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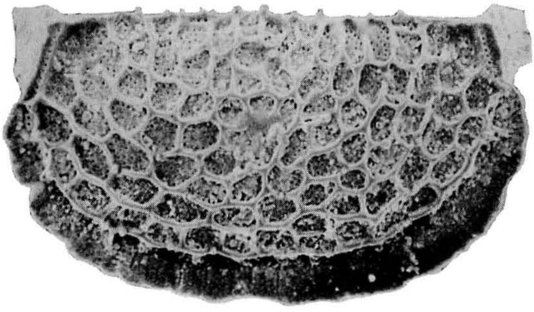

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Palaeontological Society of Japan
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Co-Editors **Itaru HAYAMI and Ikuwo OBATA**

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

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773. EARLY JURASSIC PLANTS IN JAPAN. PART 6*

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Abstract. This is the sixth of our serial papers on the early Jurassic plants in Japan. In this paper we describe *Ginkgo* ex gr. *sibirica*, *Sphenobaiera* cfr. *eurybasis*, *S. nipponica* sp. nov., *S.* cfr. *ophioglossum* and *Ginkgoidium*? sp. belonging to Ginkgoales, *Czekanowskia* ex gr. *rigida* and *Phoenicopsis* ex gr. *angustifolia* belonging to Czekanowskiales, and *Elatocladus* sp. A, *E.* sp. B, *Storgaardia spectabilis*, *Podozamites* ex gr. *distans*, *P.* sp. A, *P.* sp. B, *P.* (*Cycadocarpidium*?) sp. C and *Swedenborgia* sp. A belonging to Coniferales, together with the supplementary description of *Neocalamites* sp. A (Equisetales), *Marattia asiatica* (Marattiaceae) again and *Coniopteris* sp. A (Dicksoniaceae) based on our additional material. This paper gives the first record of *Sphenobaiera* in the older Mesozoic floras in Japan. As our specimens are mostly poorly preserved impression, it is difficult to give clear specific names but they are all characteristic constitutional elements of the early Jurassic flora in Japan.

Introduction and Acknowledgements

In continuation of our previous papers (Kimura and Tsujii, 1980a, b, '81, '82, '83), we here describe the fossil plants belonging to Ginkgoales, Czekanowskiales and Coniferales from the Lower Jurassic Kuruma Group and Iwamuro Formation. In addition we also describe three forms belonging to Pteridophyte as a supplement based on our additional material newly obtained.

The details of stratigraphy of plant-bearing formations and localities were already given in our first paper (Kimura and Tsujii, 1980a). The characteristics of the early Jurassic flora in Japan and its significance for stratigraphy and phytogeography will be discussed in detail in the last (Part 7) of our serial papers, together with the detailed correlation between the early Jurassic flora in Japan and the coeval floras in East Asia and other regions.

We express our sincere gratitude to Professor Emeritus Thomas M. Harris, F.R.S. of the University of Reading for his helpful suggestions and critical reading over the present manuscript. We also give our thanks to Mr. Gumpei Mori, Mr. Noriyuki Sasaki, Mr. Akihiro Kobayashi and many students of the Tokyo Gakugei University for their kind help in collecting the fossils here described.

Systematic Description

Ginkgoales

Genus *Ginkgo* Linnaeus

Ginkgo ex gr. *sibirica* Heer

Pl. 54, Figs. 1—3; Pl. 56, Figs. 1—2;
Text-figs. 1a—j

Ginkgoites digitata (Brongniart) var. *huttoni* Seward: Oishi, 1931, p. 247, pl. 18, figs. 1B, 4 (Tsuchizawa, Kuruma Group): 1940, p. 378 (pars) (ditto).

Ginkgoites ? sp.: Kimura, 1959a, p. 25, pl. 10, fig. 7 (Iwamuro).

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Baiera ? sp.: Kimura, 1959a, p. 25, pl. 10, fig. 5, text-fig. 14 (ditto).

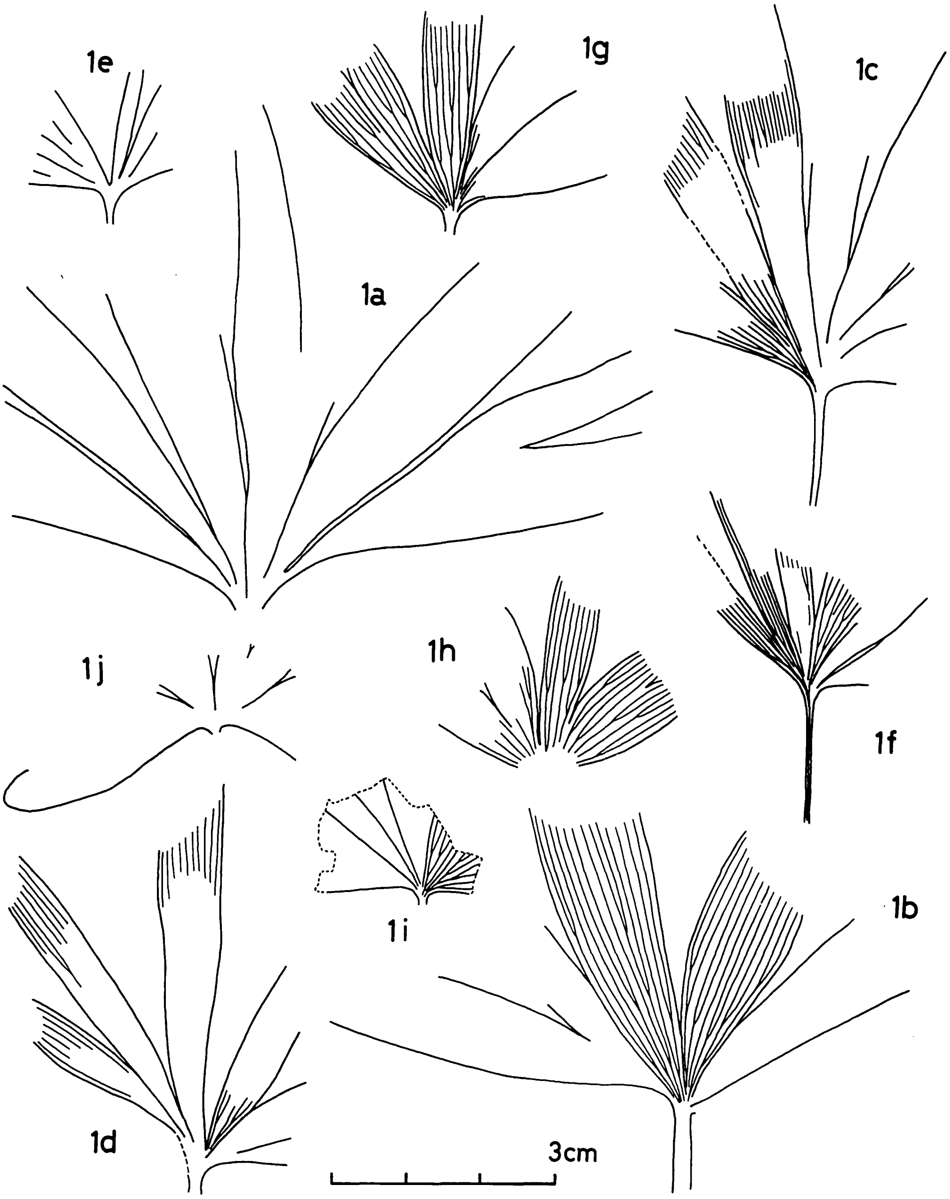
Comparable specimens:

