日本古生物学會
報告・紀事

Transactions and Proceedings

of the

Palaeontological Society of Japan

New Series   No. 119

The fossil on the cover is *Nipponitella explicata* HANZAWA, an aberrant uncoiled fusulinacean from the Lower Permian Sakamotozawa Formation, southern Kitakami, Northeast Japan.

718. EARLY JURASSIC PLANTS IN JAPAN, PART 1*

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Abstract. This is the first of serial papers on the early Jurassic (Liassic) floras of Japan. Here we review their geological background and give lists of all recorded species, together with some revisions of taxonomic names. Furthermore, we describe *Equisetites iwamuroensis* KIMURA, *E. mori-gumpeii* KIMURA & TSUJII sp. nov., *E. nipponicus* KIMURA & TSUJII sp. nov., *E.* sp. A, *E.* sp. B and *E.* sp. C.

Foreword

In Japan, Lower Jurassic (Liassic) plant-bearing strata are the Higashinagano Formation of Yamaguchi Prefecture, the Yamaoku Formation of Okayama Prefecture, the Kuruma Group extending over Toyama, Niigata and Nagano Prefectures, the Iwamuro Formation of Gumma Prefecture, and the Shizugawa Group of Miyagi Prefecture. Their localities are shown in Fig. 1.

In this paper we review the localities and horizons of Lower Jurassic plant-bearing beds in this country, giving lists of all recorded species with some nomenclatorial revisions. Furthermore, we describe specimens of *Equisetites*, most of which were collected by us from the Kuruma Group in 1976-79 and by Mr. N. SASAKI from the Iwamuro Formation in 1975-77, with the help of Mr. A. KOBAYASHI and many students of Tokyo Gakugei University.

The rich flora of the Kuruma Group includes most species which have been known from the Lower Jurassic of Japan. We intend to discuss the relation with several floras of other regions, after their

* Received Dec. 25, 1979; read Oct. 20, 1979 at Nagoya.

description is completed.

Previous works

1) Fossil plants of the Kuruma Group

On the basis of KRYSHTOFOVICH's identification, YAGI (1918) recorded the following species from Tsuchizawa (or Tunzawa), Nagano Prefecture; *Equisetites* sp., *Clathropteris* sp., *Cladophlebis denticulata* (BRONGNIART), *Ginkgo* sp., *Czekanowskia* sp., *Phoenicopsis angustifolia* HEER forma *media* KRASSER and *Podozamites lanceolatus* (LINDLEY & HUTTON). This was the first record of the fossil plants from the Kuruma Group, but no descriptions were given.

KOBAYASHI (1927) listed *Equisetites sarrani* ZEILLER, *Cladophlebis haiburnensis* (LINDLEY & HUTTON), *C. raciborskii* ZEILLER, *Ptilophyllum* sp., *Taeniopteris* cfr. *virgulata* ZEILLER and *T.* sp. from Tsuchizawa, and *Dictyophyllum* sp. and *Pagiophyllum* sp. from the Dairagawa area.

OISHI (1931) revised YAGI's *Cladophlebis denticulata*, *Ginkgo* sp., *Czekanowskia* sp. and *Phoenicopsis angustifolia* forma *media* as *Cladophlebis raciborskii*, *Ginkgoites sibirica* (HEER), *Czekanowskia rigida* HEER and *Phoenicopsis* sp., and KOBAYASHI's *Cladophlebis haiburnensis*, *Ptilo-*
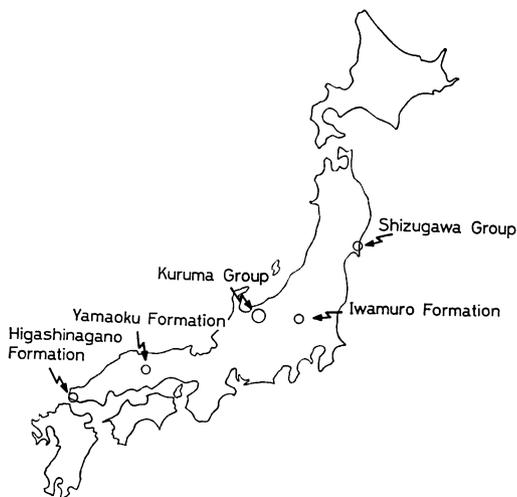
Fig. 1. Distribution of the early Jurassic plant-bearing formations in Japan.

phyllum sp., *Taeniopteris* cfr. *virgulata* and *Pagiophyllum* sp., as *Cladophlebis raciborskii* ZEILLER, *Pterophyllum propinquum* GOEPPERT, *Marattiopsis muensteri* (GOEPPERT) and *Elatocladus* sp., respectively. He listed the following species:
Tsuchizawa locality; *Equisetites* sp., *Neocalamites hoerensis* (SCHIMPER), *Clathropteris* sp., *Marattiopsis muensteri* (GOEPPERT), *Cladophlebis argutula* (HEER), *C. denticulata* (BRONGNIART), *C. haiburnensis* (LINDLEY & HUTTON), *C. raciborskii* ZEILLER, *Pterophyllum jaegeri* BRONGNIART, *P. propinquum* GOEPPERT, *Ginkgoites sibirica* (HEER), *Czekanowskia rigida* HEER, *Phoenicopsis?* sp., *Pityophyllum longifolium* (NATHORST), *Podozamites lanceolatus* (LINDLEY & HUTTON) and *Carpolithes* sp.
Shimodera locality; *Equisetites* sp., *Czekanowskia rigida* HEER and *Podozamites lanceolatus* (LINDLEY & HUTTON).
Kuruma locality; *Equisetites* sp., *Woodwardites microlobus* SCHENK, *Cladophlebis denticulata* (BRONGNIART), *Czekanowskia rigida* HEER and *Pityophyllum longifolium*

(NATHORST).
Dairagawa locality; *Dictyophyllum* sp. and *Elatocladus* sp.
OISHI (1931b) revised his *Woodwardites microlobus, Cladophlebis argutula, C. raciborskii* and *Ginkgoites sibirica* as *Thaumatopteris schenki* NATHORST, *Cladophlebis* sp. B, *C.* cfr. *raciborskii* ZEILLER and *Ginkgoites digitata* (BRONGNIART) var. *huttoni* SEWARD, respectively. He described all of these species. This is the first description of the fossil plants from the Kuruma Group.
Moreover, OISHI (1932) revised his *Cladophlebis* sp. B as *C. pseudodelicatula* OISHI, and OISHI & TAKAHASHI (1936) revised OISHI's *Cladophlebis* cfr. *raciborskii* as *C. raciborskii* forma *integra* OISHI & TAKAHASHI.
In addition, OISHI (1940) revised his *Thaumatopteris schenki* as ? *T. elongata* OISHI, and described the following species:
Neiridani locality in the Dairagawa area; *Todites goeppertianus* (MUENSTER) KRASSER, *Clathropteris meniscoides* BRONGNIART, *Sagenopteris nilssoniana* (BRONGNIART) WARD and *Nilssonia orientalis* HEER.
Kuruma locality; *Sagenopteris nilssoniana* (BRONGNIART) WARD and Cfr. *Nilssonia tenuicaulis* (PHILLIPS) FOX-STRANGWAYS.
K. KOBAYASHI (1948) listed the following species from Tsuchizawa, Kuruma and Komyoshita localities: *Equisetites* sp., *Neocalamites hoerensis* (SCHIMPER), *Annulariopsis inopinata* ZEILLER, *Todites roesserti* (PRESL), *Marattiopsis muensteri* (GOEPPERT), *Clathropteris meniscoides* BRONGNIART, *Thaumatopteris schenki* NATHORST, *Hausmannia nariwaensis* OISHI, *Cladophlebis denticulata* (BRONGNIART), *C. haiburnensis* (LINDLEY & HUTTON), *C. nebbensis* (BRONGNIART), *C. raciborskii* ZEILLER, *Nilssonia* sp., *Taeniopteris* sp., *Ginkgoites digitata* (BRONGNIART) var. *huttoni* SEWARD, *Baiera* cfr. *muensteriana*

(PRESL), *Czekanowskia rigida* HEER, *Phoenicopsis* sp., *Pityophyllum longifolium* (NATHORST), *Podozamites lanceolatus* (LINDLEY & HUTTON), *Carpolithes* sp.

Based on SASAI's collection from the Kotaki Coal-Field, Niigata Prefecture, KIMURA (1959b) described the following species: *Equisetites* sp., *Neocalamites carrerei* (ZEILLER) HALLE, *N. hoerensis* (SCHIMPER) HALLE, *N.* sp., *Dictyophyllum?* sp., *Cladophlebis denticulata*(BRONGNIART), *C. haiburnensis* (LINDLEY & HUTTON), *C. raciborskii* ZEILLER, *Pterophyllum propinquum* GOEPPERT, *Ginkgoites digitata* (BRONGNIART) var. *huttoni* SEWARD, *G.* sp., *Czekanowskia* sp., *Phoenicopsis* sp., *Pityophyllum longifolium* (NATHORST), *Podozamites lanceolatus* (LINDLEY & HUTTON), *P.* sp. cfr. *griesbachi* SEWARD, *Taeniopteris* sp.

2) Fossil plants of the Iwamuro Formation

KIMURA (1952) found many fossil plants at Iwamuro of Gumma Prefecture and named the plant-bearing strata the Iwamuro Formation. Subsequently the following species were described by KIMURA (1959a): *Equisetites iwamuroensis* KIMURA, *Neocalamites hoerensis* (SCHIMPER), *Coniopteris* sp., *Clathropteris?* sp., *Thaumatopteris elongata* OISHI, *T. nipponica* OISHI, *Hausmannia* (*Protorhipis*) sp., *Cladophlebis clavata* KIMURA, *C. denticulata* (BRONGNIART), *C. fastuosa* KIMURA, *C. haiburnensis* (LINDLEY & HUTTON), *C. raciborskii* ZEILLER, *C. raciborskii* ZEILLER forma *integra* OISHI & TAKAHASHI, *C.* spp. (A, B), *Nilssonia orientalis* HEER, *N.* sp., *Ctenis?* sp., *Anomozamites* sp., *Otozamites fujimotoi* KIMURA, *Pterophyllum* spp. (A, B), *Baiera?* sp., *Ginkgoites?* sp., *Czekanowskia rigida* HEER, *Pityophyllum* (*Pityocladus*) sp., *Podozamites lanceolatus* (LINDLEY & HUTTON), *P.* sp., *Swedenborgia cryptomerioides* NATHORST, *Taeniopteris gracilis* KIMURA, *T.* sp. cfr. *nabaensis*

OISHI, *T.* spp. (B, C).

3) Fossil plants of the Yamaoku Formation

KONISHI (1954) listed the following species: *Equisetites yamadai* KONISHI (MS), *Neocalamites?* sp., *Marattiopsis* sp., *Todites williamsoni*(BRONGNIART)SEWARD, *Clathropteris meniscoides* BRONGNIART, *Cladophlebis denticulata* (BRONGNIART), *C. haiburnensis* (LINDLEY & HUTTON), *C. gigantea* OISHI, *C. raciborskii* ZEILLER, *Ctenis* sp., *Taeniopteris* sp., *Pityophyllum* n. sp. KONISHI (MS), *P.* sp., *Podozamites lanceolatus* (LINDLEY & HUTTON).

4) Fossil plants of the Higashinagano Formation and the Shizugawa Group

Only two species, *Nilssonia brevis* BRONGNIART (OISHI, 1940) and doubtful *Brachyphyllum expansum* (STERNBERG) (TAKAHASHI, 1957, '59) have been known from the Higashinagano Formation, and *Baiera?* sp. (YOKOYAMA, 1904) and a wood species, *Dadoxylon* (*Araucarioxylon*) *sidugawaense* SHIMAKURA (SHIMAKURA, 1937) have been known from the Shizugawa Group together with some indeterminable leaf-fragments.

Geology

1) Kuruma Group

This Group is distributed in the steep mountainous area extending over Toyama, Niigata and Nagano Prefectures in the Inner Zone of Central Japan. The western main distribution along the Dairagawa and its tributaries was stratigraphically studied by KOBAYASHI et al. (1957). According to them, the group is divided into the following formations in downward sequence.

Kurobishiyama Formation; conglomerate bearing *Podozamites?* sp. and small bivalves.
——unconformity——
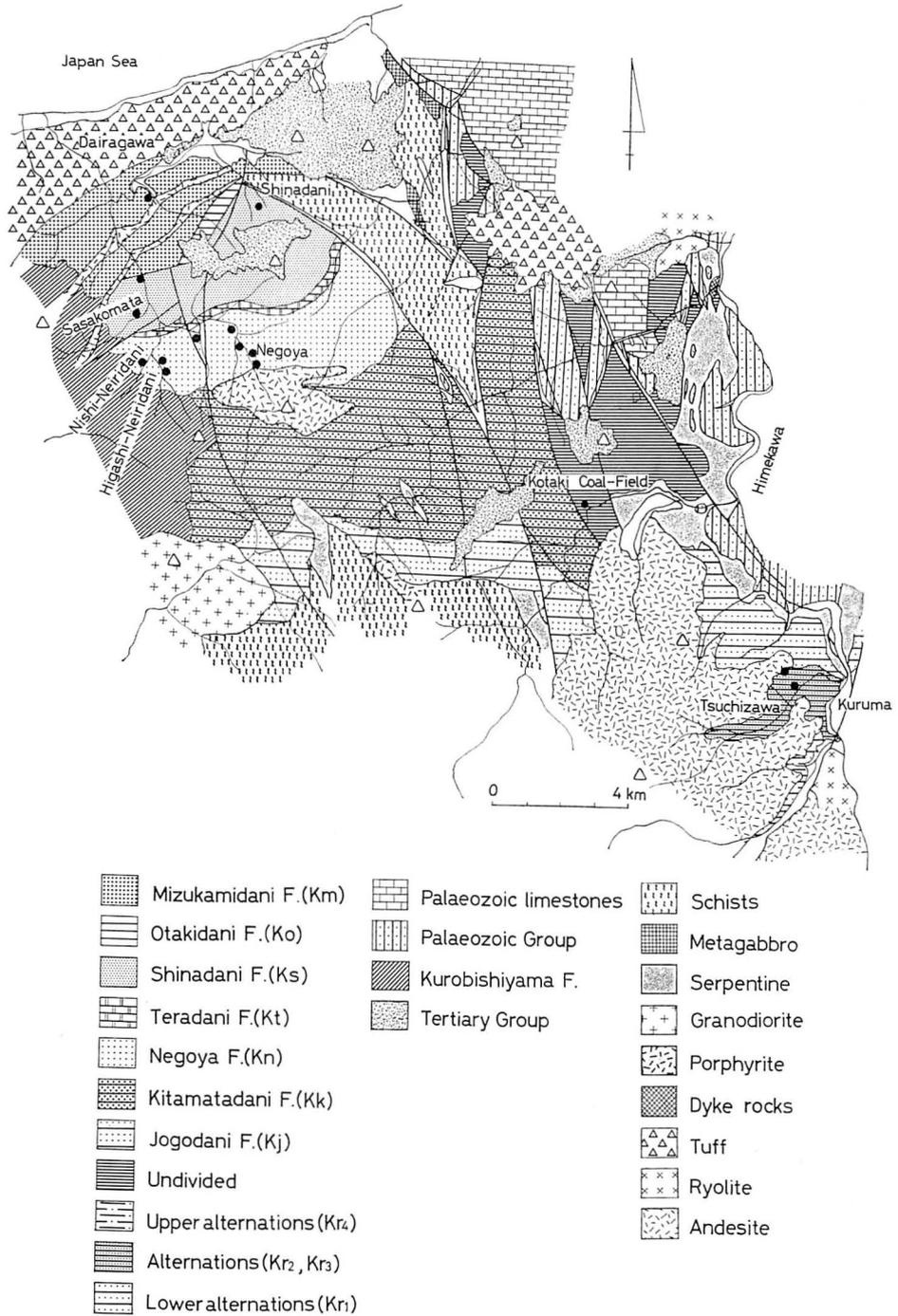
Fig. 2. Geological map of the Kuruma Group (redrawn from KOBAYASHI et al., 1957;
● =localities of fossil plants).

Legend:

Mizukamidani F.(Km)
Otakidani F.(Ko)
Shinadani F.(Ks)
Teradani F.(Kt)
Negoya F.(Kn)
Kitamatadani F.(Kk)
Jogodani F.(Kj)
Undivided
Upper alternations (Kr₄)
Alternations (Kr₂, Kr₃)
Lower alternations (Kr₁)

Palaeozoic limestones
Palaeozoic Group
Kurobishiyama F.
Tertiary Group

Schists
Metagabbro
Serpentine
Granodiorite
Porphyrite
Dyke rocks
Tuff
Ryolite
Andesite

Mizukamidani Formation (Km); conglomerates and sandstones with subordinate shales (+2000 m thick); barren of fossils.

Otakidani Formation (Ko); sandy shale, with subordinate thin sandstones-conglomerates of marine origin (850 m thick); ammonites indicating Upper Toarcian.

Shinadani Formation (Ks); sandstones and shales (+700 m thick), bearing littoral shells and plants above, and marine shells below.

Teradani Formation (Kt); sandy shale (600 m thick); ammonites indicating Upper Pliensbachian.

Negoya Formation (Kn); alternation of sandstone and shale, bearing littoral shells and plants above, and sandstone bearing littoral shells below (total 1600 m thick).

Kitamatadani Formation (Kk); alternation of sandstone and shale above, shale middle, and sandstone below (total 2000 m thick), all bearing littoral shells.

Jogodani Formation (Kj); conglomerates and sandstones with thin shales above and basal conglomerate (+700 m thick); barren of fossils.

——unconformity——

Sangun-type schists

The southeastern subordinate distribution including several classical localities of fossil plants, was also studied by KOBA-YASHI et al. (1957). According to them, the group was divided into the following members in downward sequence.

Upper alternations of sandstone and conglomerate (Kr_4); barren of fossils.

Alternations of sandstone and shale (Kr_3); (+400 m thick); bearing littoral shells and plants.

Alternations of sandstone and shale (Kr_2); bearing plants (including Tsuchizawa, Shimodera and Kuruma localities).

Lower alternations of sandstone and conglomerate (Kr_1); (500 m thick).

——supposed unconformity——

Palaeozoic formations

Unfortunately, the stratigraphical relation between this southeastern section and the section in the main area is unknown.

The northeastern subordinate distribution including the Kotaki Coal-Field was studied by SASAI. The detailed stratigraphy and the occurrence of plants were shown by KIMURA (1959b). The stratigraphical relation between this area and the main area is uncertain. Fig. 2 shows the localities of fossil plants on the geological map redrawn from KOBA-YASHI et al. (1957).

2) Iwamuro Formation

This formation is exposed at the small area along the middle course of Kata-shinagawa, in the Inner Zone of Northeast Japan. Its detailed stratigraphy and the occurrence of fossil plants were already shown by KIMURA (1952).

Acknowledgements

Systematic description

Pteridophyta

Equisetales

In our collection, two genera, *Equisetites* and *Neocalamites* were recognized in this order. *Neocalamites* species will be described later.

Genus *Equisetites* STERNBERG, 1833: 43

Key to the early Jurassic *Equisetites* species in Japan

They are conveniently distinguished by the size of erect vegetative stems and the number of leaf-segments.

1 . Erect vegetative stem large in size, more than 7 cm in diameter....*E. mori-gumpeii*
1'. Erect vegetative stem medium in size, less than 5 cm wide (3.2 cm in diameter) 2
2 . The number of leaf-segments, less than 28 .... *E. iwamuroensis*
2'. The number of leaf-segments, more than 40 3
3 . The number of leaf-segments, less than 48 .... *E. nipponicus*
3'. The number of leaf-segments, 52-74.....
.... *E.* sp. A

Besides the above, there are two little known species: *E.* sp. B is based only a rhizome and *E.* sp. C is based on a large nodal diaphragm.

Equisetites iwamuroensis KIMURA

Pl. 38, Figs. 1-9; Pl. 39, Figs. 1-6;
Pl. 40, Figs. 1-2; Text-figs. 1a-k

Equisetites sp.: OISHI, 1931b, p. 228, pl. 16, fig. 1 (Tsuchizawa and Shimodera)
Equisetites iwamuroensis KIMURA: KIMURA, 1959a, p. 6, pl. 1, figs. 1-6; pl. 12, figs. 1, 10; text-figs. 1-2 (Iwamuro).

Material: Lectotype; A-3051. Paralectotypes; A-1036, 2058, 2070, 3056, 3072, 3075, 3076, 3081, 3088, 3088C, 3093, 4071, 7577, 7582, 7584, 75183, 7901A, 7901B, 7902, Kr-006,

009, 011, 013, 020, 021, 025, 027, 028 and 23 additional specimens (A; from the Iwamuro Formation, Kr-; from the southeastern subordinate distribution of Kuruma Group). *Stratum typicum:* Middle member of the Iwamuro Formation. *Locus typicus:* Iwamuro, Shirasawa-mura, Toné-gun, Gumma Prefecture. *Derivatio nominis:* After the locality, Iwamuro where the original specimens were collected.

Emended diagnosis: Erect vegetative stem simple, unbranched, 35 mm wide below, but suddenly contracted at base, narrowing gradually upwards, about 10 mm wide at an apical part. Lower nodes crowded and upper ones at intervals of 36~78 mm, both without bulges. Internode typically 78 mm long and 20 mm wide, with smooth surface, but marked with numerous pits, 125 μm$\times$75 μm, 125 μm$\times$100 μm in size. When partly or fully decorticated surface showing longitudinal ridges as numerous as leaf-segments. Leaf-sheath 12~25 mm long, composed of 24~28 raised leaf-segments (typically 24), number reduced to 22 on the upper nodes, slightly swollen into cup-like form; lower 80% of leaves united by flanges to form a sheath, upper 20% forming free teeth. Commissural flanges nearly truncate above, narrowing downwards, forming commissural furrows continued for about 0.5~1 cm below the node. Leaf-segments 1~2 mm wide below, abruptly thickened in texture at the top of coherent sheath. Coherent leaf-segments covered with crowded fine pits similar in size to those on the internodes. Free teeth 2.5~4 mm long, elongate-triangular in form, rigid and thickened in texture, often with reflexed margins; those on the lower nodes tapering to acuminate apex and those on the upper nodes gradually tapering to acicular apex; mostly broken off leaving its thickened and trapezoid base at upper end of

coherent sheath; midrib not visible. Leaf-sheath on upper nodes similar in form to lower ones but smaller in all their parts. Nodal diaphragm often rotated by compression but mostly not displaced up or down, sometimes isolated; circular in front view, 3~27 mm in diameter, surface finely granular, with a single outer ring of tubercles about 2 mm from the edge; tubercles dome-shaped, twice as numerous as leaf-segments. Cone terminal on a slender shoot, 2.7 mm wide. Uppermost leaf-sheath composed of about 10 segments, 1~10 mm connected above by flanges, free teeth missing. Nodal diaphragm normal, rotated but very small, just over 1 mm wide. Next leaf-sheath below composed of more numerous but much narrower leaf-segments about 0.25 mm wide. Cone (unexpanded) about 6 mm wide, barely 4 mm long, showing 3 whorls of sporangiophore heads, heads hexagonal and in contact. In surface view heads (in disintegrated cone) up to 2 mm wide, marginal regions raised, central part sunken with 6~7 circular marks (sporangia), inner surface showing end of a central stalk. Rhizome sparsely branched, 4~14 mm wide with comparatively long internode; internodes smooth but often showing broad and irregular ridges (thought to have been produced by compression); leaf-sheath similar in form to that of erect vegetative stem, with 24 closely appressed leaf-segments, without pits both on internodes and leaf-sheath. (Root unknown.)

Distribution and occurrence: Equisetites iwamuroensis is abundant in the middle member of the Iwamuro Formation and the Alternation of sandstone and shale (Kr₂) in the southeastern subordinate distribution of Kuruma Group at Tsuchizawa and Shimodera localities, where it is the commonest fossil and no other *Equisetites* species has been found.

Most specimens are broken and flattened stems and rhizomes. Accordingly it is considered that they are not in the site of growth.

Observations: Pl. 38, Fig. 1 shows the base of an erect vegetative stem which is from 3.4 cm wide (2.2 cm in diameter) above to 1.8 cm wide (1.2 cm in diameter) below for the length of 4.8 cm; its nodes are crowded at intervals of 1.0~1.8 cm. It may represent the basal part of an erect stem below water surface. This would explain the absense of pits (stomata). No bulges were found at the nodal region. The stem often shows a distinct swelling at the node. This may be due at least in part to the existence of transverse nodal diaphragms which resisted compression. Lower halves of leaf-sheaths and commissural furrows are well preserved but upper halves of leaf-sheaths are all lost together with their free-teeth.

Three internodes of typical width are represented by the specimen shown in Pl. 38, Fig. 2 (Text-fig. 1a; lectotype), which is strongly compressed. Similar specimens are shown in Pl. 39, Fig. 1 (Text-fig. 1b) and Text-fig. 1c. Two nodal diaphragms are marked with arrows in Text-fig. 1a. They have rotated but are at their original levels. The upper is 0.9 cm in diameter, the lower 1.05 cm, both occupy about 70% of both nodal diameters. A similar specimen is shown in Pl. 40, Fig. 1 (Text-fig. 1e). In this specimen the free-teeth are missing, but the sheath 2 cm long is composed of about 22~28 segments. Leaf-segments in a leaf-sheath alternate with those of the nodes immediately above and below. Commissural flanges connecting the adjacent leaf-segments are nearly truncate above, and the two flanges together are narrower than the leaf-segments at the top of leaf-sheath and taper to a point downwards. Below the node they are continued as

commissural furrows for about 1 cm (Pl. 38, Fig. 5 and Text-fig. 1d, Pl. 39, Fig. 2).

Free-teeth are acuminate (Text-figs. 1c, 1d and 1e) or acicular (Pl. 38, Fig. 4 and Text-fig. 1f) in form, 0.6 cm long (Text-fig. 1c), 0.45 cm (Text-fig. 1f) and 0.25 cm (Pl. 38, Fig. 5 and Text-fig. 1d), often missing leaving their trapezoid bases thickened especially at the upper edges as typically shown in Text-figs. 1a-c.

Pl. 38, Fig. 3 shows a slender erect vegetative stem compressed obliquely to the bedding plane. Pl. 38, Figs. 6 and 7 show leaf-sheaths compressed obliquely.

The surface of internodes is smooth apart from the fine pits, but on their decorticated surface there are weak longitudinal ridges which are twice as numerous as leaf-segments as partly shown in Text-fig. 1b. These ridges are not thick strand as in a calamite pith cast, but mere corrugations in an evenly thin film of coaly material. This is an evidence that they had very little woody tissue, probably metaxylem strands.

There are small pits on the surface of internodes and the abaxial surface of leaf-sheaths in aerial vegetative stem. These pits are longitudinally oriented, 64 per mm^2 on leaf-sheath and 19 per mm^2 on internode in density, as shown in Text-fig. 1g. These pits are not recognized on
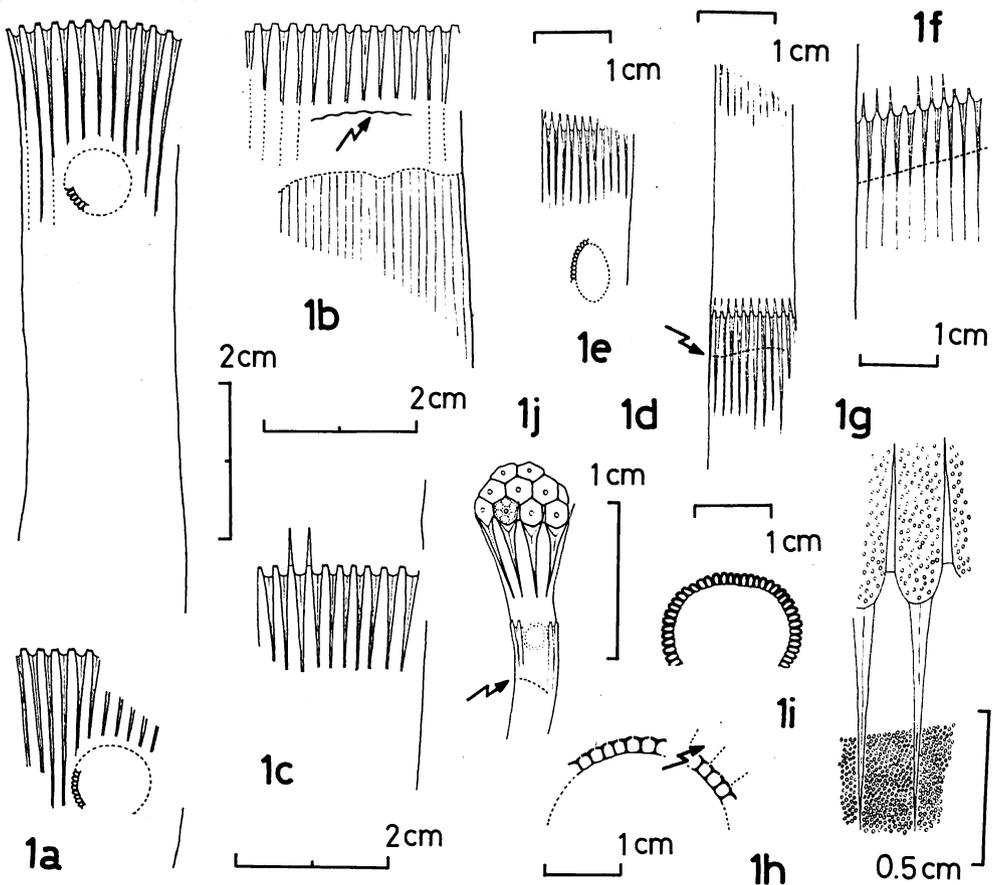
the internodes and the leaf-sheaths of rhizomes and lower parts of stems thought to have been below water surface. Pits are also invisible on the free-teeth.

