil locality, north of Kuji City is called here the Taneichi district. Two thirds of the trunk was embedded in sandstone which is widely distributed along the coast. Fukkiri used the specimen to decorate a corner of his garden. Ryozo Sugiyama of the Ichinohe Senior High School (Taneichi Senior High School at that time) noticed the peculiar shape of the specimen and advised Fukkiri to donate it to the Iwate Prefectural Museum. The specimen is now deposited in that museum. I was asked to identify the specimen by the curator of the

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Text-fig. 1. Map showing fossil locality.

museum. Through anatomical studies the specimen has been identified as a new species of *Tempskya* and this paper deals with its description and taxonomical treatment.

Geological setting and the age of the fossil:-In the Taneichi district the Taneichi Formation of late Cretaceous period is exposed along the Pacific coast between Kuji City and Taneichi Town. The Taneichi Formation was formerly thought to be Miocene. It consists mainly of shallow-marine sediments and can be subdivided into three members.

The lowest member unconformably overlies the granite basement. It consists of basal conglomerate and overlying sandstone in which coal seams and tuff beds are intercalated. The middle member, which is a major part of the Taneichi Formation, consists of greenish gray sandstone. Oyster beds partly intercalate in the lower part of this member. From this member Terui *et al.* (1975) reported the occurrence of a Cretaceous marine fauna including *Ino*- ceramus (Sphenoceramus) naumanii Yokoyama and Polyptycoceras cf. subundulatum (Yokoyama) that clearly indicate Santonian age (Matsumoto, 1977). This major sandstone member is exposed along the coast at Yagi where Fukkiri found the stem embedded in the sandstone of the intertidal zone. It is highly probable that the age of the stem is Santonian. The upper member consists of alternating layers of coarsegrained sandstone and conglomerate.

In the Kuji district, about 20 km south of the Taneichi district, the Upper Cretaceous shallow marine to terrestrial sediments called the Kuji Group are exposed. The Kuji Group is divided into three formations, the Tamagawa, the Kunitan and the Sawayama in ascending order. Three members of the Taneichi Formation can be stratigraphically correlated with three formations of the Kuji Group, respectively (Matsumoto *et al.*, 1982).

Tanai (1979) described a fossil flora from the Tamagawa and Sawayama Foramations of the Kuji Group. The former is dated as Late Coniacian and the latter as Early Campanian based on both marine faunas and comparisons of floral composition with that of other localities, especially that of North Saghalien. The middle member of the Taneichi Formation is, therefore, correlated with the Kunitan Formation, which is Santonian in age.

Off the Pacific coast of the Taneichi district the Paleogene sediments of the Noda Formation are exposed. Petrified woods are also known to occur from the Noda Formation, although they have not yet been studied taxonomically. It seems unlikely that the *Tempskya* specimen could have been derived from the Paleogene sediments.

Ikeya (1981) examined ESR (Electron Spin Resonance) of the petrified woods that had been collected as rolled stones at the coast of Taneichi district. He reported that other biological materials of the same age show characteristic ESR patterns. Ikeya compared the ESR of the rolled stones of Taneichi district with that of *in situ* petrified woods collected from both the Taneichi and the Noda Forma-
tions. The result indicated that the ESR of the rolled stones is very similar to that of the Cretaceous *in situ* material. To ascertain the age of the *Tempskya* specimen the examination of its ESR pattern will provide useful evidence.

Material and method

The specimen before cutting was a petrified columnar trunk, yellowish white on the surface, about 50 cm long, with diameters ranging from 7 to 11.5 cm. One end is almost smooth but is slightly knobby. The trunk weakly tapers to one end. It was cut into five pieces as is shown in Text-fig. 2.

Peels prepared by etching the material about four minutes in 20 to 25 percent hydrofluolic acid solution were made into slides for study.

Systematic description

Order Filicales

Family Tempskyaceae Read and Brown, 1937

Genus Tempskya Corda, 1845

Tempskya iwatensis H. Nishida, sp. nov.

Pls. 87-89; Text-fig. 2.

Description:-Other than some longitudinal grooves the specimen has a rather smooth external surface. It constitutes a so-called false stem that is characteristic of Tempskya, consisting of numerous adventitious roots and a small number of solenostelic rhizomes and petioles. In the false stem the rhizomes give rise to petioles in all directions. Therefore the false stem does not exhibit dorsiventrality (Text-fig. 2). In section 1 (Text-fig. 2) of the false stem no rhizome was present. Rhizomes appear and increase in number toward the other end of section 1 indicating that it is nearer the base of the false stem. Throughout the length of the false stem the exact number of rhizomes could not be determined because most of the rhizomes had been decayed before fossilization.

The rhizomes and petioles are poorly preserved because of decay and some disruption by roots. The anatomical description which will be given below is derived from observations of these incompletely preserved components. Description of certain diagnostic features that are thought to be taxonomically important, for example, the relative length of internodes and amount of xylem parenchyma, are in conformity with the characteristics used in the artificial key to the species prepared by Ash and Read (1976).

The rhizomes are very slender, 2.7 - 3.6 mm in diameter, with long to medium internodes, with slight overlapping leaf bases (usually two or three). Leaf traces depart from only one side of a rhizome alternately in two rows (Pl. 87, Fig. 1). The epidermis is not clearly defined. No dermal hairs nor their remnants are present. A hypodermal layer that is comparable to the outer cortex as described by Ash and Read (1976) was not clearly defined. The only evidence of a hypodermal layer is one or two external layers of the outer cortex that consist of less sclerotized cells (Pl. 87, Fig. 3). The cortex consists of two layers. The outer cortex, that is comparable to the middle cortex cells in other species, is sclerotic, about six or seven cells wide, with cells that are simple-pitted and contain reddish brown contents. The inner cortex is 15 - 17 cells wide, and composed of thick-walled parenchyma cells that become smaller near periphery of the layer.

The stele is solenostelic with a well-developed pith (Pl. 87, Fig. 4). The endodermis is a single layer of tangentially flattened cells. The pericycle is two to three cells thick. Internal to the pericycle is a layer of very small cells. This layer is not always detected but when present probably represents protophloem. Metaphloem is developed internally to the protophloem and is a layer three to five cells thick. The xylem plate of the concentric bundle is slightly thicker on the ventral side and the tracheids of which it is composed are scalariform. The position of the protoxylem is not clear because of nearly equal size of tracheids. However, smaller elements tend to be located at the outer edge of the xylem cylinder. Xylem parenchyma is relatively



abundant (Pl. 88, Fig. 1). Parenchyma cells are often alined in groups of five to more than eight cells. The cells of endodermis, pericycle and xylem parenchyma contain reddish brown contents similar to those occur in outer cortex.

The periphery of pith, which is about three cells thick, consists of thick-walled parenchyma cells (Pl. 87, Fig. 4). Toward the center of the pith cells become smaller and thick-walled. The preservation of the pith is quite poor and the pith area is often invaded by adventitious roots. However, at places the pith consists of sclerotic cells as in other species of *Tempskya* (Pl. 87, Fig. 2).

Roots depart endogenously from the solenostele of the rhizome. The size, shape, state of development and state of preservation of roots vary considerably (Pl. 89, Fig. 2). They are equal to the roots of other species of *Tempskya* in general structure. Root hairs are present (Pl. 89, Fig. 4). The cortex consists of outer and inner layers. The outer cortex is parenchymatous, with cells that are more thick-walled near the periphery. The inner cortex is generally sclerenchymatous, although the degree of sclerotization varies. In some roots the inner cortex is completely thick-walled parenchymatous, or in rare cases only a layer adjacent to the endodermis is parenchymtous.

In mature roots the xylem is diarch, whereas in juvenile roots such as shown in Pl. 89, Fig. 3, the central xylem mass is too small to be clearly defined. In such young roots the inner cortex is not typically sclerotized, although the degree of sclerotization is not always correlated with the age of roots.

Petioles are very slender, 1.2×1.6 mm in diameter, and do not persist in the tissue of the false stem after departure from the rhizome. However, the petiole is better preserved than the rhizome and persists for a greater distance in the false stem than the parent rhizome.

The epidermis is decayed and thus lost. The outer cortex is sclerenchymatous and consists of cells similar in structure and contents to the cells of the corresponding layer in the rhizome. It is 15 - 17 cells thick at petiole base. The inner cortex consists of thick-walled parenchyma cells. The stele is C-shaped and consists of an amphiphloic concentric bundle with a continuous C-shaped xylem plate. Both adaxial margins of xylem plate curve inward. The abaxial arc of the xylem strand is rather flat. Near the point of insertion of the petiole its xylem strand is thicker and lacks apparent protoxylem groups (Pl. 88, Fig. 3). Distally in the petiole the xylem strand diminishes in thickness until it becomes one or two cells thick except for its adaxial margins where xylem is three or more cells thick. As the xylem strand thins three protoxylem groups become apparent (Pl. 88, Fig. 2). At places endodermis, pericycle, protophloem and metaphloem are preserved (Pl. 89, Fig. 1). The center of pith consists only of thick-walled parenchyma cells (Pl. 89, Fig. 1).

Diagnosis of the species:—False stem radially symmetrical, 7 to 12 cm in diameter at base. Rhizome slender, 2.7 to 3.6 mm in diameter. Internodes long to medium usually two or three overlapping petiole bases in one section. Cortex two-layered; outer layer sclerotic, inner layer thick-walled parenchymatous. Much xylem parenchyma in xylem strand. Protoxylem indefinite in xylem of rhizome. Pith of the petiole consists of thick-walled parenchyma.

Locality:-Oh-hama, Yagi, Taneichi Town, Sannohe-Gun, Iwate Prefecture; 40°21'12''N, 141°45'30''E.

Horizon and age:-Taneichi Formation; Upper Cretaceous (Santonian).

Specimen:-Holotype (IPMM 31003) is deposited in the Iwate Prefectural Museum. Both ends of the holotype specimen and their micropreparations are deposited in the Laboratory of

Text-fig. 2. External features of specimen IPMM 31003 (E) and serial cross sections of upper part of false trunk (A-D) showing its radially symmetrical constitution. A to D correspond to the surfaces indicated as a to c. Arrowhead indicates the level where the section 1 mentioned in the text was made. Phylogenetic Botany, Faculty of Science, Chiba University.

Affinity and discussions

Affinity:-Nine species of Tempskya deserve anatomical comparisons with the specimen represented here (Table 1). According to the separation of species by Ash and Read (1976) the specimen belongs to the intragenetic group that has radially symmetrical false stems. Among species with radially symmetrical false stem T. rossica is compared favorably with the Iwate specimen in the histology of the cortex, amount of xylem parenchyma and the length of internodes, which are characters regarded by earlier workers to be taxonomically valuable. The new form is distinguished from T. rossica by the smaller size of the rhizome and the absence of a central depression in the abaxial arc of a leaf trace. Although T. zelleri also has a histology similar to the Iwate specimen, it is highly characteristic in having angular stelar strands that never occur in the species described here, as well as other early described species.

Apart from the radially symmetrical composition of the false stem the specimen anatomically resembles T. knowltoni and T. minor, both belonging to the dorsiventral group. Smaller size of rhizome, simple disposition of cortical tissues and long to medium internodes are the common features. The specimen is distinguished from T. knowltoni in having many free petioles in the false stem and in having a larger quantity of parenchyma in xylem strand. T. minor has many free petioles in the false stem but lacks xylem parenchyma. The petiolar pith consisting of thick-walled parenchyma is characteristic of the specimen and is a feature not found in other species. Although the Iwate specimen is partially characterized by poorly delineated characters such as the variable amount of xylem parenchyma, the combination of features described here lead me to designate the specimen as a new species.

Size of the plant:—Absence of well-preserved rhizomes and petioles in whole length of the

false stem indicates that the specimen represents a basal part of the false stem. Based on careful examination of numerous false stems, Andrews and Kern (1947) estimated that T. wesselii attained a height of 3.6 m if the basal diameter is 25 cm. The thickest false stem of T. wesselii attains a diameter of 40 cm or more. With this diameter as a basis for calculation the plant would have been nearly 5.8 m high. If it is postulated that the height of a plant is in proportion to the basal diameter of its stem, the height of T. iwatensis with a false stem 10 - 12 cm in diameter at base, is estimated as 1.45 - 1.74 m. Andrews and Kern also mentioned that the lower one sixth of the false stem consists of a root mass alone. The lower 25 to 30 cm of the Iwate specimen appears to consist of a root mass without rhizomes.

Age of Tempskya:-Most Tempskya species known to date are derived from the Lower Cretaceous strata. Ash and Read (1976) revised the age of Tempskya-bearing beds in North America including the Patapusco Formation bearing T. whitei. Most beds are now believed to be Late Albian in age (Table 1). Some species extend from Late Albian into Early Cenomanian. According to Read and Brown (1937), European tempskyas occur mainly in Wealden (Berriasian to Barremian), but in part in Aptian (Lower Greensand). Peručer beds in Czechoslovakia, which yield T. varians Velenovsky, are considered to be Cenomanian in age (Read and Brown, 1936). Tempskya rossica from the Karaganda River Basin is the only specimen that is derived from unconfirmed Upper Cretaceous strata. With the possible exception of T. rossica, T. iwatensis is presentely the only Tempskya known to occur in the Upper Cretaceous.

Ferns associated with Tempskya:-Fern leaves are lacking in the Tempskya beds of the Taneichi Formation. However, from the Kuji Group rich fern flora has been recorded by Tanai (1979). Although the Kunitan Formation, which is correlated with the Tempskya-bearing bed of the Taneichi Formation does not contain plant fossils, both the Tamagawa and Sawayama Formations are rich in ferns. The Gyliakian

Table 1.	Anatomical comparisons of Tempskya iwatens	sis, sp. nov.	, with nine species of anatomically preserved <i>Tempskya</i> .