Ginkgo sibirica Heer: Heer, 1876, p. 61, pl. 7, fig. 6; pl. 9, fig. 5B; pl. 11; pl. 20, fig. 36; pl. 22, fig. 3 (Ust-Balei and River Amur).

Ginkgo lepida Heer: Heer, 1876, p. 62, pl. 12, figs. 1—10 (Ust-Balei).

Comparable Japanese specimens:

Ginkgo sibirica Heer: Geyler, 1877, p. 231, pl. 31, fig. 6 (Kuwashima) ?: Yokoyama, 1889, p. 60 (remarks).



Text-figs. 1a—j. *Ginkgo* ex gr. *sibirica* Heer: Showing varied leaf-forms (all natural size). 1a, b (A-0406, Pl. 54, Fig. 2), 1c (Kr-060, Pl. 54, Fig. 1), 1d (Kr-062), 1e (NNW-053), 1f (Kr-064), 1g (A-0420), 1h, j (A-0354, Pl. 56, Figs. 1—2), 1i (A-2045, redrawn from Kimura, 1959a, pl. 10, fig. 5).

Ginkgoites sibirica (Heer) Seward: Oishi, 1932a, p. 347, pl. 49, figs. 4—5 (Upper Triassic Nariwa Group): 1940, p. 380, pl. 38, fig. 11 (Upper Jurassic Kiyosué Formation); pl. 39, fig. 1 (Kuwashima): Kimura and Sekido, 1976, p. 365, text-fig. 22 (Lower Cretaceous Akaiwa Formation).

Ginkgo cfr. *lepida* Heer: Yokoyama, 1889, p. 60, pl. 14, fig. 10 (Hakogase, Upper Jurassic Kuzuryu Group)?

References of other regions, see Harris and Millington (in Harris et al., 1974, pp. 20—21) and Samylina (in Vakhrameev et al., 1980, pp. 109—110).

Material: A-035 (0420, counterpart), 0395, 0406, 0425, 2046, 2059 (Iwamuro), Kr-016, 051, 055, 060, 062, 064, 127 (Tsuchizawa), NNW-053 (Nishi-Neiridani), 4980804-7 (Kotaki Coal-Field).

Description: The leaves are long petiolate; the longest petiole is more than 1.6 cm long (Text-fig. 1f). The laminae are nearly semicircular, forming angle of 145—225 degrees, variable in size, with radius up to 6.5 cm (the smallest one, 1.8 cm) from the first dichotomy (the top of petiole). The lamina is divided into two parts by the median sinus reaching at or near the top of petiole. Typically the second dichotomy in each part sends off the inner lobe and an outer branch which sends further off the middle and outer lobes at the third dichotomy. Thus the typical number of lobes in a leaf is six. The lobes are mostly simple, but often shallowly lobed at the fourth dichotomy. Generally the distance between adjacent dichotomies is small except that between the third and fourth dichotomies. The lobes are fairly varied in form, elongate-oblong, lanceolate, oblanceolate or sometimes linear with rounded apex. The veins are 3—5 in number at the base of lobe, then dichotomously forking 2—3 times at all levels in the lower half of lobe, thus the number of veins is 10—16 (12—19 per cm) at the distal portion of lobe. Cuticle is not preserved.

Distribution and occurrence: Rather rare, but locally common in the Iwamuro Formation and Tsuchizawa of the Kuruma Group (Kr_2). A single specimen was collected from the Negoya Formation.

Remarks: Our leaves are similar in form and branching habit of lobes to original leaves described by Heer from the Irkutsk Basin and Amur Region, but somewhat differ from them in the following: In our leaves the lobes are broader than those of the original leaves and the veins are more crowded (10—16 at the distal portion of lobe) than those of the original leaves (5—9 at the corresponding portion of lobe). If the differences between our and Siberian leaves mentioned above be due to the specific difference, the number of *Ginkgo* species would increase enormously. Thus we at present regard our leaves as *Ginkgo* ex gr. *sibirica* owing to the general resemblance of their form and branching habit of lobes to Heer's *Ginkgo sibirica.*

We think Heer's species from Ust-Balei, *Ginkgo sibirica*, *G. lepida*, *G. schmidtiana*, *G. flabellata* and *G. pusilla* are conspecific and ought to be included into *G. sibirica*, because in their leaves, the branching habit of lobes and venation are fundamentally the same. In Ust-Balei and some other regions, *Ginkgo sibirica* leaves are in close association with *G. concinna* leaves in which laminae are further divided by the dichotomies of four times into slender or filiform ultimate segments each with a few veins. But from our localities, *Ginkgo concinna*-type leaves have not been found.