Besides rotated nodal diaphragm in stem, there are several isolated nodal diaphragms of various size as shown in Pl. 38, Figs. 8 and 9 (Text-fig. 2i), and Pl. 39, Fig. 3 (Text-fig. 1h). Pl. 39, Fig. 4 shows the underside of a nodal region.

Pl. 40, Fig. 2 shows a detached cone, the detail of which is shown in Text-fig. 1j. Pl. 39, Fig. 6 shows crushed cones, in which sporangiophores are scattered. Rhizomes as shown in Pl. 39, Fig. 5 (Text-fig. 1k) are frequent.

Comparison: In his monographical study dealing with Equisetacean plants in Japan and adjacent areas, the late Professor KON'NO (1962) described several new *Equisetites* species; *Equisetites asaensis, E. (Equisetostachys) bracteosus,*

E. minensis, E. nagatensis, E. naitoi, E. naitoi subsp. *minor, E. takahashii* and *E. takaianus* from the Carnic formations in Yamaguchi Prefecture, *E. nariwaensis* from the Noric Nariwa Group in Okayama Prefecture, *E. koreanicus* from the Lower Daedong Group (Upper Triassic in KIMURA's opinion), North Korea and *E. paotensis* from the Lower Jurassic of Neimung, North China.

Among these, *Equisetites naitoi, E. naitoi* subsp. *minor, E. nariwaensis, E. koreanicus* and *E. paotensis* differ from *E. iwamuroensis* in having branched aerial stems.

It seems to be true in the modern species of *Equisetum* and in the better known fossil species of *Equisetites* (or *Equisetum*) that most stems have a fairly constant number of leaf-segments in their leaf-sheath. So if we have enough specimens to show what is normal, the number

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Text-figs. 1a–j. *Equisetites iwamuroensis* KIMURA.

1a. Compressed stem showing two leaf-sheaths with broken leaf-segments and two rotated nodal diaphragms. Redrawn more in detail from the lectotype (A-3051) formerly illustrated by KIMURA (1959a, pl. 1, fig. 1 and text-fig. 1; both were upside down), shown also in Pl. 38, Fig. 2.

1b. A part of erect stem showing longitudinal striations on the decorticated surface of an internode. An arrow indicates the position of nodal diaphragm represented by a prominent ridge. Redrawn more in detail from A-2058 formerly illustrated by KIMURA (1959a, pl. 1, fig. 2 which was upside down), shown also in Pl. 39, Fig. 1.

1c. A broken leaf-sheath on which two free-teeth are still retained. Drawn partly from A-7584.

1d. A part of small-sized erect stem with two internodes. Free-teeth are all preserved. An arrow indicates the position of nodal diaphragm. Drawn from Kr-021, shown also in Pl. 38, Fig. 5.

1e. A leaf-sheath of similar size to 1d, with a rotated and contorted nodal diaphragm which appears to be displaced downwards. The bordered line between free-tooth and its base is indistinct. Drawn from Kr-013, shown also in Pl. 40, Fig. 1.

1f. Showing a leaf-sheath. The dotted line indicates the position of nodal diaphragm. Drawn from Kr-027, shown also in Pl. 38, Fig. 4.

1g. Details of leaf-segments, commissural flanges and the distributional patterns of pits both on leaf-sheath and internode. Drawn partly from 1f.

1h. The largest isolated nodal diaphragm. An arrow shows a vertically compressed leaf-sheath. Drawn from A-1036.

1i. Medium-sized isolated nodal diaphragm. Drawn from A-3093, shown also in Pl. 38, Fig. 9.

1j. A small-sized cone supported by an erect stem. An arrow indicates the position of a nodal diaphragm. Drawn from A-7901B, shown also in Pl. 40, Fig. 2.

seems to constitute a specific character.

Thus *Equisetites iwamuroensis* with 24~28 leaf-segments differs from KON'NO's species, *E. asaensis* (with 12~14), *E. minensis* (with 12~14), *E. nagatensis* (with 16~20) and *E. takahashii* (with 14~16). *Equisetites iwamuroensis* also differs from *E. takaianus* with sparsely branched or unbranched erect vegetative stems, because, according to KON'NO, the number of leaf-segments of *E. takaianus* is said to be less than 16.

In addition, we have *Equisetites multidentatus* originally described by OISHI (1932) from the Nariwa Group. *Equisetites iwamuroensis* is safely distinguishable from OISHI's species, because in OISHI's species the number of leaf-segments, as its specific name indicates, is over 80. *Equisetites (Equisetostachys) bracteosus* KON'NO is quite different from the present species. It is a large cone with alternating whorls of sporangiophores and bracts, in this respect differing generically from *Equisetum*. But below the cone the stem has leaf-sheaths of the *Equisetum*-type. Thus no similar species with *Equisetites iwamuroensis* has so far been known in Japan.

In dimensions, erect vegetative stems of *Equisetites iwamuroensis* resemble those recorded under the name of *E. ferganensis* SEWARD (SEWARD, 1907, p. 17, pl. 2, figs. 25-29; 1911, p. 35, pl. 1, figs. 5-8; 1912, p. 4, pl. 1, figs. 2-14, 19; KAWASAKI, 1939, p. 9, pl. 1, figs. 4, 5; pl. 2, figs. 6-8; text-fig. 1), of *E.* cfr. *lateralis* (PHILLIPS) MORRIS (SZE, 1931, '33) and of *E.* sp. (YABE & OISHI, 1933) from the older Mesozoic of Asia, but these are different from *E. iwamuroensis* first in their wheel-like nodal diaphragms.

Equisetites iwamurensis has erect stems of similar width to *E. sarrani* ZEILLER (ZEILLER, 1903, p. 144, pl. 39, figs. 1-3) from the Upper Triassic of Hongay Coal-Field, North Viet-Nam, but *E. sarrani* has not more than 20 leaf-segments. KOBAYASHI's *Equisetites sarrani* (1927) from Tsuchizawa, may belong to *E. iwamuroensis*.

In the number of leaf-segments and the structure of nodal diaphragms, *Equisetites iwamuroensis* is similar to the European species, *E. scanicus* (STERNBERG) HALLE (HALLE, 1908, p. 22, pl. 6; pl. 7; pl. 8, figs. 1-5; pl. 9, figs. 16-17) and the Indian species, *E. rajmahalensis* (OLDHAM & MORRIS) FEISTMANTEL (OLDHAM & MORRIS, 1863; FEISTMANTEL, 1877; SAHNI & RAO, 1933; SURANGE, 1966; BOSE & SAH, 1968). However, *Equisetites scanicus* is much larger in size than *E. iwamuroensis*, and *E. rajmahalensis* appears to be distinct in having longer and keeled free-teeth and longer and wheel-like tubercles on the nodal diaphragm.

A very large number of *Equisetites* (or *Equisetum*) species have been described from various regions of the world. Of these we consider only a few species are similar to *E. iwamuroensis* in the following respects: Aerial stems unbranched, commonly about 2~3 cm wide. Leaf-sheath composed of about 24 segments, segments often about 2 cm long and terminating in narrow teeth about 3 cm long. Commissural franges truncate above, narrowing and vanishing below the node. Nodal diaphragm robust, often rotating, surface granular, with a marginal ring of slightly elongated tubercles. The following are somewhat similar: *Equisetites asiaticus* PRYNADA (in TESLENKO, 1970) and *E. laevis* HALLE (HALLE, 1908; LUNDBLAD, 1950; HARRIS, 1926, '31). But *Equisetites iwamuroensis* is distinguished from *E. asiaticus* by having shorter tubercles on the nodal diaphragm, and from *E. laevis* by its rather narrower aerial stems and shorter free-teeth.

Equisetites mori-gumpeii KIMURA and

TSUJII sp. nov.

Text-figs. 2a–c

Material: Holotype; KS–001 (KS–; from the Shinadani Formation). *Stratum typicum:* Lower member of the Shinadani Formation, Kuruma Group. *Locus typicus:* At the upper course of Shinadani, Omi-machi, Nishi-Kubiki-gun, Niigata Prefecture. *Derivatio nominis:* The specific name is dedicated to Mr. Gumpei MORI who vigorously cooperated with us in collecting fossil plants from the Kuruma Group.

Diagnosis: Stems preserved erect in position of growth, diameter up to 81 mm below but tapered upwards, length exceeding 1 m; unbranched; nodes closely placed below. Surface of internodes mainly smooth but with striations corresponding to leaf-teeth just above node. Total number of leaf-segments in sheath typically 114; leaf-sheath 0.5 cm long, appressed; commissural flanges narrower rapidly below and not extended by grooves onto internode; free-teeth unknown (broken off at top of leaf-sheath). Nodal diaphragm not known in surface view but nodal part of stem robust enough to form a well marked ridge.

Distribution and occurrence: This species occurs as a crowded fossil forest in the sandstone bed of the Lower member of Shinadani Formation at the northeastern corner of its distribution. Unfortunately we have not succeeded to restore this *Equisetites* forest, because of the limited exposures. The occurrence of this species seems to be restricted to the above mentioned locality where no other *Equisetites* species have been found.

Observations: *Equisetites mori-gumpeii* is locally abundant, but no specimen is perfect. So it is impossible to show the specimens clear by photographic illustration.

Text-fig. 2a shows a part of erect vegetative stem in lateral view on which the above diagnosis is mainly based. The arrows indicate the position of robust nodal diaphragms. Apart from the fallen free-teeth, the leaf-sheath is low in height, 0.5 cm high and appressed to the stem.

Leaf-segments are about 114 in number, 3.5∼4 mm wide at the base and 3 mm wide at the tip of appressed part, and coherent by sunken wedge-shaped commissural flanges, 1.5 mm wide at the tip. The commissural flange does not pass into a commissural furrow (Text-fig. 2b) which is commonly represented in other *Equisetites* species in Japan.

The fallen free-teeth left the thickened and semi-circular bases at the tip of appressed leaf-segment just below the nodal diaphragm as shown in Text-fig. 2b, so there are double angular brims around a nodal region; one above is due to a nodal diaphragm itself and another below due to a row caused by the thickened free-tooth bases as shown in Text-fig. 2c in side view. The longitudinal striation on the decorticated surface extends down to the nodal diaphragm brim to hide behind the appressed part of leaf-segment and its number corresponds to that of leaf-segment as shown in Text-fig. 2b. It is uncertain whether the leaf-segments of one internode do alternate with those of the internode immediately above and below or not.

Comparison: *Equisetites mori-gumpeii* is characterized by its large-sized erect vegetative stem, low leaf-sheath consisting of about 114 leaf-segments, and by the junction between free-teeth and appressed leaf segments which lies just below the angular brim caused by the nodal diaphragms. Then it is safely distinguished from the known *Equisetites* species in Japan including *Equisetites* species described here.

Equisetites beani (BUNBURY) SEWARD,

an imperfectly known species from the Bajocian of England has a more strongly striated interior, the ridge being closer than in *E. mori-gumpeii*. Its leaf-sheath is unknown but there are sometimes commissural furrows passing down from the node (see HARRIS, 1961). Its size is similar.

Equisetites arenaceus BRONGNIART, an Upper Triassic species has much larger stems (80~160 mm wide). *Equisetum columnare* BRONGNIART of similar size has a longer leaf-sheath.

Thus *Equisetites mori-gumpeii*, although it is not fully known, is distinct and

would be regarded as new to science.

Equisetites nipponicus KIMURA and TSUJII sp. nov.

Pl. 38, Fig. 10; Pl. 39, Figs. 7-9; Pl. 40, Figs. 3-6; Text-figs. 3a-g

Equisetites sp.: KIMURA, 1959b, p. 66 (Kotaki Coal-Field).

Material: Holotype; NNW-800. Paratypes; NNW-224, 322, 456, 466, 792, 793, 796, 798, 811, NEE-128, 340 (aerial and submerged stems), NNW-814 (nodal diaphragm), NNW-808, NEE-284 (rhizomes) and many other leaf-

sheath fragments (NNW-; from the Nishi-Neiridani, and NEE-; Higashi-Neiridani). *Stratum typicum:* Negoya Formation, Kuruma Group. *Locus typicus:* At the middle course of the Neiridani Valley, Asahi-machi, Toyama Prefecture. *Derivatio nominis:* The specific name is derived from 'Nippon' meaning Japan in Japanese.
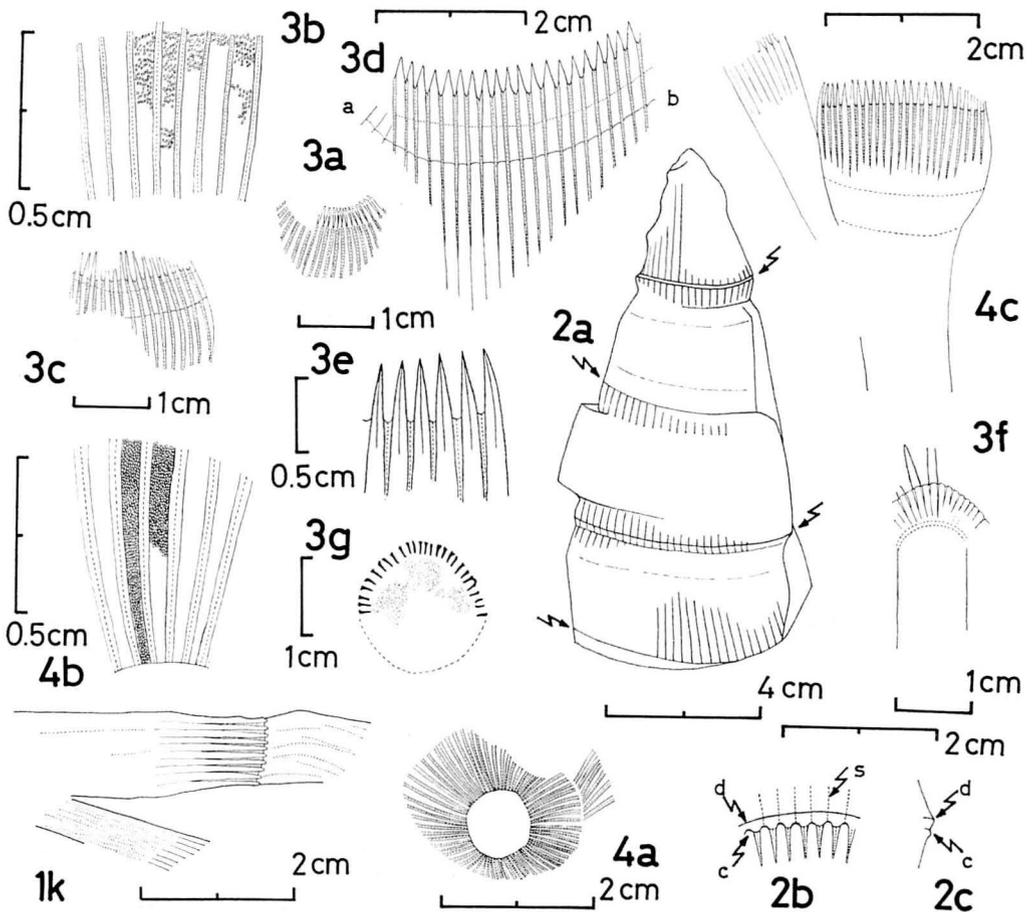
Diagnosis: Erect vegetative stem un-branched, basal part thicker, 3.6 cm wide but suddenly contracted at base, and gradually narrowing upwards, 9 mm wide at the apical part. Lower nodes crowded, upper ones typically at 7 cm, both without bulges. Nodes usually slightly swollen. Internodes smooth, 12 mm × 24 mm, 30 mm × 29 mm, 76 mm × 36 mm to 70 mm × 9 mm, without internal or external ribs or angles. Lower sheath appressed to stem, with 40~48 (typically 48) segments in the

Text-fig. 1k. *Equisetites iwamuroensis* KIMURA. Showing a part of rhizome. Internodes are generally longitudinally wrinkled as indicated by the dotted lines. Drawn from Kr-006, shown also in Pl. 39, Fig. 5.

Text-figs. 2a-c. *Equisetites mori-gumpeii* KIMURA and TSUJII sp. nov.

2a. A part of thick erect stem, standing in the site of growth. The arrows indicate the position of nodal diaphragms. Drawn from KS-001 (holotype).

2b. Front view of a leaf-sheath. Note that commissural furrows are absent on the internode surface. c; semi-circular free-tooth-base of which margin is thickened. d; indicating the position of a nodal diaphragm. s; fine striation on the decorticated surface of internode. Drawn from 2a.

2c. Lateral view of the nodal diaphragm (d). c; a tubercle caused by the thickened free-tooth-base. Drawn from 2a.

Text-figs. 3a-g. *Equisetites nipponicus* KIMURA and TSUJII sp. nov.

3a. A detached and broken leaf-sheath with free-teeth. Drawn from NNW-456, shown also in Pl. 39, Fig. 8.

3b. Showing crowded fine pits distributing on the whole surface of appressed part of leaf-segments. Drawn from 3a.

3c. Showing a broken leaf-sheath on which free-teeth are still retained. Two hoop-like lines are seen on the leaf-sheath. Free-teeth are mostly reflexed at the tip and the margins. Drawn from NNW-796C, shown also in Pl. 40, Fig. 4.

3d. A crushed leaf-sheath probably on the lower part of erect stem. Two hoop-like lines are seen on the leaf-sheath; one (a-b) below is comparatively strong and another (dotted line) above is weak. The a-b line may indicate the position of a nodal diaphragm. Drawn from NNW-792, shown also in Pl. 39, Fig. 7.

3e. Showing leaf-segments, free-teeth and commissural furrows enlarged from 3d. Each free-tooth has a midrib. The bordered line between the free-tooth and the appressed part of leaf-segment is indistinct.

3f. A broken internode with a crushed leaf-sheath probably on the upper part of an erect stem. Note that the fallen free-teeth leave a more or less thickened straight edge at the top of appressed leaf-sheath. Drawn from NNW-332, shown also in Pl. 39, Fig. 9.

3g. An isolated nodal diaphragm. Drawn from NNW-814, shown also in Pl. 38, Fig. 10.

Text-figs. 4a-c. *Equisetites* sp. A.

4a. A vertically compressed cup-shaped leaf-sheath with a nodal diaphragm. Free-teeth were all lost. Drawn from NEE-008, shown also in Pl. 40, Fig. 7.

4b. Fine strong and crowded projections on the adaxial surface of leaf-sheath. Drawn from 4a enlarged.

4c. Showing the branching rhizome with cup-shaped leaf-sheaths. Drawn from NEE-002. Its counterpart is shown in Pl. 39, Fig. 10.

lower part of the stem, number reduced to about 30 on the upper nodes. Sheath on lower nodes typically 30 mm high, but commissural furrows continued for 6∼10 mm (rarely 15 mm) below the node, composed of raised leaf-segments and sunken commissural flanges; flanges truncate above. Leaf-segment with a midrib and numerous oblong fine pits on its outer surface of coherent part, 75∼125 (90) μm long and 25∼75(45) μm wide, 65 per mm^2 in density. Free-teeth 4∼6 mm long, elongate-triangular in shape, gradually tapering into acuminate apex, often broken off leaving thickened horizontal rim at upper end of coherent sheath. Nodal diaphragm not rotated on compression, but very rarely isolated; circular, finely granular, showing a single ring of simple tubercles, 2∼2.5 mm from the edge, tubercles twice as numerous as leaf-segments. Rhizome sparsely branched, 7∼14 mm wide with long internode. Internode smooth but longitudinally wrinkled (thought to have been produced in compression). Nodal region more or less swollen. Leaf-sheath similar in form to that of erect vegetative stem, and with about 40 closely appressed leaf-segments. (Cone and root unknown.)

Distribution and occurrence: Equisetites *nipponicus* is abundant in the Negoya Formation of the main distribution of Kuruma Group, where it is the commonest fossil and no other *Equisetites* species has been found. Most specimens are broken and flattened stems and rhizomes. Accordingly it is considered that they are not in the position of growth. In addition, a few stem fragments referable to this species were found at the Kotaki Coal-Field in the northeastern subordinate distribution of Kuruma Group.

Observations: Pl. 40, Fig. 3 (holotype) shows two erect vegetative stems lying parallel; the left one shows four faintly

preserved smooth internodes, and the right one, crowded nodes with crushed leaf-sheaths above and appressed ones below. The suddenly contracted base of erect vegetative stem as shown in the right might have been perpendicularly attached to the horizontal rhizome which was lost in the course of collection. Nodal diaphragms are not rotated, but represented by prominent brims in compressed stems. No evidence of branches or bulges was recognized on the nodal regions. These erect vegetative stems may be from submerged bases, because no pits (stomata) are visible anywhere.

Pl. 39, Fig. 8(Text-fig. 3a) shows a single leaf-sheath preserved obliquely to the bedding plane. Such occurrence of isolated leaf-sheaths is quite common. The illustrated leaf-sheath is about 13 mm in diameter, more than 7 mm high and still with free-teeth but their apices are broken as shown in Text-fig. 3a. Leaf-segments are estimated at 48, 0.5∼0.6 mm wide, connected with narrow sunken commissural flanges, 0.12∼0.24 mm in total width. The median suture of adjoining flanges is prominent, continuing the sunken commissural furrows below the node as clearly shown in Text-fig. 3d (Pl. 39, Fig. 7). Crowded fine pits are distributed on the whole surface of leaf-segments as shown in Text-fig. 3b enlarged. The pits are oriented in parallel to the leaf-segment. No pits were visible on the free-teeth.

Judging from its size, Pl. 39, Fig. 9 (Text-fig. 3f) may represent the upper portion of an erect vegetative stem. Its internode is 9 mm wide with a compressed leaf-sheath consisting possibly of 36∼38 leaf-segments. A few free-teeth are still attached. Broken free-teeth are marked by a more or less thickened edge at the top of the leaf-sheath. The commissural furrows below the node are indistinct in this specimen.

Judging from its size, Pl. 39, Fig. 7 may represent the lower part of an erect vegetative stem. In this specimen the free-tooth is elongate-triangular in shape with a midrib (Text-fig. 3e, enlarged) often with reflexed tip and margins. The tooth-apices appear to be rounded.

The leaf-sheath show two transverse ridges or furrows of unknown nature (Text-figs. 3c, 3d).

The more or less swollen nodal region is shown by Pl. 40, Fig. 5. All the free-teeth are lost, leaving a thickened straight edge at the top of appressed leaf-sheath as well as seen in Text-fig. 3f. The sunken commissural furrows below the node are clearly seen. The specimen shown in Text-fig. 3f is unusual in showing a transverse line across the base of the free-teeth, such a line is, however, often seen in *Equisetites iwamuroensis*.

Pl. 38, Fig. 10 (Text-fig. 3g) is only an isolated nodal diaphragm in our collection. It is 15 mm in diameter, consisting of a central circle with finely granular surface and a ring of tubercles. The tubercles are elongate-oval in shape, 2~2.5 mm long and about 48 in number. It may correspond to the typical number of leaf-segments.

Comparison: *Equisetites nipponicus* differs from *E. iwamuroensis* in the following points : 1) *Equisetites nipponicus* has 40~48 (typically 48) leaf-segments in a sheath instead of 24~28 (typically 24) in *E. iwamuroensis*. 2) In *E. nipponicus* free-tooth-bases left at the tip of appressed part of leaf-segment are thickened, forming a straight rim instead of leaving a row of thickened and trapezoid bases in *E. iwamuroensis*. 3) Free-tooth of *E. nipponicus* has a midrib, but such a midrib has not been found in *E. iwamuroensis*. 4) The nodal diaphragms are not rotated and rarely isolated in *E. nipponicus*, but

they are often rotated or isolated in *E. iwamuroensis*.

Of KON'NO's species, *Equisetites koreanicus, E. nariwaensis, E. naitoi, E. naitoi* subsp. *minor* and *E. paotensis* differ in having branched stems, and other six unbranched species by him have fewer segments in their leaf-sheaths.

Equisetites ferganensis SEWARD, *E. rajmahalensis* (OLDHAM & MORRIS) FEISTMANTEL and *E. sarrani* ZEILLER are well known Asiatic species. They are also distinguishable from *E. nipponicus*, because their numbers of leaf-segments are 25~32, 25~30 and 20, respectively.

Equisetites veronensis ZIGNO (ZIGNO, 1856) or *Equisetites veronense* (ZIGNO) (KILPPER, 1964) resembles *E. nipponicus* in external form of aerial stem, but differs from *E. nipponicus* in having much laterally expanded leaf-sheath.

We know similar species to *E. nipponicus* such as *Equisetum columnare* BRONGNIART (BRONGNIART, 1828 ; HARRIS, 1961) and *Equisetites grosphodon* HARRIS (HARRIS, 1931). *Equisetum columnare* is only a little broader and has 50~80 leaf-segments (nodal bulges are only present at stem bases). The Greenland Lower Liassic *Equisetites grosphodon* is 15~40 mm wide and has 30~40 leaf-segments. However, so far as we know, there are no other species having typically 48 leaf-segments in a sheath.

Equisetites sp. A

Pl. 39, Fig. 10 ; Pl. 40, Figs. 7-9 ; Text-figs. 4a-c

Material: NEE-002, 002B, 008, 057, 094, 362, NEG-059, 073 (NEE- ; Higashi-Neiridani, and NEG- ; Negoyadani).

Distribution and occurrence: This form is only known from the Negoya Formation, but rather rare.

Description: Pl. 40, Fig. 7 (Text-fig. 4a) shows an apically expanded cup-shaped leaf-sheath with a nodal diaphragm compressed vertically. Leaf-sheath is more than 1.2 cm high and with 74 leaf-segments. Leaf-segments are 0.5 mm wide below and 1.3 mm wide above, and coherent by narrow commissural flanges above and by commissural furrows below. Free-teeth are unknown. On the adaxial surface of each leaf-segment, numerous fine projections are recognized as shown in Text-fig. 4b. They are 90~125 (100) μm long and 75 μm wide, and 70 per mm^2 in density. They possibly show the position of stomata. If so, the strong projections are due to the greater thickness of the wall of the guard cells. Nodal diaphragm is concave above, neither rotated nor isolated, and about 9 mm in diameter with a narrow marginal ring consisting of tubercles, the number of which corresponds to that of leaf-segments.

Pl. 40, Fig. 9 shows another vertically compressed node from below. The deformed nodal diaphragm is 1.8×1.5 cm, convex below and with a marginal ring consisting of 64 tubercles. Around the nodal diaphragm, part of the leaf-sheath extends outwards from the node.

Pl. 40, Fig. 8 shows a similar specimen to that shown in Pl. 40, Fig. 9. The slightly deformed nodal diaphragm is narrower, 1.25×1 cm in diameter, and there are 52 tubercles.

In rhizomes internodes are comparatively slender, 0.7~1.2 cm wide with long internodes, about 4 cm long. The surface of internode is smooth and no pits are recognized. Leaf-sheaths are expanded and cup-like form, twice as wide as the internodes. Pl. 39, Fig. 10 (Text-fig. 4c) shows a nodal region and a leaf-sheath on a thicker rhizome on the right and a possible branch on the left. The leaf-sheath on the right is 1.5 cm high and 2.2 cm wide, and consisting of 25 (total 50) leaf-segments with elongate-triangular free-teeth, 0.3 cm long. The number of leaf-segments is reduced on the slender branches.

Remarks: Several specimens were

Explanation of Plate 38

Figs. 1–9. *Equisetites iwamuroensis* KIMURA

    1. A part of basal erect stem. Loc. Tsuchizawa (Kr–025). natural size.

    2. A part of typical erect stem. Loc. Iwamuro (A–3051, lectotype), reappeared from KIMURA, 1959a, pl. 1, fig. 1, natural size.

    3. A slender erect stem, obliquely preserved to the bedding plane. Loc. Tsuchizawa (Kr–011), enlarged twice.

    4. Showing acicular free-teeth. Loc. Tsuchizawa (Kr–027), enlarged twice.

    5. A slender stem with long internodes. Loc. Tsuchizawa (Kr–021), enlarged twice.

    6. Showing a obliquely preserved leaf-sheath to the bedding plane. Loc. Iwamuro (A–4071), enlarged twice.

    7. Ditto. Loc. Tsuchizawa (Kr–019), enlarged twice.

    8. An isolated nodal diaphragm. Loc. Iwamuro (A–3076), enlarged twice.

    9. Ditto. Loc. Iwamuro (A–3093), enlarged twice.

Fig. 10. *Equisetites nipponicus* KIMURA and TSUJII sp. nov.; showing a single isolated nodal diaphragm. Note that its tubercles are longer than those of *Equisetites iwamuroensis*. Loc. Nishi-Neiridani (NNW–814), enlarged twice.