Species	Age	False stem*	Size of rhizome (mm)	Internode length**	Outer cortex***	Inner cortex	Size of false stem (cm in diam.)	Xylem paren- chyma
T. rossica Kidston et Gwynne-Vaughan	Senonian?	R	6.0-7.0	0	sc.	pa.	5.5-9.5	2****
T. knowltoni Seward	L. Albian- E. Cenomanian	D	2.5-3.5	0	sc.	pa.	1.5-6.5	2
T. grandis Read et Brown	L. Albian	R	4.6-6.0	-	sc.	pa. + irr. sc.	10.4-12.2	3
T. minor Read et Brown	L. Aptian- Albian	D	2.0-3.5	0	sc.	pa.	9.0-14.4	1
T. wesselii Arnold	L. Albian	R	4.0-5.0	+	sc.	pa. + doub. sc.	7.0—40.0 or more	3
T. wyomingensis Arnold	L. Albian	R	6.0-8.0	0	sc.	pa. + doub. sc.	?	3
<i>T. superba</i> Arnold	L. Albian?	R	10.0—15.0	_	sc.	pa. + irr. sc.	more than 12.0	3
T. reesidei Ash et Read	L. Albian	R	3.0-5.0	0	pa.	pa. island in sc.	10.0-30.0	2
T. zelleri Ash et Read	L. Albian	R	3.0-8.0	+	sc.	pa.	17.0	2
T. iwatensis, sp. nov.	Santonian	R	2.7-3.6	0	sc.	pa.	7.0-12.0	3

*R: radially symmetrical, D: dorsiventral.

**+: very long, 0: long to medium, -: very short.

***In some species this layer is originally described as middle cortex.

****3: much, 2: little, 1: absent.

flora of North Saghalien of the same age as T. *iwatensis* contains 21 species of ferns, of which eight are common to the Tamagawa and Sawayama floras. Because the affinities of Tempskya are still uncertain it is impossible to relating Tempskya stems to the isolated remains of fern leaves.

In looking for possible affinities of *Tempskya* to fern families several earlier workers have emphasized the occurrence of *Anemia fremonti* Knowlton foliages (Schizaeaceae) in a horizon the same as or close to that bearing *Tempskya* (Seward, 1924; Read and Brown, 1937). The Sawayama flora contains *A. elongata* (Newb.) Knowlton and the Gyliakian flora contains *A.* cf. elongata (Kryshtofovich and Bykovskaya, 1960).

Many anatomically preserved fragments of ferns embedded in Late Cretaceous calcareous nodules have been described from Hokkaido (Stopes and Fujii, 1910; Ogura, 1927, 1930; Hashimoto, 1971; Nishida and Nishida, 1979; Nishida, 1981a, b). Most of these belong to Cyatheaceae. The age of the strata bearing such nodules extends from Cenomanian to Campanian, and is partly comparable with the age of the Taneichi Formation. Only one sporebearing fragment, *Schizaeopteris mesozoica* Stopes et Fujii, however, suggests the presence of Schizaeaceae. There is no record of *Tempskya* from either Hokkaido or Saghalien. To avoid further speculation I emphasize here the need for much wider and detailed investigations on these Cretaceous ferns in an effort to clarify the taxonomic position of *Tempskya*.

Other plants associated with Tempskya:-Seward (1924) reported the occurrence of an araucarian root associated with T. knowltoni. When Arnold (1945) described T. wyomingensis he recorded Cyacadeoidea sp. from the same locality. According to Andrews and Kern (1947) Cupressinoxylon sp., Cycadeoidea sp. and dicotyledonous woods occur with T. wesselii in Idaho.

From the Taneichi Formation four species of gymnospermous woods have been recognized by M. Nishida (pers. com.). Although the detailed taxonomic accounts will be published elsewhere, he tentatively recognizes Araucarioxylon kiiense Ogura, Cupressinoxylon vectense Barber, Taxodioxylon albertense Shimakura and a new species of Piceoxylon. Cycadeoidea was described from the Late Cretaceous Upper Yezo Group of Hokkaido (Kryshtofovich, 1920; Endo, 1925). The floral components associated with Tempskya in Japan and those in North America are very similar and indicate similar paleoecological conditions at these localities. A possible habitat for Tempskya, suggested by Andrews and Kern (1947) is a tropical montane cloud-forest, where most species of the tree ferns occur today.

Distribution of Tempskya and its relation to paleoclimate:-Parrish et al. (1982) predict rain-

Explanation of Plate 87

- Fig. 1. C.s. of dorsal half of a half-decayed rhizome, showing leaf traces and free petioles (arrowheads) departing in two rows. X 15.6. Bar 1 mm.
- Fig. 2. C.s. of a best preserved rhizome. Sclerotic pith is partly preserved (arrowhead). Outer cortex is decayed but inner cortex consisting of thick-walled parenchyma is well preserved. × 29.0. Bar 0.5 mm.
- Fig. 3. C.s. of a rhizome showing construction of tissues. Outer cortex is preserved only at its periphery. Cells of outermost layer of outer cortex are larger and thinner-walled than inner cells, indicating the presence of a hypodermal layer. ic; inner cortex, oc; outer cortex, vb; vascular bundle, p; pith. \times 30.7. Bar 0.5 mm.
- Fig. 4. Vascular tissue in fig. 3 enlarged. Protoxylem indefinite. Note abundant xylem parenchyma. Phloem is badly preserved. Periphery of pith consists of thick-walled parenchyma.
 e; endodermis, pe; pericycle, ph; phloem, xy; xylem. × 61.4. Bar 0.1 mm.



fall patterns, based on atmospheric circulations of the past, to explain the distribution of coals and evaporites in the Mesozoic and Cenozoic. Paleobotanical data are useful in testing such a hypothesis. Text-fig. 3 shows a distribution of Tempskya plotted on a paleogeographic map. The base map (Owen, 1983) shows the distribution of the continents in the Turonian stage. Contours of rainfall patterns (relative values only) are based on Cenomanian data by Parrish et al. (1982) who also present Maestrichtian data. Although the age of Tempskya extends from Berriasian to Santonian, I preferred here to use Cenomanian data as being representative of the paleoclimate of Tempskya age. Because judging from the paleoclimate maps by Parrish et al. (1982), the paleogeography and paleoclimate of Tempskya-bearing localities had been subject to minor change through the Cretaceous period.

The worldwide occurrence of Tempskya is

reviewed by Read and Brown (1937). North American localities are mapped by Ash and Read (1976). In North America, *Tempskya* occurs in the Rocky Mountain Geosyncline, Mexican Geosyncline and Atlantic Coastal Plain, extending from 31° N to 48° N and 103° W to 118° W. In Europe *Tempskya*-bearing beds are located from 50° N to 53° N and 2° W to 65° E. The locality of *T. iwatensis* is approximately 40° N, and 141° E.

The Rocky Mountains and Mexican Geosynclines, which are major sources of North American *Tempskya*, are developed in the eastern interior of the Rocky Mountains that provided a rain shadow against the westerlies. Another North American locality faces the Atlantic coast. In Europe, England and Ireland localities and French to Bohemian localities are all on islands. The Karaganda River Basin near the Ural Mountains is situated at the margin of the Asian conti-



Text-fig. 3. Distribution of *Tempskya* on paleogeographic map showing rainfall patterns in Cenomanian. Paleogeography and rainfall patterns are redrawn after Parrish *et al.* (1982) on base map by Owen (1983). Numbers show relative values of rainfall. 200; high, 200-100; moderately high, 100-50; moderately low, 50; low, shaded; approximate contour of land masses.

nental lowland on the north coast of Tethys. The Taneichi district is located at the east Pacific margin of Asia continent.

Tree ferns need high humidity for their continuous growth and thus the postulated habitat for *Tempskya* is a tropical or subtropical humid forest developed at high elevations (1,200 - 2,100 m) on undulating hills or mountains (Andrews and Kern, 1947). In tropical to subtropical South America, cloud-forests rich in ferns are well developed on the Andean slopes at higher elevations (1,800 - 2,600 m).

Species of *Tempskya* are distributed in lowlands at rather high latitudes except in North America where several localities occur at nearly 31° N. In these localities rainfalls are predicted to be moderately high as well as moderately low without affecting the distribution of *Tempskya*. These paleogeographical and paleoclimatological conditions differ somewhat from the postulated habitat of *Tempskya*.

From my observations of living species of Cyatheaceae in South America, Australia and south Japan, continuous atmospheric moisture seems to be a most important factor limiting their growth rather than total amount of rainfall, if the temperature is moderate. Under moderate temperatures coastal cliffs or mountains of no more than 400 - 500 m seems to be high enough to produce sufficient humidity for tree-fern growth. The Juan Fernandez Islands and Pacific coast of South Chile are examples of such localities. According to Parrish et al. (1982) the climate in a given area is regarded to be wet when precipitation exceeds evaporation, even though the total amount of precipitation is low. All localities are placed either near the coast or on islands that are influenced by wet oceanic winds. The possible habitat of Tempskya could be a humid low to high montane forest in subtropical or even a warm temperate climate. The fact that evaporites are never associated with these localities supports the idea of a lower evaporation rate resulting in high humidity (Parrish *et al.*, 1982).

Tempskya has not yet been described from Asian inlands at latitudes comparable to those of other localities. This may be the product of a dry climate. Much more information must be obtained, however. Wide latitudinal distribution of the American Tempskya is in marked contrast to the restricted distributional pattern of the European members. In North America a moist habitat occurs along the northward extension of the north Atlantic, whereas in Europe land masses are confined to latitudes around 50°N. This may account for restricted distribution of Tempskya in Europe.

On the naturalness of intragenetic groups:-Whether the false stem of *Tempskya* is radially symmetrical or dorsiventral has been used as one of important criteria in classifying species into two subgeneric groups (Read and Brown, 1937; Andrews and Kern, 1947; Arnold, 1958; Ash and Read, 1976). However, Andrews and Kern (1947) questioned this grouping and suggested that dorsiventrality reflects either a juvenile stage or only a part of an entire false stem of a plant. No fossil evidence supporting these suggestions has been discovered as yet.

The dorsiventral group (*T. knowltoni* and *T. minor*) has slender rhizomes less than 3.5 mm in diameter. The radially symmetrical group has thicker rhizomes usually more than 4.0 mm in diameter, except for *T. reesidei* and *T. zelleri* where diameters decrease to 3.0 mm in the lower

Explanation of Plate 88

- Fig. 1. C.s. of rhizome. Part of a xylem strand. Abundance of xylem parenchyma is better displayed. \times 170. Bar 0.1 mm.
- Fig. 2. Enlargement of a free petiole shown in Plate 87, Fig. 1. Thin xylem strand with three protoxylem groups (arrowheads) is shown. Outer cortex is lost. × 140. Bar 0.1 mm.
- Fig. 3. C.s. of a petiole base showing a vascular strand without central depression on its abaxial arc. Protoxylem is not clear in xylem plate. Upper side is abaxial. × 43. Bar 0.5 mm.



extremities of the rhizome. The simple structure of cortical tissues is another feature common to the dorsiventral group. The consistent relationship between internal structure and the dorsiventrality appears to support the naturalness of the grouping.

T. iwatensis, however, displays characteristics that are intermediate between the two groups. This species belongs to the radially symmetrical group, but at the same time displays a slender rhizomes and a simple disposition of cortical tissues as in the dorsiventral group. This combination of characteristics in T. iwatensis suggests that there is no strict boundary between the two groups. The construction of the false stem is still, however, a good feature in identifying Tempskya species.

The rhizomes of Tempskya are dorsiventral. Therefore, the fern that is hypothetically ancestral to Tempskya could have had prostrate, dorsiventral rhizomes like those of the living schizaeaceous ferns. The false stems first formed by such an ancestor probably was a dorsiventral type, so that the primitive form of Tempskya would have structure similar to T. minor with its dorsiventral stem and that exhibits the simplest structure of all. The slightly younger age of T. minor supports this idea. However, it remains uncertain whether or not T. minor and another dorsiventral species, T. knowltoni, are direct descendants of the ancestral form. Tempskya is a highly variable group that diversified from a simple ancestral form in the Cretaceous. T. iwatensis is a species, that in the course of its evolution, has retained the simple internal structures of some other tempskyas.

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Taneichi 種市, Kuji 久慈, Oh-hama 大浜, Yagi 八木, Tamagawa 玉川, Sawayama 沢山, Kunitan 国丹, Noda 野田, Hokkaido 北海道.

日本産テンプスキアの新種について: 岩手県三戸郡種市町八木大浜の 潮間帯付近の 砂岩よ り,地元採集家が収集した硅化木が,本邦未記載の木生シダ,テンプスキア (Tempskya)属 の直立根茎とわかった。標本は種市層中部層からの産出とみられ,時代は同層併産の動物化石 と,久慈地域に分布する久慈層群との生層序学的比較から,上部白亜系サントニアンと推定さ れた。ピール法による組織解剖の結果,直立茎に背腹性が無いこと,木部柔組織が多いこと, 葉柄の髄に厚膜組織が発達せず,かわりに膜の厚い柔組 織 があること などから,新種, Tempskya iwatensis として記載した。同属の他種の分布を含め,白亜紀の古気候図上での分 布から, Tempskya の生育環境を推定した。沿岸性の低山からやや高地に生育し,従来考え られたような熱帯域よりはむしろ,温帯域に分布したことがうかがわれる。属内の分類群につ いても是非を論じた。 西田治文

Explanation of Plate 89

- Fig. 1. Enlargement of a petiolar vascular bundle at its adaxial margin. Pith consists of thickwalled parenchyma (arrowhead). e; endodermis. × 227. Bar 0.1 mm.
- Fig. 2. Adventitious roots displaying various degrees of preservation and construction of tissues. \times 31. Bar 0.5 mm.
- Fig. 3. Adventitious root with inner cortex composed of cells having less thickened walls. Xylem mass is poorly developed. × 81. Bar 0.1 mm.
- Fig. 4. Long intermingled root hairs. × 163. Bar 0.1 mm.



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819. THE SECOND ADDITION TO THE SILURIAN TRILOBITE FAUNA OF YOKOKURA-YAMA, SHIKOKU, JAPAN*

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Abstract. Nine species of trilobites including six new species and two new subspecies from Mt. Yokokura are described in this article. A new genus, *Ichiyamella*, is instituted on *Ichiyamella subglobula*, sp. nov. Besides this genus *Japonoscutellum* and *Apolichas* are indigenous to Japan or Eastern Asia. Some notes are given on the Scutelluidae, Meroperixinae, Illaenidae, Goldillaeninae, Sphaerexochinae, Dindymeniae and the Lichidae in addition to Sphaerexochus, Dindymene and Dicranopeltis and Dindymene (?) megacranidia.

In the monograph on Silurian Trilobites of Japan etc. (1974), 26 species of trilobites were described from Mt. Yokokura. Recently 11 species were added to them (1984, 1985). A further addition is made here with 9 species and subspecies as listed below. The faunal analysis is postponed to another occasion.

Palaeontological notes are given on the families and subfamilies marked with plus in the list below beside a few genera. *Ichiyamella* is a new genus proposed on this occasion.