Oishi (1931) described *Ginkgo* leaves from Tsuchizawa as *Ginkgoites digitata* var. *huttoni.* But his leaves are more deeply dissected into lobes than those of *Ginkgo digitata* and are very close in broader lobes and venation to some of our leaves as shown in Text-figs. 1g and 1h.

We distinguished our leaves from the leaves of *Ginkgo digitata* and *G. huttoni*, as interpreted by Harris and Millington (in Harris et al., 1974), because in *G. digitata* laminae are less deeply dissected and in *G. huttoni* lobes are irregularly truncated or notched.

In Japan, several *Ginkgo* leaves were described under the names of *Ginkgoites sibirica* and *G.* cfr. *lepida* as listed above, among which the leaves described by Geyler (1877) and Yokoyama (1889) were doubtful in specific identity because they were all represented by broken leaves. Other Japanese leaves are rather similar in form and number of veins to ours than Heer's original leaves.

The Yorkshire leaves described in detail by Harris and Millington (in Harris et al., 1974) as *Ginkgo* sp. cfr. *sibirica* are also similar in form and venation to ours.

The leaves described by Takahasi and Okafuji (1967, '68) from the Carnic Momonoki Formation, Yamaguchi Prefecture as *Ginkgoites sibirica*, may belong to *Baiera furcata*-group including *B. lindleyana*-type leaves.

Genus *Sphenobaiera* Florin, 1936: 105

Sphenobaiera cfr. *eurybasis* Sze

Pl. 54, Figs. 4—5; Text-figs. 2a—e

Pityophyllum (*Pityocladus*) sp.: Kimura, 1959a, p. 27, pl. 9, fig. 5 (A-2050) (Iwamuro).

Comparable specimen:

Sphenobaiera eurybasis Sze: Sze, 1959, pp. 12, 28, pl. 6, fig. 8; text-fig. 3 (Chaidamu, Qinghai, China): Sze et al., 1963, p. 241, pl. 83, fig. 4, 4a (Sze's specimen).

Material: NEE-207 (232, counterpart) (Higashi-Neiridani), NNW-053 (772) (Nishi-Neiridani), NEG-151 (Negoya), DAI-069 (Dairagawa), SHI-89 (099) (Shinadani), A-2050 (Iwamuro).

Description: The leaves are long and narrowly wedge-shaped, more than 7 cm long, divided by the first dichotomy into uneven parts and each by as many as three successive dichotomies into narrow ultimate segments. The basal undivided portion of leaf is at least half as long as divided part of leaf and 2—2.5 mm wide, gradually widening upwards to up to 0.8 cm wide below the first dichotomy. In Text-fig. 2e [Kimura (1959a) misidentified it as *Pityophyllum* (*Pityocladus*) sp.], the leaf appears to be attached to the axis which is 3 mm wide and at an angle of about 40 degrees. The basal angle of divided part of leaf is 30—65 degrees, the angle of branching is 5—15 degrees. The dichotomies are at intervals of 0.7-1.3 cm. The leaf-segments are 1—3 mm wide, mostly contracted at their base, gradually increasing in width upwards, and at their maximum width immediately below the dichotomy. The apices of lobes are all missing. The veins are not visible. Cuticle is not preserved.

Distribution and occurrence: Sphenobaiera cfr. *eurybasis* is rarely known from the Kuruma Group and Iwamuro Formation.

Remarks: Our leaves are characterized by their narrowly wedge-shaped divided part and long undivided part. Their general feature is most similar to *Sphenobaiera eurybasis* originally described by Sze (1959) from the Lower—Middle Jurassic of Chaidamu Basin, Qinghai, China. But we determined our leaves as *Sphenobaiera* cfr. *eurybasis*, because Sze's species was based on a single imperfect specimen with rather broader undivided part.

Sphenobaiera pecten Harris (1945) from Yorkshire is another allied form to ours, but is distinguished by its narrower or filiform segments.

Sphenobaiera nipponica
Kimura and Tsujii sp. nov.