Fig. 11. *Equisetites* sp. C; showing an isolated nodal diaphragm. Loc. Sasakomata (SAS–007), enlarged twice.
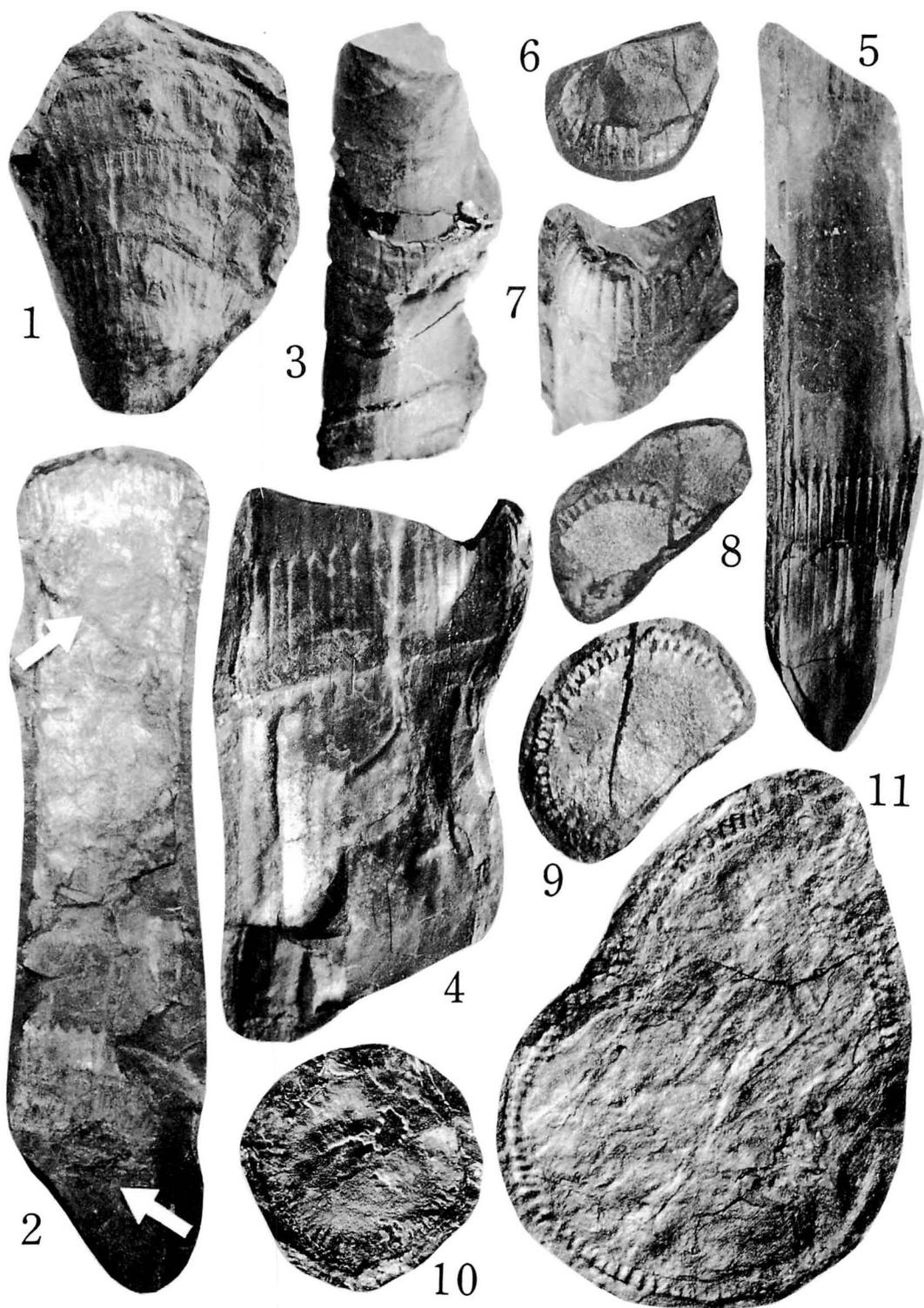
obtained from the Higashi-Neiridani and Negoyadani. The present material is characterized by the expanded cup-like leaf-sheath and the numerous leaf-segments on an aerial leaf-sheath, 52~74 (52 possibly common) in number. Accordingly the present material does not correspond to *Equisetites iwamuroensis* and *E. nipponicus* here described.

So far as the number of leaf-segments is concerned, the present material differs from hitherto known species of *Equisetites* or *Equisetum*. So far as we know, the leaf-segments are more than 80 in *Equisetites multidentatus* originally described by OISHI from the Nariwa Group (OISHI, 1932, p. 266, pl. 20, figs. 1-2) and 114 in *E. mori-gumpeii* here described.

Under these circumstances, the present material seems to belong to a new species, although the aerial internodes and the cones have not been found. We, however, adhere to *Equisetites* sp. A to the present material until more satisfactory data are available.

Equisetites sp. B

Pl. 39, Fig. 11

Material: SAS-001 and 006 (counterpart) (SAS-; from Sasakomata).

Distribution and occurrence: A single rhizome is obtained from the Shina-dani Formation of Sasakomata.

Description: The rhizome is rather slender, 1.2 cm wide, with internodes, 3~3.5 cm long. The surface of internodes is smooth but longitudinally and roughly wrinkled. The leaf-sheaths are faintly preserved in which the number of leaf-segments are, 34, 40 and 40 on each leaf-sheath indicating by arrows in Pl. 39, Fig. 11. No pits were recognized both on the leaf-segments and the internodes.

Remarks: So far as the size and the number of leaf-segments are concerned, the present rhizone resembles those of *Equisetites nipponicus* described here. Owing to the ignorance of associated aerial stems and other organs, the present rhizome is not specifically determined, and we call it *Equisetites* sp. B.

Equisetites sp. C

Pl. 38, Fig. 10

Material: SAS-003, 007 (counterpart). 001 and 009 (associated leaf-sheaths) (SAS-; from Sasakomata).

Distribution and occurrence: A single isolated nodal diaphragm and associated broken leaf-sheaths were obtained from Sasakomata of the Shinadani Formation.

Description: The nodal diaphragm is large-sized, but deformed, 2.2×3.8 cm in diameter with a marginal ring of 84 dome-shaped tubercles. The ring of tubercles is 1.5~1.8 mm wide.

The leaf-sheaths are 1.5 cm high above the node and are so fragmental that we cannot make the exact number of leaf-segments clear. But we suppose that these associated leaf-sheaths and the nodal diaphragm belong to the same species, because these leaf-sheaths are also large-sized and the number of leaf-segments is evidently more than 62.

Remarks: The present nodal diaphragm is obviously different in size and the number of tubercles from other *Equisetites* species here described.

So far as the size and the number of tubercles are concerned, the present nodal diaphragm may referable to *Equisetites multidentatus* OISHI with a thick stem and more than 80 leaf-segments on each leaf-sheath. But in OISHI's species, the leaf-sheaths are decidedly shorter, 0.7~1.0 cm high instead of 1.5 cm high in the present leaf-sheaths.

Under these circumstances, the present material is not specifically determined, and we call it *Equisetites* sp. C.

(to be continued)

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Explanation of Plate 39

Figs. 1-6. *Equisetites iwamuroensis* KIMURA

1. A detached internode. Loc. Iwamuro (A-2058), reappeared from KIMURA, 1959a, pl. 1, fig. 2, natural size.

2. Similar internodes to those shown in Pl. 38, Fig. 5. Loc. Tsuchizawa (Kr-020), enlarged twice.

3. An isolated nodal diaphragm. Loc. Iwamuro (A-75183), enlarged twice.

4. A vertically compressed nodal diaphragm (back-side view), Loc. Iwamuro (A-7577), enlarged twice.

5. Rhizomes. Note that the surface of internode is longitudinally wrinkled. Loc. Tsuchizawa (Kr-006), enlarged twice.

6. Crushed cones and scattered sporangiophores. Loc. Tsuchizawa (Kr-009), enlarged twice.

Figs. 7-9. *Equisetites nipponicus* KIMURA and TSUJII sp. nov.

7. A basal erect stem with short internodes. Loc. Nishi-Neiridani (NNW-792), natural size.

8. A leaf-sheath obliquely preserved to the bedding plane. Loc. Nishi-Neiridani (NNW-456), enlarged twice.

9. A slender erect stem with a crushed leaf-sheath. Loc. Nishi-Neiridani (NNW-322), enlarged twice.

Fig. 10. *Equisetites* sp. A; showing rhizomes with cup-like leaf-sheath. Loc. Higashi-Neiridani (NEE-002), enlarged twice.

Fig. 11. *Equisetites* sp. B; showing a rhizome; arrows show the position of nodes. Loc. Sasa-komata (SAS-011), natural size.
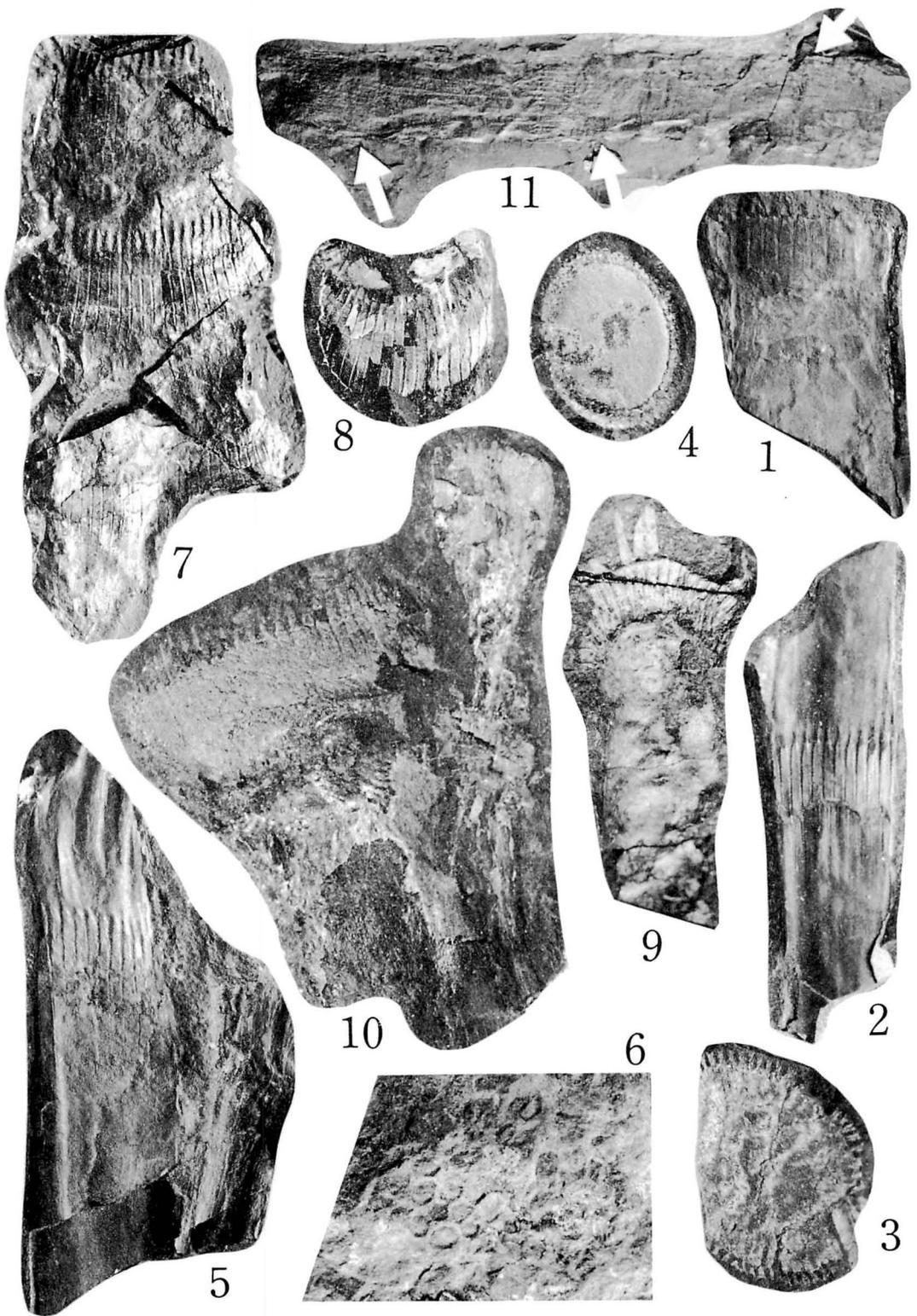
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Daedong (Korea) 大同, Dairagawa 太平川, Higashinagano 東長野, Higashi-Neiridani 東寝入谷, Iwamuro 岩室, Jogodani 漏斗谷, Katashinagawa 片品川, Kitamatadani 北又谷, Kita-Otari 北小谷, Komyoshita 光明下, Kotaki 小滝, Kurobishiyama 黒菱山, Kuruma 来馬, Mizukamidani 水上谷, Nariwa 成羽, Negoya 似虎谷, Neimong (China) 内蒙, Neiridani 寝入谷, Nishi-Neiridani 西寝入谷, Omi 青海, Sangun 三郡, Sasakomata 笹小又, Shimodera 下寺, Shinadani 椙谷, Shizugawa 志津川, Teradani 寺谷, Tsuchizawa 土沢, Yamaoku 山奥

日本の初期ジュラ紀植物化石. その1：日本の初期ジュラ紀植物化石は, 豊浦層群東長野層（山口県）, 山奥層（岡山県）, 来馬層群（富山, 新潟, 長野県）, 岩室累層（群馬県）, 志津川層群（宮城県）から知られている. 以上のうち, 植物化石を多産するのは, 来馬層群および岩室累層である. 私どもは, この数年間にわたり, 来馬層群および岩室累層から多量の植物化石を採集したので, これらを日本の初期ジュラ紀植物群の代表者として以後順次記載・報告する.

本論文は, 産地の地質および従来報告された属種について概観するとともに, とくさ目に属する, *Equisetites iwamuroensis* KIMURA, *E. mori-gumpeii* KIMURA and TSUJII sp. nov., *E. nipponicus* KIMURA and TSUJII sp. nov., *E.* sp. A, *E.* sp. B および *E.* sp. C を記載した.

日本の初期ジュラ紀植物群の特徴および他地域の同時代の植物群との比較は最終編において述べる予定である.

木村達明・辻井正則

Explanation of Plate 40

Figs. 1-2. *Equisetites iwamuroensis* KIMURA
   1. A slender erect stem with a rotated nodal diaphragm. Loc. Tsuchizawa (Kr-013), enlarged twice.
   2. A small-sized cone supported by an erect stem. Loc. Iwamuro (A-7901B), enlarged twice.
Figs. 3-6. *Equisetities nipponicus* KIMURA and TSUJII sp. nov.
   3. Basal part of two erect stems. Loc. Nishi-Neiridani (NNW-800, holotype), natural size.
   4. A broken leaf-sheath. Loc. Nishi-Neiridani (NNW-796C), enlarged twice.
   5. Showing a leaf-sheath, of which all the free-teeth are lost. Loc. Nishi-Neiridani (NNW-796B), enlarged twice.
   6. A leaf-sheath with free-teeth. Loc. Higashi-Neiridani (NNW-811), enlarged twice.
Figs. 7-9. *Equisetites* sp. A.
   7. A vertically compressed leaf-sheath with nodal diaphragm (upside view). Loc. Higashi-Neiridani (NEE-008), enlarged twice.
   8. Ditto. (back-side view). Loc. Negoyadani (NEG-059), enlarged twice.
   9. Ditto. Loc. Higashi-Neiridani (NEE-094), enlarged twice.
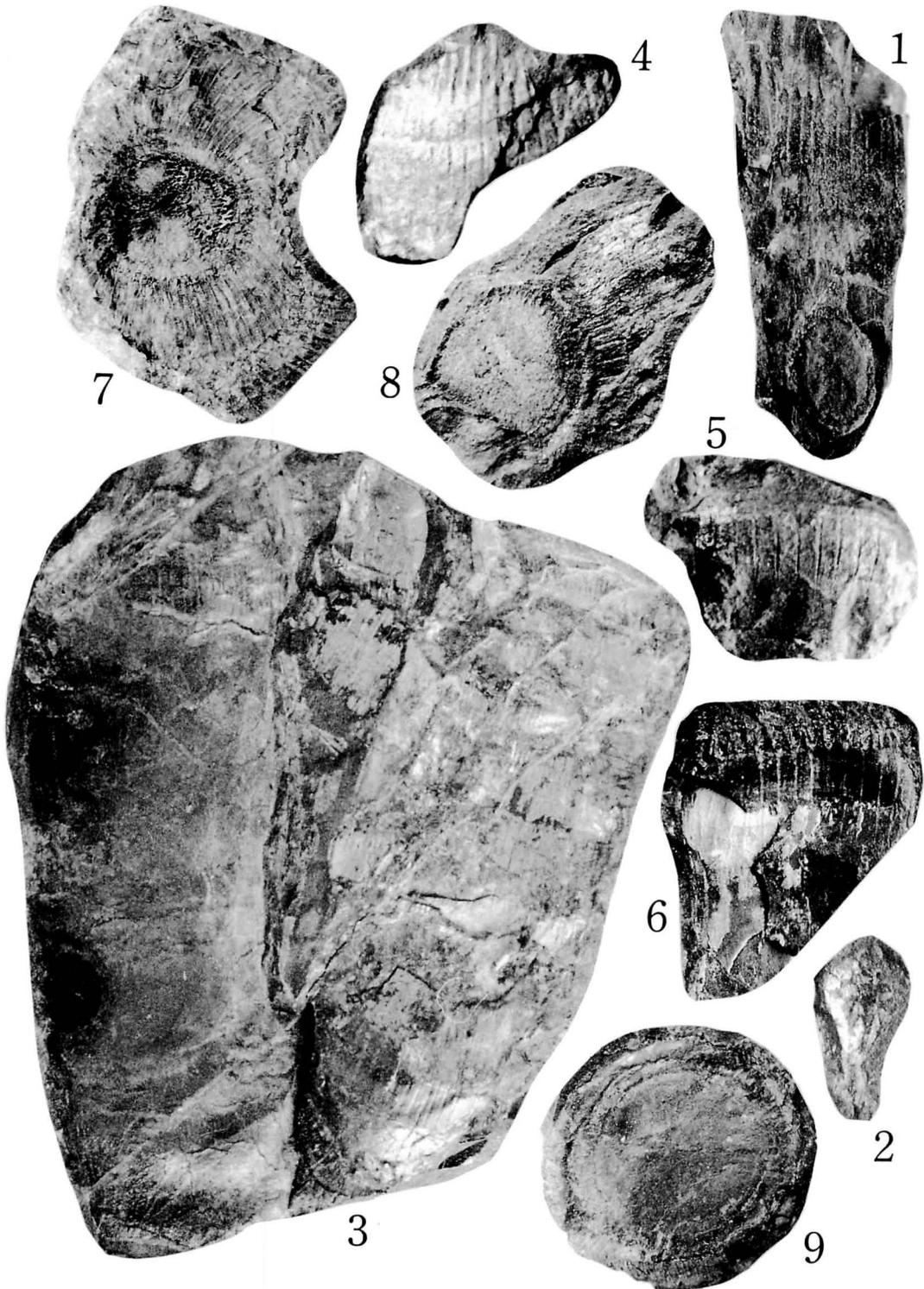
719. VISÉAN BRACHIOPODS FROM THE KARAUMEDATE FORMATION, SOUTHERN KITAKAMI MOUNTAINS*

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Abstract. A late Viséan brachiopod fauna consisting of 9 species is described from the uppermost part of the Karaumedate Formation at Jizodo, Nagasaka area, Southern Kitakami Mountains, Northeast Japan. It contains a new species: *Karavankina jizodoensis*.

The late Viséan age assignment for the Jizodo fauna does not contradict the stratigraphic data suggesting that the Karaumedate Formation is conformably overlain by the Upper Viséan to probable Westphalian Takesawa Formation.

Introduction

Brachiopod fossils treated in this paper were collected from the uppermost part of the Karaumedate Formation exposed at the hill of Jizodo, Higashiyama-Cho, Higashiiwai-Gun, Iwata Prefecture, i. e. the Nagasaka area, western marginal part of the Southern Kitakami Mountains, Northeast Japan (Text-fig. 1). The fossils are abundant in grey, tuffaceous sandy slate of about 20 m in thickness. The sandy slate occupies the top of the Karaumedate Formation which consists mainly of sandstone and attains a thickness of about 260 m at Jizodo. This fossiliferous sandy slate is conformably overlain by dark grey limestone of the lower part of the Takesawa Formation.

The latter contains the following smaller foraminifer and corals: *Endothyra?* sp., *Palaeosmilia* sp., *Dibunophyllum* sp. and *Lonsdaleia* sp. (OSAWA, 1980 MS).

* Received March 12, 1980; read June 9, 1979, at Tatsunokuchi.

ISHIZAKI (1968) described some ostracodes from the formation, and noted that "the Takezawa Formation may be, in the case of the youngest age, equivalent to the Viséan to which the Onimaru Formation has been correlated, or more likely to the Osagian in age" (ISHIZAKI, 1968, p. 12). Judging from the fossil evidences mentioned above, the Takesawa Formation, at least the lower part of it, is regarded as late Viséan in age.

In the previous works, it has been considered that the Karaumedate Formation is equivalent to the Lower Tournaisian Hikoroichi Formation, while the Takesawa Formation is correlated with the Upper Viséan Onimaru Formation plus the Namurian to Westphalian Nagaiwa Formation, and there is a considerable stratigraphic break between these two formations (IWAMATSU, 1975; MINATO, 1952, 1955; MINATO and KATO, 1978; MINATO et al., 1979; ONUKI, 1956, 1969; TACHIBANA, 1952a, 1952b). However, the age of the upper part of the Karaumedate Formation has not been substantiated,
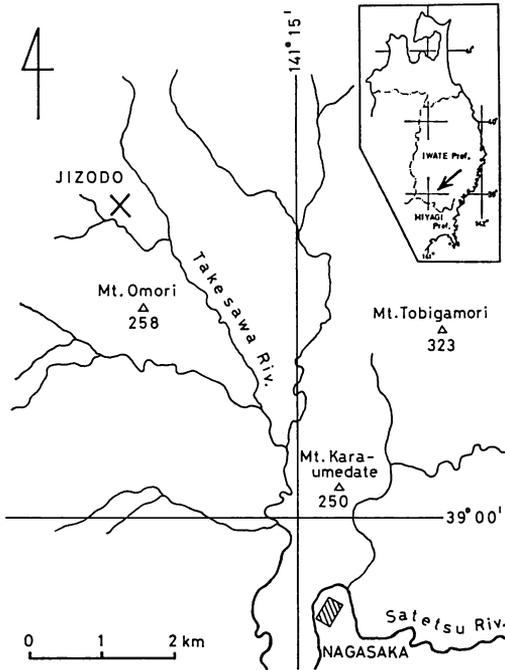
Text-fig. 1. Map showing the fossil locality.

because all of the early Tournaisian brachiopods and trilobites described from the Nagasaka area (MINATO, 1952; TACHIBANA, 1956, 1969; KOBAYASHI and TACHIBANA, 1978) are regarded as specimens from the lower part of the Karaumedate Formation or the upper part of the "Upper Devonian" Tobigamori Formation.

Recently TAZAWA and OSAWA (1979) reported the occurrence of *Martinia*, an element of the Jizodo fauna, and pointed out that the top of the Karaumedate Formation is a late Viséan in age and it is conformably overlain by the Takesawa Formation.

The purpose of this paper is describe the brachiopods of the Jizodo fauna and to discuss its stratigraphic significance.

The present author thanks Messrs. Masahiro OSAWA and Hiroshi NAGURA, students

Age of the Fauna

The brachiopod fauna of Jizodo consisting of 9 species described in this paper is listed below.

> *Rugosochonetes* sp.
> *Krotovia* sp.
> *Productus* cf. *P. concinnus* J. SOWERBY
> *Karavankina jizodoensis*, sp. nov.
> *Balakhonia* sp.
> *Yanishewskiella* ? sp.
> *Brachythyris* cf. *B. elliptica* ROBERTS
> *Phricodothyris* sp.
> *Martinia* aff. *M. glabra* (J. SOWERBY)

Among these species, *K. jizodoensis* and *M.* aff. *M. glabra* are dominant.

The genera *Productus* s. s., *Balakhonia* and *Martinia* are not found below the Viséan (MUIR-WOOD and COOPER, 1960, p. 240; MUIR-WOOD and WILLIAMS, 1965, p. H903; CARTER, 1975, p. 73). In addition, *Phricodothyris* is not common below the Viséan (CAMPBELL, 1957, p. 37). On the other hand, the genus *Brachythyris* is not found above the Viséan (BOUCOT et al., 1965, p. H707). The species closely related to the Jizodo forms, such as *Phricodothyris tripustulosa* DEMANET and *Martinia glabra* (J. SOWERBY) are characteristic Upper Viséan elements. *Brachythyris elliptica* ROBERTS is considered to be ranging up into the Upper Viséan (ROBERTS, 1975, table 1).

The Jizodo fauna from the uppermost part of the Karaumedate Formation is regarded as late Viséan in age. This

conclusion does not contradict the fact that the fossiliferous sandy slate of the topmost part of the Karaumedate Formation is succeeded upwards by the limestone of the Takesawa Formation without any structural discordance.

The genus *Karavankina* has hitherto been described from the Upper Carboniferous and the Lower Permian (RAKUSZ, 1932; RAMOVŠ, 1966, 1969; SARYTCHEVA, 1968; WINKLER PRINS, 1968; YANAGIDA and AW, 1979), but not known from the Lower Carboniferous. So the new species, *K. jizodoensis* is the oldest record of the genus in the world.

Description of Species

Order Strophomenida ÖPIK, 1934

Suborder Chonetidina MUIR-WOOD, 1955

Superfamily Chonetacea BRONN, 1862

Family Chonetidae BRONN, 1862

Subfamily Rugosochonetinae
MUIR-WOOD, 1962

Genus *Rugosochonetes* SOKOLSKAJA, 1950

Rugosochonetes sp.

Pl. 41, Figs. 1a, 1b.

Material:—One specimen; internal mold of a pedicle valve: IGPS coll. cat. no. 96252.

Remarks:—This specimen is assigned to the genus *Rugosochonetes* on the basis of its high median septum in the pedicle valve which is originating slightly anterior to the beak and extending to about one-third of the length of the valve. The Kitakami specimen is characterized by its a pair of vascular trunks, which are commencing at just anterior to the end of, and parallel to, the median septum.

But the specific assignment is uncertain.

In Japanese Carboniferous, only one species of *Rugosochonetes* has hitherto been described: *Rugosochonetes* aff. *R. hardrensis* (PHILLIPS) from the Lower Namurian of Akiyoshi, Southwest Japan (YANAGIDA, 1965, p. 115, pl. 27, figs. 2-8; YANAGIDA et al., 1977, p. 141). The Akiyoshi specimens differ from the present form in their smaller dimensions.

Suborder Productidina WAAGEN, 1883

Superfamily Productacea GRAY, 1840

Family Overtoniidae MUIR-WOOD
and COOPER, 1960

Subfamily Overtoniinae MUIR-WOOD
and COOPER, 1960

Genus *Krotovia* FREDERICKS, 1928

Krotovia sp.

Pl. 41, Figs. 2a, 2b.

Material:—One specimen; external cast of a pedicle valve: IGPS coll. cat. no. 96253.

Remarks:—This single specimen is assigned to the genus *Krotovia* on the basis of its size, shape and ornamentation. The specimen from Jizodo is a small, transverse subrectangular, and slightly convex pedicle valve, ornamented by irregular, concentric rows of spine bases and numerous weak growth lines.

Externally, this specimen somewhat resembles the shells referred to *Krotovia granulosa* (PHILLIPS), figured by WINKLER PRINS (1968, p. 80, pl. 1, figs. 25-30) from the Upper Carboniferous of the Cantabrian Mountains, Northwest Spain. But the Kitakami specimen is an incomplete material and not sufficient for the accurate comparison to the Spanish specimens.

Family Productidae GRAY, 1840

Genus *Productus* J. SOWERBY, 1814

Productus cf. *P. concinnus*
J. SOWERBY, 1821

Pl. 41, Figs. 3-6.

Compare with
1928 *Productus concinnus*: MUIR-WOOD, p. 49, pl. 1, figs. 7-10; text-fig. 12.
1952 *Productus concinnus*: SARYTCHEVA and SOKOLSKAJA, p. 134, pl. 37, fig. 184.

Material:—Four specimens; (1) external mold and cast of a pedicle valve: IGPS coll. cat. no. 96254, (2) external casts of two pedicle valves: IGPS coll. cat. no. 96255, 96256, (3) external mold of a brachial valve: IGPS coll. cat. no. 96257.

Description:—Shell small size for the genus, transverse subrectangular in outline, with long trail. Hinge line straight, a little less than the greatest width of the shell; the latter occurring near the anterior margin of the shell. Length 13 mm, width 17 mm (IGPS coll. cat. no. 96256); length of trail over 13 mm (IGPS coll. cat. no. 96254).

Pedicle valve with slightly convex visceral disc, geniculated into trail with almost right angles. Umbo small, rounded and incurved. Ears rather large, clearly marked off from visceral disc. Shallow sulcus on visceral disc. Lateral slopes steep. Median fold may be present on trail.

Brachial valve with almost flattened visceral disc, strongly geniculated. Diaphragm horizontally extends around the anterior and lateral margins of the visceral disc of brachial valve, widest at the middle portion and its measurements 6 mm, tapering posterolaterally.

External surface of pedicle valve ornamented by regularly developed costellae; 8 costellae in 5 mm width near the anterior margin of the visceral disc, 7 costellae in 5 mm width on trail. Rugae on visceral disc. Very fine growth lines on the whole surface of the valve; they especially visible on trail. No spine bases observed. Brachial valve ornamented by fine costellae and some weak rugae on visceral disc; 14 to 18 costellae in 5 mm width near the anterior margin. Diaphragm rather smooth except for some sparse costellae.

Remarks:—The present specimens are safely assigned to the genus *Productus* s. s. on the basis of its long trail and a crescent-shaped, flattened diaphragm.

The Kitakami specimens resemble the shells of *Productus concinnus* J. SOWERBY from the Upper Viséan (D₂) to lower Upper Carboniferous (Millstone Grit) of Britain (MUIR-WOOD, 1928), and the Upper Viséan to Namurian of the Moscow Basin (SARYTCHEVA and SOKOLSKAJA, 1952) in size, and having relatively large ears and a median fold on trail of pedicle valve.

Productus productus (MARTIN) is distinguished from the present form by its larger dimensions, smaller ears, and coarser, more irregular costellae.