List of additional trilobites

Family Scutelluidae R. and E. Richter⁺ Subfamily Planiscutelluinae Kobayashi

and Hamada.

Japonoscutellum japonicum puteatum, subsp. Japonoscutellum japonicum laticephalum, subsp. nov. Subfamily Scutelluinae R. and E. Richter (?) Scutelluid, gen. et sp. indet. Subfamily Meroperixinae Kobayashi and Hamada⁺ Opoa (?) trinodosa, sp. nov. Family Illaenidae Hawle and Corda+ Subfamily Goldillaeninae Balashova+ Illaenoides (?) magnisulcatus, sp. nov. Illaenoides (?) abnormis, sp. nov. Family Proetidae Salter Subfamily Cyphoproetinae Pillet Cyphoproetus latiaxis, sp. nov. Family Cheiruridae Salter Subfamily Sphaerexochinae Öpik+ Sphaerexochus hiratai Kobayashi and Hamada Family Encrinuridae Angelin Subfamily Dindymeninae Kielan+

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Dindymene (?) sp. indet.

Ichiyamella subglobula, sp. nov.

Ichiyamella megacranidia (Kobayashi and Hamada)

Family Lichidae Hawle and Corda⁺ Subfamily Lichinae Hawle and Corda Dicranopeltis tricornis, sp. nov. Subfamily Homolichinae Phleger Apolichas truncatus Kobayashi and Hamada

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Description of trilobites

Family Scutelluidae Richter and Richter, 1956

Leioscutellum and Lamposcutellum were described from China respectively by Wu (1977) and Yin (1980). The latter is one of the oldest scutelluids that bear some characteristics of the Eobronteinae as well as the Planiscutelluinae. The former may be the oldest genus of the Paralejurinae.

Lamposcutellum Yin, 1980, whose type is L. guizhouense Yin, 1980, from Middle Ordovician in Guizhou, is allied to Eobronteus, Protobronteus and Planiscutellum in one or another characteristic. Its glabella is constricted at about one-third of the cephalon from the posterior margin, more expanded in anterior, reaching the frontal margin and provided with three pairs of lateral furrows; occipital furrow transversal; neck ring uniform in sagittal length; axial furrow well pronounced in middle and posterior; small paraxial nodes occasionally present at the constriction; eyes of medium size opposed at posterior furrows and lobes; eye-ridge extending from middle lateral furrow to eye; fixed cheek anterior to this ridge divided into two subequal parts by another ridge; lateral marginal borders extending from two sides of glabella

and produced into genal spines. Pygidium is bell-shaped; axial lobe nearly as long as broad, a little shorter than one-third of pygidium; median rib bifurcate in posterior; 7 pairs of pledural ribs present on its two sides. *Lamproscutellum shaanxiense* Zhou, 1982 and *L. latilimbatum* Zhou, 1982, occur in Middle Ordovician, Shaanxi.

Leioscutellum Wu, 1977 founded on L. tenuicaudatum Wu, 1977 from Lower Silurian in Guizhou, resembles Paralejurus, but its glabella is less expanded in anterior, occipital furrow describing two arcs, eye large and genal angle rounded on cephalon and 8 pairs of pleural ribs on two sides of the simple somewhat broad median rib on the bell-shaped pygidium.

Australoscutellum Chatterton and Campbell, 1980 was instituted on Bronteus longispinifer Mitchell, 1887 from the Ludlovian in New South Wales, Australia. According to the authors of the genus it is allied to Microscutellum in the glabellar pattern, but it has only 5 or 6 pairs of pleural ribs, besides a median rib which seems to be trisected. This genus indicates probably an early isolate branch of the Thysanopeltinae.

Unicapeltis Maximova, 1977, whose typespecies is Unicapeltis unica Maximova, 1977 from Middle Devonian of Salair, is quite distinctive in its glabellar configuration, particularly in the connection of the posterior pair of profound lateral furrows in describing a backwardly convex arc in the axial part. A pair of shallow paraxial furrows extend forward from both sides of this arc delimiting middle lateral lobes. Nevertheless, this genus resembles *Thysanopeltella*, *Arctopeltis* and *Altaepeltis*. It would be another aberrant genus of the Thysanopeltinae.

> Subfamily Planiscutelluinae Kobayashi and Hamada, 1974

Genus Japonoscutellum Přibyl and Vaněk, 1971

Japonoscutellum japonicum (Kobayashi and Hamada) puteatum, subsp. nov.

Pl. 90, Figs. 1a-c.

This cephalon agrees with *J. japonicum* in major aspects, but it disagrees with the typical form of the species in the middle and anterior lateral furrows which are disconnected from the axial furrow and strongly pitted, somewhat smaller eyes and the distinct eye-ridge and ala.

The cheek is narrow and depressed, but provided with a narrow convex lateral border. A narrow ridge runs along the lateral margin of the eye. The anterior branch of the facial suture extends from the eye and then diagonally crosses the cheek to the marginal border, interrupting the above ridge. Fine linear ornaments are seen on the glabella, particularly well in its anterior part.

Occurrence:-Gomi quarry, Yokokura-yama; collected by Kojima.

Japonoscutellum japonicum (Kobayashi and Hamada) laticephalum, subsp. nov.

Pl. 90, Figs. 2a-b.

Description:-Cranidium broader than long, most expanded laterally in anterior, gently inflated and becoming subvertical along frontal margin with forward convexity; sagittal profile nearly straight except for occipital furrow and anterior bent of frontal lobe. Glabella fungiform, most expanded at frontal lobe, strongly contracted at posterior lateral furrow and as wide as occipital ring at middle lateral furrow; posterior furrow expanded adaxially, separating posterior and middle lateral lobes of subequal length; middle furrow longer and anterior furrow longest; both linear; anterior lateral lobe shorter than middle or posterior lobe; these three pairs of lateral furrows all interrupted by axial zone which is a little narrower than posterior furrow; unfurrowed axial zone becoming a little wider between anterior pair of furrows; occipital furrow deeper than these lateral furrows; occipital ring somewhat shorter than posterior lateral lobe on lateral side; frontal lobe arching down in anterior and becoming subvertical; axial furrow deep. Fixed cheek narrow and depressed; eyes of medium size opposed at posterior lateral lobes; eye-ridge extending from middle lateral furrow to palpebral lobe; ala small, suboval, located on lateral side of posterior lateral lobe of glabella. Facial suture diagonal posterior to eye; its anterior branch extending from eye to lateral end of frontal glabellar lobe. Fine striae like terrace-lines on doublure seen most of dorsal test which are subparallel anterior margin on glabella, particularly dense and distinct on frontal lobe, more or less longitudinal on neck ring and subparallel to axial furrow on fixed cheek.

Comparison:-This cranidium resembles those of Planiscutellum and Kosovopeltis, but the essential distinction from them is the absence of the preglabellar depression. Planiscutellum has the large concave preglabellar depression in front of the glabella. The depression is very narrow in Kosovopeltis, but it separates the glabella from the subvertical doublure clearly. This cranidium reveals the characteristics of Japonoscutellum in the glabellar pattern, but it disagrees with $J_{iaponicum}$ s, str. in the lateral expansion of the cranidium in anterior, eyes located more posteriorly and possession of distinct eye-ridges and smaller alae. The linear ornamentation is well developed in this subspecies.

Occurrence:—The Yokokura-yama limestone; collected by Noda.

(?) Subfamily Scutelluinae R. and E. Richter, 1956 Scutelloid, gen. et sp. indet.

Pl. 90, Fig. 3.

A small dorsal shield, about 14 mm long.

Thorax is composed of ten segments, most expanded laterally at about posterior one-third, axial lobe broader than pleural lobe in anterior, but regularly narrows back as far as the axial and pleural lobes become subequal in breadth. Pleural furrows are absent.

Pygidium is suboval, wider than long and moderately convex, convexity being emphasized in one-third near anterior margin; axial lobe small subtriangular and well inflated; its median part smooth, parallel-sided and slightly elevated above lateral parts. Pleural ribs seven on each side; median rib a little broader than others; all of them flat-topped and separated from one another by narrow furrows; doublure about half as wide as pleural lobe.

The pygidium disagrees with other pygidia from the Yokokura-yama limestone in the outline and convexity of the pygidium and the flat ribs and narrow furrows. The median rib may be simple. Because the cephalon is illpreserved, its generic reference cannot be made.

Occurrence:-Gomi quarry, Yokokura-yama; collected by Kojima.

Subfamily Meroperixinae Kobayashi and Hamada, 1974

Ligiscus Lane and Owen, 1982, whose typespecies is L. arcanus Lane and Owen, 1982 from the Silurian near the Llandovery-Wenlock boundary, in western North Greenland, is an effaced scutelluid probably referable to the Meroperixinae. In this genus the occipital ring is ill-defined, but a median tubercle is present in the palce.

Genus Opoa Lane, 1972

Opoa (?) trinodosa Kobayashi and Hamada, sp. nov.

Pl. 90, Figs. 4a-c.

1974. Microscutellum primigenium Kobayashi and Hamada (pars), p. 74, pl. 5, figs. 9a-c only

Description:—Glabella three-fourths as long as broad, semielliptical transversally expanded in anterior one-third of sagittal length and conical and tapering back as far as its half breadth in the remainder, gently ascending to one-third of sagittal profile from posterior margin where a large median tubercle exists; lateral slope steep in conical part, whereas it is gentle in expanded anterior; frontal rim narrow with terrace lines separated from glabella by narrow marginal furrow; irregular linear ridges distributed in anterior and middle parts of glabella which are subparallel to frontal margin, but they become wavy backward; many tubercles spread in whole glabella, mostly in interspace between ridges, but ridges are absent in posterior part; median tubercle at two-thirds from front very large; a pair of tubercles on its postero-lateral sides, second largest; axial furrow deep; basal lateral lobes subtriangular; eyes of medium size opposed in posterior.

Observation and comparison:—This species is represented by an imperfect cranidium whose fixed cheeks and neck ring are largely gone, but a semicircular scar of the right eye-band suggests that the fixed cheek is very narrow.

It is certain that this cranidium belongs to the Scutelluidae, but it does not fit in any generic diagnosis so far known. The nearest to it is *Opoa* whose glabella is, however, simply parallel-sided in posterior, but it is truncateconical and provided with a pair of the basal lateral lobes in this species. The test is granulate as in *Opoa*, but the interspace reveals a honeycomb structure in *Opoa*, while it is ridged in the anterior side and three large tubercles are present in the posterior part of the glabella in this species. Therefore, it is probable that this species will be found to be a distinct genus in future.

Among the pygidia referred to *Microscutel-lum primigenium* there are two kinds. With this find it becomes probable that the strongly granulate pygidium having geniculate pleural area like *Opoa damesi* Lane to which the authors have compared belongs probably to this species.

Occurrence:-Yokokura-yama limestone, at Gomi quarry, collected by Asami.

Family Illaenidae Hawle and Corda, 1874

Raymond's bipartition of the Illaenidae into the Illaeninae and Bumastinae (1916) has been widely accepted by Hupé (1955), Balashova (1975) and others. In Moore's Treatise (1959) Jaanusson discriminated the Ectillaeninae in the family and provisionally added the Theamataspidae Hupé, 1953 to it as a subfamily. Later Bruton (1970) erected the Panderininae for *Panderia*. In additing the Goldillaeninae Balashova, the authors (1974) classified the family into the Illaeninae, Panderininae, Ectillaeninae, Buamastinae, Goldillaeninae and (?) Theamaspidinae beside three genera whose subfamily reference is uncertain.

Balashova (1960) instituted the Goldillaeninae in the Scutelluidae to include *Goldillaenus* and *Goldillaenoides* the latter of which had the occipital ring. While Jaanusson (1979) accepted *Goldillaenus* as a subgenus of *Illaenoides* Weller, 1908, Lane (1972) brought back the Goldillaeninae to the Scutelluidae.

Chatterton and Ludvigsen (1976) instituted a new genus, Failleana with Failleana clava as its type species and suggested that the Bumastinae be placed in synonymy with the Illaeninae as they found the rostral flange in Bumastus (Bumastoides) aplatus. Lane and Thomas (1978) on the other hand referred Bumastus to the Scutelluidae and added three new Bumastuslike Silurian genera, i.e. Cybantyx, Litotix and Rhax the last of which is based on Rhax pollincitrix Lane and Thomas from the Llandovery-Wenlock of Queensland, Australia. Thus the taxonomy of the family Illaenidae and its relation to the Scutelluidae is now a moot question.

The Typhlokorynetidae Shaw, 1966 and the Portaginidae Lespérance, 1968 are represented respectively by *Typhlokorynetes* Shaw, 1966 and *Portagius* Lespérance, 1968. If they are included in the Illaenacea, the superfamily is certainly comprehensive and much remains to be solved particularly of the effaced illaenoids.

The Illaenidae appeared already in the early Ordovician and died out before the Devonian period. The Scutelluidae on the contrary first appear in the Middle Ordovician rocks in China and the wide divergence has taken place from the Planiscutelluinae during the late Silurian and Devonian periods. The trend of evolution was quite different between the two families. It is improbable that the Scutelluidae were derived from the effaced Illaenidae or vice versa. In the Scutelluidae the effacement of the cephalic segmentation for example is most advanced in the Meroperixinae (Upper and Middle Silurian), but still the occipital lobe is generally well defined. In the Illaenidae, on the contrary, the occipital furrow is completely effaced, at least in the grown stage, although it may remain in the immature stage as seen in *Faillaena clava* Chatterston and Ludvigsen, 1976, in fig. 34, pl. 6. Among the Illaenidae *Bumastus* (Middle Ordovician-Silurian) reveals particularly high specialization in the very broad glabella and almost complete obliteration of the trilobation in the thorax and pygidium before the appearance of the Scutelluidae.

Distribution:-In the Ordovician fauna of China this family is well represented by eight or nine genera in four or five subfamilies as follows:

Illaenus, Stenopareia, Nanillaenus, Cekovia, Trigocekovia and Spinillaenus in Illaeninae Zdicella and Zbirovia in Ectillaeninae Bumastus and Dysplanus in Bumastinae Meitanillaenus in Goldillaeninae (?) Theamatopsis in Theamatopsinae

Trigocekovia Xia, 1978 whose monotypic species is T. fonicatus Xia, 1978, resembles Cekovia, but its cephalon is triangular in dorsal view and hemisphaeric in frontal view. Spinillaenus Xia, 1978, of which S. sinensis Xia, 1978 is monotypic is similar to Illaenus and Octillaenus, particularly to the latter, but it has the concave marginal border which is produced postero-laterally into a triangular genal spine as far as the third thoracic segment. The thorax consists of 10 segments, instead of 8 in Octillaenus. Meitanillaenus which appeared first in Hunan in the late Ordovician age survived in the Silurian period when Ptilillaenus and Wuchuanella also occur.