Pl. 54, Fig. 6; Pl. 55, Figs. 1—4;
Pl. 56, Figs. 3—4; Text-figs. 3a—j

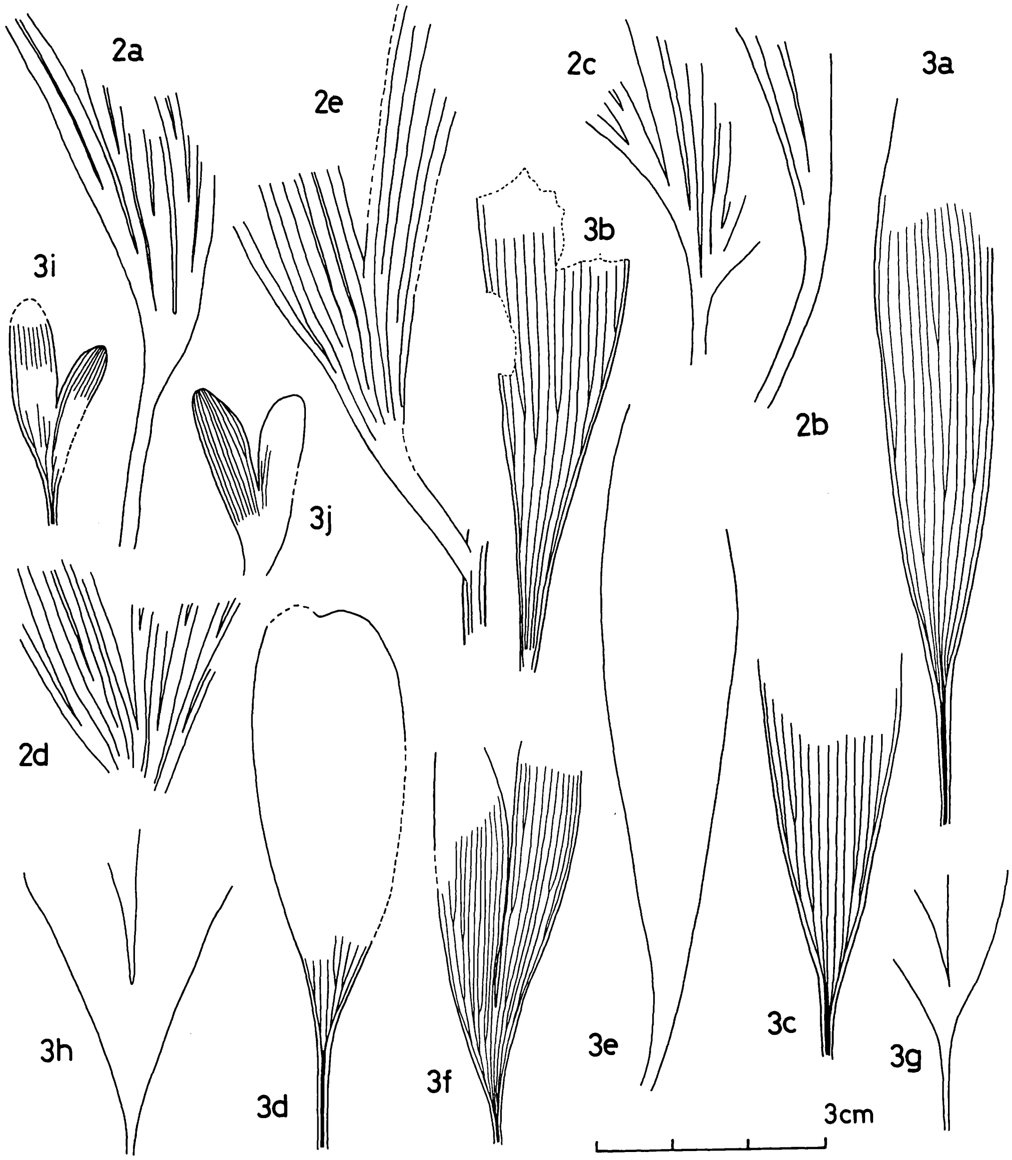
Material: Holotype: NNW-627 (Nishi-Neiridani). Paratypes: NNW-616, 632, 639 (Nishi-Neiridani) (Divided leaves), NNW-217, 602, 345, NEE-283 (Higashi-Neiridani) (Undivided leaves).

Other specimens: NNW-230, 449, 565, 567, 609, 617 (divided leaves), NNW-172, 320, 334, 340, 386, 535, 746, 864, NEG-127 (Negoya) (undivided leaves).

Stratum typicum: Negoya Formation, Kuruma Group. *Locus typicus*: The Nishi-Neiridani, Asahi-machi, Shimo-Niikawa-gun, Toyama Prefecture.

Derivatio nominis: After Nippon meaning Japan in Japanese.

Diagnosis: Leaf dimorphic, entire or deeply lobed. Entire leaf oblanceolate in outline, up to 12 cm long and 1.5—2 cm wide at the widest portion, gradually narrowing towards the petiole. Petiole narrow, about 1—1.2 mm wide, length at least 1.5 cm. Apex shallowly emarginated. Bilobed (divided) leaf variable in size, length 3—6 cm or more, sinus reaching the basal narrow part, each lobe oblanceolate in outline, up to 1.5 cm wide at the widest portion. Apex rounded. Vein



Text-figs. 2—3 (all natural size).

2q—e. *Sphenobaiera* cfr. *eurybasis* Sze: 2a (NNW-053, Pl. 54, Fig. 4), 2b (DAI-069), 2c (NEE-207, Pl. 54, Fig. 5), 2d (NNW-053, Pl. 54, Fig. 4), 2e. A leaf attached obliquely to the axis (A-2050, drawn from Kimura, 1959a, pl. 9, fig. 5).

3a—j. *Sphenobaiera nipponica* Kimura and Tsujii sp. nov.: 3a—e; undivided (entire) leaves. 3f—j; divided (bilobed) leaves. 3a (NNW-602, Paratype, Pl. 55, Fig. 1), 3b (NNW-851), 3c (NNW-334), 3d (NNW-345, Paratype, Pl. 55, Fig. 2), 3e (NEE-283, Paratype, Pl. 55, Fig. 3), 3f (NNW-627, Holotype, Pl. 56, Fig. 3), 3g (NNW-616, Paratype), 3h (NNW-639, Paratype), 3i (NNW-632, Paratype, Pl. 56, Fig. 4), 3j (NNW-230).

in the narrow basal part or petiole being single and thick, bifurcating at or near the top of narrow basal part, each branch giving off repeatedly forking parallel veins; 13—16 in number (8—9 per cm) at the middle of entire leaf; veins not converging at apex. (Cuticle not preserved. Reproductive organs not known.)

Distribution and occurrence: Locally common in the Negoya Formation.

Discussion and comparison: We think our entire and bilobed leaves belong to a single species, because the venation of both types of leaves agrees with each other and the leaves of both types occur in close association.

Sphenobaiera gyron originally described by Harris and Millington (in Harris et al., 1974) from Yorkshire also has dimorphic leaves, simple (entire) and bilobed. In *Sphenobaiera gyron* the leaf apex appears truncate (e.g. their text-fig. 18D) and not rounded and its veins branch lower in the lamina. The vein concentrations are so similar that they scarcely constitute a specific difference.