Productus sp. described from the Lower Carboniferous Arisu Formation of the Kitakami Mountains (MINATO, 1951, p. 366, pl. 1, figs. 4a, 4b) may be assigned to the subfamily Dictyoclostinae STEHLI, 1954.

Family Echinoconchidae STEHLI, 1954

Subfamily Karavankininae RAMOVŠ, 1966

Genus *Karavankina* RAMOVŠ, 1966

Karavankina jizodoensis, sp. nov.

Pl. 41, Figs. 8-16; Pl. 42, Fig. 14; Text-fig. 2.

Material :—Eighteen specimens; (1) external and internal molds of a conjoined valve : IGPS coll. cat. no. 96258 (holotype), (2) external and internal molds of two pedicle valves : IGPS coll. cat. no. 96259, 96260, (3) internal molds of two pedicle valves : IGPS coll. cat. no. 96261, 96262, (4) external mold of a brachial valve and internal mold of a conjoined valve : IGPS coll. cat. no. 96263, (5) internal mold of a conjoined valve : IGPS coll. cat. no. 96264, (6) external and internal molds of two brachial valves : IGPS coll. cat. no. 96265, 96266, (7) external molds of four brachial valves : IGPS coll. cat. no. 96267, 96268, 96269, 96270, (8) internal molds of three brachial valves : IGPS coll. cat. no. 96271, 96272, 96273, (9) external molds of fragments of valves : IGPS coll. cat. no. 96274, 96275.

Diagnosis :—Large-sized, transverse sub-rectangular-shaped species of *Karavankina*. Ornamentation of wider lamellose bands with one row of large spine bases and two rows of small ones. Interior of brachial valve with a ventrally bilobed, but dorsally unknown, cardinal process.

Description :—Shell large size for the genus, transverse subrectangular in outline. Hinge line straight, a little less than the greatest width of the shell; the latter occurring at slightly anterior to midvalve. Length 21 mm, width 40 mm in the holotype.

Pedicle valve gently convex in both profiles; without sulcus. Ears large, flattened, trigonal in shape, and clearly demarcated from visceral disc by a concavity. Umbo rounded and strongly incurved. Brachial valve almost flattened at visceral disc, weakly concave near the anterior and lateral margins of the valve; no fold.

Both valves ornamented by concentric lamellose bands bearing numerous, elongate spine bases. Bands narrower and more

regular on brachial valve; 4 to 5 bands in 10 mm length on pedicle valve, 8 to 9 bands in 10 mm length on brachial valve. Two series of spine bases concentrically and more or less quincuncially arranged on each band (Pl. 2, Fig. 14). Larger spine bases forming a single row posteriorly, and two rows of smaller ones occurring anteriorly; 3 larger spine bases and 24 to 30 smaller spine bases in 5 mm width at the anterior portion of brachial valve.

Internally, pedicle valve having narrow, elongated, smooth adductor scars at the posterior portion of the valve. Brachial valve having elongate trigonal-shaped buttress plates on both sides of median septum; the latter thin, extending to about one-third of the length of the valve. A ventrally bilobed, but dorsally unknown, cardinal process supported by two buttress

2 mm
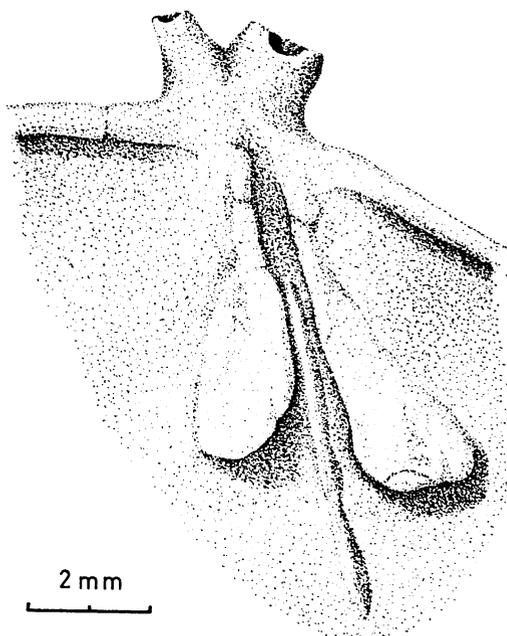
Text-fig. 2. Posterior portion of the brachial valve interior of *Karavankina jizodoensis*, sp. nov. (IGPS coll. cat. no. 96264), showing cardinal process, lateral ridges, buttress plates and median septum.

plates and lateral ridges (Text-fig. 2). Lateral ridges short, slightly diverging from hinge line. Adductor scars and brachial ridges not observed.

Remarks:—In outline of shell, and having rather large ears, the Kitakami species resembles *Karavankina dobsinensis* (RAKUSZ) from the Moscovian of Hungary (RAKUSZ, 1932, pl. 2, figs. 21, 22; pl. 3, fig. 2), and *Karavankina* cf. *K. dobsinensis* from the Moscovian of Spain (WINKLER PRINS, 1968, p. 96, pl. 4, figs. 17, 19) and the Moscovian of Malaysia (YANAGIDA and AW, 1979, p. 128, pl. 29, figs. 6a, 6b). But they differ from the present form in their smaller shells ornamented by narrower bands.

Karavankina rakuszi WINKLER PRINS from the Moscovian of Spain (WINKLER PRINS, 1968, p. 97, pl. 4, figs. 11–16, 18, 20; text-fig. 16) is also having a ventrally bilobed cardinal process. But the Spanish species differs from the present form in its highly convex pedicle valve with narrower lamellose bands.

Karavankina typica RAMOVŠ and *Karavankina paraelegans* (SARYTCHEVA) are clearly distinguished from the Kitakami species by their small-sized, subtrigonal-shaped pedicle valves.

Family Linoproductidae STEHLI, 1954

Subfamily Linoproductinae STEHLI, 1954

Genus *Balakhonia* SARYTCHEVA, 1963

Balakhonia sp.

Pl. 41, Fig. 7.

Material:—One specimen; external mold of a brachial valve: IGPS coll. cat. no. 96276.

Remarks:—This specimen is assigned to the genus *Balakhonia* on the basis of its ornamentation. The surface ornament of this valve consists of costellae and some irregular rugae. The costellae themselves are sculptured with numerous, very fine growth lines. This feature is the characteristic of *Balakhonia*.

The specific determination is impossible for this poorly preserved specimen.

Order Rhynchonellida KUHN, 1949

Superfamily Rhynchonellacea GRAY, 1848

Family Tetracameridae LIKHAREV, 1956

Genus *Yanishewskiella* LIKHAREV, 1957

Yanishewskiella? sp.

Pl. 42, Figs. 1a–4.

Material:—Four specimens; (1) external mold and cast of a pedicle valve: IGPS coll. cat. no. 96277, (2) external mold of a pedicle valve: IGPS coll. cat. no. 96278, (3) external molds of two brachial valves: IGPS coll. cat. no. 96279, 96280.

Remarks:—These specimens may be assigned to the genus *Yanishewskiella* by their small, rhynchonelliform shells with a few subrounded costae, although their internal structures are unknown.

The Kitakami specimens superficially resembles the shells of *Janischewskiella* (?) *angulata* (JANISCHEWSKY), figured by KALASHNIKOV (1974, p. 100, pl. 38, fig. 8) from the Namurian of the Northern Urals.

Yanishewskiella japonica YANAGIDA from the Lower Namurian of Akiyoshi (YANAGIDA, 1962, p. 117, pl. 19, figs. 4–5; pl. 20, figs. 1–2; text-figs. 18, 19; YANAGIDA et al., 1977, p. 141) differs from the present form in its short costae occurring only near the anterior margin of the valve.

Order Spiriferida WAAGEN, 1883

Suborder Spiriferidina WAAGEN, 1883

Superfamily Spiriferacea KING, 1846

Family Brachythyrididae
FREDERICKS, 1919 (1924)

Genus *Brachythyris* M'COY, 1844

Brachythyris cf. *B. elliptica*
ROBERTS, 1963

Pl. 42, Figs. 12a-13.

Compare with
1963 *Brachythyris elliptica* ROBERTS, p. 17,
    pl. 4, figs. 1-4.

Material:—Three specimens; (1) external and internal molds of a pedicle valve: IGPS coll. cat. no. 96281, (2) internal mold of a conjoined valve: IGPS coll. cat. no. 96282, (3) internal mold of a pedicle valve: IGPS coll. cat. no. 96283.

Description:—Shell large size for the genus, transverse elliptical in outline. Hinge line straight and short. Cardinal extremities rounded. Pedicle valve moderately convex with the maximum convexity at umbo. Beak small, pointed and strongly incurved. Brachial valve flattened except for the slightly convex umbo and broad, low fold. Length 22 mm, width 79 mm in the largest specimen (IGPS coll. cat. no. 96281).

Fold commencing at umbo, becoming broader anteriorly, and subdivided by a median groove and three minor furrows. Plicae rounded, bifurcated near the anterior margin; 14 to 16 plicae on pedicle valve, 14 plicae on brachial valve.

Pedicle valve interior, with some vascular markings radially branching out from the umbonal portion.

Remarks:—In size, shape and ornamentation, the present species is most similar to *Brachythyris elliptica* ROBERTS, described by ROBERTS (1963) from the Upper Tournaisian Bingleburra Formation of Lewinsbrook, New South Wales.

Brachythyris kitakamiensis MINATO from the Lower Carboniferous Hikoroichi Formation of the Kitakami Mountains (MINATO, 1951, p. 368, pl. 3, fig. 3; pl. 4, fig. 1) somewhat resembles the present form in having a fold of the GEORGE's (1927, p. 108) group A of *Brachythyris* species (*Brachythyris pinguis* Group) on the brachial valve. But the comparison to this species is difficult, because *B. kitakamiensis* has been established based only on a single specimen of brachial valve (UHR 16465).

Suborder Delthyrididina IVANOVA, 1972

Superfamily Reticulariacea
WAAGEN, 1883

Family Elythidae FREDERICKS,
1919 (1924)

Genus *Phricodothyris* GEORGE, 1932

Phricodothyris sp.

Pl. 42, Figs. 5a, 5b.

Material:—One specimen; external mold of a brachial valve: IGPS coll. cat. no. 96284.

Remarks:—The specimen from Jizodo is represented by a brachial valve of a medium-sized, wider *Phricodothyris* species, probably a new form. This species is characterized by its ornamentation which consists of numerous, concentrically and regularly arranged spine bases and interspinous pustules; namely, three interspinous pustules are always recognized between two spine bases (Pl. 2, fig. 5b). The spine bases show the characteristic of double-barreled spines,

and are counted 18 to 20 in 10 mm width near the anterior margin of the valve.

The present species is most similar to *Phricodothyris tripustulosa* DEMANET, described from the Upper Viséan (V_3) of Belgium (DEMANET, 1938, p. 95, pl. 9, figs. 11-15, text-fig. 29). But the Belgian species is smaller in size, and its valve is ornamented by more closely arranged spine bases (30 to 40 in 10 mm width; after DEMANET, 1938 p. 96).

Phricodothyris sp. from the Lower Permian Sakamotozawa Formation of the Kitakami Mountains (NAKAMURA, 1959, p. 200, pl. 1, figs. 1a-1c) is clearly distinguished from the present form by its ornamentation which is similar to that of *Neophricadothyris asiatica* (CHAO).

Superfamily Martiniacea
WAAGEN, 1883

Family Martiniidae WAAGEN, 1883

Subfamily Martiniinae WAAGEN, 1883

Genus *Martinia* M'COY, 1844

Martinia aff. *M. glabra*
(J. SOWERBY, 1820)

Pl. 42, Figs. 6-11b.

1927 *Martinia* aff. *M. glabra*: GEORGE, p. 112, text-figs. 3-11.
1938 *Martinia* aff. *M. glabra*: DEMANET, p. 103, pl. 9, figs. 24-29.
1979 *Martinia* sp.: TAZAWA and OSAWA, p. 775, text-figs. 2.1a-2.5b.

Material:—Thirty-three specimens; (1) external molds of three pedicle valves and internal molds of three conjoined valves: IGPS coll. cat. no. 96285, 96286, 96287, (2) external molds of three brachial valves and internal molds of three conjoined valves: IGPS coll. cat. no. 96288, 96289, 96290, (3) external and internal molds of a pedicle valve: IGPS coll. cat. no. 96291, (4) internal molds of four conjoined valves: IGPS coll. cat. no. 96292, 96293, 96294, 96295, (5) internal molds of twenty-two pedicle valves: IGPS coll. cat. no. 96296, 96297, 96298, 96299, 96300, 96301, 96302, 96303, 96304, 96305, 96306, 96307, 96308, 96309, 96310, 96311, 96312, 96313, 96314, 96315, 96316, 96317.

Description:—Shell medium size for the genus, transverse suboval in outline. Hinge line straight, much less than the greatest width of the shell; the latter occurring at or slightly anterior to midvalve. Umbo narrow and highly inflated. Beak pointed and incurved. Cardinal extremities well rounded. Length 23 mm, width 51 mm in the largest specimen (IGPS coll. cat. no. 96291).

Pedicle valve gently convex except for the umbonal portion and median sulcus. Sulcus shallow and broad, originating at slightly posterior to midvalve. Brachial valve slightly convex, almost flattened near the posterior and lateral margins of the valve. Fold low and broad, developing at anterior half of the valve. External surface of both valves smooth.

Pedicle valve interior, muscle scars small, rhomboidal, and impressed at slightly below the umbo; some vascular markings radially branching out from around muscle scars and extending to two-thirds of the length of the valve. Brachial valve interior with elongate muscle scars at posterior portion of the valve; vascular markings not observed.

Remarks:—MUIR-WOOD (1951, p. 111) proposed that the trivial name *Conchyliolithus Anomites* (*glaber*) of MARTIN, 1809 should be referred to J. SOWERBY, 1820 ("*The Mineral Conchology of Great Britain*" vol. 3, p. 123). She selected the lectotype of *Martinia glabra* (J. SOWERBY) (BM(NH) BB.102; MUIR-WOOD, 1951, pl. 3, figs. 2a-2c) from the SOWERBY's material.

The specimens from Jizodo resemble the lectotype in shape and having broad and shallow sulcus. But the comparison to *M. glabra* is difficult, because the internal structure of the lectotype is unknown.

The Kitakami specimens are quite similar to the shells, figured as *Martinia* aff. *M. glabra* (MARTIN) by GEORGE (1927) and DEMANET (1938), from the Upper Viséan of Wales and Dinant, respectively.

Martinia aff. *M. glabra* (J. SOWERBY) from the Namurian of Spain (MARTINEZ CHACON and WINKLER PRINS, 1977, p. 22, pl. 11, figs. 2a–2c) differs from the present form in its weakly developed sulcus.

The shells referred to *Martinia glabra* var. *decora* PHILLIPS, from the Lower Carboniferous of Omi, Central Japan (HAYASAKA, 1924, p. 48, pl. 6, fig. 14) is distinguished from the present form by its very narrow sulcus on the pedicle valve.

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Explanation of Plate 41

(Nat. size unless otherwise specified)

Figs. 1a, 1b. *Rugosochonetes* sp.
  Internal mold of pedicle valve : IGPS coll. cat. no. 96252 (1b.×2).
Figs. 2a, 2b. *Krotovia* sp.
  External cast of pedicle valve : IGPS coll. cat. no. 96253 (2b.×3).
Figs. 3-6. *Productus* cf. *P. concinnus* J. SOWERBY
  3. External cast of pedicle valve : IGPS coll. cat. no. 96256, 4. Rubber cast of pedicle valve
  exterior : IGPS coll. cat. no. 96254, 5. External cast of pedicle valve : IGPS coll. cat. no.
  96255, 6. External mold of brachial valve : IGPS coll. cat. no. 96257.
Fig. 7. *Balakhonia* sp.
  External mold of brachial valve : IGPS coll. cat. no. 96276.
Figs. 8-16. *Karavankina jizodoensis*, sp. nov.
  8. Rubber cast of brachial valve interior : IGPS coll. cat. no. 96272, 9a. External mold of
  pedicle valve, 9b. Internal mold of pedicle valve, 9c. External mold of brachial valve, 9d.
  Internal mold of brachial valve : IGPS coll. cat. no. 96258 (holotype). 10. Internal mold of
  pedicle valve : IGPS coll. cat. no. 96261, 11a. Internal mold of pedicle valve, 11b, 11c.
  Internal mold of brachial valve : IGPS coll. cat. no. 96264 (11c.×3), 12a. External mold of
  brachial valve, 12b. Rubber cast of brachial valve interior : IGPS coll. cat. no. 96259, 13.
  External mold of brachial valve : IGPS coll. cat. no. 96269, 14. External mold of fragment of
  valve : IGPS coll. cat. no. 96275, 15. External mold of brachial valve : IGPS coll. cat. no.
  96267, 16. Internal mold of brachial valve : IGPS coll. cat. no. 96265 (×3).

1a
1b
2a
2b
3
4
5
6
7
8
9a
9b
9c
9d
10
11a
11b
11c
12a
12b
13
14
15
16
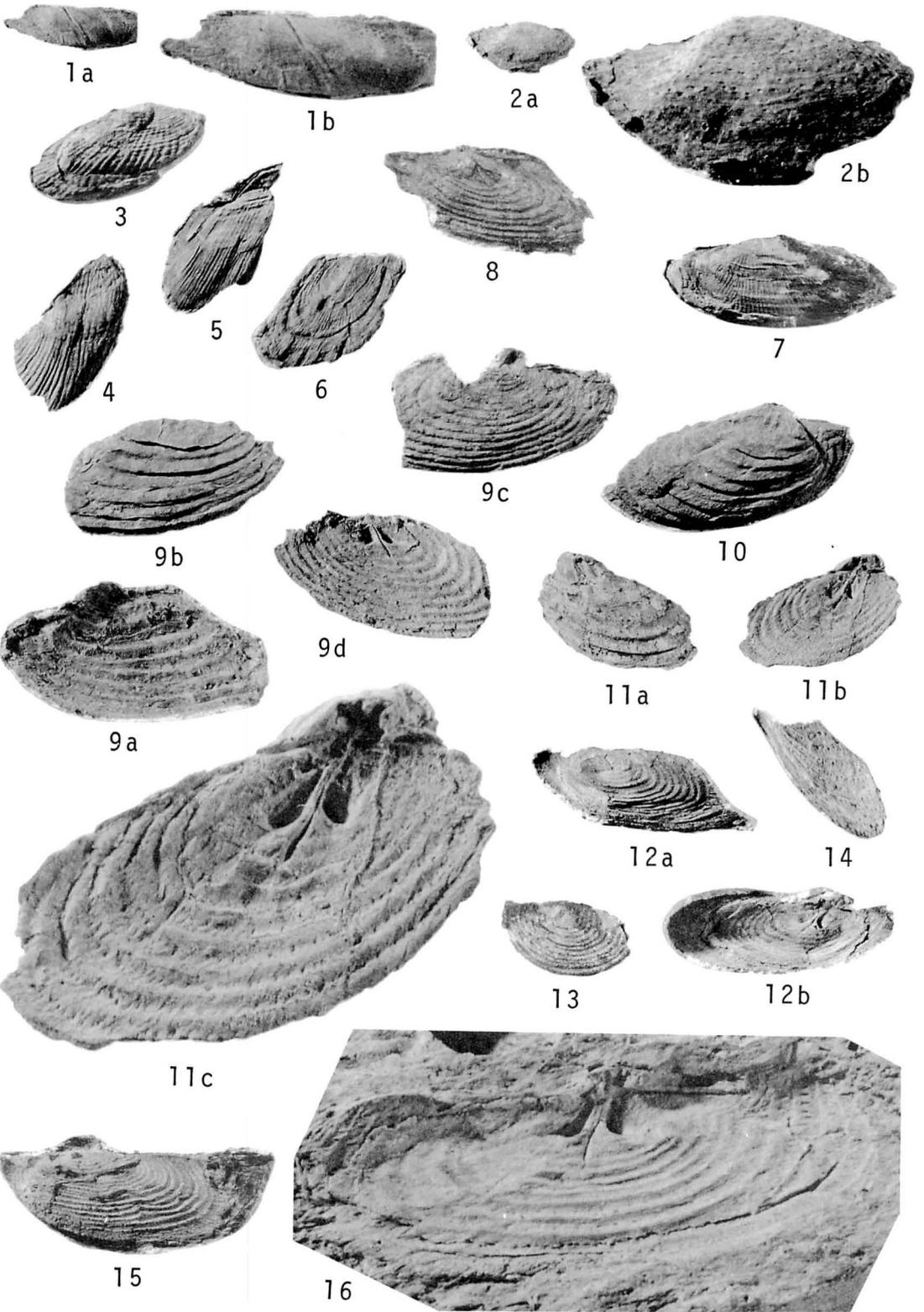
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南部北上山地の唐梅館層より産出したビゼー期腕足類：南部北上山地長坂地域，地蔵堂に露出する唐梅館層の最上部層より，9種の腕足類からなる後期ビゼー期のフォーナが得られたので記載する。この腕足類フォーナは1新種を含む：*Kararankina jizodoensis*。
地蔵堂フォーナが後期ビゼー期を示すことは，唐梅館層が上位の上部ビゼー階～ウェストファリア階(?)竹沢層に整合的に覆われるという野外事実と矛盾しない。 田沢純一

Explanation of Plate 42

(Nat. size unless otherwise specified)

Figs. 1a-4. *Yanishewskiella* ? sp.

1a, 1b. Rubber cast of brachial valve exterior: IGPS coll. cat. no. 96280 (1b.×2), 2. Rubber cast of brachial valve exterior: IGPS coll. cat. no. 96279 (×2), 3. Rubber cast of pedicle valve exterior: IGPS coll. cat. no. 96278 (×2), 4. Rubber cast of pedicle valve exterior: IGPS coll. cat. no. 96277 (×2).

Figs. 5a, 5b. *Phricodothyris* sp.

5a. External mold of brachial valve, 5b. Enlarged portion of Fig. 5a showing doublebarreled spine bases and interspinous pustules: IGPS coll. cat. no. 96284 (5b.×20).

Figs. 6-11b. *Martinia* aff. *M. glabra* (J. SOWERBY)

6. Internal mold of pedicle valve: IGPS coll. cat. no. 96313, 7. Internal mold of pedicle valve: IGPS coll. cat. no. 96315, 8. Internal mold of pedicle valve: IGPS coll. cat. no. 96296, 9a. Internal mold of pedicle valve, 9b. Internal mold of brachial valve: IGPS coll. cat. no. 96294, 10. Internal mold of pedicle valve: IGPS coll. cat. no. 96307, 11a. Rubber cast of pedicle valve exterior, 11b. Internal mold of pedicle valve: IGPS coll. cat. no. 96291.

Figs. 12a-13. *Brachythyris* cf. *B. elliptica* ROBERTS

12a. Internal mold of pedicle valve, 12b. Internal mold of brachial valve: IGPS coll. cat. no. 96282, 13. Internal mold of pedicle valve: IGPS coll. cat. no. 96281.

Fig. 14. *Karavankina jizodoensis*, sp. nov.

Enlarged portion of Fig. 15 of Pl. 41, showing elongate spine bases (×5).

1a

1b

2

3

5a

4

7

9a

9b

6

8

10

11a

11b

12a

12b

13

14

5b
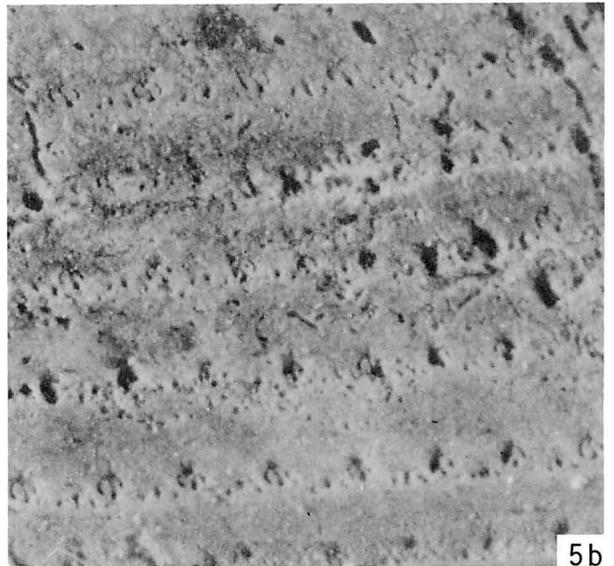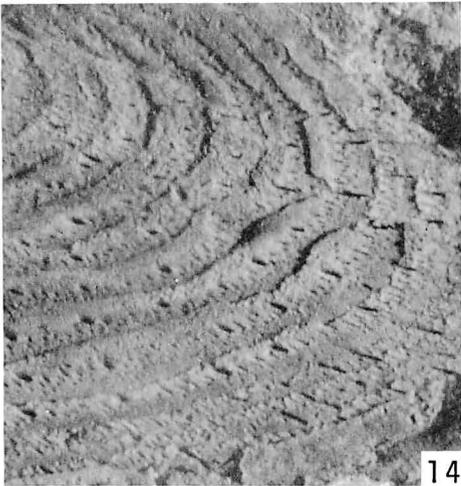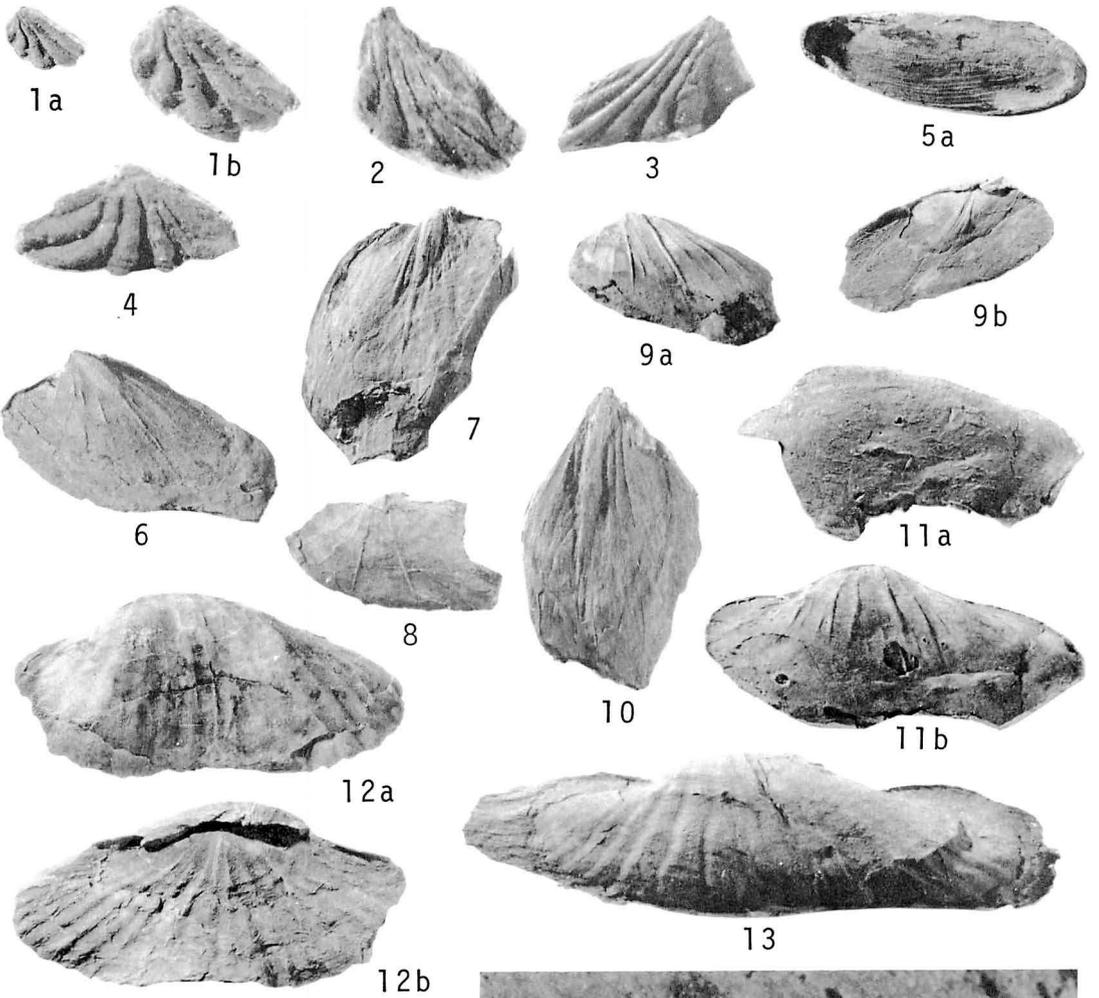
720. ONTOGENIES OF A FEW UPPER CAMBRIAN TRILOBITES FROM THE DEADWOOD FORMATION, SOUTH DAKOTA*

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Abstract. The present report illustrates the ontogenic deveolpment of three species of trilobites and two species of agnostids. They are : *Aphelotoxon triangulata*, n. sp., *Pulchricapitus davisi* KURTZ, *Housia ovata* PALMER, *Pseudagnostus communis* (HALL and WHITFIELD), and *Homagnostus tumidosus* (HALL and WHITFIELD). The former three species are well known and the latter ones are incomplete. The studied materials were all collected from the Deadwood Formation, Upper Cambrian, *Elvinia* Zone, South Dakota. The result of this study indicates that the phylogenic development of *Aphelotoxon triangulata* is related to *Ponumia*, *Housia*, and *Cliffia*, and that of *Pulchricapitus davisi* to *Coosina* and *Wilsonella*. The meraspid *Housia ovata* is possibly diversified from some species of cooselloid—*Coosia longocula* PALMER or *Coosella convexa* TASCH.