In Japan the family is represented by many Silurian species in two subgenera, *Bumastus* and *Bumastella* of *Bumastus* beside a species of *Goldillaenus* and two species of "*Illaenoides*" which belong probably to a new genus.

Subfamily Goldillaeninae Balashova, 1959

In the Silurian fauna of China the family Illaenidae is represented by the following three endemic genera whose type-species are cited in brackets.

- Ptilillaenus Lu, 1962 (Ptilillaenus lojopingensis Lu, 1962)
- Meitanillaenus Chang, 1974 (Meitanillaenus binodosus Chang, 1974)
- Wuchuanella Wu, 1978 (Wuchuanella quadrata Wu, 1978)

Ptilillaenus lojopingensis was primarily founded on cranidium and pygidium. A free cheek from Lojoping which Chang (1974, pl. 18, fig. 8) referred to this species has the lateral border which is rounded at the genal angle and becomes broader near the angle. A shallow marginal furrow runs along the border. The axis of the associate pygidium is long, conical and composed of 7–8 rings and a round terminal lobe. The marginal border is nearly flat and moderate in breadth.

Meitanillaenus binodosus from Meitan, Guizhou has the cranidium nearly as long as wide and strongly contracted at about one-fourth from posterior, much more expanded in anterior than posterior where it is about half as broad as the cranidium; a pair of semicircular nodes present on fixed cheeks at glabellar constriction; eyes there opposed, fairly large; free cheek with narrow lateral border and short genal spine. Like Bumastus hypostoma is provided with a pair of large triangular wings; central body subcircular and divided into two parts by middle furrow and maculae. Thorax distinctly trilobed by axial furrow; axial ring slightly broader than pleuron. Pygidium semicircular; axis short and trigonal; articulating facet distinctly limited by pleural furrow.

Meitanillaenus zhitangensis Wu, 1983 from the Upper Ordovician of Xijiang which has a distinct occipital furrow and lobe may be excluded from this genus. Wuchuanella quadrata Wu is represented by two cranidia resembling Meitanillaenus, but lacking alae.

Finally, the Brontocephalidae Kolobova, 1973, including Brontocephalus Tschugaeva, 1975, and Brontocephalina Tschugaeva, 1975, but excluding Bulanaspis Tschugaeva, 1956 is allied to the Goldillaeninae. Its glabella is strongly expanded in anterior. Brontocephalina marginatula Tschugaeva, 1975, from the Upper Ordovician of Northeast USSR has the pygidium with axial lobe composed of the trapezoidal short anterior part and the longer posterior part but ill-defined near the terminal part.

Genus Illaenoides Weller, 1907

Illaenoides (?) magnisulcatus Kobayashi and Hamada, sp. nov.

Pl. 90, Figs. 5a-b.

Description:-Illaenoid pygidium gently convex except for marginal inclination, semielliptical in outline, widest a little behind anterior margin where axis is a little projected beyond pleural lobes; anterior margin forming a broad obtuse angle near median point of pleural part; convexity of pygidium reaching maximum at about one-third from posterior end. Axial furrow completely effaced; axial projection of anterior margin one-third as broad as pygidium. First pleural furrow extending postero-laterally from lateral end of axial projection and confluent with marginal furrow. Lateral border relatively thick for illaenid. Facetted area defined by obtuse ridge extending postero-laterally from median angulation of anterior pleural margin; lateral marginal furrow tending to shallow backward. Sagittal profile of pygidium in exfoliated part simply arching down to posterior margin from highest point. Test smooth.

Observation:—The pygidium is 8.5 mm long and 11 mm wide. The axial projection of the anterior margin measures 5.8 mm in breadth and the lateral border exclusive of marginal furrow 1.8 mm.

Comparison:—The convex marginal border and well developed marginal furrow are most distinctive of this pygidium, suggesting that this pygidium belongs to an undescribed genus. Among the Japanese trilobites it is similar to Bumastus (Bumastella) bipuncatus, but the lateral margins converge more rapidly and the marginal border is depressed. It resembles also the pygidium of Ptilillaenus lojopingensis Lu in the presence of marginal border which is, however, not convex and the marginal furrow is absent in that species. Occurrence:-Yokokura-yama limestone; collected by Fujiyama.

Illaenoides (?) abnormis Kobayashi and Hamada, sp. nov. Pl. 90, Figs. 6a-c.

Description:—Pygidium parabolic in outline, broader than long in ratio of 1:0.7, regularly and gently convex with narrow marginal border and narrow marginal furrow; posterior one-third of pygidium distinctly arching down below the general base level.

Observation and comparison:—The margin of this pygidium is not perfect, but if perfect, it is probably 19.3 mm long and 27 mm broad. The axial part is about 13 mm wide on the articulating margin. The lateral border is 3 mm across.

Like the preceding pygidium the axial furrow is completely effaced in this pygidium, but the marginal border is evidently narrower and not so convex as in that pygidium. This pygidium is more convex and distinctly bent down in posterior one-third. Because it looks the original curvature, it is quite an unique aspect among illaenids.

Occurrence:-Yokokura-yama limestone; collected by Mizuno.

Family Poetidae Salter, 1864 Subfamily Cyphoproetinae Pillet, 1969 Genus Cyphoproetus Kegel, 1927 Cyphoproetus latiaxis Kobayashi and Hamada, sp. nov.

Pl. 91, Figs. 1a-g, 2a-c.

Description:—Cephalon semicircular in outline, well convex except for distinctly concave and smooth marginal border; glabella half as wide as cephalon, subconical, but much more expanded in posterior and broadly arcuate in front; anterior lateral furrow (2p) weak and short; posterior lateral lobe isolated by strong lateral furrow (1p), which is long and straight, but postero-laterally bent near its posterior end and disconnected from occipital furrow; neck ring composed of large median lobe and a pair of very small lateral lobes; occipital and axial furrows profound; eye medium sized, semicircular closeset glabella behind anterior lateral furrow and provided with distinct eye-socle; palpebral lobe flat and simply slanting to axial furrow; preglabellar field short, arching down to concave frontal furrow which is in turn bent up toward frontal edge; facial sutures widely divergent diagonally from eyes with postero-lateral convexity, incurved through marginal furrow and rim a little beyond eyes' limit; posterior branch running backward along axial furrow, then becoming diagonal to cut the cheek border on parallels through eyes; narrow ridge running along posterior facial suture till it becomes confluent with posterior cheek border; test densely granulose.

Pygidium two-thirds as long as broad; anterior pleural margin obtusely angulated at median point; postero-lateral margin broadly arcuate; posterior margin nearly transversal. Axial lobe one-third as wide as pygidium, well convex, rapidly tapering back to rounded posterior end whence a short postaxial ridge issues; six axial rings separated from one another by deep ring furrrows. Pleural lobe divided into five flat-topped ribs, all geniculate, less slanting in inner part than outer part; first rib distinctly facetted; succeeding ribs forked by narrow interpleural furrows which are deepened in distal part. Marginal border flat and smooth; its inner side depressed where pleural and interpleural furrows die out. Test granulose.

Observation:—Because the occipital lobe is mesially exfoliated, it is indeterminable whether or not a median tubercle is present. The test is broken also near the genal angles. Therefore the weak incurvature of the cephalic margin, commonly seen near the angle in *Cyphoproetus* cannot be ascertained in this specimen. Noteworthy is that a round-topped narrow ridge resembling the so-called eye-socle by Owens, 1963 is running in this cephalon along the posterior branch of the facial suture as far as the posterior cheek border. On the left cheek a narrow ridge is clearly seen behind the eye. The associate pygidium has a flat marginal border of moderate breadth, but no distinct marginal furrow on its inner side where pleural ribs and furrows terminate. The pleural ribs are distinctly flat-topped in the inner part.

Comparison:—This cranidium belongs to the group of Cyphoproetus with a narrow preglabellar area and granulose test like Wenlockian C. strabismus Owen, 1963, but the granulation is coarser and the cranidium and glabella are broader and the eyes smaller in this species.

Occurrence:-Yokokura-yama limestone at Gomi quarry; collected by Uchida.

Family Cheiruridae Angelin, 1854

Subfamily Sphaerexochinae Öpik, 1937

Beside Sphaerexochus and Pompeckia Whittington (1963, 1965), this subfamily included Heliomera Raymond, 1905, Kawina Barton, 1915, Cydonocephalus Whittington, 1963, and Xystocrania Whittington, 1965. Kolymella and Parasphaerexochus are two additional genera which were instituted by Tschugaeva, 1973, Kawina plana Tschugaeva, 1964, and Parasphaerexochus galeatus Tschugaeva, 1973, being the respective type-species. The former occurs in Middle Ordovician and the latter in late Lower Ordovician, both in Eastern Siberia, Northeast USSR.

Genus Sphaerexochus Beyrich, 1845

This is an Ordovician-Silurian genus of Trilobita whose type-species is *Sphaerexochus mirus* Beyrich, 1845. According to Lane (1971) it comprises 23 other species including one doubtful reference. Most of them are European species, but a quarter is American and one, namely, *Sphaerexochus taimyricus* Balashova, 1960, is an Asian species. *S. mirus* is reported from Turkestan by Weber (pygidium, 1932, cranidium and pygidium, 1951) and also from Australia and North America. The authors added one Silurian (up. Llandoverian-low. Wenlockian) species from Malaysia (1971) and two Ludolovian species from Japan (1974, 1976). Recently Sphaerexochus fimbrisulcatus Lu, 1975, and S. granosus Ju, 1983, were described from the Middle Ordovician in East China, S. dongzhuangensis Zhou, 1982, from Middle Ordovician in Shaan-Xi, Northwest China, S. luoheensis Nan, 1980, from Upper Ordovician, Heilongjiang, Northeast China, and S. guizhouensis Wu, 1977, from Lower Silurian, Guizhou, Southwest China. Sphaerexochus tisulcatus Tschugaeva, 1973 occurs in Lower Ordovician of Northeast USSR.

Further additions were made from Canada and Australia as follows:

- Sphaerexochus arenosus Chatterton & Ludvigsen, 1976, from Middle Ordovician, Canada
- Sphaerexochus dimorphus Perry & Chatterton, 1977, from Middle Silurian, Canada
- Sphaerexochus molongoensis Chatterton & Campbell, 1980, from Middle Silurian, Australia
- Sphaerexochus lorum Chatterton & Campbell, 1980, from Upper Silurian, Australia
- Sphaerexochus glaber Holloway, 1980, from Middle Silurian, U.S.A.
- Sphaerexochus brundlyi Chatterton, 1984, from Middle Silurian, Canada
- Sphaerexochus johstoni Chatterton & Perry, 1984, from Middle Silurian, Canada

These species are represented by many excellent specimens, some of which are silicified and show their ontogeny. Thus our concept of the genus was greatly clarified.

Finally, supplemented with Sphaerexochus seto Lane and Owens, 1982, from the Silurian (up. Llandovery-low. Wenlock) from Greenland it is nearly cosmopolitan, although none is reported from South America, so far as the authors are aware.

Sphaerexochus hiratai Kobayashi and Hamada, 1974

Pl. 90, Figs. 7a-c.

1974. Sphaerexochus hiratai Kobayashi and Hamada, p. 88, pl. 6, figs. 6–10, pl. 7, figs. 1–8, pl. 8, figs. 1–7, text-fig. 6F. This species is well represented by many cranidia and pygidia, but its free cheek, hypostoma and thorax were unknown. In a small complete rolled shield from the same locality the pygidium is seen to fit nicely the broad sinuate frontal margin of the cranidium.

Its thorax is tapering back slowly and composed of ten segments. The axial ring is nearly as wide as the pleuron which is unfurrowed and abruptly rounded near lateral extremity. The anterior segments whose pleurae are more or less geniculate are more convex than the posterior ones. Two small round bosses are seen on the left side of the sixth and seventh axial rings at their antero-lateral ends, instead of the postero-lateral ends.

The free cheek has a narrow rim and a broad concave border outside the relatively small cheek-roll. The anterior branch of the facial suture runs forward and a little inward from the eye. Its posterior branch in form of a suture ridge extends from the eye to the genal angle taking a broad arcuate course and meets the lateral margin just in front of the angle where a very short rudimentary spine issues.

Occurrence:-Yokokura-yama limestone; collected by Kojima.

Subfamily Dindymeninae Kielan, 1959 non Henningsmoen, 1959

Family Dindymeninae was proposed in 1959 by Kielan to include Dindymene Hawle and Corda, 1847 and a new genus, Eodindymene whose type-species is Dindymene pulchra Olin, 1906, but she excluded Plasiaspis Prantl and Přibyl, 1948. In the same year Henningsmoen proposed also the Dindymeninae as a subfamily of the Encrinuridae, but he included Plasiaspis and possibly Prosopiscus Salter, 1865 beside Dindymene in his subfamily. Because only the year, 1959, is cited for their dates of publication, it is a question which of the family or subfamily possesses the priority. The present authors, however, consider that Plasiaspis and Prosophiscus are to be eliminated out of the subfamily, because these two genera have well segmented glabellae and Plasiaspis has more segments in its thorax and pygidium than Dindymene. Furthermore, the difference in the ventral facial suture between Dindymene and Plasiaspis is emphasized by Kielan.

Incidentally, *Dindymenella* Lu, 1976, instituted on *Dindymenella sulcata* Lu, 1976, from the early Upper Ordovician in Yunnan differs from *Dindymene* as well as *Eodindymene* in the possession of 12 segments in thorax, instead of 10 segments in those two genera and the axial lobe of the pygidium is comparatively small and its spines are fairly stout and long. The distinct lateral furrows in three pairs on its glabella are quite distinctive from those two genera.

Genus Dindymene Hawle and Corda, 1847

Recently Dindymene orientalis Zhou and D. deflecta Ju were described from the Upper Ordovician, respectively in Jiangxi and Xijiang, both Central China (Chou et al., 1983). Dindymene brevicaudatus Kolobova, 1972, is known from the Upper Ordovician in Kazakhstan.

Dindymene (?) sp. indet.

Pl. 91, Fig. 4.