The entire leaf of *Sphenobaiera nipponica* is similar in form to those of *Eretmophyllum*, but no forked *Eretmophyllum* leaves have been reported. The leaves of *Eretmophyllum glandulosum* (Samylina) Krassilov are distinguished from our entire leaves by its well marked marginal veins from which the others arise.

Our bilobed leaves are similar in form to some bilobed *Ginkgoidium* leaves (e.g. *Ginkgoidium nathorsti* Yokoyama). The leaves described as *Ginkgoidium nathorsti* (Yokoyama, 1889: Oishi, 1940: Kimura and Sekido, 1965, '76) from the Lower Cretaceous Itoshiro Group, in the Inner Zone of Japan, consist of both entire and bilobed ones. But they differ from ours in that they have strong marginal veins from which all other veins arise and these veins are parallel, very crowded and forked near their marginal origin. Similar bilobed *Sphenobaiera* leaves to ours are those of *S. huangi* (Sze) Hsü and *S. pulchella* (Heer) Florin. But they are represented only by bilobed leaves and no entire leaf has been known. Leaves of *Sphenobaiera huangi* are often larger in size than ours.

Ginkgoidium (?) *longilobatum* originally described by Lebedev (1965) from the Upper Jurassic of the Zeia River area is represented by bilobed leaves. It is distinguished from our bilobed leaves by its longer lobes each with small number of branched veins (7 in each lobe).

Although there is no direct evidence, we think our bilobed leaves might have been attached singly to the long shoot and our entire ones spirally to the top of short shoot with very short internode, like those of extant *Ginkgo biloba.*

Similar thought was mentioned by Kimura and Sekido (1965). They described both entire and bilobed leaves as *Eretmophyllum tetoriense* and *Ginkgoidium nathorsti* respectively from the Lower Cretaceous Ishoshiro Group in close association in occurrence. Their *Eretmophyllum* leaves were still attached to the top of a fairly long short shoot. Both types of leaves have such similar venation that they supposed that their *Eretmophyllum tetoriense* and *Ginkgoidium nathorsti* may be conspecific, and their bilobed leaves may have been attached singly to the supposed long shoots.

Sphenobaiera cfr. *ophioglossum* Harris and Millington

Pl. 54, Fig. 7; Pl. 55, Figs. 5—6;
Pl. 56, Fig. 5A; Text-figs. 4a—d

Comparable specimens:

Sphenobaiera ophioglossum Harris and Millington: Harris and Millington, in Harris et al., 1974, p. 48, pl. 2, figs. 1—5; text-figs. 16—17 (Yorkshire).

Material: NEG-005, 012, 021, 029, 072, 084, 095, 108, 112, 123, 137, 146, 149, 254, 263, 279 (Negoya), NNW-652, 664 (Nishi-Neiridani), NEE-041 (123, counterpart) (Higashi-Neiridani), NE-135 (Neiridani).

Description: The leaves are narrowly wedge-shaped with broad leaf-base and without marked petiole, varied in form and size; the basal angle is typically 40 degrees. The leaves are divided into two nearly equal or unequal lobes by the deep median sinus; the lobes are often divided once more. The largest leaf at hand is more than

14 cm long and its undivided basal part is at least 3.3 cm long.

The primary lobes are contracted at base, gradually widening upwards to 1—1.9 cm wide just below the second dichotomy, while the ultimate lobes (or segments) are narrowing gradually towards the apex; the dichotomies are at intervals of 1.9—3.9 cm and the branching angle is 20 degrees at the first dichotomy and 12—20 degrees at the second dichotomy. The apex of lobe is not known.

The veins are bifurcating from the base of undivided lamina, then repeatedly bifurcating at all levels except the distal portion of lobes, parallel and not converging at apex; the number of veins is 9—10 (4—5 per cm) in primary lobe. Cuticle is not preserved.

Distribution and occurrence: Locally common in the Negoya Formation.

Remarks: Although none of our leaves is complete, our leaves are macroscopically close to those of *Sphenobaiera ophioglossum*, but do not fully agree with Yorkshire leaves. Differences are: In our leaves they are mostly divided twice and with veins of 4—5 per cm in primary lobe, but mostly once and with veins of 20 per cm in *Sphenobaiera ophioglossum.* We therefore determined our leaves as *Sphenobaiera* cfr. *ophioglossum.*

Sphenobaiera longifolia (Pomel) Florin is an another allied form, but it is distinguished by its leaves typically forking four times and with slender lobes. However, some of the less divided leaves described as *Sphenobaiera longifolia* are macroscopically indistinguishable from ours.

The following species of *Sphenobaiera* also resemble our leaves but each has a distinguishing feature:

Sphenobaiera huangi (Sze) Hsü: Sze, 1949 (as *Baiera huangi*): Hsü, in Sze and Hsü, 1954 (name): Sze et al., 1963 (Sze's specimen) (Lower—Middle Jurassic Xiangxi Formation): Krassilov, 1972 (Upper Jurassic of Bureja Basin): Krassilov and Schorochova, 1973 (Lower Jurassic of Primorye): Leaves mostly bilobed.

Sphenobaiera ikorfatensis (Seward) Florin: Seward, 1926 (Lower Cretaceous of Greenland): Samylina, 1963 (*S. ikorfatensis* f. *papillata*) (Upper Jurassic of Aldan River area): Krassilov, 1972 (ditto) (Lower Cretaceous of Bureja Basin): Leaves once or twice forked but rather small-sized.

Sphenobaiera pulchella (Heer) Florin: Heer, 1876 and many others (known mainly from Jurassic—Lower Cretaceous of Siberia): Leaves mostly bilobed.

Sphenobaiera spectabilis (Nathorst) Florin: Nathorst, 1906 and others (mainly Lower Liassic of Sweden and Greenland): Leaves often further divided (five times).