Introduction

The purpose of the present report is to illustrate the ontogenic development of three species of trilobites and two species of agnostids. They are : *Aphelotoxon triangulata*, n. sp., *Pulchricapitus davisi* KURTZ, *Housia ovata* PALMER, *Pseudagnostus communis* (HALL and WHITFIELD), and *Homagnostus tumidosus* (HALL and WHITFIELD). The growth series of the first three species are well known and those of the other ones are incomplete.

The occurrence of the species *Aphelotoxon triangulata* possibly pertains to the latest member of the *Elvinia* Zone, however, its early progenitor occupies mainly the *Dunderbergia* Zone. The earliest instars of this species are closely similar to those of *Ponumia obscura* (LOCHMAN),

Housia canadensis WALCOTT (HU, 1970), *Cliffia typica* HU (1979), and *H. ovata* PALMER of the present study, and may suggest that these genera are derived from a similar or common ancestor. The late meraspid cranidium of *Aphelotoxon triangulata* has a narrow preglabellar field similar to those of adult forms reported from the *Dunderbergia* Zone by PALMER (1965), shows the recapitulation of its earlier progenitors.

The meraspid cranidium of *Pulchricapitus davisi* is morphologically similar to the adult forms of *Coosina* (LOCHMAN, 1959), and *Wilsonella* (HU, 1968); it suggests that the ancestor of this genus is possibly a cooselloid form. The late meraspid cranidium of *Housia ovata* shows the characteristics of *Coosia* and *Coosella* (LOCHMAN, 1959). It possibly derived from some species of cooselloid such as *Coosia longocula* PALMER (1962) or

Coosella convexa TASCH (HU, 1968).

The ontogenic development of *Pseudagnostus communis* and *Homagnostus tumidosus* are incompletely known. However, it may generally be stated that the distinct morphologic variations during their ontogenic stages are rather simple; i. e., the axial lobe changes from narrow to wide and the pygidial margin becomes narrower. Since the ontogenic development of agnostids is poorly known, their phylogenic details are not predictable.

The studied materials were all collected from the Deadwood Formation, Upper Cambrian, *Elvinia* Zone, along the Black Hills, South Dakota, during attendance of a summer field camp, 1962. These collections were made under the supervision of Dr. Christina LOCHMAN-BALK, New Mexico Institute of Mining and Technology. The author wishes to express his thanks for her guidance during the field work. Appreciation also goes to Dr. K. E. CASTER, University of Cincinnati, for reading over the present manuscript. All of the figured specimens are stored in the Geology Museum, University of Cincinnati (GMUC), Ohio, U. S. A.

Systematic Paleontology

Family Agnostidae WHITEHOUSE, 1936

Genus *Pseudagnostus* KAEKEL, 1909

Pseudagnostus communis (HALL & WHITFIELD)

Pl. 43, Figs. 1-8 and Text-fig. 1

Agnostus communis HALL and WHITFIELD, 1877, p. 228, pl. 1, figs. 26, 27.
Agnostus neon HALL and WHITFIELD, 1877, p. 229, pl. 1, figs. 25, 26.
Pseudagnostus josepha (HALL) : FREDERICKSON, 1949, p. 362, pl. 72, fig. 17.

Pseudagnostus prolongus (HALL and WHITFIELD) : PALMER, 1955, pl. 19, fig. 18; LOCHMAN & HU, 1959, p. 412, pl. 57, figs. 7-16.
Pseudagnostus communis (HALL and WHITFIELD) : PALMER, 1955, p. 94, pl. 19, figs. 16, 19-21, pl. 20, figs. 4-11, 14; KURTZ, 1975, p. 1021, pl. 4, figs. 3, 4. (synonymy up to date)

Remarks.—About a dozen small and large sized instars and mature specimens have been recovered from a light gray limestone. They are identical with those occurrences from the Dunderburg Shale reported by PALMER (1955). The earliest instars of the present study are assigned to the late meraspid stage which equals the "adult stage" of PALMER (1955, p. 95, pl. 20, figs. 6, 9, 10). In this stage the glabella is slenderly conical and the preglabellar field is narrow, and the pygidial terminal portion is narrow and sharply posteriorly pointed.

It is interesting to note that in the earlier instar the pygidial terminal portion is narrow conical, and deeply delimited by dorsal furrows. This conical axis increases in width during ontogeny, and the dorsal furrows are divergent laterally; the posterior terminal furrow is faint to evanescent. During this development there is simultaneously developed a pair of faint grooves, or new axis, along the median lobe. These morphologic characteristics might indicate that the original axial furrows, those marked along the pygidial terminal portion, may hark back to an ancestral agnostid form, and the median grooves are a newly developed axis of a secondary nature. The author believes that the paired furrows, present posterolaterally from the sides of the second axial ring, are original dorsal furrows which degenerated secondarily. The two rows of pits or grooves which are present along the median terminal

portion are a secondary feature, and are possibly muscle scars which are impressed upon the exoskeleton (Text-fig. 1F; PALMER, 1955, pl. 20, figs. 11, 14). If this postulation is reasonable, then evite likely the early instars of this animal was a pelagic or swimming form; it may have employed the pygidium functionally as a uropod much as is show in some crustaceans without appendages, while in the adult *Pseudagnostus communis* the animal become benthonic with well-developed appendages. Hence the stronger muscle scars. KOBAYASHI (1935) indicated, and PALMER (1955) agreed, that the diagonal furrows are accessory and the median lobe, i. e., new axial lobe is a pseudolobe. However, they give no phylogenic discussion of these morphologic characteristics.

Occurrence.—North side of road cut, Little Elk Creek, about 10 miles northwest of Rapid city, South Dakota,

Figured specimens.—GMUC, 43413, 43414a–g.

Genus *Homagnostus* HOWELL, 1935

Homagnostus tumitosus (HALL and WHITFIELD)

Pl. 43, Figs. 9–12 and Text-fig. 2

Agnostus tumidosus (HALL and WHITFIELD), PALMER, 1960, p. 63, pl. 4, figs. 1, 2; KURTZ, 1975, p. 1021, pl. 4, figs. 1, 2. (synonymy to date.)

Remarks.—A few specimens were recovered from a light gray limestone. They are associated with *Pseudagnostus communis* (HALL and WHITFIELD). The smallest cranidium is about 0.6 mm in sagittal length, showing a quadrate outline; the preglabellar field is slightly concave. The pygidium is 1.8 mm in length (sag.), in an adult form with a rather broad axial lobe and a round terminal portion.

A few small pygidial shields have been reported from the Eureka district of Nevada by PALMER (1955). These show the axial lobe to be conical, tapering posteriorly and divided into three subequal segments. It is clear that in its morphogenic sequence of this species the axial lobe (especially on pygidial axis)

A   B   C

D   E   F
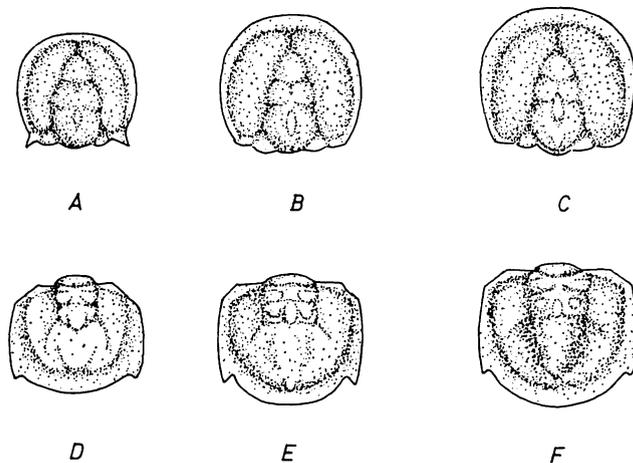
Text-fig. 1. *Pseudagnostus communis* (HALL and WHITFIELD). A, B, two meraspid cranidia, ×28, ×16; C, holaspid cranidium, ×13; D, meraspid pygidium, ×20; E, F, a small and a large sized holaspid pygidia, ×15, ×8. (drawings were made from photographs.)
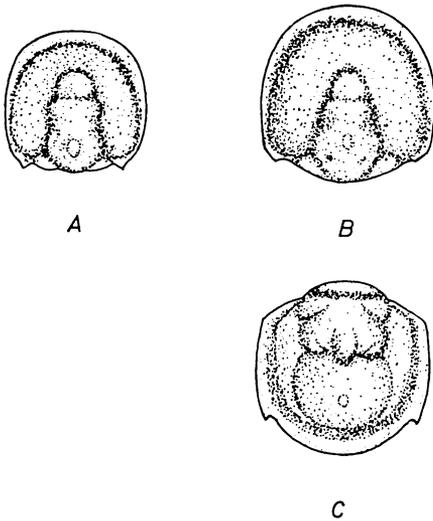
Text-fig. 2. *Homagnostus tumidosus* (HALL and WHITFIELD). A, meraspid cranidium, ×29; B, a small holaspid cranidium, ×10; C, an holaspid pygidium, ×11. (all drawings were made from photographs.)

increases in breadth, and the preglabellar field becomes convex. These are the common morphogenic characters of the agnostid group.

Occurrence.—North-side of road cut, Little Elk Creek, about 10 miles northwest of Rapid city, South Dakota.

Figured specimens.—GMUC. 43414, 43414a-d.

Family Unassigned

Genus *Pulchricapitus* KURTZ, 1975

Pulchricapitus davisi KURTZ

Pl. 43, Figs. 14-32 and Text-fig. 3

Pulchricapitus davisi KURTZ, 1975, p. 1038, pl. 2, figs. 24-26.

Remarks.—The present species is represented by both mature and immature

specimens. The morphologic characteristics are identical with those of silicified materials reported from Missouri by KURTZ (1975). The present materials and also the Missouri ones all show two different morphological groups; i. e., one with short truncato-conical glabella and broad fixigenae, the other with narrow elongate glabella, and narrow and relatively convex fixigenae. This bimodal phenomenon may indicate sexual dimorphism within the same species population. The first group is postulated as female and the later as male as is commonly shown by many trilobites, i. e., *Welleraspis late* (HU, 1964), *Coosella convexa* TASCH (HU, 1968), *Welleraspid swartzi* TASCH (HU, 1968), *Pelthopeltis arbuklensis* STITT (HU, 1975) etc.

Occurrence.—Galena section, about 4 miles southeast of Deadwood city, South Dakota.

Figured specimens.—GMUC. 43416, 43416a-r.

Pulchricapitus davisi KURTZ,

ontogeny

Metaprotaspid stage (Pl. 43, Fig. 14 and Text-fig. 3D).—The shield is subround in outline, moderately convex, and is about 0.3 mm in length; the axis and the pleuron are marked by a shallow but recognizable dorsal furrow; the axis contains a large frontal lobe, three pairs of central nodes and a small terminal tubercle; the three pairs of central nodes are faintly delimited by longitudinal and transverse furrows; the anterior pits are faintly depressed; the pleural lobe is about the same width as the axis. The instar's surface is minutely granulated.

Paraprotaspid stage (Pl. 43, Figs. 15-17 and Text-fig. 3B, C).—The shield consists either protopygidium or a cranidial shield
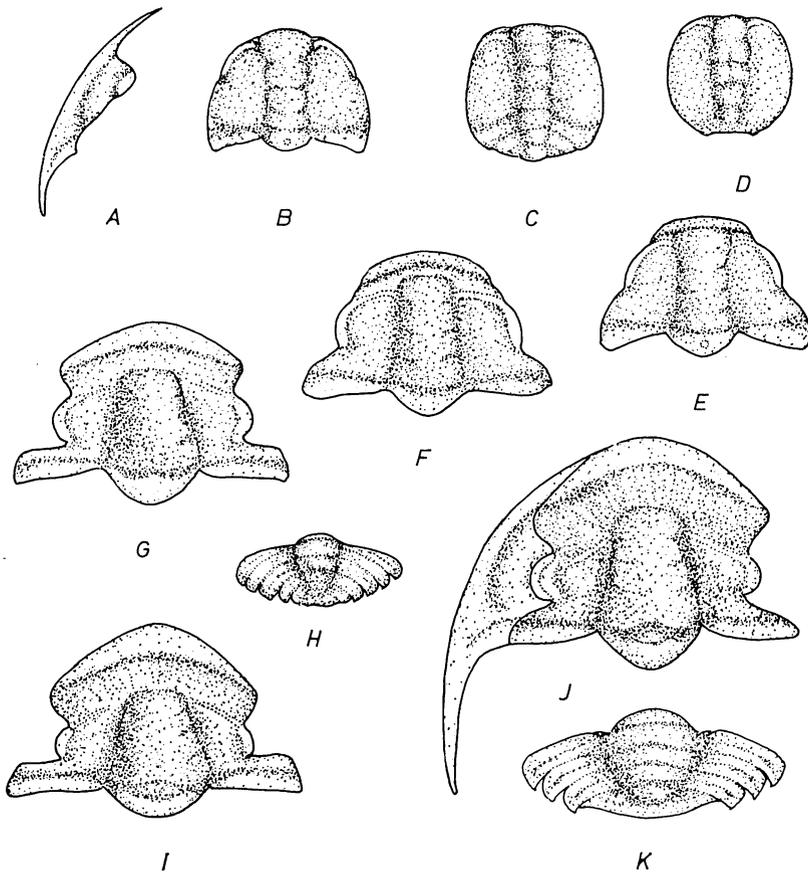
Text-fig. 3. *Pulchricapitus davisi* KURTZ. A, an immature librigena, ×10; B, C, two para-protaspid shields, ×21, ×35; D, a metaprotaspid shield, ×47; E, an early meraspid cranidium, ×24; F, a late meraspid cranidium, ×23; G, a small holaspid cranidium, ×13; H, an immature pygidium, ×15; I, J, two holaspid cranidia, showing the morphologic varieties, ×8, ×14. (all drawings were made from photographs.)

only; the cranidium is about 0.4 to 0.55 mm in length (sag.) and moderately convex; the axis is divided into five rings by transverse ring furrows; the frontal lobe which is distinctly demarked by a pair of eyebrow ridges, it extended from the sides of the frontal lobe and runs posterolaterally to end in front of the palpebral lobes; the palpebral lobe is narrow, elevated ridge, situated in front of the transverse mid-line of the glabella;

the occipital ring is lenticular, convex, and deeply separated by the occipital furrow; the pleuron of the fixigena is either about the same width as the axis, or slightly wider, and convex. The skeletal surface is faintly granulated.

During the present stage the proto-pygidium appears, the cylindrical glabella becomes wider, and the transverse ring furrows are shallower, the median longi-tudinal furrows disappear, and the palpebral

ridges are located poster to the eye-brow ridges.

Early meraspid stage (Pl. 43, Figs. 18–20, 22 and Text-fig. 3E).—The cranidium is trapezoidal in outline, moderately convex, and is about 0.6–0.75 mm in sagittal length; the dorsal furrow is deeply demarked; the glabella is cylindrical, expands both anteriorly and posteriorly from the anterior second glabellar furrow; the glabellar furrows are deeply demarked laterally and shallowly so across the central axis; the lenticular occipital ring is convex both vertically and posteriorly, and possibly bearing a minute median node; the narrow anterior border arches forward and is well elevated; it is marked by a frontal furrow; the fixigena is triangular, convex, and of about the same width as the glabella between the palpebral lobe and the dorsal furrow; the posterior fixigena is broad, and the well elevated fixigenal border is narrower than the occipital ring (tr.); the anterior suture is convergently convex, and the posterior one is posterolaterally divergent and is straight without any curvature. The skeletal surface is covered by faint granules.

In the morphogenesis of the present stage the glabella increases in width, the glabellar furrow becomes complete, the anterior border appears and develops from narrow to wide, and the palpebral lobe moves backward from the side of the anterior border.

Late meraspid stage (Pl. 43, Figs. 23–25, 31 and Text-fig. 3F).—The late meraspid cranidium is trapezoidal in outline, moderately convex, and is about 0.75–1.24 mm in length (sag.); the dorsal furrow is deeply impressed; the glabella is conical, tapering slightly forward, convex, and has three pairs of short glabellar furrows; the occipital ring is crescentically convex, bearing a minute median node, and is

well separated by a deep occipital furrow; the narrow preglabellar field slopes downward from the anterior glabellar margin and distinctly delimited frontal furrow; the anterior border is narrow, arches forward, and is convex; the convex fixigena is less narrow than the glabella and with narrow palpebral lobe located at the transverse mid-line of the glabella; the posterior fixigena is triangularly convex; the fixigenal border is elevated, deeply delimited by a border furrow, and is about the same width as that of the occipital ring; the anterior facial suture line is divergently convex, and the posterior one is posterolaterally divergent.

The crescentic meraspid librigena is gently convex, with the ocular platform and the lateral border of about the same width; the lateral border is narrow, faint, and continuous with a medium-sized genal spine. The skeletal surface is covered by both faint and coarse granules.

In the morphogenesis during the present stage the preglabellar field increases in width; the glabella becomes a shorter cone; the fixigena is narrower than in the previous stage and the palpebral lobe moves backward, becoming situated on the mid-length of the glabella.

Remarks.—The protaspides of the present species are closely similar to those of *Aphelaspis, Parabolinoides* (HU, 1969), *Glyphraspis* (HU, 1971), *Welleraspis* (HU, 1964, 1968). This possibly indicates that they originated from a common ancestral stock; the meraspides are similar to the adult forms of *Wilsonella* (HU, 1968) and *Coosina* (LOCHMAN, 1959), which suggests that these two genera may be the nearest progenitors of *Pulchricapitus.*

Family Solenopleuridae
ANGELIN, 1854

Subfamily Acrocephalitinae

HUPÉ, 1953

Genus *Aphelotoxon* PALMER, 1965

The family assignment of the present genus has been discussed by PALMER (1965), who suggested that it has some similarities to the genera *Dresbachia*, *Menomania*, and *Densonella*, etc. This may not tenable, due to the fact that all of these genera have a rather forwardly located palpebral lobe, broader posterior fixigena, proparian facial suture, and narrower glabella. PALMER at the same time suggested also *Aphelotoxon* is similar to *Clelandia*—an early Ordovician trilobite without family assignment. HU (1970) believed *Aphelotoxon*, *Cliffia*, *Ponumia*, and *Elyaspis* (KURTZ, 1975) to be natural group, since they have several characteristics in common: all possess a triangular cranidium, broad conical glabella, small palpebral lobe located rather forwardly to the anterior border, nearly triangular pygidium, and coarse granulated skeletons. The author proposes that all of these five genera; i. e., *Aphelotoxon*, *Cliffia*, *Ponumia*, *Elyaspis*, and *Clelandia* are solenopleurids, belonging to the Subfamily Acrocephalitinae HUPÉ (1953).

Aphelotoxon triangulata, n. sp.

Pl. 44, Figs. 1-31 and Text-fig. 4

Diagnosis.—Cranidium trapezoidal to subtriangular in outline, and convex; glabella broad conical, rounded anteriorly, marked by three pairs of glabellar furrows; occipital ring transverse triangular, convex, bearing a minute median tubercle; no preglabellar field is known; the anterior border is deeply delimited by a broad frontal furrow; fixigena slopes downward below the glabella, being narrow triangular, and about one-third the width of the glabella between the small palpebral lobe and the dorsal furrow; the posterior fixigenal border is more than one-half the width of the occipital ring, convex, and elevated from the broad border furrow. Librigena nearly crescentic, convex, and possesses a small short genal spine. Pygidium triangular to rhombic, convex; axial lobe narrow conical, sharply pointed posteriorly divided into 6 axial rings by furrows; the pleural lobe is less narrow than the pleural lobe, convex, with deeply impressed interpleural grooves; no distinct inner marginal furrow is known.

Description.—The cranidium is trapezoidal to triangular in outline, convex, with a disitnct dorsal furrow; the glabella is broadly conical, tapering forward with a rounded anterior margin and faintly defined by three pairs of distinct glabellar furrows; the anterior first pair of glabellar furrows is the shortest and faint; the second and third pairs are longer and deeply impressed; all of them are directed obliquely posterolaterally from the dorsal furrows; the occipital ring is crescentic, convex both vertically and posteriorly, and bears a medium-sized spine, and a minute median tubercle; the occipital furrow is narrow and shallow across the central axis, and deeply impressed laterally; no preglabellar field is known; the narrow lenticular anterior border is convex both vertically and horizontally, and deeply delimited by a frontal furrow.

The fixigena is about one-third the width of the glabella between the small elevated palpebral lobe and the dorsal furrow; the palpebral lobe is situated in front of the mid-line of the glabella (tr.), and continuous with a narrow palpebral ridge directed obliquely toward the anterolateral glabellar margin; the posterior fixigena is triangular, convex, slopes downward from the dorsal furrow, and with a convex posterior fixigenal border;
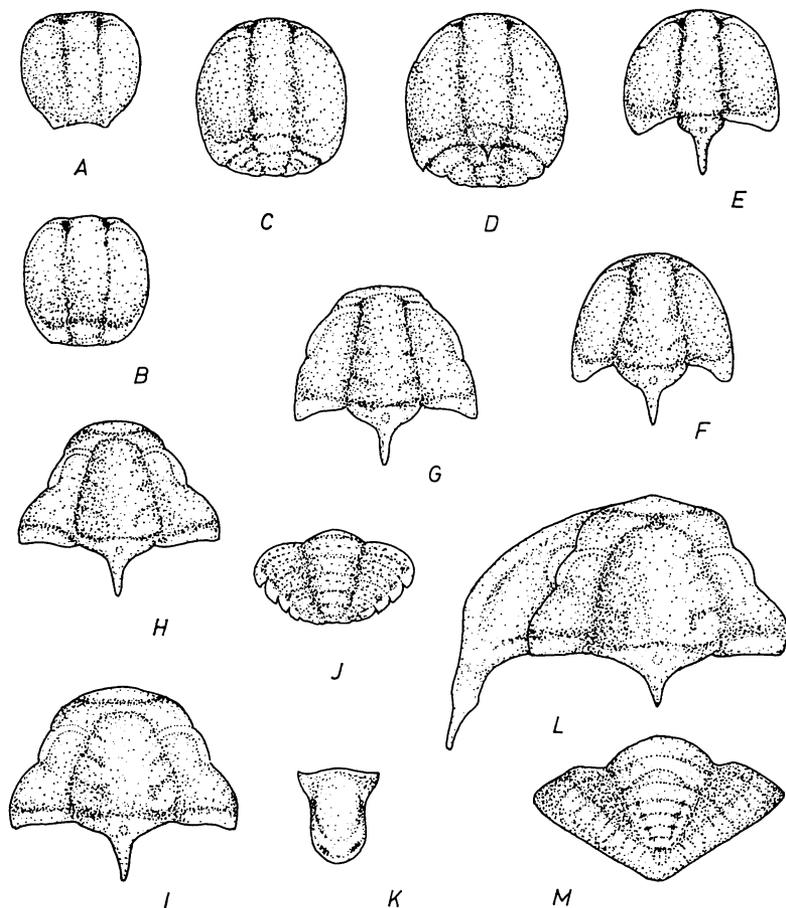
Text-fig. 4. *Aphelotoxon triangulata* n. sp. A, anaprotaspid shield, ×52; B, metaprotaspid shield, ×50; C–E, paraprotaspides, ×42, ×42, ×40; F, G, early meraspid cranidia, ×45, ×35; H, late meraspid cranidium, ×20; I, L, holaspid cranidia, ×21, ×24; K, hypostoma, ×2; J, M, an immature and a mature pygidia, ×21, ×10. (drawings were made from photographs.)

the posterior fixigenal border is more than one-half as wide as the occipital ring between the dorsal furrow and the lateral end; the anterior facial suture is convergently convex; and the posterior facial suture is divergent posteriorly from the posterior margin of the palpebral lobe, and with a round fixigenal angle.

The librigena is crescentic, convex, with a short slender genal spine projected posteriorly; the ocular platform is medium-

wide, slightly convex, with a faint lateral furrow; the small ocular ridge is located in front of the mid-line (tr.) of the free margin—the facial suture line.

The pygidium is rhomboid in outline, convex, and has the dorsal furrow well depressed; the axis is conical, tapering posteriorly to end in a sharply pointed projection, and it is not extended the full length of the pygidium; the five to six convex axial rings are well marked, of

which the anterior two are complete, and the posterior ones are incompletely divided; the pleural lobe is about two-thirds the width of the axis, convex, and slopes downward from the inner third; no distinct inner marginal furrow or spines are visible. The surface of the exoskeleton is covered by medium-sized granules.

Remarks.—The present species is represented by more than a hundred mature and immature skeletons which shown a well preserved growth sequence. It is differentiated from the published species of PALMER (1965): *Aphelotoxon acuninata* PALMER, *A. punctata* PALMER, *A. granulosus* PALMER, *A. limata* PALMER, *A. spinosus* PALMER, and *A. marginata* PALMER, from the *Dunderbergia* Zone by the absence of the preglabellar field, shallower dorsal furrow, and the broadly rhomboid pygidium. It is interesting to note that the immature or the late meraspid cranidium has a narrower preglabellar field similar to the adult forms found from the *Dunderbergia* Zone, but this feature absence latterly. It shows the recapitulatory phenomenon.

Occurrence.—South side of Dark Canyon, about 4 miles west of Rapid city, South Dakota.

Figured specimens.—Holotype, GMUC. 43417y; paratypes, GMUC. 43417, 43417a-x, z, a'-c'.

Aphelotoxon triangulata, n. sp.,

ontogeny

Anaprotaspid stage (Pl. 44, Figs. 1, 2 and Text-fig. 4A).—The shield is subround in outline, moderately convex, and about 0.25-0.28 mm in length (sag.); the dorsal furrow is faintly impressed; there are no axial segments and the terminal lobes are recognizable; the posterior shield margin is bent inward, and with the posterolateral corners projected posteriorly. The fixigena is slightly narrower than the axial lobe or of about the same width as the axis; no marginal border furrow is known; the paired frontal pits are rather faint and located near the anterior shield margin; the surface of the instars is minutely granulated.

Metaprotaspid stage (Pl. 44, Figs. 3-5 and Text-fig. 4B).—The shield is subround in outline, convex, about 0.30-0.35 mm in sagittal length, and with a rather faintly demarked dorsal furrow; the axial lobe has no defined segmental ring or furrows, except for faint longitudinal dorsal furrows; the anterior pits are faintly impressed; the skeletal surface is covered by minute granules.

The distinct characteristics of this stage are that the axial lobe is well defined by dorsal furrows, the posterior shield margin with a well development marginal border and a median terminal lobe—the occipital ring.

Paraprotaspid stage (Pl. 44, Figs. 6-11 and Text-fig. 4C, D).—The shield is subround in outline, convex, about 0.40-0.48 mm in sagittal length, and with the pleural and axial lobes well defined by dorsal furrows; the axial lobe is slenderly fusiform, convex, and tapering slightly both anteriorly and posteriorly; no defined axial ring or segmental furrows are seen, except for three or four pairs of pits along the dorsal furrows; the terminal portion of the axial lobe is occupied by a small lenticular occipital ring; the paired frontal pits are minutely depressed, and delimited by a pair of supercilioid ridges; the posterior fixigenal border is narrow near the occipital ring but broadens laterally, convex, well demarked by a border furrow; behind the cephalic shield is a transverse lenticular protopygidium, which slopes downward rapidly, and is

divided into two or three axial rings by segmental furrows; the axial rings are convex, with well defined axis and furrows. The surface of the shield is covered by faint granules.

The morphogenic characteristics of the present stage are that the posterior cephalic shield has a well developed fixigenal border, the protopygidium is present, the anterior pits become shallower, and the rudimentary glabellae furrows are visible.

Early meraspid stage (Pl. 44, Figs. 11–19 and Text-fig. 4F, G).—The early meraspid cranidium is trapezoidal in outline, convex, about 0.60-0.75 mm in length (sag.), and has the dorsal furrow distinctly impressed; the glabella is conical, tapering forward, and faintly demarked by three to four pairs of glabellar furrows; the occipital ring is transversely triangular, convex, bearing a median spine, and distinctly separated by an occipital furrow which deepens laterally and shallowly across the central line; no preglabellar field is known; the narrow anterior border arches forward and is faintly marked by a frontal furrow; the fixigena is about the same width as the glabella or slightly narrower, convex, slopes roundly downward from the dorsal furrow; the narrow elongate palpebral lobe is situated in front of the transverse mid-line of the glabella, and has the faint elevated palpebral ridge directed from the palpebral lobe to the anterolateral margin of the glabella; the posterior fixigenal border is convex, elevated, distinctly marked off from the fixigenal border furrow, and is about the same width as the occipital ring; the anterior facial suture line is convergently convex, and the posterior one is laterally divergent; the skeletal surface is minutely granulated.

During the present stage, the anterior border appears and it expands from narrow to wider, the glabella changes from the same width as the glabella to narrower; the glabellar furrows are faint and complete.

Late meraspid stage (Pl. 44, Figs. 21–24 and Text-fig. 4H).—The late meraspid cranidium is trapezoidal in outline, moderately convex, and is 0.85 to 1.2 mm in length (sag.); the glabella is broad conical, distinctly delimited by dorsal furrows, and has three pairs of well recognizable furrows; the convex occipital ring is crescentic, bearing a medium-sized occipital spine, and possibly a minute median tubercle; the occipital furrow is transverse W-shaped, slightly deepens laterally and shallows across the central line; the narrow preglabellar field is slightly depressed at the central portion, and the distinct frontal furrow arches less inwardly; the anterior border is gently convex, narrowly crescentic, arches anteriorly; the convex fixigena slopes downward from the dorsal furrow, and is about one-third the width of the glabella; the small palpebral lobe is deeply demarked by a palpebral furrow; it is elevated, convex, and located in front of the midline of the glabella (tr.); the posterior fixigenal border is about two-thirds as wide as the occipital ring (tr.), distinctly marked off by a broad border furrow, and is elevated and convex; the anterior facial suture is gently convergently convex, and the posterior facial suture line is divergently convex. The cranidial surface is faintly granulated.