A blind cephalon composed of large vaulted glabella and less convex cheeks of moderate size. Glabella suboval, broader in anterior, gradually narrowing in middle and posterior parts; posterior margin transversal and nearly straight; lateral furrows absent; a large median tubercle present at a point slightly anterior to center of glabella. Cheeks separated from glabella by narrow straight axial furrows and opposed at posterior half of glabella. Marginal furrow and rim very narrow. Small tubercles densely distributed on whole surface except for axial and marginal furrows where they are absent or sparce; medium sized tubercles scattered irregularly among small ones.

The genal and posterior parts of the cephalon are obscure, but the antero-lateral outline can be figured out by tracing the tuberculate marginal rim and smooth marginal furrow. Little is known of facial suture. This cephalon belongs most probably to Dindymene or the Dindymeninae s. str., but it is quite distinct from most species of the genus in its proportionally large glabella to the cheeks and accordingly the much greater forward projection of the glabella. The anterolateral outline of the cheek is also different from typical Dindymene. These differences suggest its subgeneric or generic distinction from Upper Ordovician Dindymene in Europe.

Occurrence:-Gomi quarry of the Yokokurayama limestone; collected by Fujiyama.

Genus Ichiyamella Kobayashi and Hamada, gen. nov.

Diagnosis:—Cephalon strongly vaulted, more or less hemisphaeric and divided into a large glabella and two small cheeks by gently arcuate or nearly straight and forwardly divergent axial furrows; no lateral furrows on glabella, but a pair of short linear furrows cutting into glabella from frontal margin; occipital ring relatively large; cheek lacking eyes and facial stures.

Type-species:—Ichiyamella subglobula Kobayashi and Hamada, sp. nov.

Remarks:—The authors are of opinion that Dyndymene (?) megacranidia is referable to this genus. No median tubercle is present on the glabella in these two species.

Distribution:-Silurian in Japan.

Ichiyamella subglobula Kobayashi and Hamada, sp. nov. Pl. 91, Figs. 3a-f; Text-figs. A1-4.

Description:—Cephalon strongly vaulted, a little broader than long. Glabella very large, strongly expanded forward from narrow base and well rounded in anterior; lateral furrows absent, but a pair of weak short linear furrows inserted from frontal margin in two lateral parts of glabella; occipital ring much wider than glabellar base and abruptly narrowing near lateral ends; axial furrow diagonal and gently arcuate. Cheek ovoid, very small in comparison with glabella; marginal border thickened



Text-figs. A—C. Restoration of Three Silurian Trilobites from Mt. Yokokura. (vide p. 457)

A1-4: Ichiyamella subglobula.

toward genal angle where it is remarkably hanging down below general level of cephalon; eyes and facial suture absent; test densely granulate.

Observation:—The holotype cephalon is 14.7 mm long, 16 mm broad and 7.5 mm high; its glabella 11.5 mm long, 13 mm at the widest and 4.7 mm at the base; occipital ring 3 mm long and 7.5 mm wide; and its cheek 4.6 mm wide, 5 mm high and 7.3 mm in diagonal length.

Because the diagonal furrows are confluent with the occipital furrow far inside of the lateral extremities of the neck ring, they look similar to the preoccipital furrows of *Sphaerexochus*. In this cephalon, however, there are neither axial furrows nor cheeks, if they be really the posterior lateral glabellar furrows. Therefore these diagonal furrows are evidently the axial furrows.

Occurrence:-Ichiyama, near Ochi-town; collected by Nakajima.

Ichiyamella megacranidia Kobayashi and Hamada, 1985

1985. Dindymene (?) megacranidia Kobayashi and Hamada, p. 213, pl. 28, figs. 3a-c.

This species agrees with the preceding in the trilobation of the strongly convex cephalon, a pair of short linear frontal furrows on the glabella, small cheeks and granulate test, but it is different from that species in the roundly quadrate glabella limited laterally by nearly straight axial furrows. A very narrow marginal rim and a little broader and deep intramarginal furrow are also present in this species. The posterior mrgin of this cephalon is unknown.

Occurrence:-Gomi quarry of the Yokokurayama limestone.

Family Lichidae Hawle and Corda, 1874

In the Ordovician fauna of Asia this family is represented by Metopolichas, Amphilichas, Acrolichas (?) and Lyralichas in China, Indochina, Burma and Turkestan. Acanthopyge, Lobopyge, Craspedarges and Lichas s.l. are reported from the Devonian of Western, Central and Eastern Asia where in the last Acanthopyge is known from the Amur region and Radiolichas (?) from Mongolia, Lichas, s.l. from Viet-Nam. Craspedarges and Acanthopyge (Lobopyge ?) were found in Japan. Compared to them, the occurrences of Silurian lichids are scarce in Asia. Lichas (Corydocephalus) in two species are described from the Middle Silurian of Western Mongolia by Tschernysheva (1937) and Acanthopyge (3 spp.), Acanthoma, Tetralichas and Discrnopeltis (?) from the Kuznetsk region and Kazakhstan, Turkestan by Weber (1932, 1951), Tchernysheva (1951), Maximova (1960) and Balashova (1968). Corydocephalus is now synonymized with Trochurus.

Subfamily Lichinae Hawle and Corda, 1874

Genus Dicranopletis Hawle and Corda, 1974

Phleger (1936) erected two new genera, Dicranopletoides and Makromuktis on Lichas decipiens Winchell and Marcey, 1865 and Dicranopeltis nasutus Weller, 1907, respectively, but they were synonymized with Dicranopeltis by Warburg (1939) and this opinion was upheld by Tripp (1957 and in Moore's Treatise, 1959). Makromuktis is Dicranopeltis having a median anterior projection on the glabella. It is noteworthy that such forms occur not only in the Niagaran in North America but in the Wenlockian in Britain and also in the Yokokurayama limestone in Japan. Tsungilichas Chang, 1974 from the Lower Silurian of Guizhou, China was synonymized with Dicranopeltis by Thomas (1978). Recently Dicranopeltis cf. polytoma (Angelin) was reported by Zhou and Zhou (1982) to occur in the Upper Ordovician of Inner Mongolia.



C1-3: Dicranopeltis tricornis.

Dicranopeltis tricornis Kobayashi and Hamada, sp. nov.

Pl. 92, Figs. 1a-g; Text-figs. C1-3.

Description:-Cephalon large, broad, pentagonal, well vaulted, most elevated at a little anterior to glabellar center whence a stout median spine issues, subvertical anterior to spine, but gently sloping down backward; its length about five-eights of cephalic breadth exclusive of genal spines; anterior margin nearly straight, diagonal and forming a broad obtuse blunt angle of about 110 degrees, slightly more protruded forward in median part than anterolateral parts; posterior margin almost as broad as anterior one, transversal, but more extended back at neck ring and forming obtuse angles at lateral ends; antero-lateral and postero-lateral margins meeting at genal angle whence a stout long lateral spine issues.

Glabella large, occupying more than a half of cephalon, broadest through a point a little posterior to median spine and broadly sinuate toward mid-length of lateral glabellar lobes; front-median lobe composed of laterally expanded frontal part, long conical middle part narrowing back, and small posterior part expanding toward neck ring; lateral lobes quite different in size; anterior lateral lobe long and occupying major part; posterior lateral lobe small but a little larger than basal lobe; dorsal and occipital furrows stronger than lateral ones.

Fixed and free cheeks well fused; eyes small, located a little anterior to cheek-center; no eyeridge discernible; suture ridge extending laterally from eye, describing an arc on cheek, then facial suture cutting diagonally through lateral border as far as near intergenal angle; anterior branch of facial suture apparently running forward and inward from eye and crossing doublure between frontal and antero-lateral parts of marginal border. Genal spine stout, protruding in same line with antero-lateral border and then slightly bent backward; posterior cheek border divided into two parts by intergenal angle at its median point.

Explanation of Plate 90

Figs. 1a—c. Japonoscutellum japonicum (Kobayashi and Hamada) puteatum, subsp. nov.
Page 448
a: dorsal, b: frontal and c: left lateral views of the holotype cranidium. PA 18071, $\times 2.0$, coll. Kojima.
Figs. 2a-c. Japonoscutellum japonicum (Kobayashi and Hamada) laticephalum, subsp. nov. Page 449
a: dorsal, b: frontal and c: right lateral views of the holotype cranidium. PA 18072, x2.8. coll. Noda.
Fig. 3. Scutelloid, gen. et sp. indet. Page 449 A dorsal view of an almost complete shield with 10 thoracic segments, though they
 Figs. 4a-c. Opoa (?) trinodosa Kobayashi and Hamada, sp. nov
 Figs. 5a, b Illaenoides (?) magnisulcatus Kobayashi and Hamada, sp. nov Page 452 a: dorsal and b: left lateral views of the holotype pygidium, PA 18075, x3.2, coll. Fujiyama
Figs. 6a—c. Illaenoids (?) abnormis Kobayashi and Hamada, sp. nov
Figs. 7a-c. Sphaerexochus hiratai Kobayashi and Hamada



Fine granules distributed on test from glabella to convex marginal border and three spines, excluding various smooth furrows; smooth interspace, however, wider than granules in total space.

Observation:—This species is represented by a half of a cephalon which is, however, scarcely deformed. If complete, the cephalon exclusive of three spines is about 26 mm long, 40 mm broad and 16 mm high.

These spines are all broken, but they are presumably fairly long. The left eye is indicated by an eye-scar whose outline is obscure on the axial side. Its lateral and posterior margins are, however, traceable along the peripheral narrow furrow of the eye-socle and also with reference to the suture ridge behind the eye. The posterior branch of the facial suture is seen in the further extension, while its anterior branch is recognizable only on the doublure and its vicinity.

Comparison:-This species agrees with Lichas scabra scabra (Beyrich, 1845), the type-species of Dicranopletis Hawle and Corda, 1947 in the broad pentagonal outline of the cephalon with a pair of lateral spines and the essential configuration of the cranidium, although the glabella of this species disagrees with the lectotype of Dicranopeltis scabra in fig. 1, pl. 4 and Dicranopeltis scabra propiqua (Barrande, 1846) restored in text-fig. 13, both in Vaněk (1959) in the outline of the median lobe, the proportional length of bicomposite lobe with the posterior lobe and other minor details. The most important distinction of this species from *Dicranopeltis* scabra is the possession of the median glabellar spine.

Dicranopeltis polytomus (Angelin, 1854) with which Lichas elegans Tornquist, 1884 was synonymized by Warburg (1939) has also a similar cranidium which, however, lacks the median spine. Tsungilichas pustulosus Chang, 1974, from the Lower Silurian of Guizhou is represented by a strongly vaulted cranidium resembling this species, but it has no spine on the somewhat longer glabella.

In regard of the median projection this species is comparable to *Makromuktis nasuta* (Weller, 1907), although it is not a proboscis-like projection in this species. *Dicranopeltis woodwardi* (Reed) and *Dicranopeltis* sp. l by Thomas (1981) has an upwardly directed spine on the median glabellar lobe which is bifurcated at a distance from its root. *Lichas (Metopolichas) celorhin* Angelin var. *coniceps* Herz von Leuchtenberg by Reed 1917 form the Ordovician of Shihtien, Yunnan also has a median spine on the frontal lobe of the glabella.

Occurrence:-Yokokura-yama limestone; collected by Asami.

Subfamily Homolichinae Phleger, 1936 Genus *Apolichas* Kobayashi and Hamada, 1974 *Apolichas truncatus* Kobayashi and Hamada, 1974 Pl. 92, Figs. 2a-c; Text-figs. B1-3.

1974. Apolichas truncatus Kobayashi and Hamada, p. 80, pl. 8, figs. 9-12; text-fig.
6A.

Little has been known on the cheek of this species. A new cephalon shows that a left cheek is separated from the tricomposite lateral lobe of the glabella by a deep axial furrow and overhanging the narrow marginal border. It is reniform and strongly vaulted, but its top is lower than the lateral lobe. Its eye is very large for the Lichidae.

Compared to the type specimen this cephalon is somewhat different in the anterior outline. The main lobe of its glabella is protruded forward, forming weak concavity on each side of the frontal margin of the cephalon. Furthermore the convexity of the glabella is a little stronger, attaining the maximum shortly behind its center. The posterior margin of the cephalon is not well preserved and the genal spine which existed on the left cheek of the type specimen is lost in this cephalon. On the basis of these two cephala combined the dorsal aspect of the cephalon can now be restored completely.

Occurrence:-Yokokura-yama limestone. KAC-St-0032(a); collected by Kaneko.

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Explanation of Plate 91

- Figs. 1a-g. Cyphoproetus latiaxis Kobayashi and Hamada, sp. nov. Page 453 a, e: dorsal, b, f: frontal, c: right lateral and d, g: left lateral views of the holotype cephalon, PA 18078. a, b, c, d ×4.5, e, f, g ×3.0, coll. Uchida.
- Figs. 2a-c. Cyphoproetus latiaxis Kobayashi and Hamada, sp. nov. Page 453 a: dorsal, b: right lateral and c: posterior views of a pygidium, PA 18079, ×7.0, coll. Uchida.
- Figs. 3a-f. Ichiyamella subglobula Kobayashi and Hamada, gen. et sp. nov. Page 456
 a: dorsal, b: posterior, c: left oblique, d: frontal, e: right lateral and f: left lateral views of the holotype cephalon, PA 18080, ×2.0, coll. Nakajima.

Plate 91



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See also Kobayashi and Hamada (1974 and 1984) for other references here omitted.

Ertaogon 二道溝, Gomi 五味, Guizhou 貴州, Heilongjiang 黒龍江, Ichiyama 市山, Jiangxi 江西, Kweichou (=Guizhou) 貴州, Shaan-Xi 陝西, Shihtien 施句, Tienshan 天山, Yunnan 雲南, Xijiang 浙江.

四国橫倉山のシルル紀三葉虫群への第2追加:本論文には5科に属する9種の三葉虫が記 載されている。そのうちには6新種と2新亜種が含まれていて、新属 Ichiyamella もある。 その他に保存不完全のために正確な鑑定の出来ない2種がある。これらの三葉虫と関係のある 科,属に就いても若干論及している。Ichiyamella, Japonoscutellum, Apolichas は現在日本 特産の属である。 小林貞一・浜田隆士

Explanation of Plate 92

- Figs. 1a-g. Dicranopeltis tricornis Kobayashi and Hamada, sp. nov. Page 458 a, d: dorsal, b, e: left lateral and c, f: frontal views of the holotype cranidium showing an inflated shield with long and stout spines, PA 18082, a, b, c x2.0, d, e, f x1.0, coll. Asami.
- Figs. 2a-c. Apolichas truncatus Kobayashi and Hamada Page 459 a: dorsal, b: frontal and c: left lateral views of a cranidium to show the trilobation and the large eye, PA 18083, ×3.5, coll. Kaneko.