Genus *Ginkgoidium* Yokoyama, 1889: 56

Ginkgoidium ? sp. A

Text-fig. 5

Material: A-75154 (Iwamuro).

Description: Only a single broken leaf as shown in Text-fig. 5 was obtained. The leaf is possibly entire, oblong in outline, more than 4.5 cm long, nearly parallel-sided for the most part, 1.8 cm wide, abruptly narrowing near base. Its apical half is missing. The venation is characterized by marked marginal veins from which all other veins arise; these veins are parallel, dichotomously once forked near their origin except median ones which are simple, 27 in number (15 per cm) at the middle of leaf. Cuticle is not preserved.

Distribution and occurrence: A single specimen from the Iwamuro Formation.

Remarks: As mentioned above, this leaf is characterized by its marginal veins from which all other veins arise. From this our leaf would possibly be included in the category of *Ginkgoidium*, and we regard it as *Ginkgoidium* ? sp. A. However, as the apex is missing we cannot exclude the possibility that the veins might converge as in *Podozamites.*

Ginkgoidium ? sp. A is distinguished from *Sphenobaiera nipponica* here described together by its marked marginal veins and more crowded veins.

Ginkgoidium ? sp. A is also distinguished from *G. nathorsti* Yokoyama known abundantly from the Lower Cretaceous Itoshiro Group by its small number of veins (20—40 in each leaf in *G. nathorsti*).

Czekanowskiales

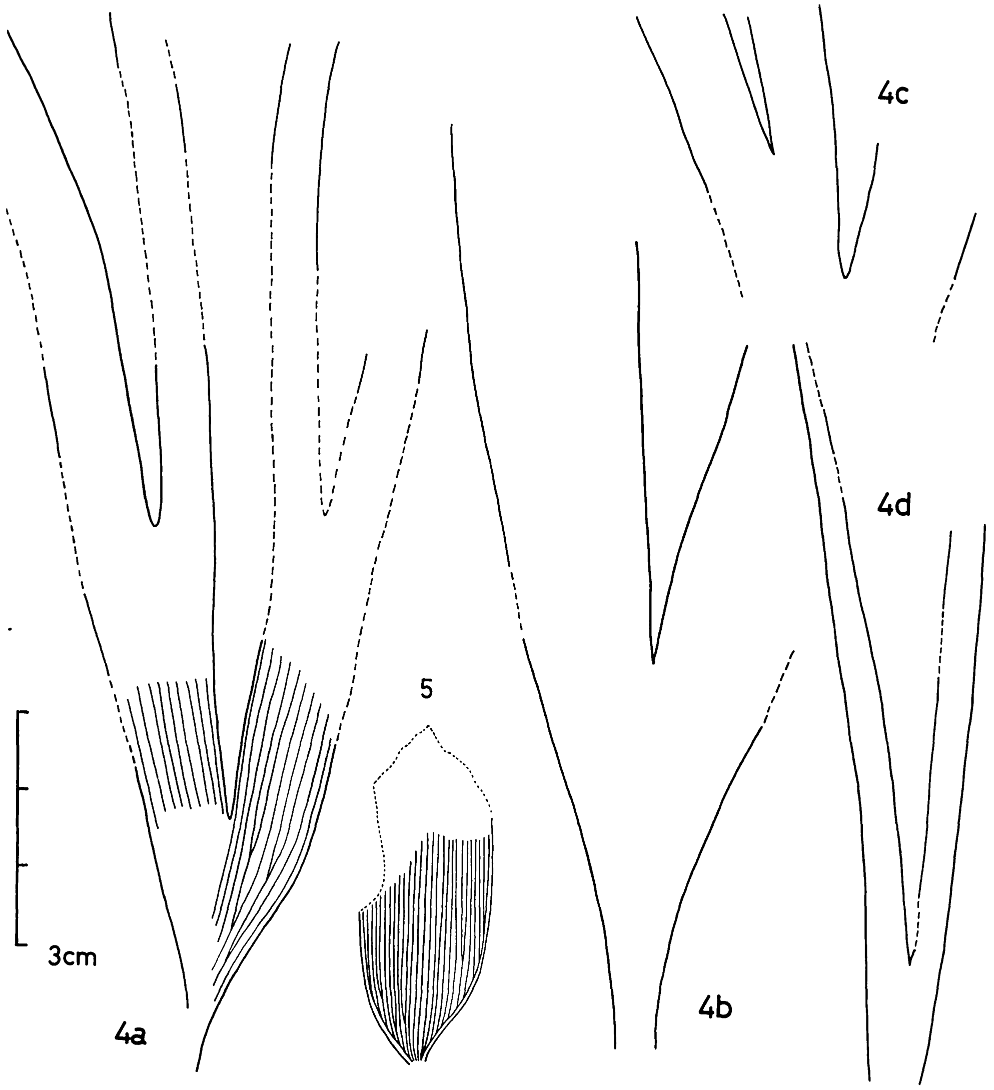
In this order, two genera, *Czekanowskia* and *Phoenicopsis* are represented in our collection, but no specimen of their reproductive organs has yet been found. As our specimens lack preserved cuticles we cannot compare them fully with description of leaves in which details of cuticles are important.

Genus *Czekanowskia* Heer, 1876: 65

Czekanowskia ex gr. *rigida* Heer

Pl. 56, Fig. 5B; Text-figs. 6a—b

Czekanowskia rigida Heer: Oishi, 1931, p. 249,



Text-figs. 4—5 (all natural size).

4a—d. *Sphenobaiera* cfr. *ophioglossum* Harris and Millington: 4a (NEG-095, Pl. 54, Fig. 7), 4b (NEE-123, Pl. 55, Fig. 6), 4c (NEG-108), 4d (NEG-279, Pl. 56, Fig. 5A).