The supposedly meraspid pygidium (Pl. 44, Figs. 28, 29 and Text-fig. 4J), is transversely semicircular in outline, convex, and separated into 3–5 free segments; the broad axis is convex, elevated from the pleural lobe, and tapers posteriorly; the pleural bends are directed posterolaterally, and distinctly demarked by interpleural grooves; no pleural border or

furrows are known. The surface of the skeleton is covered by medium-sized granules along the anterior and the posterior half of the pleural bends.

Family Housiidae HUPÉ, 1953

Genus *Housia* WALCOTT, 1916

Four species are known of this genus: *Housia varra* WALCOTT, *H. canadensis* WALCOTT, *H. caccuna* (WALCOTT) (WALCOTT, 1924, 1925), and *H. ovata* PALMER (1965). Most of these are preserved in a shale matrix or sandstone. Therefore, the original features of the animal are somewhat obscure, especially the nature of the convexity due to compaction of the bed rocks. The present materials are identical with *H. ovata* reported from Great Basin region by PALMER (1965) and from Missouri by KURTZ (1975); all are embedded in a limestone without deformation. PALMER (1965) distinguished this species on the presence of the genal spine and relatively elongate pygidium. It is the author's opinion that these specific criteria may not be tenable, because the genal spine may be absent during its later growth stage, and the pygidium may have variable shapes due to the presence or absence of the pygidial spines as indicated earlier by HU (1970). Therefore, the specific characteristics of the present species need further examination. The Black Hills specimens of *Housia* are assigned to *H. ovata* on the basis of preservation and the general skeletal outline.

Housia ovata PALMER

Pl. 45, Figs. 1–34 and Text-fig. 5, 6.

Housia ovata PALMER, 1965, p. 65, pl. 12, figs. 8–11; KURTZ, 1975, p. 1033, pl. 4, figs. 19, 20.

Remarks.—The present species is represented by more than a hundred of both large and small skeletons, of which the largest cranidium is about 8.0 mm in length (sag.) and the small instars 0.30 mm long (sag.); all show very well preserved growth sequences.

The ontogenic development of the present species is comparable with that of *H. canadensis* WALCOTT, reported from the Flathead Formation, Big Horn Mtns., Wyoming by HU (1970), except that the preservation of the present materials are better and show the continuous growth series from early protaspid to the adult forms.

Occurrence.—Galena section, about 5 miles southeast of Deadwood, South Dakota.

Figured specimens. — GMUC. 43418, 43418a–q, s–z, a′–c′.

Housia ovata PALMER, ontogeny

Metaprotaspid stage (Pl. 45, Figs. 1–4 and Text-fig. 5A, B).—The metaprotaspid shield is round to subround in outline, convex, and has the pleural and the axial lobes well differentiated by dorsal furrows, and is about 0.30–0.35 mm in sagittal length; the axial lobe is slender fusiform, tapering both anteriorly and posteriorly; the axial lobe is made up of a round frontal lobe, three pairs of glabellar nodes, and a round, terminal occipital ring; the larger specimens have an axis composed of five indistinctly divided segments; a pair of distinct pits is present at the sides of the frontal lobe; the supercilioid ridges are extended from the anterolateral margin of the frontal lobe, and end in front of the anterior first glabellar furrow (tr.); the pleural lobe or the fixigena is crescentic, convex, and having the same width as the axis; no marginal border or furrow is seen. The skeletal

surface is minutely granulated.

During the present stage, the morphogenesis shows the glabellar nodes fusing together to complete five axial segments, the central furrow is absent and the small occipital segment is distinctly marked off by a furrow, and is situated at the posterior shield margin.

Paraprotaspid stage (Pl. 45, Figs. 5-9 and Text-fig. 5C, E).—The shield is made of a cephalon and a protopygidium, subround, convex, and well divided into axial and pleural lobes by dorsal furrows; the shield varies from 0.40-0.60 mm in sagittal length; the cephalon is larger than the protopygidium, convex, and the slender glabella tapers slightly and is defined by furrows; the occipital ring is convex, distinctly separated by a furrow, and with no recognizable median tubercle; the paired frontal pits are seen, but shallower than in previous stage; the short eye-brow ridges are extended from the anterolateral glabellar segment or the frontal lobe, and are well separated from the palpebral ridge by furrows; the convex fixigena is about the same width as the axis; the posterior fixigenal border is convex, narrow near the glabellar base, and broadens laterally.

The protopygidium is transverse shuttle-shaped, narrow, turned-downward from

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Explanation of Plate 43

Figs. 1-8. *Pseudagnostus communis* (HALL & WHITFIELD)

    1, 2, two meraspid cranidia, ×28, GMUC. 43413; ×34, GMUC. 43413a.

    3-5, three holaspid cranidia. 3, ×16, GMUC. 43413b; 4, ×10, GMUC. 43413c; 5, ×13, GMUC. 43413d.

    6, 7, two immature pygidia. 6, ×15, GMUC. 43413e; 7, ×5, GMUC. 43413f.

    8, an adult pygidium, ×4, GMUC. 43413g.

Figs. 9-12. *Homagnostus tumidosus* (HALL & WHITFIELD)

    9, an immature cephalic shield; notice the preglabellar depression. ×27, GMUC. 43414.

    10, a large sized cephalic shield; notice the preglabellar convexity. ×11, GMUC. 43414a.

    11, 12 a small and a larger sized pygidial shield, showing the expansion of the terminal portion. ×10, ×9, GMUC. 43414b, c.

Fig. 13.   Agnostid, gen. et sp. undet. (undescribed). ×6.5, GMUC. 43415.

    Specimen was collected from Deadwood Formation, Upper Cambrian, *Elvinia* zone; Little Elk Creek, Black Hills, South Dakota.

Figs. 14-32. *Pulchricapitus davisi* KURTZ

    14, a complete metaprotaspid shield; notice the faintly differentiated axial and pleural lobes. ×47, GMUC. 43416.

    15-17, three paraprotaspid shields, showing the presence of the protopygidium, and the separation of the axial ring furrows. 15, ×35, GMUC. 43416a; 16, ×27, GMUC. 43416b; 17, ×23, GMUC. 43416c.

    18-20, 22, four early meraspid cranidia, showing the development of the preglabellar field. 18, ×21, GMUC. 43416d; 19, ×24, GMUC. 43416e; 20, ×23, GMUC. 43416f; 22, ×23, GMUC. 43416h.

    21, 23-25, 31, four late meraspid cranidia, showing the development of the preglabellar field. 21, ×11; 23, ×23; 24, ×25; 25, ×15; 31, ×13. GMUC. 43416i-l, q.

    26, a late meraspid librigena. ×10, GMUC. 43416m.

    27, a complete holaspid librigena. ×10, GMUC. 43416n.

    28, a pygidium. ×23, GMUC. 43416o.

    29, 30, 32, a few small and large sized cranidia. 29, ×8; 30, ×8; 32, ×14; GMUC. 43416p, r, s.
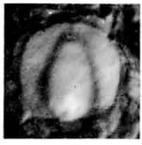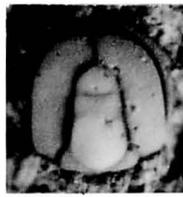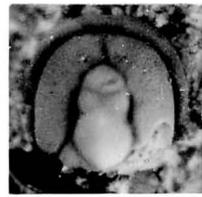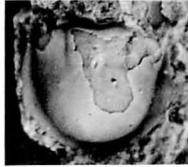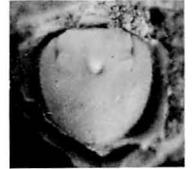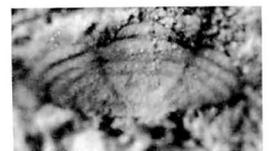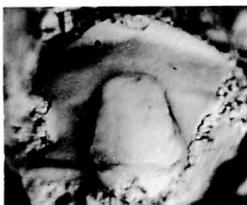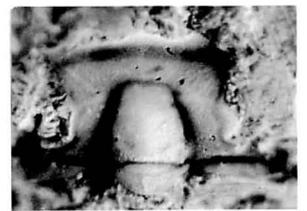
the posterior cephalic margin, and divided into two or more segments by well-defined furrows. The skeletal surface is minutely granulated.

In the morphogenesis of the present stage, the main features are the appearence of a narrow protopygidium, the glabella tapers forwardly, the posterior fixigenal border broadens, and the occipital ring is larger.

Early meraspid stage (Pl. 45, Figs. 11–15, 17 and Text-fig. 5G).—The cranidium is trapezoidal in outline, convex, about 0.75–1.25 mm in sagittal length; the glabella is bottle-shaped, expands posteriorly from the first glabellar furrow, and is distinctly delimited by dorsal furrows; the three pairs of glabellar furrows are complete; they are faint, shallow, and curve posterolaterally from the dorsal furrow; the occipital ring is convex both posteriorly and vertically, and well-defined by a broad occipital furrow, and bears a minute median node; the anterior border appears, either with or without a distinct frontal furrow; the fixigena is the same width as the glabella or slightly narrower, convex below the axis, and the narrow well-defined palpebral lobe is located in front of the mid-line of the cranidium (tr.); the broad posterior fixigena is triangular, with well defined posterior border which is convex, deeply delimited by a broad border furrow, and less narrow than the occipital ring (tr.); the skeletal surface is covered by minute granules.
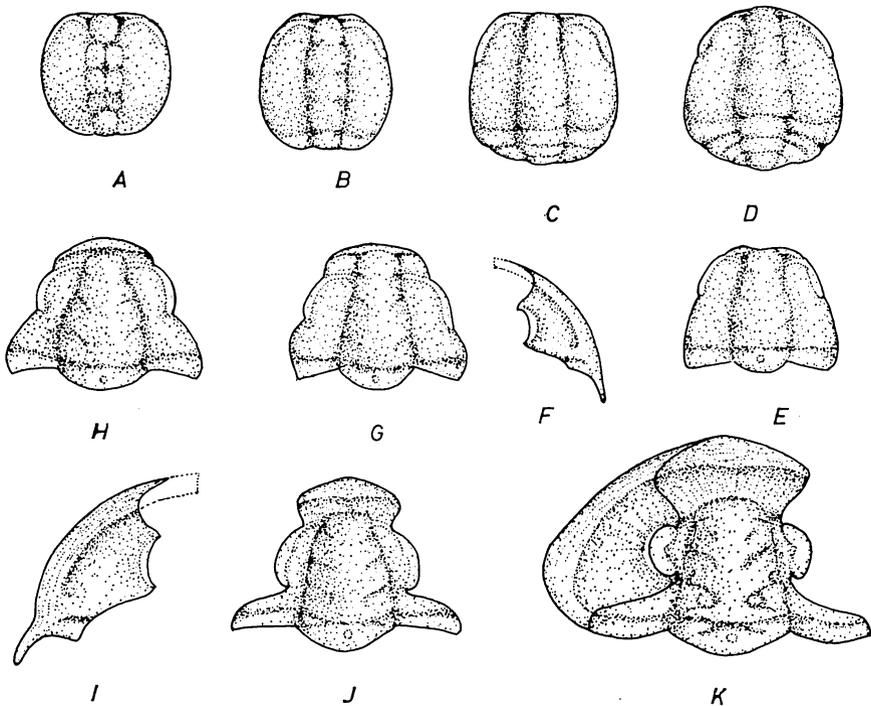
Text-fig. 5. *Housia ovata* PALMER. A, B, two metaprotaspides, ×41; C–E, three parapro-taspides, ×40, ×40, ×35; F, I, two immature librigenae, ×4; G, an early meraspid cranidium, ×22; H, J, two different sized late meraspid cranidia, ×18, ×10; K, an holaspid cranidium with restored librigena, ×3. (all drawings were made from photographs.)

The present stage is differentiated from the previous instars in that the anterior border appears, the palpebral lobe is located posterior to the anterior border, the width of the fixigena is the same as that of the glabella in small form, but becomes narrower in larger ones.

Late meraspid stage (Pl. 45, Figs. 18, 26–28 and Text-fig. 5H, J).—The late meraspid cranidium is elongate, trapezoidal in outline, convex, and has the conical glabella well-defined by dorsal furrows; the glabella tapers forward with three pairs of distinct glabellar furrows directed nearly horizontally (tr.); the occipital ring is crescentic, convex both vertically and posteriorly, and bears a minute median node; the occipital furrow is broad, distinct, and bifurcate laterally; the narrow preglabellar field is depressed in front of the glabella, and is connected to the distinct frontal furrow so as to form a median niche; the anterior border is narrowly crescentic with the median point projected both anteriorly and posteriorly, and convex; the narrow fixigena is

convex and has the large horizontal palpebral lobe located on or near the midline of the cranidium (tr.); the broad triangular posterior fixigena slopes downward from the dorsal furrow, narrower than the occipital ring (tr.), and has the posterior border well elevated from the broad border furrow; the anterior branch of the facial suture line is short, straight divergently convex; the posterior facial suture line is divergent laterally and convex. The skeletal surface is minutely granulated.

The skeletal development during the present stage sees the preglabellar field change from narrow to broad, the median depression which has been marked on the preglabellar field gradually disappears, the palpebral lobe moves backward from the anterior mid-transverse line to the mid-transverse line of the cranidium, and the fixigena and the posterior fixigenal area are both reduced in width.

The morphogenesis of librigena (Pl. 45, Figs. 10, 19, 32 and Text-fig. 5F, I, K) during the different stages sees the ocular

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Explanation of Plate 44

Figs. 1-31. *Aphelotoxon triangulata*, n. sp.

    1, 2, two anaprotaspid shield, showing the morphogenesis of the axial lobe. 1, ×52; 2, ×57; GMUC. 43417, 43417a.

    3-5, metaprotaspid shields, showing the slender fusiform glabella and the protopygidium. 3, ×53; 4, ×56; 5, ×50; GMUC. 43417b-d.

    6-10, paraprotaspides, showing morphogenesis of the protopygidium and the glabella. 6, ×42; 7, ×41; 8, ×42; 9, ×43; 10, ×42; GMUC. 43417e-g.

    11-19, several early meraspid cranidia, showing the presence of the anterior border and the complation of the glabella. 11, ×35; 12, ×45; 13, ×35; 14, ×24; GMUC. 43417j-m. 15, ×19; 16, ×26; 17, ×29; 18, ×28; 19, ×32; GMUC. 43417n-r.

    20, a nearly complete librigena. ×8, GMUC 43417d'.

    21-24, several late meraspid cranidia, showing the presence of the narrow preglabellar field. 21, ×20; 22, ×17; 23, ×21; 24, ×22; GMUC. 43417s-v.

    25-27, three nearly complete cranidia, showing the absence of the preglabellar field and broadens of the glabella. 25, ×21; 26, ×24; 27, ×21; GMUC. 43417w-y.

    28-31, a few small and large sized pygidia, showing the morphogenesis during their different growth stages. 28, ×12; 29, ×12; 30, ×8; 31, ×4; GMUC. 43417z, 43417a'-c'.
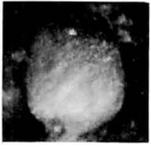
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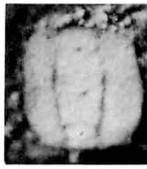
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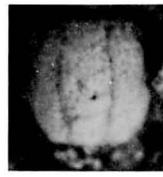
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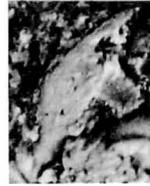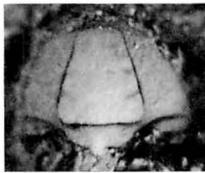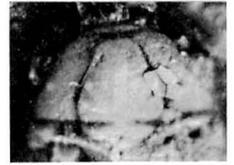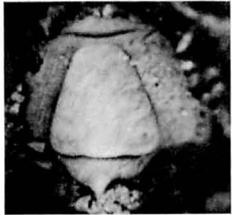
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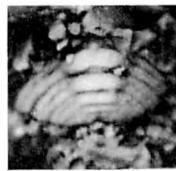
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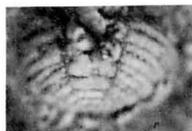
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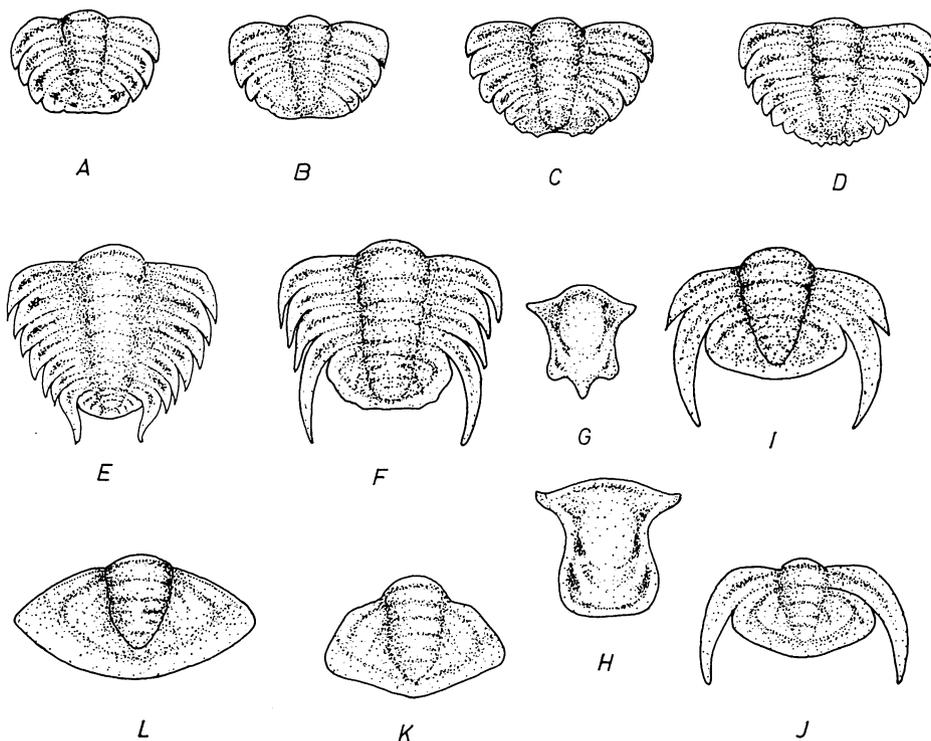
Text-fig. 6. *Housia ovata* PALMER. A–F, I, J, a growth sequence of pygidia, showing the thoracic segments and the pygidial morphogenesis, A, ×34, B–E, ×30; F, ×23; I, ×13; J, ×10; G, H, an immature and mature hypostomata, ×8, ×3; L, K, two different sized holaspid pygidia, ×9, ×15. (drawings were made from photographs.)

platform increase in width, the occular ring becomes shifted from the anterior to the posterior free margin—the facial suture line, the genal spine is reduced from long to short, and eventually disappears.

The morphogensis of the hypostoma (Pl. 45, Fig. 16 and Text-fig. 6H, G) during its different growth stages sees the median body increase in width, the lateral marginal spine is absent, the U-shaped posterior area increases in width and convexity, and the median posterior projection disappears.

The growth of the pygidium (Pl. 45, Figs. 20–25, 29, 30, 33 and Text-fig. 6A–F, I–L) is as follows: the holaspid pygidium is transversely semicircular to subround in outline, convex, and has 4 to 5 axial rings and a terminal portion; the plerual lobe is broader than the axis, without a distinct pleural furrow or interpleural grooves; the marginal border is broad and becomes concave, and is well defined by an inner marginal furrow. The smallest pygidium (Figs. 20, 21) is round and has 6 or more free thoracic segments and an ankylosed pygidial plate; the last thoracic segment which lies in front of the pygidium is the largest one and bears a pair of long caudal spines, which are directed posteriorly. The thoracic segments are well impressed by interpleural grooves and each ends in a pair of short

spines; the pygidial plate lying between the caudal spines is small, and consists of 2 to 5 ankylosed segments; the marginal border is narrow.

The morphogenetic sequence of the pygidium the anterior margin of the rudimentary pygidium gives up the thoracic segments, and simultaneously the posterior margin of the pygidium gains a pygidial segment; lastly the pygidial segments ankylose to complete a holaspid pygidium; the holaspid pygidium may also be modified by a broadening of the pygidial margin, by increase in pygidial size, and the reduction of the free thoracic segments.

Remarks.—The morphology of the late meraspides of the present species is closely similar to that of the genera *Crepicephalus* (i. e., *C. deadwoodensis* HU, 1971) and *Coosia* (i. e., *Coosia longocula* PALMER, 1965). This might suggest that the genus *Housia* possibly evolved from the coosiid group.

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Explanation of Plate 45

Figs. 1-34. *Housia ovata* PALMER

    1-4, four complete metaprotaspides, showing the well preserved glabellar lobes and the complation of the glabellar segments. ×41; GMUC. 43418, 43418a-c.

    5-9, a few paraprotadpides, showing the presence of the protopygidium. 5, 6, ×40, GMUC. 43418d, e ; 7-9, ×35, GMUC. 43418f-h.

    10, 19, 32, three different sized librigenae, showing the reduction of the librigenal spine. 10, 19, ×4; GMUC. 43418i, s; 32, ×3; GMUC. 43418g'.

    11-15, 17, several early meraspid cranidia. 11, ×23; 12, ×25; 13, ×21; 14, ×22; 15, ×15; 17, ×19. GMUC. 43418k-n, p.

    16, a broken hypostoma. ×7, GMUC. 43418o.

    18, 26-28, four late meraspid cranidia, showing the presence of the preglabellar field and the narrowing of the fixigena. 18, ×18; 26, ×13; 27, ×10; 28, ×10; GMUC. 43418q, z, a', c'.

    20-25, 29, a growth sequence of the pygidium, showing the presence of the thoracic segments during their different growth stages. 20, ×34; 21, ×34; 22, ×20; 23, ×22; 24, ×15; 25, ×13; 29, ×15; GMUC 43418t-y, d'.

    30, 33, two nearly complete holaspid pygidia. 30, ×9; 33, ×2.5; GMUC. 43418e', h'.

    31, 34, two nearly complete cranidia. ×3.5; ×4; GMUC. 43418f', i'.

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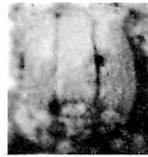
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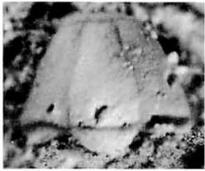
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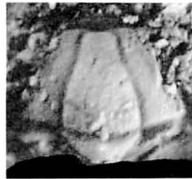
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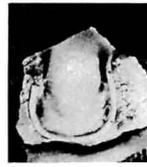
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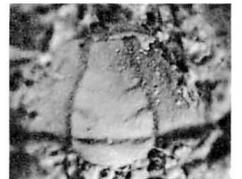
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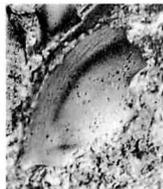
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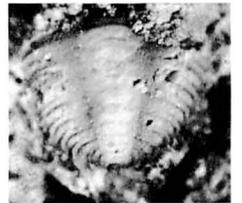
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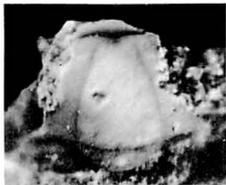
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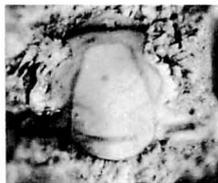
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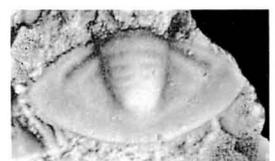
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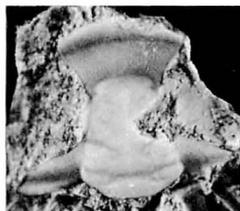
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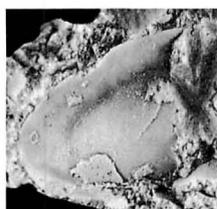
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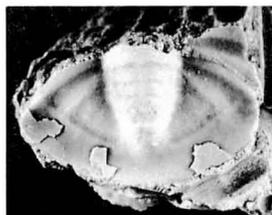
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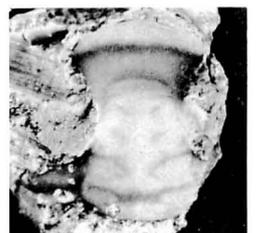
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　南ダコタ Deadwood 層産若干のカンブリア紀後期三葉虫の個体発生：本報告においては，三葉虫3種，アグノスタス類2種の個体発生を図示記載する。すなわち，前者は *Aphelotoxon triangulata*, n. sp., *Pulchricapitus davisi* KURTZ, *Housia ovata* PALMER であり，後者は *Pseudagnostus communis* (HALL and WHITFIELD) および *Homagnostus tumidosus* (HALL and WHITFIELD) である。これらの材料はすべて南ダコタ州のカンブリア紀後期の Deadwood 層 *Elvinia* 帯から得られたものであるが，前3者については比較的良く研究されたものの，後2者に関してはやゝ不完全である。研究の結果，*Aphelotoxon triangulata* の系統発生が *Ponumia*, *Housia* ならびに *Cliffia* 各属に，また *Palchricapitus davisi* のそれが *Coosina* および *Wilsonella* 属に近縁であることが明らかとなった。*Housia ovata* の後期幼生はおそらくクーセラ類のあるもの—例えば *Coosia longocula* PALMER あるいは *Coosella convexa* TASCH など—から放散，由来したものと考えられる。　　　　　　　　胡忠恒

721. A NEW SPECIES OF *INOCERAMUS* (BIVALVIA) FROM THE UPPER CRETACEOUS OF HOKKAIDO*

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Abstract. In this paper a peculiar new species of *Inoceramus* is described on a set of specimens from the lower part of the Middle Turonian of the Obira area, northwestern Hokkaido. It belongs to the group of *I.* (*I.*) *lamarcki* PARKINSON and is somewhat allied to *I.* (*I.*) *paralamarcki* EFREMOVA, from the Ust. Yenisei depression (USSR), but is distinguished by its extremely high outline, extraordinary convexity, well developed and somewhat convex posterior wing and less inequivalveness.

The occurrence of this kind of inoceramid species is rather unusual in the Upper Cretaceous of Japan and its palaeobiogeographical and evolutionary implications are discussed in an Appendix by MATSUMOTO and NODA.

Introduction

In the course of restudying inoceramids from the Cretaceous of Japan, which one of us (M. N.) is undertaking, sometimes with T. MATSUMOTO or others, it is noticed that there occur occasionally several species which have been little known from the Japanese province. In this paper one of them is described under a new specific name.

This unexpected discovery came from our fossil hunting in the Obira area on August 10th, 1977, when only two valves of probably a single individual were obtained. Having been encouraged by Prof. T. MATSUMOTO, we reinvestigated there again in the summer of 1979,

* Received May 15, 1980; read Oct. 14, 1978 at Yamagata.

getting a few more specimens. One of us (K. M.) further continued the field work, with a result to obtain still more. These are the basic material of the present study. The holotype is registrated at Kyushu University (GK) and others at Mikasa Museum (MC).

As the specimens are very peculiar as compared with the better known species which occur commonly in the Upper Cretaceous of Japan, a biometric examination is added for careful comparison with the species home and abroad.

After the palaeontological description, some remarks are given on the phylogenetic relations and palaeobiogeographic implications as an appendix.

In this study NODA is mainly responsible for the palaeontological description, but as MURAMOTO has much co-operated in the field and laboratory works, the co-

authorship is taken.

Before going further, we thank Emeritus Professor Tatsuro MATSUMOTO of Kyushu University for his cordial help and advice, including critical reading of the first draft. We are indebted to Mr. Kinichi KAMIZUMA and Mrs. Tomiko SUGAWARA for their help in the field work.

Furthermore, one of us (M. N.) is indebted to Prof. MATSUMOTO who has co-operated in the discussions of the phylogeny and palaeobiogeography.

Notes on Stratigraphy

The Obira area in northwestern Hokkaido is famous for the well exposed Cretaceous sequences and occurrence of well preserved fossils. Aside from the classical works of JIMBO (1894) and YABE (1909), the

Cretaceous stratigraphy of this area has been recently described by TANAKA (1963), MATSUMOTO et al. (1976-issued 1978) and TANABE et al. (1977) among others, with lists of fossils from the subdivided units. Geological maps by TSUSHIMA et al. (1958) and IGI et al. (1958) are also available.

The present discovery of a new species happened to come from our hunting of fossils in the Zone of *Inoceramus (I.) hobetsensis* (Middle Turonian).