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820. ON NEOCRIOCERAS SPINIGERUM (JIMBO), A SPECIES OF CRETACEOUS HETEROMORPH AMMONOIDS (STUDIES OF THE CRETACEOUS AMMONITES FROM HOKKAIDO-LV)*

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Abstract. Neocrioceras spinigerum (Jimbo), the type species of Neocrioceras, is redefined on the basis of the specimens in our collections as well as the hitherto described ones. Its adult body-chamber is spirally coiled in the same way as the phragmocone. It is quadrituberculate at intervals and the disposition of the ventrolateral tubercles is variable (opposite or alternate or irregular) among individuals and also with growth-stages. The quadrilobate suture is florid; I trifid and as deep as U; other elements bifid and of dove-tail form. Reliable records show that this species occurs in the Santonian of Hokkaido and Sakhalin. Comparison with other species is described at length, with a result that certain species previously referred to Neocrioceras should be transferred to other genera.

In an appendix the genus *Neocrioceras* is redefined and its relationships with other genera are discussed.

Introduction

For some reasons, the genus *Neocrioceras* Spath, 1921 has been understood inadequately by some authors. To remove this misunderstanding, the first step is to redescribe its type species, *Crioceras spinigerum* Jimbo. This has been done concisely in a recently published paper (Matsumoto, 1985), in which only two syntypes of Jimbo have been photographed because of the page limitation. This paper is

to describe this species in detail with more illustrations.

In this study the senior author is primarily responsible for the paleontological description and discussion; all the authors were engaged in field work of collecting fossils in respective areas concerned and in developing specimens from calcareous nodules.

Description of a species

Neocrioceras spinigerum (Jimbo)

Pl. 93, Figs. 1-8; Pl. 94, Figs. 1-16; Text-fig. 1

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- 1894. Crioceras spinigerum Jimbo, p. 184, pl. 24, figs. 1, 1a, 1b.
- 1921. Neocrioceras spinigerum (Jimbo); Spath, p. 51.
- 1933. Neocrioceras spinigerum (Jimbo); Shimizu, p. 13, pl. 2, figs. 4-9.
- 1963. Neocrioceras spinigerum (Jimbo); Matsumoto, p. 45, pl. 67, figs. 1, 1a, 1b.
- 1981. Neocrioceras spinigerum (Jimbo); Tanabe et al., p. 220, pl. 37, figs. 2a, b; text-fig. 5.
- 1985. Neocrioceras spinigerum (Jimbo); Matsumoto, p. 56, text-figs. 1, 2.

Lectotype:--UMUT. MM7521 (Jimbo, 1894, pl. 24, fig. 1, 1a; Matsumoto, 1985, figs. 1A, 1B; this paper, Pl. 93, Figs. 1-2) from Ikandai of the Urakawa area (southern central Hokkaido), designated by Matsumoto, 1985 (p. 56).

material:--Paralectotype, Other UMUT. MM7522 (Jimbo, 1894, pl. 24, fig. 1b; Matsumoto, 1985, figs. 2A, 2B; this paper Pl. 93, Figs. 3-5) from Ikandai. TTC. 400819 (this paper, Pl. 94, Figs. 1-2) from Ikdandai; UMUT. MM7640 from the Sosushi, a branch of the Sanushibe, Hobetsu area (H. Yabe Coll.); TTC. 360806 (Pl. 94, Figs. 6-9) from a branch stream called the Y-sawa of the Kikume-zawa, a tributary of the Ikushumbets, Mikasa district; UMUT. I-3531 (TMC.) from loc. T 55 p and UMUT. I-3582 (TMC) from loc. T 277 e of the Saku-Abeshinai area (see Matsumoto, 1942, for the numbered localities of TMC); TTC. 360815 (Pl. 94, Figs. 14–16) from the Saku-gakko-no-sawa, two other unnumbered specimens of MYC. and YKC., all the above six from the Saku-Abeshinai area in the Teshio Nakagawa district; MC. Hbo-3695 (Pl. 93, Figs. 6-8) from the Haboro area. YKC. (without number) from the Obira area; H. Maeda's collection from the Onkono-sawa, Kotanbetsu area. Also UMUT. MM7708 (M. Kawada Coll.) and TMC from the Naibuchi area; IGPS. 36836 from Namikawa (Shimizu, 1933, pl. 2, figs. 4-9; this paper Text-fig. 1); GK. H5204, GK. H5205 (Pl. 94, Figs. 3-5) and GK. H5218 from Kawakami (S. Nagaoka Coll.), all the above six from South Sakhalin; NSM. PM9491 (Tanabe et al., 1981, pl. 37, figs. 2a, b; text-fig. 5) from somewhere in Sakhalin (?).

Repositories are as follows with abbreviation in parentheses:

- Geological Collections, Kyushu University, Fukuoka (GK).
- Institute of Geology and Palaeontology, Tohoku University, Sendai (IGPS)
- National Science Museum, Tokyo (NSM)
- University Museum, University of Tokyo (UMUT)

The Muramotos' Collection (on display at the Museum of Mikasa City), Mikasa (MC)

Takemi Takahashi's Collection, Mikasa (TTC) Minoru Yamashita's Collection, Mikasa (MYC) Yoshitaro Kawashita's Collection, Mikasa (YKC)

The specimens collected by T. Matsumoto (TMC) are kept at GK and UMUT.

Diagnosis:—Shell medium-sized, consisting of slightly open crioceratoid planispiral whorls, which are depressed in cross-section. Bodychamber about three fifths of the last whorl.

Ribs fine and numerous, gently projected on the dorsum, sinuous on the dorsolateral part, somewhat prorsiradiate on the flank, crossing the venter nearly vertically. Spiny tubercles in four rows at intervals, with looping of minor ribs. The ventrolateral tubercles normally opposite, resting on low major ribs, but sometimes deviate slightly or even considerably from this disposition to give rise to irregular or alternate configuration, thus variable among individuals and/or with growth-stages. The ventrolateral tubercles often more numerous than the lateral tubercles by addition of intercalated ones. Depending on the frequency of tuberculation, the intervening nodeless ribs vary from one to four, occasionally showing outward branching.

Sutural formula E, L., U, I; lateral saddles and lobes (L, U) bifid and of dove-tail shape; I nearly as deep as U and trifid; all the elements finely and deeply incised.

Description:—A completely preserved adult shell is very rare. MC Hbo-3695, about 75 mm in diameter, is probably an adult shell, in which body-chamber, although partly destroyed, occupies about 210° and its last septum is at 48 mm

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Measurements (in mm):

Specimens	Diameter	Umbilicus	Height	Breadth	B/H
Lectotype	34.4	18.3 (.53)	9.5 (.28)	14.5(.42)	1.53
Paralectotype*	39.5	19.7 (.50)	11.6 (.29)	15.3 (.39)	1.32
$Paralectotype - 180^{\circ}$	31.0	13.8(.45)	8.5 (.27)	11.0 (.35)	1.29
TTC. 400819	24.4	11.7(.48)	7.8 (.32)	11.6 (.48)	1.49
TTC. 360806*	26.6	12.8(.48)	9.0 (.34)	14.4(.54)	1.60
TTC. 360815	42.5	18.0(.42)	13.8 (.32)	(distorted)	
TTC. 360815*	36.0	16.8(.47)	12.4(.34)	18.2 (.51)	1.47
MC. Hbo-3695	75.0	37.0 (.49)	\sim_{21} (.28)	34.5 (.46)	~ 1.6
MC. Hbo-3695*	48.0	22.5(.47)	16.3 (.34)	24.2 (.50)	1.48
TTC. 370817*	~ 43	$\sim \!\! 22.5$ (.52)	~ 15 (.35)	~23 (.53)	~ 1.5
UMUT. MM7640	20.4	11.4 (.54)	5.6(.27)	8.0 (.39)	1.43
GK. H5205	33.2	15.6 (.47)	10.8 (.33)	15.2 (.46)	1.41
GK. H5204	27.7	13.2(.48)	8.4 (.30)	11.7 (.42)	1.40
GK. H5118	34.0	16.0 (.47)	10.0 (.29)	14.4(.42)	1.44
IGPS. 36836*	50.0	22.8 (.45)	16.5(.33)	24.5 (.49)	1.48

* measured at the end of the phragmocone

 \sim approximate

in shell diameter. It should be noted that the body-chamber is coiled in the same form as the phragmocone and never extended to a straight shaft as in *Anisoceras*. This denies the presumption of Spath (1921, p. 51).

IGPS. 36836, described by Shimizu (1933, p. 13, pl. 2, figs. 4-9), is also an adult shell, but its body-chamber is incompletely preserved and secondarily squashed.

The lectotype is wholly septate. Some other specimens, e.g. paralectotype, TTC. 360815, TTC. 370817, TTC. 360806, GK. H5118 and GK. H5204, show the last septum at smaller diameters, from 40 mm to 25 mm, and only a portion of the body-chamber is preserved. They may be more or less immature but some of them may be small adult shells. On the probably adult body-chamber the ribs and tubercles are somewhat coarser than those on immature shells, but the difference is by no means great and it is difficult to know the variation in size.

The ammonitella and early immature shell are not preserved in mot cases. NSM. PM 9491, reported by Tanabe *et al.* (1981), may be a comparatively better preserved example, but is yet incomplete in lacking the very initial conch. The observable part of the ammonitella is subhelical and soon followed by a nearly planispiral crioceratoid whorl.

Shimizu's (1933) specimen was actually reconstructed with artificial connection between the outer and inner whorls. Therefore, the slightly helicoidal form in his diagram is doubtful.

The whorl is characteristically depressed, but the ratio of B/H is considerably variable from an individual to another and also with growth-stage. The measurements show that B/H ranges from 1.3 to 1.5 in many cases but occasionally exceeds beyond that range. Anyhow, the ventral part is broad and its central zone between the tubercles is nearly flat, whereas the flanks are convex, with the maximum breadth between the rows of lateral tubercles.

In the diagram of whorl-section by Jimbo (1894, pl. 8, fig. 1a) the four tubercles are illustrated as equidistant, but in the actual specimen the distance between the left and right ventrolateral tubercles is wider than that between the lateral and ventrolateral ones. The same feature is observable in almost all the specimens examined. In this respect the diagrams by Shimizu (1933, pl. 2, figs. 7, 8; disordered in the explanation of plate) as well as Text-fig. 1C in this paper are correct.

The disposition of tubercles is considerably variable in this species. Some authors regarded the alternate disposition of the ventral (i.e. ventrolateral) tubercles as a diagnosis of Neocrioceras. This came probably from Shimizu's (1933) specimen whose illustration was cited in the first edition of the Treatise (Wright in Moore (ed.), 1957). In this specimen, IGPS. 36836, the ventrolateral tubercles are alternate on the figured part (Shimizu, 1933, pl. 2, fig. 5), *i.e.* on the last half of the phragmocone and the first 30° of the body-chamber, but they are opposite or nearly so on other observable parts. At the changing point from the alternate to opposite disposition on the bodychamber a few ribs cross the venter obliquely for adjustment (Text-fig. 1B). Incidentally the highly squashed last part of the body-chamber of this specimen was excluded from the illustration by Shimizu (1933, pl. 2, fig. 4).

In MC. Hbo-3695, the ventrolateral tubercles are opposite on the body-chamber but irregular, if not quite alternate, on the late part of the phragmocone (see Pl. 93, Figs. 8, 7). In the lectotype and many other specimens (e.g. TTC. 360815, TTC. 370817, TTC. 360806, UMUT. MM7640, UMUT. I-3581, GK. H5118, etc.) the ventrolateral tubercles are opposite or nearly so. The paralectotype has also the opposite ventrolateral tubercles in its young stages but on the preserved last half whorl there is no left ventrolateral tubercle and the ribs run irregularly. This is unusual and interpreted as probably pathologic. In GK. H5205, which is wholly septate, the ventrolateral tubercles are disposed irregularly or rather alternate in the later part, but in the younger part they are opposite and rest on the low major rib. In GK. H5204 they are opposite on the phragmocone and tend to deviate from that disposition on the succeeding part of the body-chamber.

The lateral tubercles number 7 or 8 in a half whorl, occurring as a rule at regular intervals but occasionally at a longer or shorter interval than the normal or average ones. In addition to the ventrolateral tubercles which correspond to the lateral ones, more ventrolateral tubercles occur in an intercalated disposition variably in some specimens or at some growth-stages. The tubercles in the late growth-stage have a long spine with a septate node at the base. The lateral nodes are somewhat larger than the ventrolateral ones. The ventrolateral spines stretch upward and forward; the lateral ones sideward.

The ribs are mostly simple and some of them are looped at the tubercles. Occasionally the ribs are bifurcated outward.

The curvature of the rib, as described in the diagnosis, is indeed characteristic of this species, but the degree of curvature varies to some extent. The feature of the curvature, such as dorsal projection, dorsolateral sinuosity and forward inclination on the flank, are generally weak on younger whorls, becoming more distinct later. The ribs cross the siphonal zone of the venter nearly vertically between the rows of ventrolateral tubercles and some of them, looped by the tubercles, show a faint sinus (*i.e.* backward arc). There are also indistinct constrictions behind some of the major ribs which have opposite tubercles.

The sutural pattern described in the diagnosis is kept constantly. Jimbo (1894, pl. 24, fig. 1b) illustrated correctly the general pattern but ignored minor incisions, probably because the specimen (paralectotype) was somewhat eroded. Shimizu's (1933, pl. 2, fig. 9) illustration shows minor details as well as the general pattern. Some more figures (Text-figs. 1A, D) are added in this paper. Even in small, immature specimens the suture is fairly deeply and finely incised. In mature shells the suture is florid, with deep and fine incisions and narrowed stems and branches of the elements. Spath (1921) misunderstood that suture of this species was simple.

Occurrence:—Some of the above described specimens are not precisely located in the stratigraphic sequence; others from the Upper Urakawan (K6b), approximately Santonian, and often associated with Sphenoceramus naumanni


Text-fig. 1. Some features on IGPS. 26836, an example of *Neocrioceras spinigerum* (Jimbo).