Four localities grouped into two are concerned with the basic material. Their locations are indicated in the route maps of Text-figs. 1 and 2 and also recorded as follows:

(1) Loc. Ob1010 : Osarunaidake Quad. (Topographic Map 1 : 25000). Long. 142°0′22″E, Lat. 44°03′49″N. 108 Rinpan-no-sawa, about 400 m upperstream from the confluence with
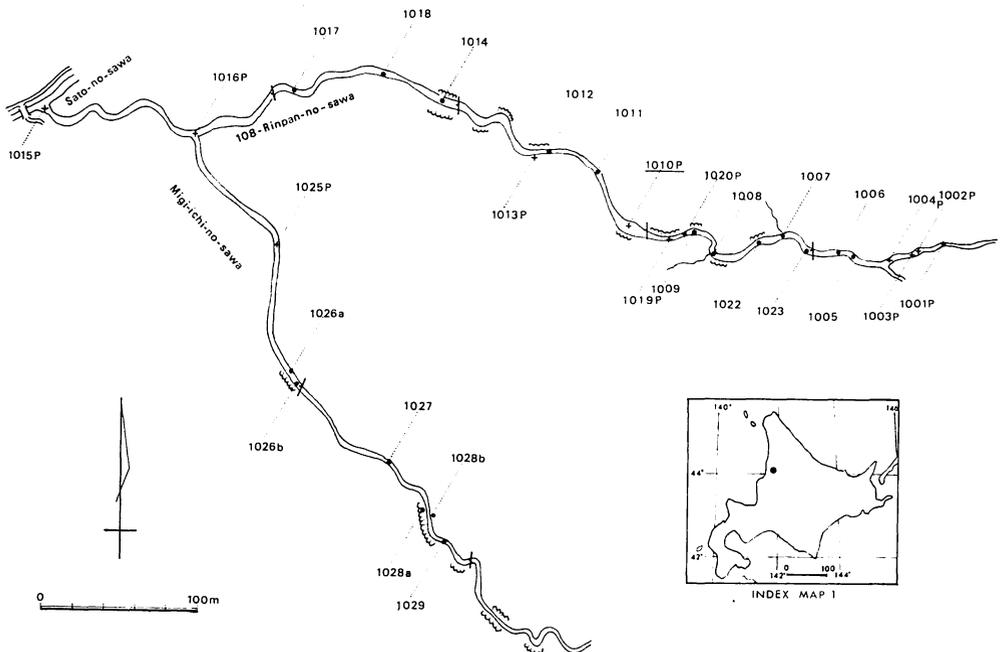
Text-fig. 1. Locality map of *Inoceramus (Inoceramus) obiraensis* n. sp. (108 Rinpan-no-sawa). For the index map refer together with that of the Text-fig. 2.
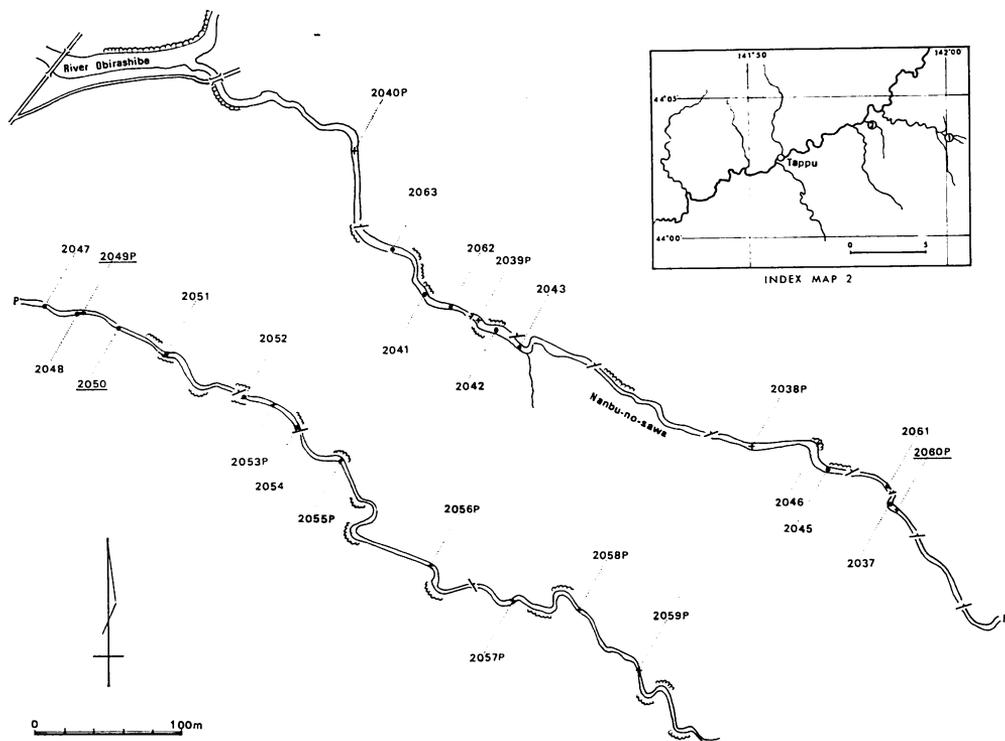
Text-fig. 2. Locality map of *Inoceramus* (*Inoceramus*) *obiraensis* n. sp. (Nanbu-no-sawa). For the index map refer together with that of the Text-fig. 1.

Sato-no-sawa, a branch of Kamikinenbetsu-zawa, a tributary of the River Obirashibe, administratively in Kamikinenbetsu, Obira-Machi, Rumoi-gun, Hokkaido.

(2a) Loc. Ob2049: Takishita Quad. (Topographic Map 1 : 25000). Long. 141°56′39″E, Lat. 44°03′49″N. Nanbu-no-sawa, a tributary of the River Obirashibe, about 800 m upward from the confluence with the main stream of the Obira, along the course of stream.

(2b) Loc. Ob2050: Takishita Quad. (Topographic Map 1 : 25000). Long. 141°56′41″E, Lat. 44°03′49″N. Nanbu-no-sawa, about 50 m upperstream of Loc. Ob2040.

(2c) Loc. Ob2060: Takishita Quad. (Topographic Map 1 : 25000). Long. 141°56′32″E, Lat. 44°03′54″N. Nanbu-no-sawa, about 150 m downstream from Loc. Ob2049.

As has been described by aforementioned previous authors these localities are within the area of the Middle Yezo Group. This group in the Obira area is subdivided into 15 units, from Ma to Mo in ascending order.

(1) Loc. Ob1010 is situated within Unit Mj in the published geological map of TANAKA (1963, map 1), but according to MATSUMOTO (personal comm.), who investigated there with K. MURAMOTO on other days, there is a thrust at some distance on the west side of the locality, by which Unit Mk seems to reappear there. Unit Mk is characterized by the common occurrence of an inoceramid, which is temporarily called *I.* (*I.*) aff. *hobetsensis* *nonsulcatus* NAGAO et

MATSUMOTO, and *Eubostrychoceras japonicum* (YABE) (emended by MATSU-MOTO, 1977) and other heteromorph ammonoids. Lithologically clay is predominant in Mj, whereas sandy siltstone is so in Mk. It is highly possible that the inoceramid specimens obtained at Ob1010 came from Unit Mk, and accordingly lower part of the "Middle Turonian" [K4b$_2$ of MATSUMOTO, 1980 in press] on the Japanese scale.

(2) Locs. Ob2049, Ob2050 and Ob2060 are in the limited part of the lower course of the Nanbu-no-sawa, a tributary of the River Obirashibe, which Unit Mk, Ml and Mm are indicated in the pubished geological map of TANAKA (1963, map 1). Loc. Ob2050 is certainly within Unit Mk, but nodules at Locs. Ob2049 and Ob2060 are floats derived from some exposures in the upstream and their stratigraphic assignment to Unit Mk is presumed from the associated *I.* aff. *hobetsensis non-sulcatus* as well as their somewhat downstream position as compare with Loc. Ob2050.

Method of Examination

The basic morphology for measurements is shown in Text-fig. 3.

Calipers of JIS standard, 200 mm in
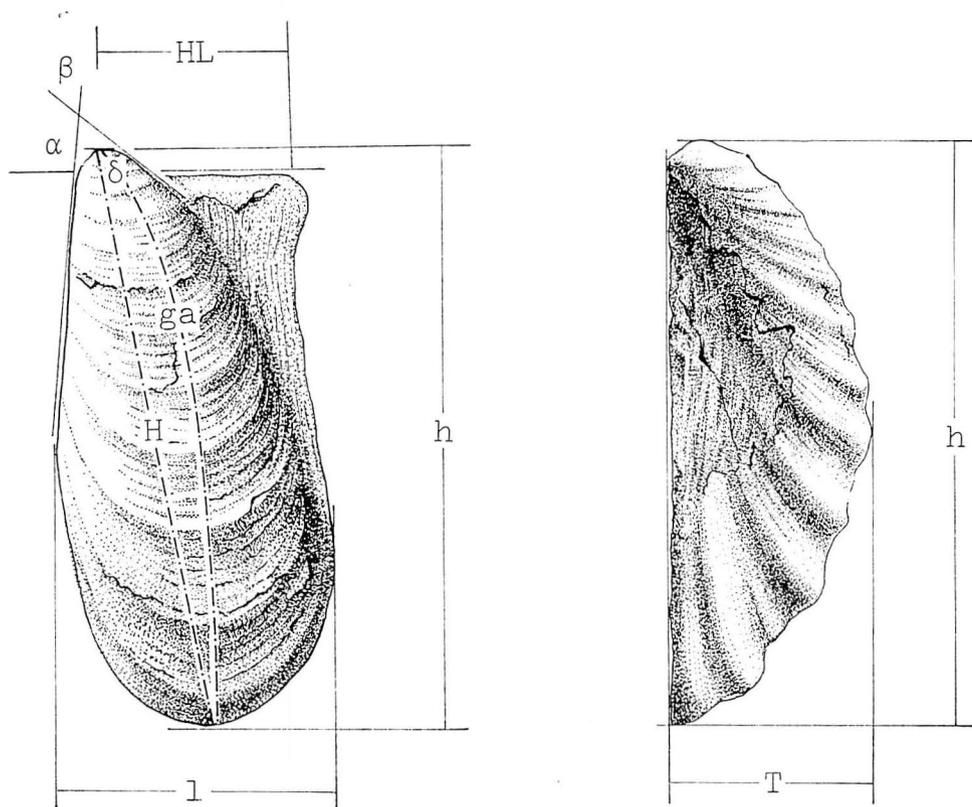
Text-fig. 3. Basic morphology for measurements. l: shell length, h: shell height, HL: hinge-line, T: thickness, ga: growth axis, H: maximum dimension from umbo to ventral extremity, α: angle between anterior margin and hinge-line, β: beak angle, δ: obliquity—angle between hinge-line and H, or at a certain growth stage of ga.

measurable extent and 1/20 mm in accuracy, and contact goniometer were used for measurements of length and angle respectively. A flexible gauge was applied for measurements of the vertical and cross sections of ontogeny. Measurements are made three times for the same part, and the mean values are shown.

The process of the numerical analyses and calculations are omitted. For details readers may refer to HAYAMI (1969), and HAYAMI and MATSUKUMA (1971).

Palaeontological Description

Family Inoceramidae GIEBEL, 1852

Genus *Inoceramus* SOWERBY, 1814

Subgenus *Inoceramus* SOWERBY, 1814

Inoceramus (Inoceramus) obiraensis
NODA et MURAMOTO, sp. nov.

Pls. 46–49

Material.—Holotype. GK. H10107, separate valves of a single individual, which must have been articulated originally, from Loc. Ob1010, probably Unit Mk of the Middle Yezo Group (obtained by M. NODA and K. MURAMOTO, 1977). Paratypes. MC540827, left valve from Loc. Ob2049: presumably middle or upper part of Unit Mk (obtained by K. MURAMOTO, 1979), MC540728, right valve from Loc. Ob2050: middle part of Unit Mk (obtained by joint field work of M. NODA, K. MURAMOTO, K. KAMIZUMA and T. SUGAWARA, 1979) and MC540729, left valve from Loc. Ob2060, middle or upper part of Unit Mk of the same group (obtained by M. NODA, K. MURAMOTO, K. KAMIZUMA and T. SUGAWARA, 1979).

Diagnosis.—Shell of medium size, inequivalve, extremely strongly convex antero-posteriorly and also dorso-ventrally.

Umbo terminal, less conspicuous, projected beyond the hinge-line, and curved inwards and a little forwards. Anterior side very broad and concave to the valve plane, posterior one also steep or truncated and demarcated clearly from the posterior wing, which is considerably wide and inflated dorso-ventrally. Right valve less convex than left, but its wing is more inflated than that of left valve. Anterior margin straight or slightly concave, antero-ventral one broadly round, ventral margin narrowly rounded, passing into broadly arcuate postero-dorsal margin. Hinge-line somewhat shorter than two thirds of shell length.

Surface ornamented with concentric ribs and rings in combination. The concentric ribs coarse, round-topped, regular in strength and size in the middle stage, then becoming irregular and separated by somewhat wider and concave interspaces. The concentric rings cover the ribs and interspaces. The ribs much weakened on the anterior part and also on the posterior wing where only concentric rings are discernible. Hinge-structure unknown.

Measurements.—See Table 1.

Ontogeny.—The individual relative growth of the holotype is examined separately for the left and the right valves. The three variables, height (h), length (l), and thickness (T) of each valve are examined.

Plotting l and T in the ordinate and h in the abscissa on logarithmic graph paper, and the reduced major axes are calculated (for the calculation refer to HAYAMI and MATSUKUMA, 1971). The relative growth of l and h, and l and T are shown in Text-fig. 4. For comparison, those of *I. (I.) hobetsensis nonsulcatus* collected from the same area are shown.

The ontogenetic changes of characters are also illustrated in Text-figs. 5A, B

Table 1. Measurements. linear dimension in mm.

Specimen	1	h	T	H L	β	$\delta_{H=60\,mm}$
GK.H10107 RV	73.3+	137.7	58.0	44.5+	72	80
GK.H10107 LV	59.1+	107.3+	64.6	—	68	86
MC540728 RV	39.4	65.5	26.9	24.6	74	82
MC540729 LV	31.9+	60.0	25.4	—	59	—
MC540827 LV	—	100.3	47.2	—	64	—

Specimen	1/h	1/h=60 mm	T/h	HL/h	h/1	T/1	HL/1
GK.H10107 RV	0.53+	0.76	0.42	0.32+	1.88−	0.79−	0.61
GK.H10107 LV	0.55	0.64	0.60−	—	1.82	1.09−	—
MC540728 RV	0.60	0.64	0.41	0.38	1.73	0.68	0.62
MC540729 LV	0.53+	0.53+	0.42	—	1.88−	0.80−	—
MC540827 LV	—	—	0.47	—	—	—	—

reference.   1: shell length. h: shell height.   T: thickness. HL: hinge-line. β: beak angle. $\delta_{H=60\,mm}$: angle between hinge-line and H, at a growth stage of 60 mm in H. GK: specimens of Kyushu University. MC: specimens of Mikasa Museum. LV: left valve. RV: right valve.

and 6A, B. As are clearly shown in Text-figs. 4 and 6, in the juvenile stages the specimens closely resemble those of *I. (I.) hobetsuensis nonsulcatus* but are much more inflated antero-posteriorly and also along the growth axis, and considerably elongate along the growth axis.

Descriptive remarks.—In the holotype, a portion of the posterior wing is eroded out at the marginal part, thus the simple ratios of 1/h and HL/h of each valve may be slightly larger than the value shown in Table 1. The left valve of the holotype is also somewhat eroded out from the flank to the venter and the hinge part, the values of T/h and T/1, therefore, may be somewhat smaller than those shown in Table 1. MC540729 is deficient in the posterior half and hinge part and MC540827 is so at the umbo and wing. The test, which remained on MC540728

and MC540827, is fairly thick near the umbo, where the surface sculpture is precisely observed. On the surface of the internal mould, faint radial striae are discernible in the anterior part, where concentric ornaments disappear. The beak angle and the shell convexity vary among individuals. For example, MC540827 has much stronger convexity than other specimens, although it is impossible to express numerically.

Comparison

I. (I.) lamarcki PARKINSON, a widespread species of the Middle to Upper Turonian, is considerably variable in outline and shell convexity (WOODS, 1912a; TRÖGER, 1967). Some specimens of that species somewhat resemble the present specimens in the elongate outline along the growth
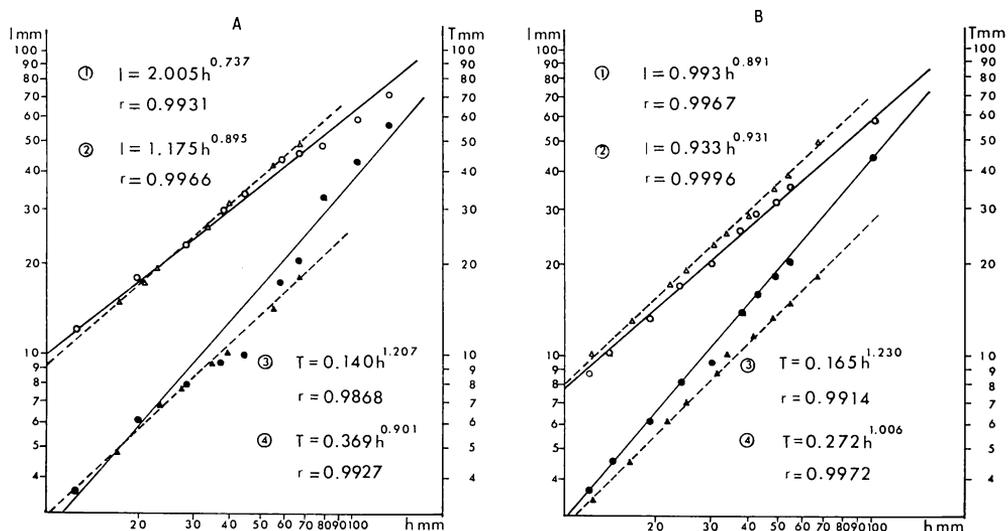
Text-fig. 4. Diagram showing the individual relative growth. A: right valve, B: left valve
1, 3: *I. (I.) obiraensis*, solid line, 2, 4: *I. (I.) hobetsensis nonsulcatus*, broken line.
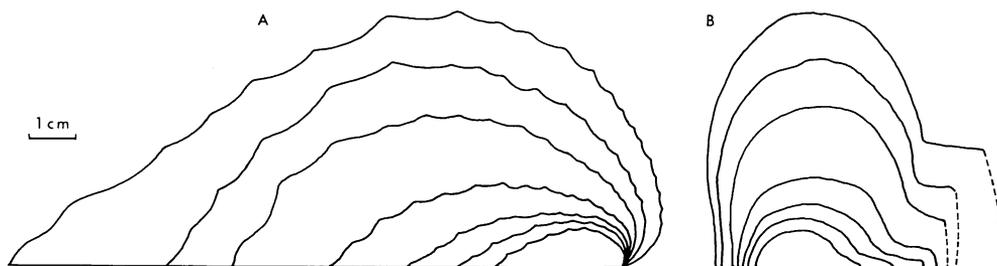
Text-fig. 5. Ontogenetic change of shell convexity. A: anterior view, B: dorsal view.

axis and well developed wing. Judging from the illustrations and a plaster cast (GK. H9586) of WOODS (1912a, pl. 213, fig. 66, BM4753; 1912b, p. 8, figs. 34-36), a well inflated specimen has a smaller proportion of h/l, and other specimens with an elongate form are highly inequivalve. Our specimens are still more elongated and more convex and less inequivalve than any illustrated examples of *I. (I.) lamarcki*. TRÖGER (1967) examined biometrically some characters of *I. (I.) lamarcki* *lamarcki* from the Middle Turonian of Sachsen and Harzvorland, East Germany, showing them in p. 189, text-fig. 16a, b, for the left and the right valves respectively. As is clear from Text-fig. 6a, the ontogenetic change of the simple ratio l/h of the holotype of our species agrees well with that of *I. (I.) lamarcki lamarcki* var. I in the right valve, but never in the left valve. TRÖGER did not demonstrate the ontogenetic change of T/h, which should be more effective to
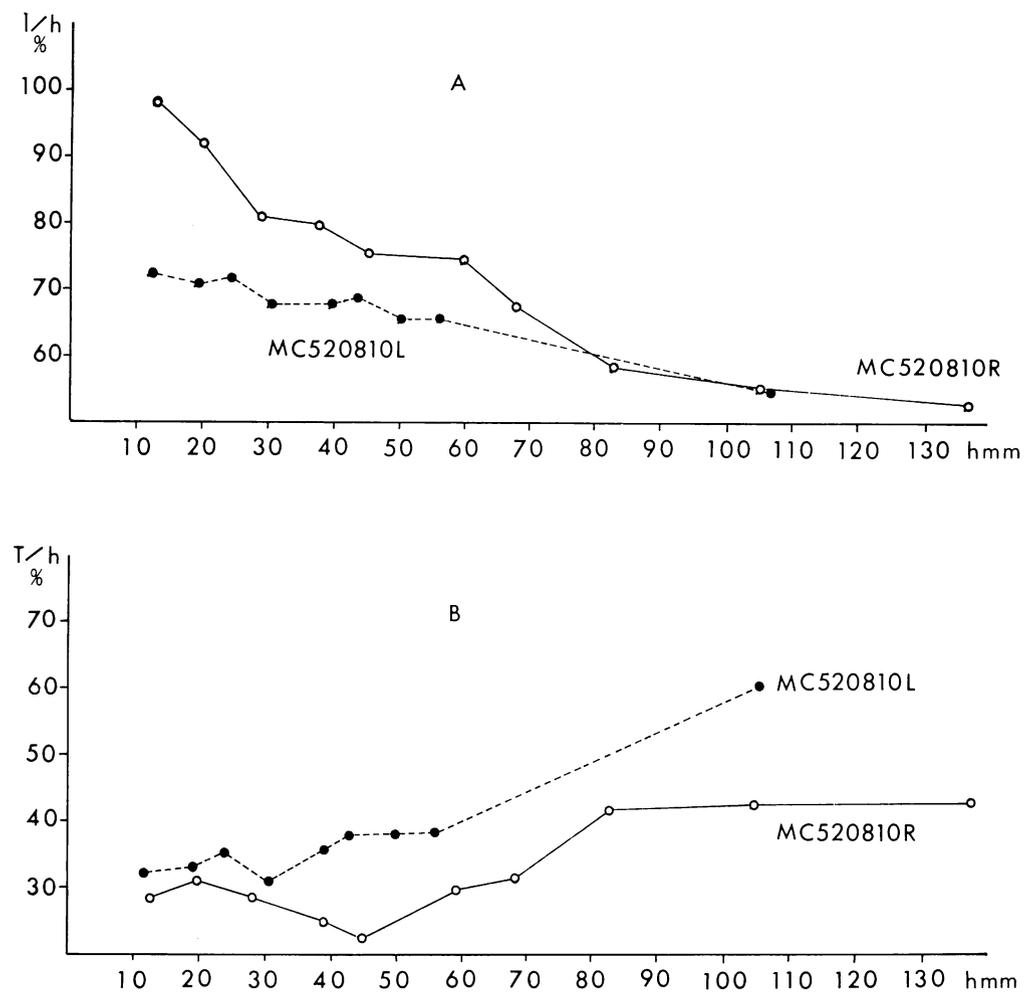
Text-fig. 6A. Diagram showing the ontogenetic change of simple ratio l/h.   6B. Diagram showing the ontogenetic change of simple ratio T/h.

compare the two species. The shell convexity of the TRÖGER's specimens is also considerably strong in both valves, so far as his illustration (p. 61, fig. 16) is concerned.

As has been kindly suggested by MATSUMOTO (personal comm.), the holotype of *I. (I.) paralamarcki* EFREMOVA (1978, p. 82, pl. 1, fig. 1), from the lower part of the Nasonovsk Formation (Zone of *I.*

lamarcki) of the Ust-Yenisei depression, resembles the present species in obliquity, shell convexity and sharply demarcated posterior wing. But the former is discriminated from the latter in its more remarkable inequivalveness, smaller proportion of h/l, shorter and less inflated wing and much weaker concentric ornamentation.

As has been also suggested by MATSU-

MOTO (personal comm.), *I.* (*I.*) *najdini* IVANNIKOV (1979) from the Upper Turonian of the Donets Basin looks similar to the present species, so far as his photograph (IVANNIKOV, 1979, pl. 21, figs. 2, 3) is observed, but distinct from the latter in the equivalve shell, smaller proportions of T/l and h/l and also a smaller triangular wing.

Appendix

Notes on Phylogeny and Palaeobiogeography

by

Tatsuro MATSUMOTO* and

Masayuki NODA

To evalute the present discovery of a peculiar *Inoceramus* species of the *lamarcki* group from the Turonian of Hokkaido, let us discuss the phylogeny and palaeobiogeography on the basis of the available data.

The present species occurred in association with an undescribed form which is provisionally called *Inoceramus (Inoceramus)* aff. *hobetsensis nonsulcatus* and they agree well in shell-form and ornamentation in their early growth stage. This suggests some phylogenetic relation between them, but we found no transitional form which could link the two species in Hokkaido. The stratigraphic

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position of these species is in a relatively lower part of K4b$_2$ of the Japanese scale (MATSUMOTO, 1977), i.e. the lower part of the Zone of *Inoceramus hobetsensis*. This zone is correlated with the Middle Turonian in terms of the international scale, because it contains *Collignoniceras woollgari* (MANTELL). Strictly speaking, however, the boundary of the Lower and the Middle Turonian is not yet precisely defined even in France and England (see HANCOCK et al., 1977). Be that as it may, the origin of the present species is more reasonably ascribed to the migration from elsewhere than to the sympatric speciation within Hokkaido.

Turning to the regions outside the Japanese province, we notice *I.* (*I.*) *paralamarcki* EFREMOVA, from the Nasonovsk Formation of the Ust-Yenisei depression, as one of the closely allied species to ours. In the same formation of the Ust-Yenisei depression that species is associated with *I.* (*I.*) *pogrebovi* EFREMOVA, *I.* (*I.*) *schulginoae* EFREMOVA and *I.* (*I.*) *kolokolcevoae* EFREMOVA. These species are all ascribed to the group of *I.* (*I.*) *lamarcki* and occur in the Zone of *Inoceramus lamarcki*, that is "Upper Turonian" of her concept (EFREMOVA, 1978), which may include the Middle Turonian of others.

I. (*I.*) *pogrebovi* among others, looks similar to *I.* (*I.*) *hobetsensis nonsulcatus* in outline and surface ornamentation. In her paper, however, the right umbo is described as being more projected beyond the hinge-line than the left. This seems

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Explanation of Plate 46

Fig. la-c. *Inoceramus (Inoceramus) obiraensis* n. sp. natural size. Holotype, rg. GK.H10107, right valve. Loc. Ob1010, 108 Rinpan-no-sawa, Kamikinenbetsu, Obira machi, Rumoi gun, Hokkaido. Str. position: middle part of the Unit Mk of the Middle Yezo Group. (coll. M. NODA and K. MURAMOTO, 1977). a: lateral view, b: anterior view, c: dorsal view.

1a

1b

1c

exceptional for the normal inoceramids: otherwise the valves may have been displaced secondarily along the valve plane. *I. (I.) kolokolcevoae* is characterized by a very long hinge-line (as long as the shell length) and an extremely large posterior wing. A similar form is occasionally found as a variety of an associate form of *I. (I.) hobetsensis* (s. l.) from Unit Mk of the Obira area. In short, it is interesting to note that the assemblage of the above species in the Nasonovsk Formation is in harmony with that of *I. (I.) obiraensis*, *I. (I.)* aff. *hobetsensis nonsulcatus* and *I. (I.) hobetsensis* (s. l.) in Unit Mk of the Obira area.

The group of *Inoceramus lamarcki* is defined typically by TRÖGER (1967). We follow him, but take the group in a broad sense, in which both the sulcate and non-sulcate forms are included. We do not regard the sulcate species as a single lineage (e. g., *I. lamarcki* lineage of KAUFFMAN, 1977, p. 177), but sulcate forms developed probably from nonsulcate ones in several parallel lineages of the *lamarcki* group (s. l.).

Now, going westward, MOSKVINA (1959) recorded *I. (I.) seitzi* from the "Upper Turonian" (upper half of Turonian, probably including the Middle Turonian) of the northern Caucasus. It resembles *I. (I.) obiraensis* in the degree of inequivalveness, elongate outline, strongly involved umbo and broad anterior part, but differs in its less convexity and smaller triangular posterior wing. TRÖGER (1967, p. 60) did not identify it with true *I. (I.) seitzi* ANDERT (1934), from the "Oberturon α'β'", that is basal Coniacian, of central Europe, but has assigned it to *I. (I.) lamarcki lamarcki* with a query.

I. (I.) najdini IVANNIKOV, from the "Upper Turonian" of the Donets Basin, Ukraine, is somewhat similar to *I. (I.) obiraensis*, as has been discussed in the

preceding page. In "Turkestan" of the USSR central Asia, ARCHANGUELSKY (1916, p. 16, pl. 2, figs. 4-6; pl. 3, fig. 1) described two forms of the *lamarcki* group, one of which (1916, pl. 2, fig. 6) is seemingly similar to *I. (I.) obiraensis*, but the precise comparison is difficult because of the deficiency of its posterior wing and the absence of the right valve.

On the material from central Europe, TRÖGER (1967) discriminated three subspecies and two varieties of *I. (I.) lamarcki*, that is *I. (I.) lamarcki lamarcki* var. I, *I. (I.) lamarcki lamarcki* var. II, *I. (I.) lamarcki geinitzi* TRÖGER and *I. (I.) lamarcki stümckei* HEINZ. As to the phylogenetic relations, TRÖGER (1967, p. 134; 1976) remarked that the lineage would be *I. (I.) lamarcki* var. I—var. II—*I. (I.) lamarcki stümckei*, which were decreasing gradually in shell convexity. He has shown that these subspecies occur successively one after another with considerable overlapping.

As to the British Middle to Upper Turonian species of the *lamarcki* group (s. l.), KAUFFMAN (1978) preliminarily reported the ascending succession as follows: (1) *I. (I.) cuvieri cuvieri* SOWERBY, (2) *I. (I.) cuvieri* subsp. nov, (3) *I. (I.) flaccidus* WHITE with early *I. (I.) lamarcki*, (4) *I. (I.) costellatus* WOODS with early *I. (I.) lamarcki* (s. l.) and early *I. apicalis* WOODS and (5) *I. (I.) lamarcki* "plexus" with *I. apicalis*. No species comparable with *I. (I.) obiraensis* is known in this area.

In the Turonian of the North American Interior province, there are several species belonging to the *lamarcki* group, such as *I. (I.) flaccidus* and "*I. (I.) sp. nov. aff. I. (I.) flaccidus* and *I. (I.) lamarcki*" (KAUFFMAN, 1977b, pl. 8, figs. 11, 16). *I. (I.) flaccidus* resembles in some respects *I. (I.) hobetsensis hobetsensis*, as NAGAO and MATSUMOTO (1939, p. 285) and MATSU-

MOTO (1959, p. 85) have already pointed out and more recently KAUFFMAN (1977, p. 177) has remarked. We have noticed, however, no species among the described ones from this province which is closely allied to *I. (I.) obiraensis*.

One of us (MATSUMOTO, 1978) has shown a reconstructed palaeogeographic map of the world for the Early Turonian, showing the distribution of certain vascoceratid ammonites of the Tethyan affinity. In this paper, we show in Text-fig. 7 a tentative palaeogeographic map of the world for the Middle to Late Turonian. As compared with the Early Turonian, the epicontinental seas retreated extensively from various areas in the Middle to Upper Turonian time and the tropical Tethys Sea became narrower and less continuous. Probably for this and other reasons the ammonites of the Tissotiidae, Coilopoceratidae and other Tethys Sea elements are almost absent in the Japanese province. The inoceramids show also a remarkable change. For instance, world wide species of the *Mytiloides labiatus* group occur fairly commonly in the Lower Turonian of Japan, whereas an apparently endemic *Mytiloides teraokai* MATSUMOTO et NODA remained as a descendant in the Middle Turonian. *Inoceramus* species of the *lamarcki* group, such as *I. (I.) hobetsensis* (s. l.) and *I. (I.) iburiensis* NAGAO et MATSUMOTO, occur extensively and

abundantly in the Middle Turonian of the Japanese province and its extension. A possible ancestor of *I. (I.) hobetsensis* or that of *I. (I.) aff. hobetsensis* has not yet been found from the Lower Turonian of Japan.

In Text-fig. 7, we show the main areas where the species of the *I. (I.) lamarcki* group have been reported with clear records. As is evident from this map, their distribution is limited to the North Temperate Realm (as defined by KAUFF-MAN, 1973). In that realm the North European Province (1a in Text-fig. 7) is extended eastward to the North Central Asia Subprovince (1b) and the West Siberia Province (4) should better be defined to include the Ust-Yenisei depression. The latter province has already been indicated by TRÖGER (1976a) as a representative of the Boreal Realm in his Early Turonian faunal palaeogeographic map. In the North Temperate Realm, the North American Interior Province (2) and the North Pacific Province (3) are also included, the latter of which are subdivided into the Northeast Pacific (3a) and the Japanese-East Asian (3b) subprovinces.

As KAUFFMAN (1973) has generally stated, some of the species in the North Temperate Realm may suggest possible migration routes and patterns. It can be presumed that the group of *I. (I.) lamarcki*

Explanation of Plate 47

Fig. 1a-c.   *Inoceramus (Inoceramus) obiraensis* n. sp. natural size.   Holotype, rg. GK.H10107, left valve.   Loc. Ob1010, 108 Rinpan-no-sawa, Kamikinenbetsu, Obira machi, Rumoi gun, Hokkaido. Str. position: middle part of the Unit Mj of the Middle Yezo Group (coll. M. NODA and K. MURAMOTO, 1977).   a: lateral view, b: anterior view, c: dorsal view.

Fig. 2a-c.   *Inoceramus (Inoceramus) obiraensis* n. sp. natural size. Paratype, rg. MC540827, left valve.   Loc. Ob2049, Nanbu-no-sawa, Obira machi, Rumoi gun, Hokkaido.   Str. Position: middle to upper part of the Unit Mk of the Middle Yezo Group (coll. K. MURAMOTO, 1979). a: lateral view, b: anterior view, c: dorsal view.

1a

1b

1c

2a

2b

2c
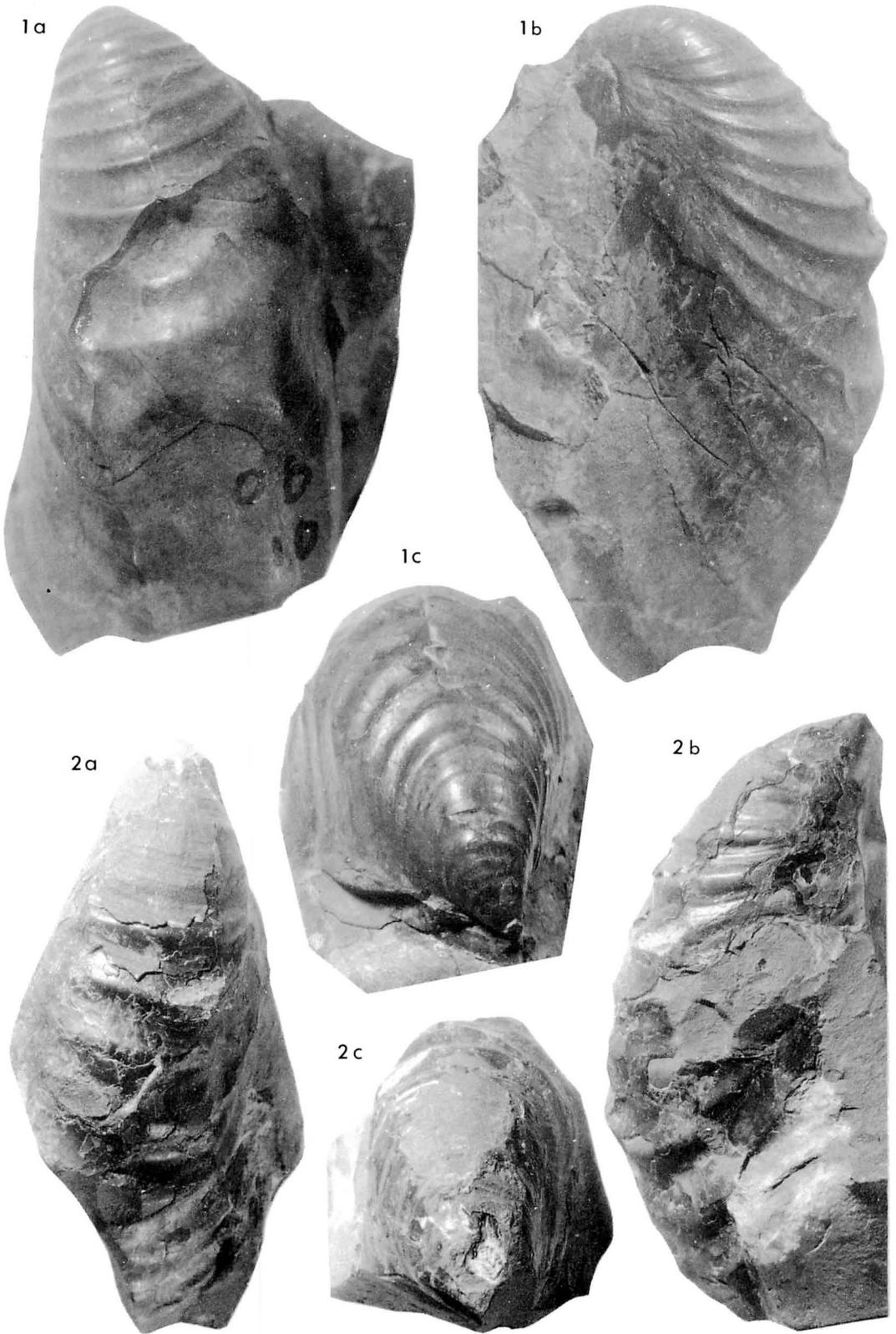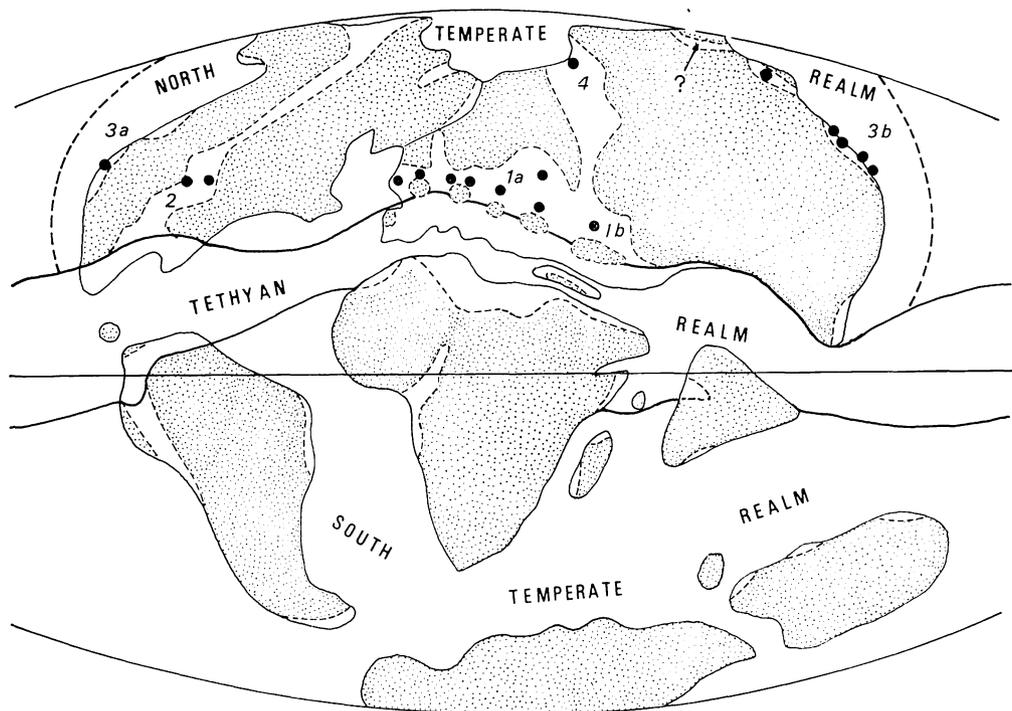
Text-fig. 7. Palaeogeographic map of the Middle to Late Turonian, showing the distribution of the group of *I.* (*I.*) *lamarcki*. (reconstruction after DIETZ and HOLDEN, 1970). 1a: North European Province (proper). 1b: North Central Asian subprovince. 2: North America Interior Province. 3a: Northeast Pacific subprovince. 3b: Japanese East Asian subprovince. 4: West Siberian Province.

was dispersed by way of the circum-polar seas rather than the tropical Tethys Sea. A question, however, remains unsettled as to the ancestor of this group. TRÖGER (1976b) has left blank for the Early Turonian below the phylogenetic tree of the *lamarcki* group and above that of the group of *I. tenuis—I. pictus*.

Another question is whether the migration took place from the North Pacific Province via the circum-polar seas to the North European Province or *vice versa* or from the Arctic Sea to the North Europe and North Pacific Provinces simultaneously. To solve this problem more careful comparison of the species, further collecting better fossils and more

precise correlation are necessary between the regions concerned.

Still another question is to find a definite route of migration among the postulated "circum polar seas".

In view of the recent results of palaeo-tectonic studies (e. g. MONGER et al., 1972; FUJITA, 1978; DICKINSON, 1978), which show general development of the mountain systems around the North Pacific from Jurassic to Cretaceous period, it seems fairly difficult to point out the actual position of the Turonian seaway for the inoceramids to migrate between North Europe or West Siberia and the North Pacific through the Arctic Sea. In Text-fig. 7, a possible route is suggested

through a postulated channel along the Yuzhno-Anyuy suture (between the massifs of Kolyma and Chukotka), which then turned to the Penzhina trough and extended southward to the trough of Saghalien-Hokkaido. We have, however, no positive evidence of the marine Middle Turonian in the Yuzhno-Anyuy area. The migration of a group of *Inoceramus* if ever occurred, must have been occasional. And such an occasional migration may indeed have given rise to a rare and unusual species in the subprovince of Hokkaido.

As a working hypothesis we can expect the ancestral species of the *I. (I.) lamarcki* group in a region of relatively uniform (i. e. less variable) conditions, which could be sought in an oceanic area. Various species of the *I. (I.) lamarcki* group inhabited in respective niches of several provinces where they may have evolved in parallel, adapting themselves to some different environments. *I. (I.) obiraensis* may have been derived from that unknown common ancestor directly or undirectly. Its too much convexity of the valves may be an extreme specialization and the species may have disappeared without giving rise to a successor.

To sum up, the phylogenetic position can be presumed to be a dead end offshoot derived from the main stock of the *I. (I.) lamarcki* group in comparatively early stage of the evolutionary history of that group.

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Explanation of Plate 48

Fig. 1a-c. *Inoceramus (Inoceramus) obiraensis* n. sp. ×1.1. Paratype, rg. MC540728, right valve. Loc. Ob2050, Nanbu-no-sawa, Obira machi, Rumoi gun, Hokkaido. Str. position: middle part of the Unit Mj-k of the Middle Yezo Group (coll. M. NODA, K. MURAMOTO, K. KAMIZUMA and T. SUGAWARA). a: lateral view, b: anterior view, c: dorsal view.

Fig. 2a-c. *Inoceramus (Inoceramus) obiraensis* n. sp. ×1.2. Paratype, rg. MC530729, left valve, Loc. Ob2060, Nanbu-no-sawa, Obira machi, Rumoi gun, Hokkaido. Str. position: middle to upper part of the Middle Yezo Group (coll. M. NODA, K. MURAMOTO, K. KAMIZUMA and T. SUGAWARA, 1979).

Fig. 3. *Inoceramus (Inoceramus) obiraensis* n. sp. ×0.93. Reconstruction of the holotype by the plaster model. dorsal view.
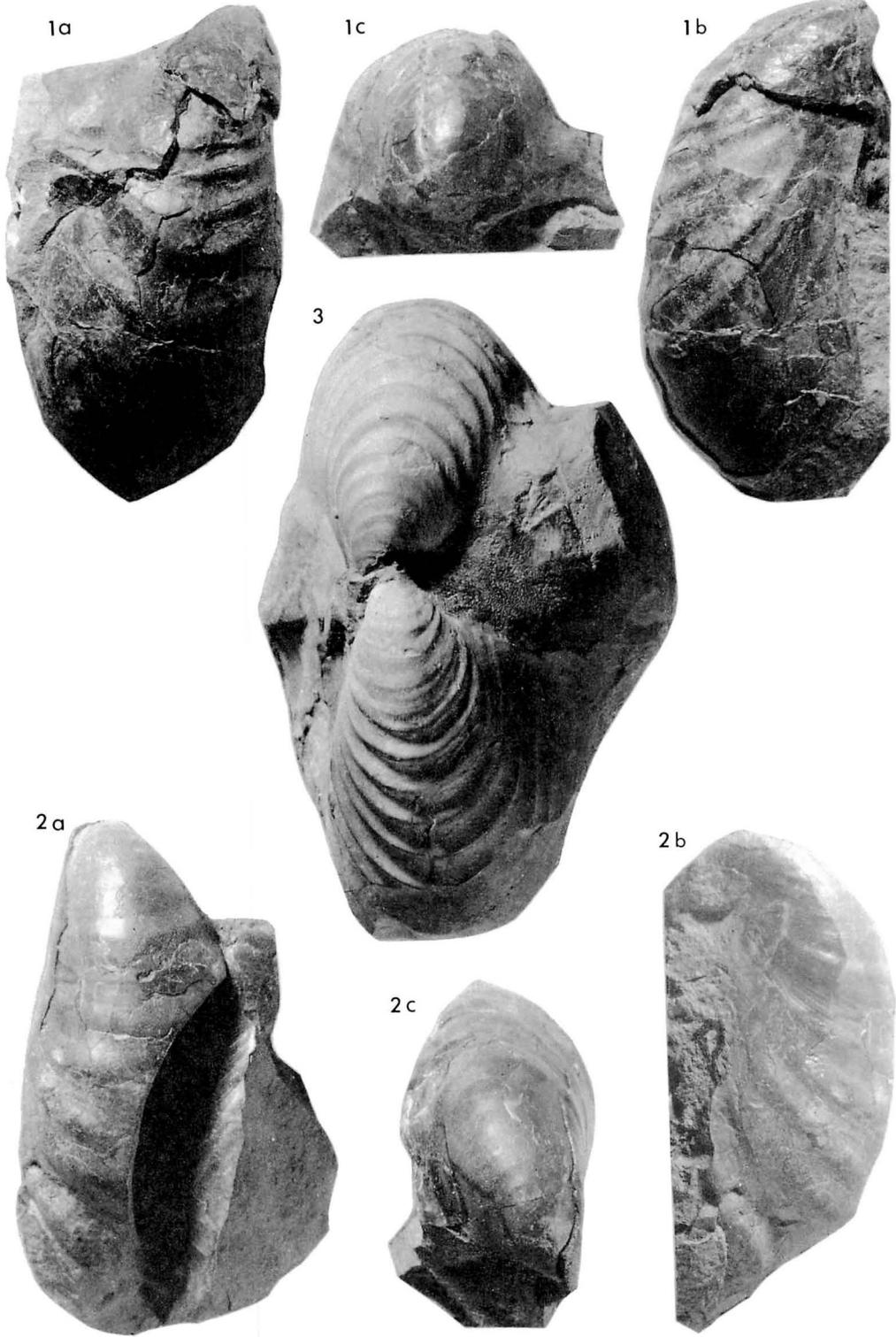
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Asahikawa 旭川,　　　Horokanai 幌加内,　　　Kamikinenbetsu-zawa 上記念別沢,　　　Migiichi-no-sawa 右一の沢,　　　Mikasa 三笠,　　　Nanbu 南部,　　　Nanbu-no-sawa 南部の沢,　　　Obira-machi 小平町,　　　Obirashibe 小平蘂,　　　Osarunaidake 長留内岳,　　　Rinpan-no-sawa 林班の沢,　　　Rumoi-gun 留萌郡,　　　Sato-no-sawa 佐藤の沢,　　　Takishita 滝下,　　　Tappu 達布,　　　Wasadahigashi 稙田東

北海道上部白亜系から発見されたイノセラムスの新種について：北海道の北西部を東西に流れる小平蘂川の中上流には上部白亜系チュロニアンの地層が広く露出しているが，この地域から採集された特異な形態をもつ *Inoceramus* について述べる。本種は，世界的に広く分布し，チュロニアン中部を代表する *I.* (*I.*) *lamarcki* に類似する点があり，とくに北シベリア Yenisei 河口低地の Nasonovsk 層 (*I. lamarcki* 帯) から産出した *I.* (*I.*) *paralamarcki* に似た点が多い。しかし，その不等殻性がそれほどいちじるしくなく，両殻ともに成長軸の方向に極端に長くのびている点や，膨らみがすこぶる大きく，さらに強く膨らんだ広い翼や強い装飾など相違する点が多いので，ここに新種として *Inoceramus* (*Inoceramus*) *obiraensis* の名のもとに記載した。研究にあたって，従来の記載や研究の方法に加えて，数量的に表わせる形質については補助的な手段として統計的な検討も試みた。この特異な種の日本での産出は珍しいので，近縁種の分布などを手がかりとして，チュロニアン中期の古地理や，本種の系統発生などについて若干の考察を付録で試みた。本論文：野田雅之・村本喜久雄，付録：松本達郎・野田雅之

Explanation of Plate 49

Fig. 1a, b. *Inoceramus* (*Inoceramus*) *obiraensis* n. sp. ×0.93. Reconstruction of the holotype
　　by the plaster model. a: posterior view showing the convexity of the wing. b: anterior
　　view showing the radial striae on the surface of internal mould.

1a
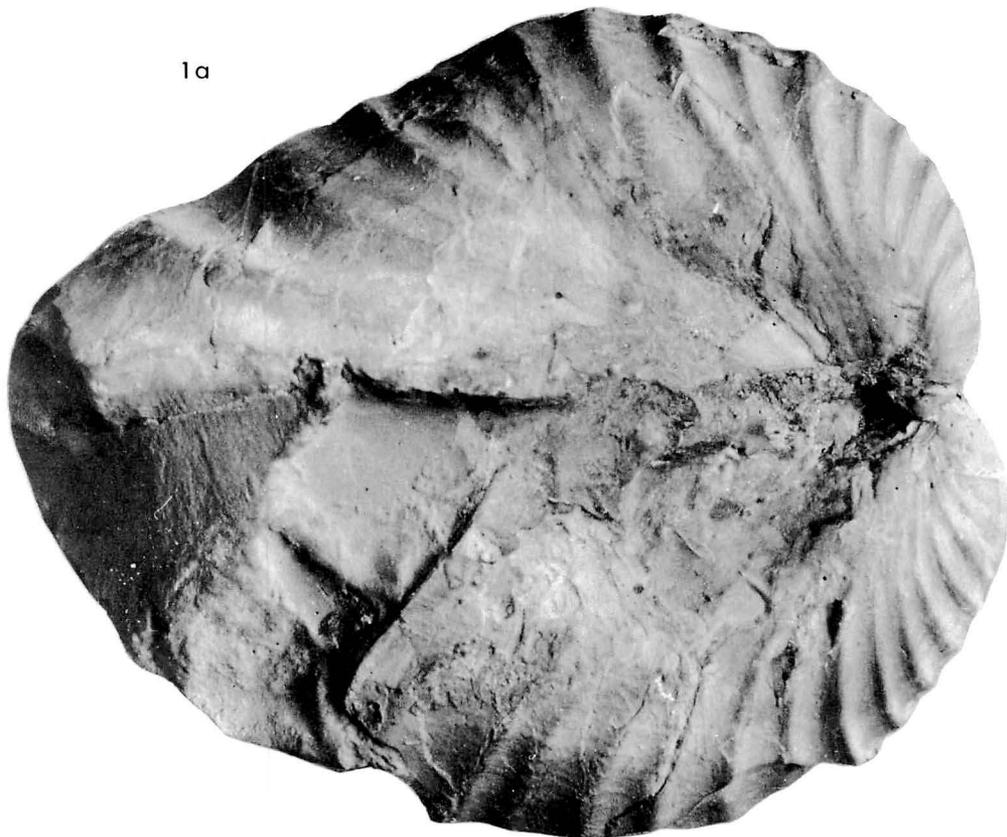
1b
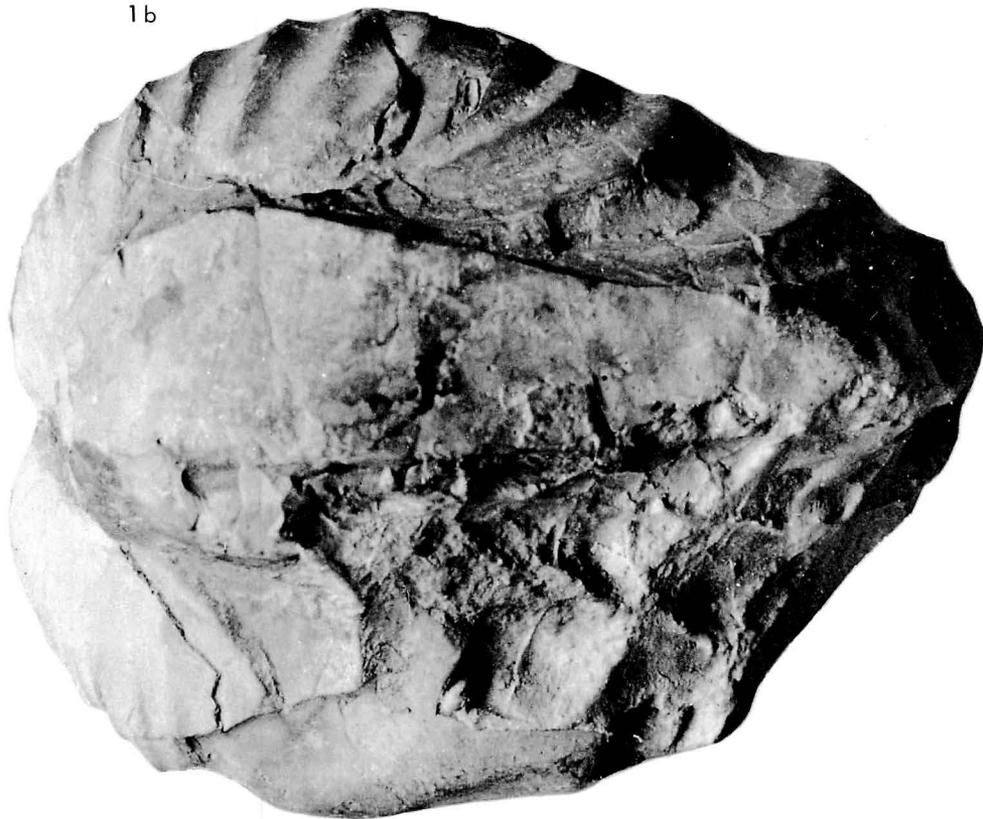
PROCEEDINGS OF THE PALAEONTOLOGICAL
SOCIETY OF JAPAN

学 会 記 事

○1980年6月28日に 高知大学で行なわれた 定例評議員会において，次の諸君の 入退会が承認された（敬称略）。

[入会者] 一ノ関鉄郎，藤井英一，柳井修一，川端 潤，相場博明，千葉 昇，大塚康雄，松原恵司，利光誠一，伊藤隆夫，平 朝彦，宮原哲仁，香西 武，松末知之，栗原 豊，鎌田耕太郎，岡本 隆，黒田登美雄（以上18名）

[退会者] 讃良紀彦，松本英二，永井浩三（以上3名）

[逝去者] 菊池勘左エ門（1名）

日本古生物学会第125回例会が1980年6月29日（日）に高知大学理学部はおいて開催された（参会者120名）。

特 別 講 演

四万十帯化石層序学の最近の進歩 ......甲藤次郎

シンポジウム

「四万十帯の生層序学の現状と今後の問題点」..
.... （世話人：甲藤次郎）
高知県四万十帯の二枚貝化石 ....
.... 田代正之・野田雅之
四万十帯の頭足類について ....松本達郎
高知県四万十帯からの白亜紀浮遊性有孔虫 ....
.... 高柳洋吉
高知県四万十帯の放散虫化石 ....
.... 岡村真・中世古幸次郎
瀬戸川帯の浮遊性有孔虫 ....斉藤常正
四国四万十帯・瀬戸川帯のナンノ化石 ....
.... 岡田尚武・岡村 真
志摩半島四万十帯の放散虫化石について ......
.... 水谷伸治郎
四万十帯放散虫生層序学の現状と問題点 ......
.... 中世古幸次郎
紀伊半島四万十帯の放散虫化石（コメント） ..
.... 中沢圭二・公文富士夫

総括と討論 ....（司会）平 朝彦

個 人 講 演

Four new trilobites from the Permian of
Japan ....KOBAYASHI, T. and HAMADA, T.
Lower Triassic biostratigraphy in the Salt
Range, Pakistan ....BANDO, Y.
Triassic bivalves from the Buko limestone
formation ....TAMURA, M.
Lithiotis および *Cochlearites*（二枚貝，下部ジュラ系）の形態・成長様式・機能形態と生態
.... 鎮西清高
高知県秩父累帯 "白木谷層群" 産出の珊瑚化石について ....山際延夫・磯崎行雄
大分県四万十累帯米水津層群 産出の 珊瑚化石について ....山際延夫・鳴橋憲一・笹田昭二
高知県 佐川盆地七良谷北方に 分布するチャート
中の化石放散虫について ....
.... 菅野耕三・岸田容司郎
Some fossil ferns from the Carnic Momonoki
formation, Yamaguchi Prefecture, Japan
.... KIMURA, T. and OHANA, T.
Upper Triassic *Parasphenophyllum* from
Omine, West Japan.....................
.... ASAMA, K. and OISHI, T.
下部ジュラ系来馬層群産材化石について ......
.... 綱田幸司・山崎純夫
関東山地鳥ノ巣層群の材化石について ....
.... 山崎純夫・岡田清史・綱田幸司
On the occurrence of *Solenites* (*Czekanowskia*
group) from the Upper Cretaceous Omichi-
dani formation, Ishikawa Prefecture, in
the Inner Zone of Japan ....
............KIMURA, T. and OKAWARA, H.
長岩筆石の断面構造 ....岡村長之助
長岩石灰岩中の所謂蛇石との同一構造について
.... 岡村長之助
いわゆる 中筋地溝帯およびその 近隣より産出するイノセラムスとその化石層序学的意義 ....
.... 野田雅之
Notes on *Inoceramus incertus* JIMBO (Creta-
ceous Bivalvia) from the Upper Turonian
of Hokkaido ....NODA, M.

なお, 6月29日夜に伊野の西北方の中追渓谷で懇親会が開かれた。 6月30日には佐川周辺への地質巡検が行われた。

行 事 予 定

	開 催 地	開 催 日	講演申込締切
第126回 例 会	富 山 大 学	1980年10月10-12日	1980年8月10日
1981年総会・年会	東 北 大 学	1981年1月23,24日	1980年11月23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

　10月10,11日の富山例会ではシンポジウム「新第三紀における日本の海洋生物地理—中新世を中心として」（世話人：藤井昭二・土隆一）が予定されている。

お 知 ら せ

○特別号 No. 17 の OYAMA, K: Revision of Matajiro Yokoyama's type Mollusca from the Tertiary and Quaternary of the Kanto Area, 148 pp. 57 pls. は昨年売切れとなり御迷惑をかけておりましたが，このほど誤植訂正の上再版されました。（定価4700円，送料300円）。購入申込は特別号の他の号と同じく特別号編集委員会 首藤次男・柳田寿一（福岡市東区箱崎九州大学理学部地質学教室）（送金先：振替口座福岡19014；三和銀行福岡支店普通預金口座12172）にお願いします。郵送によらない直接販売は東京大学総合研究資料館（速水格気付）および国立科学博物館分館（藤山家徳気付）でも取扱っています。

○日本学術会議第12期会員選挙の第4部全国区候補者として本会より特別会員大森昌衛君を推薦した。

Transactions and Proceedings of the Palaeontological Society of Japan

New Series No. 119   September 30, 1980

CONTENTS