A. External lobe of the last third suture. B. Disposition of ribs and tubercles on posterior half of the body-chamber. C. Diagrammatic whorl-section at D=50 mm. (Spines restored in which left ones (dotted lines) projected on the same plane). D. Suture at a young stage (H=5.4mm, B=7.5 mm). Scale bar=10 mm (A-C); 1 mm (D). These figures are to supplement Shimizu's (1933, pl. 2, figs. 4-9). (T.M. delin.)

(Yokoyama) and S. nagaoi (Matsumoto et Ueda).

Besides the described specimens, fossils of this species may be found occasionally from the Upper Urakawan (Santonian) of various areas in Hokkaido and also Sakhalin, although they are often hardly taken out in a complete shape from calcareous nodules.

The true stratigraphic range of this species beyond the Santonian and the geographic distribution outside Hokkaido and Sakhalin are yet uncertain.

Comparison:—The specimens from Pondoland described by Spath (1921, p. 52, pl. 7, figs. 6a c) under *Neocrioceras* cf. spinigerum are not identified with the named species, because they have compressed or nearly circular whorls. They seem to be closer to N. (?) undulosum Matsumoto, 1977, but are too incompletely preserved for a precise identification.

Neocrioceras (Schlueterella) compressum Klinger (1976, p. 74, pl. 33, fig. 5; text-figs. 8j, 10g), from the Lower Santonian of Zululand, was established on a fragmentary whorl, curved gently on a plane. The holotype clearly shows a change in the curvature which suggests a subelliptical coiling; its whorl is laterally compressed and its suture has a very small I. These are fundamentally different from the characters of N. spinigerum. As in N. spinigerum the holotype has ventrolateral and inner lateral tubercles connected by looped ribs and intervening two to three nontuberculate ribs. As only a single fragmentary specimen was available, no remark was given on the variation. This Zululand species is provisionally referable to *Schlueterella* Wiedmann, 1962 (emend. Matsumoto and Miyauchi, 1984).

The specimens from the Lower Santonian of the Gosau Group (Austria) described by Immel et al. (1982) under Neocrioceras (Schlueterella) compressum seem to show an open subelliptical coiling (op. cit., pl. 10, fig. 1a), but this might have been affected by secondary deformation as suggested by some of the normally coiled ammonites from the Gosau. A fragmentary phragmocone M 2 illustrated in the same paper (op. cit., pl. 9, fig. 3) indeed resembles the holotype from Zululand, but the body-chamber and also the late part of the phragmocone (op. cit., pl. 10, figs. 2-4; pl. 11, fig. 3) show a zigzag arrangement of tubercles in the lateral and probably also ventrolateral rows. This may be another characteristic of S. compressa. The same character occurs more distinctly in S. kawadai Matsumoto et Miyauchi, 1984, from the Campanian of Hokkaido and Sakhalin, which differs from contemporary European species S. pseudoarmata (Schlüter, 1872) at this point. Regrettably the suture is not well exposed on the Gosau specimens, but it is essential for a precise identification. In this paper, however, the Gosau specimens are provisionally identified with Schlueterella compressa. Anyhow, it is evidently distinct from Neocrioceras spinigerum.

N. (Schlueterella) mutinodosum (Schlüter, 1872) (see Wright, 1979), from the Turonian of Europe, should be referred to *Pseudoxybeloceras* or *P. (Christophoceras*), because four rows of tubercles occur not only on major ribs, with looped riblets, but also on intervening minor ribs.

Neocrioceras (Neocrioceras) maderi Immel, Klinger et Wiedmann, 1982 (p. 24, pl. 9, fig. 2; pl. 11, figs. 1–2), from the Lower Santonian of the Gosau Group, is distinguished from N. *spinigerum* in its more gently arcuate and compressed instead of depressed whorls and outward shifted rows of tubercles (*i.e.* ventrolateral and ventral rows). Its ribs do not show such a dorsal projection and dorsolateral sinuosity as those of N. spinigerum. Again its suture is not known. This Gosau species is somewhat similar to Kawashitaceras obiraense Matsumoto (1984b, p. 342, figs. 2, 3A, 3B, 4A, 4B), but whether the summit of the ventral tubercle is minutely subdivided or not should be examined on better preserved specimens. Anyhow, it is doubtful to refer this species (maderi) to Neocrioceras.

Ancyloceras kossmati Simionescu, 1899 (p. 257 [21], pl. 1, figs. 6–8), from the Upper Cretaceous of Transilvania (Roumania) was referred to Neocrioceras (Schlueterella) by Wiedmann (1962, p. 205). It has widely open whorls coiled subelliptically on a plane and the whorl seems to be higher than broad, although the specimens may be secondarily deformed. Quadrituberculate major ribs and intervening finer ribs without tubercles encircle the whorl radially without sinuosity and the ribs are looped only occasionally at a few tubercles. The ventral tubercles are opposite on the figured specimen (Simionescu, 1899, pl. 1, figs. 8A, B). Again the suture is not illustrated. This species is similar to S. compressa in shell-form but differs in its infrequent occurrence of looped ribs at a few tubercles. It is provisionally referred to Schlueterella, unless enough evidence be obtained for the establishement of a new genus or subgenus.

There are a few specimens (e.g. Hokkaido University Collection 9467 with uncertain record of locality) which may represent an unnamed new species of *Neocrioceras*. This is distinguished from *N. spinigerum* by a larger size (about 100 mm in diameter of the phragmocone), more open spiral form, subcircular whorlsection and outward shifting tendency of lateral tubercles in a late growth-stage. More specimens with reliable locality records are wanted to define clearly this species.

N. (?) undulosum Matsumoto, 1977, from the Turonian of Hokkaido, is atypical in that its immature shell shows a low helicoid shape and is followed by an open spiral shell in an undulating plane, but its body-chamber is gently curved on that plane without a retroversal hook. Its ornamentation is fundamentally similar to that of *N. spinigerum*.

Appendix

Remarks on the genus Neocrioceras

TATSURO MATSUMOTO

The genus *Neocrioceras* was proposed by Spath (1921, p. 51), but the legal designation of *Crioceras spinigerum* Jimbo, 1894 as its type species was settled by Diener (1925, p. 192). Since then this genus has been comprehended widely and was even misunderstood by some authors.

In the preceding pages the type species has been defined clearly and compared with other species. In this appendix I attempt to give a generic diagnosis of *Neocrioceras* and remarks on the relationships of this genus with other genera. The latter problem is still difficult, because heteromorph ammonite species of this kind are often based on incomplete material. Therefore, the following remarks, which are in part cited from the recently issued papers (*e.g.* Matsumoto, 1977; 1984a, b; Matsumoto and Miyauchi, 1984) with some modification, may still be tentative.

Generic diagnosis:—Whorls in the main growth-stages more or less open crioceratoid, coiled in a plane or nearly so, ornamented with numerous ribs and four rows of spiny tubercles, *i.e.* the lateral and ventrolateral ones, at intervals, with intervening nodeless ribs; typically ribs looped at the tubercles. Suture deeply and finely incised, consisting of E, L, U, I; I trifid and as deep as U; other elements bifid and of dove-tail pattern.

Distribution:—From Turonian to Santonian (possibly to Lower Campanian) in Japan and Sakhalin, so far as reliable records are concerned.

Relationships of Neocrioceras with other genera:-The phylogenetic origin of Neocrioceras is uncertain. It was tentatively sought in the plastic and long-ranging genus Hyphantoceras Hyatt, 1900 (Matsumoto, 1977), but this is a working hypothesis suggested by N. (?) undulosum Matsumoto. Neocrioceras has no affinity with Anisoceras Hyatt, because its body-chamber is spirally coiled in the same way as its phragmocone without straightly extended arm and because the suture is different in its well developed I and also because there is no species which could suggest the connection.

Schlueterella Wiedmann, 1962 is based on the incompletely known type species, Anisoceras pseudoarmatum Schlüter, 1872 from the Campanian of Germany, and supplemented by a closely allied species S. kawadai Matsumoto et Miyauchi, 1984, from the Campanian of the northern Pacific region. Its revised generic diagnosis has recently been given by Matsumoto and Miyauchi (1984, p. 59). It is similar to Neocrioceras in the general mode of ornamentation (four rows of tubercles at intervals with intervening untuberclate ribs and with looping of ribs at the tubercles) but different in its open. subelliptically (in stead of spirally) coiled whorls, which consist of nearly straigt or gently arcuate long shafts and U-curved parts, and also in having very small I in the suture. The mode of disposition of ventral tubercles does not work as a criterion. The shell-form of the type species and S. kawadai in early immature stage is not known precisely and the phylogenetic origin of this genus is uncertain. Anyhow, on the ground of the distinction mentioned above, it is better to treat Schlueterella as an independent genus rather than to affiliate it to Neocrioceras as a subgenus.

Kawashitaceras Matsumoto, 1984 was proposed for the type sepcies, Neocrioceras dentatum Matsumoto et Obata, 1981, represented by a peculiar body-chamber from the Upper Turonian of Hokkaido, and another species K. obiraense Matsumoto, 1984, from the Upper Turonian (or possibly Coniacian) of Hokkaido. It has also quadrituberculate looped ribs and intervening nodeless ribs, but the tubercles are distributed restrictedly on the ventral part and of dental form with minute crenulations on their backward sloping summit. The tubercles have long spines in Neocrioceras and Schlueterella, which would work as protection against enemies. The body-chamber of Kawashitaceras is long and broadly arcuate. The shape of the preceding phragmocone is not completely known but may be loosely open and subelliptically coiled as judged from some preserved pieces of curved parts. The peculiar tubercles of a dental form distributed on the ventral part may be favourable for this animal living in a shell of very unstable shape to repose himself (or herself) on the bottom sediments and also for him to start for occasional locomotion back upward in the sea water (Matsumoto, 1984b). The phylogenetic origin of Kawashitaceras is yet uncertain. Anyhow, Kawashitaceras is distinct enough to be treated as a genus independent of Schlueterella or Neocrioceras.

Pseudoxybeloceras Wright et Matsumoto, 1954, established on the type species, Hamites quadrinodosus Jimbo, 1895 (emended by Matsumoto, 1977), had nearly straight parallel shafts connected by U-curved parts. Numerous simple ribs encircle the shell, of which some are periodically stronger than others. Every rib on the shell of late grwoth-stages have tubercles in four rows, ventrolateral and lateral ones. The major or stronger ribs have stronger tubercles where riblets are looped in some case but not always so. Anyhow, the presence of tubercles on every rib is one of the criteria to distinguish *Pseudoxybeloceras* from Neocrioceras and Schlueterella. The suture of P. quadrinodosum figured by Jimbo shows shallow I, but that of P. lineatum (Gabb) (Matsumoto, 1959, fig. 79) clearly shows that I is as deep as U, being fairly similar to that of Neocrioceras spinigerum. I is somewhat smaller than other lobes as Matsumoto (1959, p. 162) described previously but not so small as that of Schlueterella kawadai. With respect to shell-form, Pseudoxybeloceras may be closer to Schlueterella than to Neocrioceras, but the shell-form in the early immature stage is not precisely known in both Pseudoxybeloceras and Schlueterella.

Parasolenoceras Collignon, 1969, based on the

type species *P. splendens* Collignon, 1969, from the Campanian of Madagascar, has ventrolateral tubercles alone on every rib but no lateral tubercle at any growth-stage. In its suture I is as deep as U. With respect to the shell-form and suture *Parasolenoceras* is similar to *Pseudoxybeloceras*.

Periodic major ribs with stronger tubercles are not recognized in the holotype of *P. splend*ens, but they appear more or less clearly in other species, e.g. *P. periodicum* Matsumoto et Miyauchi, 1984, *P. compressum* (Henderson, 1970) and *P. nanaimoense* (Ward et Mallory, 1977) and fine ribs may or may not be looped at the tubercle. As in the case of *Pseudoxybeloceras*, this character alone would not be sufficient to separate a genus from *Parasolenoceras*.

Lewyites Matsumoto et Miyauchi, 1984 (p. 64), established for Idiohamites (?) oronensis Lewy, 1969 (type species), I. (?) circularis Lewy, 1969, and Hamites (?) taylorensis Adkins, 1929, is distinct in that periodic major ribs have ventrolateral tubercles where minor ribs are looped and that intervening minor ribs have no tubercles. As in the suture of Schlueterella, I is much smaller and shallower than U.

Hitherto reported species of *Lewyites* and *Parasolenoceras* are all Campanian in age, whereas *Schlueterella* and *Pseudoxybeloceras* appeared earlier and ranged up to the Campanian. The lateral tubercles do not appear in young shells of *Ps. quadrinodosum* and occur infrequently in *Ps. lineatum*. These facts suggest that *Parasolenoceras* may have derived from *Pseudoxybeloceras*. Likewise, *Lewyites* may have branched from *Schlueterella*.

The degree of differentiation into major and minor ribs varies from a species to another. Therefore, there is little reason to maintain *Christophoceras* Collignon 1969 (type species *C. ramboulai* Collignon, 1969) as a genus independent of *Pseudoxybeloceras*. Some authors (e.g. Klinger, 1976) may keep *Christophoceras* as a subgenus of *Pseudoxybeloceras*, but in the type species of *Pseudoxybeloceras*, itself some ribs are somewhat (but not much) stronger than others and can be regarded as a kind of major ribs. As suggested by Ward and Mallory (1977), Solenoceras Conrad, 1860 (type species Hamites annulifer Morton, 1842) may be related to Parasolenoceras. It is characterized by a smaller shell with greater appression of shafts. Lewy (1967) has shown a gyroconic spiral form of a young shell in a species of Solenoceras from Israel.

Oxybeloceras Hyatt, 1900 (type species Ptychoceras crassum Whitfield, 1880) was suppressed by some authors as a synonym of Solenoceras but is kept by Matsumoto and Morozumi (1980, p. 20) as a subgenus of Solenoceras for its larger size and absence of constrictions. Solenoceras is world-wide in the Campanian and Maastrichtian.

Exiteloceras Hyatt, 1894 (type species Ancyloceras jenneyi Whitfield, 1880) has also ventrolateral tubercles on every rib and seems to be loosely coiled earlier in a subelliptical form and later in a crioceratoid spiral (according to the restroration by Scott and Cobban, 1966; Gill and Cobban, 1973, p. 10, fig. 6). The suture of *E. jenneyi* (cited by Wright, 1967, fig. 251-7c from Whitfield, 1880) is similar to that of *Neocrioceras spinigerum* in being deeply and finely incised and having bifid, dove-tail major elements and pointed I as deep as U. Exiteloceras may have an affinity with Parasolenoceras, but its true phylogenetic origin is uncertain.

The very initial stage of E. jenneyi has not been known precisely, but Gill and Cobban (1973, p. 10) observed nearly straight (or broadly arcuate) limbs connected by a semicircular bend in a juvenile (but not initial) stage. This suggests an affinity with such species as Parasolenoceras tomitai Matsumoto, 1984a, which, however, is based on incomplete specimens. The two species are nearly contemporary (Upper Campanian), but known in much separate provinces, one from Wyoming and the other from Japan. E. unciforme Lewy, 1969, from the Campanian of Israel, shows a crioceratoid phragmocone and an unciforme body-chamber. E. etequence Lewy, 1969 is peculiar in showing looped ribs at the tubercles and inervening nodeless ribs as in Lewyites, to which genus it could be transferred.

Axonoceras Stephenson, 1941, established for A. compressum Stephenson, 1941 (type species) and other species from the Nevlandville Marl (possibly uppermost Campanian) of Texas, looks similar to Exiteloceras in the mode of coiling. ribbing and tuberculation, but its whorls are irregularly in contact or partly open. In both genera the initial part is hooped. The suture has not been illustrated for any species of Axonoceras. In the type species almost all the ribs have ventral tubercles on either side of the siphonal zone, but occasionally a few nodeless ribs may be intercalated. On the last part (probably adult body-chamber) of A. pingue Stephenson, 1941, the tuberculate ribs are coarsen and alternated with one or two nodeless finer ribs. This character reminds us of the ornament of Nostoceras Hyatt, 1894. The available evidence, however, is by no means sufficient to connect Axonoceras phylogenetically with Nostoceras.

Anaklinoceras Stephenson, 1941 (type species A. reflexum Stephenson, 1941, from the Nevlandville Marl of Texas) and Planostoceras Lewy, 1967 (type species P. rehavami Lewy, 1967, from the Upper Campanian of Israel) are evidently offshoots of Nostoceras, taking the posture of body-chamber in a plane, as Pravitoceras Yabe, 1902 (type species P. sigmoidale Yabe, 1902 from the Upper Campanian of Japan) is a probable offshoot of Didymoceras taking a plane shell-form in the main growthstages (see Matsumoto et al., 1980; Morozumi, 1985). Some authors affiliate Anaklinoceras and Planostoceras to Nostoceras as subgenera, but the changes in shell-form seem to have occurred abruptly in these three examples.

To sum up, the tuberculate heteromorphs whose main or adult shells posture nearly or strictly in one plane are probably polyphyletic. *Neocrioceras* and certain other possibly related genera with four rows of tubercles and their presumed descendants with two rows of tubercles could be grouped into a subfamily, for which Spath (1953) suggested the Neocrioceratinae. I would evaluate this suggestion, if the intimate relationships among these genera were made clear with sufficient evidence. With regard to many of them, however, the phylogenetic origin is uncertain in our present knowledge.

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Explanation of Plate 93

Neocrioceras spinigerum (Jimbo)

- Figs. 1, 2. Lectotype, UMUT. MM7521, from Ikandai, Urakawa. Lateral (1) and ventral (2) views, ×1.5.
- Figs. 3-5. Paralectotype, UMUT. MM7522, from Ikandai, Urakawa. Lateral (3) and ventral views of pathologic body-chamber (4) and normal phragmocone (5), ×1.6.
- Figs. 6-8. MC. Hbo-3695, from Haboro. Lateral view (6) with Sphenoceramus nagaoi (Matsumoto et Ueda) and an ammonite, ventral views of a portion of phragmocone (7) and bodychamber (8), ×1.

Photos by courtesy of Mr. H. Maeda (1-5) and Dr. M. Noda (6-8).



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Abeshinai 安平志内=アベシナイ, Haboro 羽幌, Hobetsu 穂別, Ikandai 井寒台, Ikushumbets 幾春別, Kawakami 川上, Kikume-zawa 菊面沢, Kotanbetsu [Kotambets] 古丹別, Mikasa 三笠, Naibuchi 内淵, Nakagawa 中川, Namikawa 並川, Obira 小平, Onkono-sawa オンコノ沢, Saku 佐久, Saku-gakko-no-sawa 佐久学校の沢, Sanushibe サヌシベ, Sosushi ソスシ, Teshio 天塩, Urakawa 浦河.

白亜紀異常型アンモナイトの1種 Neocrioceras spinigerum (JIMBO) について: Neocrioceras 属の模式種である N. spinigerum (JIMBO) の性状が正しく理解されていない 懸念が あったので、模式標本に加え、その後諸地域から採集された標本をも検討し、同種の特徴を明 示した。海外の専門家が属の区別に使えるとしている点(外側の肩の突起が対面か交互配列か) は、個体により、また同一個体内の生長期により変異があることを具体的に示した。また成年 期の住房も未成年期の殻と同様にクリオセラス型のすきまのある平面らせん巻きを続けている ことを明らかにした。信頼し得る産地記録に基づくと、本種は浦河統上部(おもにサント=ア ン)に産し、Sphenoceramus naumani (Yokoyama) や S. nagaoi (Matsumoto et Ueda) を伴うことが多い。従来 Neocrioceras 属に入れられていた世界各地の諸種との比較を試み、 本種とかなり異なるものは他の属に移した方がよいことを論述した。

松本達郎・村本喜久雄・高橋武美・山下 実・川下由太郎

付録 Neocrioceras 属所見:この属の特徴を記し,他属との類似点と相異点を明示し,従 来の混乱した通念を批判・修正した。ある属については相互の類縁関係の可能性を示唆した。 しかし系統的類縁を明らかにするには関連する諸種についての知見に不備があることを指摘し, 今回は総括的結論を導くのを差し控えた。 松本達郎

Explanation of Plate 94

Neocrioceras spinigerum (Jimbo)

- Figs. 1-2. TTC. 400819, from Ikandai, Urakawa. Lateral (1) and ventral (2) views of an immature shell, x1.5.
- Figs. 3-5. GK. H5205, S. Nagaoka's Coll. from South Sakhalin. Ventral (3), lateral (4) and frontal (5) views, ×1.
- Figs. 6–9. TTC. 360806, from the Kikume-zawa, Mikasa. Two lateral (6, 8) and ventral (7, 9) views, x1.2.
- Figs. 10-13. TTC. 360815, from Nio-no-sawa, Toyosato. Two lateral (10, 12) and ventral (11, 13) views, x1.
- Figs. 14-16. TTC. 370817, from the Saku-gakko-no-sawa, Saku. Lateral (14) and ventral views of phragmocone (15) and a portion of body-chamber (16).

Photos by courtesy of Dr. M. Noda.

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PROCEEDINGS OF THE PALAEONTOLOGICAL SOCIETY OF JAPAN

日本古生物学会第 135 回例会

日本古生物学会第135回例会が1986年6月14・15 日北九州市立自然史博物館分室で開催された(参加 者103名)。

個人講演

北九州芦屋層群(漸新統)の Squalodon 類につ
いて岡崎美彦
Recognition of the genus Enterodon from
Iwaki Formation of Joban Coalfield and
obliteration of "Anthracothema tsuchiyai"
(nom. nud.)Y. Tomida
松本コレクション中の "大分県玖珠郡中村" 産魚
類化石について
On the genus Palaeoloxodon from the East
China SeaH. Otsuka
有明海(島原湾)の貝形虫相岩崎泰頴
海棲介形虫の性比から何がわかるか?
阿部勝巳•神谷隆宏
アマモ場のオストラコーダ その3一個体群生態の
保存神谷隆宏
飛驒外縁帯森部のベルム紀腕足類フォーナ、とく
にその古生物地理的意義田沢純一
生痕化石に記録された底生生物の成長記録と成長
に伴う行動様式の変化小竹信宏
西南日本の Nipponitrigonia kikuchiana につい
て松田智子
御所浦層群・後期アルビアンの海生二枚貝化石
姫浦層群下部亜層群の堆積環境田代正之・
谷内康浩・岡村 真・安田尚登・前田晴良
Restudy on "Inoceramus yubarensis NAGAO
et Matsumoto" from the Upper Cretaceous
of HokkaidoM. Noda
芦屋化石動物群について首藤次男
北海道渡島半島黒松内地域の瀬棚層の貝類化石群
集(その1)鈴木明彦
グリフェア型二枚貝タカハシホタテの適応形態
速水 格
博多湾貝類遺骸集団の古生態学的資料に基づく福
岡市完新世貝類化石集団の解析下山正一
ボックスコアラーによるオオシラスナガイ
Limopsis tajimae の生態観察近藤康生

腹足類ニシキウズガイ科 (Trochidae) の原殻に
ついて大塚康雄
異常巻きアンモナイトの生息姿勢の復元. 岡本 降
A record of Menabites (Ammonoidea) from
the Cretaceous of Hokkaido
T. Matsumoto and T. Takahashi
Little known ammonite Grandidiericeras
from the Cretaceous of Hokkaido
Note on an ammonite species of <i>Pachydiscus</i>
from Awaii Island, Southwest Japan
T. Matsumoto, Y. Morozumi and T. Ozawa
ソルトレンジ (パキスタン) におけるペルム紀サ
ンゴ化石
広島県帝和石灰岩上的 Fusulinella • Fusuline
化石動物群集の発見について
古田道化・佐田公経
関東山脚北西部に分布する良ノ単層群相当層の故
前日本代 お田隆里・岩崎樹曲・猪畑な素
下部白西系チェートの放散由分费と国際対比
「前口並示」を「つび放気力量と国际内比
上部始新統へ下部山新統における渓遊桃有孔山化
石港について 西辺嗣
新子島市方海域表層推着物中の底生有引中群集(予)
客)
山口甩美弥属群產裡子植物 (3) 内藤源大姐
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シンポジウム「秋吉石灰岩層群石炭紀化石群」

世話人:柳田寿一・太田正道
有孔虫およびコノドント化石群について
松末和之•配川武彦
さんご化石群について枚山哲男・配川武彦
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下部層の堆積相について太田正道・長井孝一

New members approved by the Council Meeting held on June 13, 1986

Yen-Nien, Cheng; Satoshi, Chiba; Chikara, Hiramatsu; Toshiaki, Irizuki; Megumi, Kobayashi; Fumio, Kubota; Hiroshi, Kurita; Takashi, Murota; Jun, Nakano; Yukihiro, Numabe; Yoshitaka, Ohta; Ikuo, Sunouchi; Kiyoshi, Takatsuka; Yuichiro, Tanaka; Yasuhiro, Taniuchi; Yutaka, Toda; Akira, Tsukagoshi; Michio, Yoshida.

Members resignated

Juzo, Arai (Fellow); Yoshio, Hojo; Tadashi, Horiuchi.

Bibliography の刊行について

日本古生物学会では、1981-1985年の5年間に公表された論文の Bibliography を恒例により刊行することになりました。この Bibliography には従来通り古生物学会会員の研究論文を中心に、日本の資料をあつかった非会員の論文を含めることとします。

文献の収録は各個人の申告を基礎として行いたいと思いますので、上記5年分の論文リストを下の例に従って作成し、1986年12月31日までお送り下さい。

- WATANABE Kozo (1973) Profusulinella assemblage in the Omi Limestone, Niigata Prefecture, central Japan (Studies of Carboniferous fusulinacean of Omi, part 1). Transactions and Proceedings of the Palaeontological Society of Japan, New Series, no. 95, pp. 371-394, Plates 51-53, Figure 1, Tables 1-11. Carboniferous Fusuline [雑誌中の英文論文の例]
- BANDO Yuji and KATTO Jiro (1980) On the Upper Triassic ammonoids from the Sampozan Group at Hitsuzan, Kochi City in Shikoku. In A. Taira and M. Tashiro (eds.): Selected papers in honor of Prof. Jiro Katto. Geology and Paleontology of the Shimanto Belt. Rinyakosaikai Press, Kochi, pp. 95-100. (高知市筆山の三宝山層群より産出した三畳紀後期のアンモナイ トについて) (J.E.) Triassic Ammonoidea

[単行本中の英文要約付きの和文論文の例]

- HANZAWA Shoshiro (1961): Cretaceous and Tertiary three-layered larger Foraminifera and their allied forms: their classification and geographical and stratigraphical distributions. Fossils (Palaeontological Society of Japan), no. 2, pp. 1-24, Figures 1-29, Tables 1-2. (上部白 亜紀・第三紀層大型有孔虫及びその近似種の分類ならびに地理学的・層位学的分布) (J.) Cretaceous to Tertiary [雑誌中の英文表題付き和文論文の例]
- KOBAYASHI Iwao and KAKIZAKI Takeo (1978): [Preservation of veretebrate bones in nodules from the Tsurushi Formation] Saito Ryojiro Sensei Taishoku Kinenshi, pp. 43-49, Plates 1-2. (鶴子層産ノジュールに包埋された骨化石の保存) (J.) Miocene Mammalia [論文集中の英文表題のない和文論文の例]
- 注 1. 論文は公表の年代順にタイプして下さい。そのスタイルは従来の目録に従います。
 - 2. 雑誌名は省略しないで書いてください。
 - 3. 論文中であつかった内容の分類群・時代は Index を参照し, 必ず記入してください。
 - それぞれの専門分野で、非会員(特に外国人)の研究者による日本の資料をあつかった論文をお気づ きの場合はお知らせください。

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論文リストの送付先 〒980 仙台市青葉山 東北大学理学部地質学古生物学教室内 日本古生物学会文献目録編集委員会 石崎国際・森 啓

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行事予定

	開催地	開催日	講演申込締切日
1987年 年会·総会	静岡大学	1987年1月30日~2月1日	1986年11月15日
1987年 136回 例会	福井県立博物館	1987年6月20日~21日	1987年4月5日

講演申込先:113 東京都文京区弥生 2-4-16 日本学会事務センター 日本古生物学会 行事係

お知らせ

○1987年度年会・総会では「日本とその周辺の新三紀動植物相」世話人土 隆一ならびに「南部フォッサマ グナにおける衝突と古生物地理」世話人新妻信明でシンポジュームが計画されています。

○昭和61年9月20日現在で報告・紀事の手持ちの原稿は12編です。ただいま投稿されますと、1年以内に出版される予定ですのでふるってご投稿ください。

○136回例会でのシンポジューム申込みはお早目に行事係まで。

おことわり

○編集規定には「共著者であっても,同一著者による論文は,原則として同一号には掲載されない」とあり ます。本号の No. 816 と 820 の二論文はこれに抵触いたしますが,編集の都合上特例として掲載いたし ました(編集委員長)。

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