5. *Ginkgoidium*? sp. (A-75154).

pl. 18, figs. 5—6 (Tsuchizawa, Kuruma Group): 1932a, p. 355, pl. 32, fig. 8, 8a (Nariwa Group): 1940, p. 384, pl. 39, figs. 6—7 (Upper Jurassic Kiyosue Formation): Kimura, 1959a, p. 25, pl. 11 (Iwamuro, good leaves, though impression).

Comparable specimens:

Czekanowskia rigida Heer: Heer, 1876, p. 70, pl. 5, figs. 8-11; pl. 6, fig. 7; pl. 10, fig. 2a (Ust-Balei).

Czekanowskia setacea Heer: Heer, 1876, p. 68, pl. 5, figs. 1—7; pl. 6, figs. 1—6 (Ust-Balei).

Oishi (1931) gave the list similar in macroscopical form to our leaves.

Material: A-2097 (4001, counterpart), 4004, 8001, AA-052 (053) (Iwamuro), Kr-045 (Tsuchizawa), NEE-279 (360) (Higashi-Neiridani), NNW-396 (Nishi-Neiridani).

Description: The short shoot is very small, covered by several rounded or rectangular scale-leaves which appear to be easily lost. The foliage leaves are in a bundle of more than four, each dichotomously forking four times or more, more than 13 cm long and 1 mm wide below and 0.5 mm wide above; their apices are unknown. The halves of dichotomy diverge at small angle. The veins are not visible. Cuticle is not preserved.

Distribution and occurrence: Locally common in the Iwamuro Formation, but rather rare in the Negoya Formation and the Alternation of sandstone and shale (Kr_2), Kuruma Group.

Remarks: Many *Czekanowskia* species have been described from the older Mesozoic plant-beds in the Northern Hemisphere and also from the younger Mesozoic plant-beds in the Siberian Palaeofloristic Area (Vakhrameev, 1964 and his other papers), including the Inner Zone of Japan. Most of these species are not only based on their macroscopic features but also on their cuticles. However, our leaves are macroscopically close to the well-known species *Czekanowskia rigida* shown in detail by Doludenko and Rasskazova (1972). According to them Heer's *Czekanowskia setacea* is conspecific with *C. rigida.*

The following species resemble ours but are distinguished macroscopically by the features briefly mentioned below:

Czekanowskia blacki Harris and Miller: Harris and Miller, in Harris et al., 1974 (Yorkshire): Leaves forked twice.

Czekanowskia furcata Harris and Miller and *C. thomasi* Harris and Miller: Ditto: Leaves forked only once.

Our leaves are macroscopically indistinguishable in leaf-form and number of dichotomies from both microscopically defined leaves of *Czekanowskia hartzi* Harris (1926) and *C. nathorsti* Harris (1935) both from the Liassic of Greenland. Had the cuticles of these species not been preserved, they would have been identified as *Czekanowskia rigida.*

Under the circumstances, our present designation of our leaves to *Czekanowskia* ex gr. *rigida* is comprehensive. Similar leaves were described in Japan by Oishi from the Kuruma and Nariwa Groups and the Kiyosué Formation as *Czekanowskia rigida* as cited above.

Genus *Phoenicopsis* Heer, 1876: 51

Phoenicopsis ex gr. *angustifolia* Heer

Pl. 54, Figs. 8—9; Pl. 55, Figs. 7—8;
Pl. 56, Fig. 6; Text-figs. 7a—e

Phoenicopsis ? sp.: Oishi, 1931, p. 252, pl. 17, fig. 5; pl. 18, fig. 7 (Tsuchizawa).

Phoenicopsis sp.: Kimura, 1959b, p. 73, pl. 1, fig. 8 (Kotaki Coal-Field).

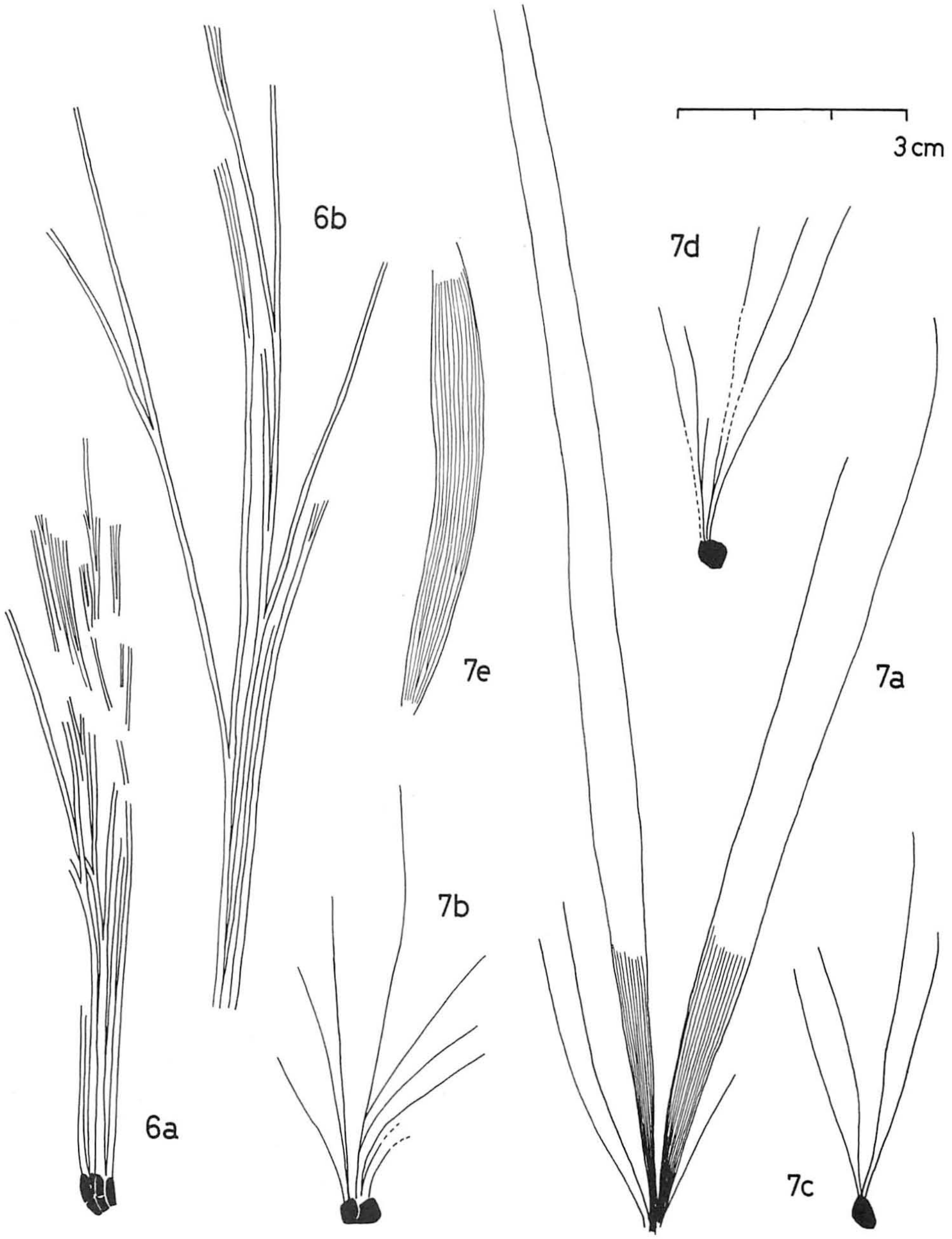
Comparable specimens:

Phoenicopsis angustifolia Heer: Heer, 1876, pp. 51, 113, pl. 1, fig. 1d; pl. 2, fig. 3b (Ust-Balei); pl. 31, figs. 7—8 (Amur River area): Krasser, 1906, p. 22 (610), pl. 3, figs. 3—4 (Lower Cretaceous of Jiaohe, Jilin, NE-China): Sze et al., 1963, p. 252, pl. 87, figs. 4-5 [Seward's (1911) specimens], fig. 6 [Sze's (1959) specimen]; pl. 88, fig. 2 [Sze's (1933) specimen], fig. 3 (Lower—Middle Jurassic of Xinjiang); pl. 89, fig. 5 (ditto).

Phoenicopsis angustifolia Heer, f. *media* Krasser: Yabe, 1922, p. 27, pl. 4, figs. 4—5 (Daanshan, Lower—Middle Jurassic mentougou Group).

For Russian references, see Kiritchkova (in Vakhrameev et al., 1980), pp. 128—130.

Material: SHI-046, 060, 063 (070, counterpart), 106 (120), 131, 134, 140, 144, 151, 171 (Shinadani), TOB-013C (Tobiiwadani), NEE-



Text-figs. 6—7 (all natural size).

6a—b. *Czekanowskia* ex gr. *rigida* Heer: 6a (NEE-279, Pl. 56, Fig. 5B), 6b (A-8001, drawn partly from Kimura, 1959a, pl. 11).

7a—e. *Phoenicopsis* ex gr. *angustifolia* Heer: 7a, c (SHI-060, Pl. 54, Fig. 8; Pl. 55, Fig. 7), 7b (SHI-120, Pl. 54, Fig. 9), 7d (SHI-070), 7e. A detached leaf and its venation (NEE-035).

035 (Higashi-Neiridani), 4962501-4 and other 2 specimens (Kotaki Coal-Field).

Description: The short shoot is caducous, small, 0.35—0.4 mm long, covered with rounded scale-leaves and gives off a bundle of foliage leaves. None of our specimen is complete, thus the number of foliage leaves and scale-leaves on a short shoot is uncertain. The foliage-leaves appear to be easily broken near base or easily shed at base, and are variable in size and form, linear and nearly parallel-sided for the most part or elongate-oblanceolate in outline, narrowing gradually towards the base, but the leaf-apices are all missing; the longest one is more than 15.8 cm long (Text-fig. 7a) and 0.6—0.7 cm wide at the middle. The veins are mostly simple, 11 in number at the apical half of each leaf, but sometimes dichotomously forking once on the basal half of leaf as shown in Text-fig. 7e. No interstitials between veins are found. Cuticle is not preserved.

Distibution and occurrence: Phoenicopsis ex gr. *angustifolia* is locally common in the Shinadani Formation, but is rather rare in the Negoya Formation, Alternation of sandstone and shale (Kr_2) and the Kotaki Coal-Field.

Remarks: The original leaves of this species are about 4—5 mm wide and each leaf has 6—10 veins without interstitials. We think that our leaves belong to this well-known species, *Phoenicopsis angustifolia*, although our leaves are somewhat broader and have more crowded veins than original leaves. However, we here regard our leaves as *Phoenicopsis* ex gr. *angustifolia* because of lacking cuticle in them.

Phoenicopsis speciosa Heer is distinguished from our *P.* ex gr. *angustifolia* by its comparatively broad leaves with crowded veins (15—23 in each leaf), a leaf-bundle consisting of 20 leaves and by having interstitials between veins.

Phoenicopsis sp. described by Oishi (1932a) from the Nariwa Group resembles ours, but according to Oishi, his leaves have faint interstitials between veins. The leaf-fragments from Tsuchizawa and the Kotaki Coal-Field regarded by Oishi (1931) and Kimura (1959b) as *Phoenicopsis* ? sp. and *P.* sp. respectively, are referable to *P.* ex gr. *angustifolia.*

Coniferales

Form-Genus *Elatocladus*
Halle em. Harris, 1979: 104

Elatocladus sp. A

Pl. 56, Fig. 8; Text-figs. 8a—c

Material: SHI-018, 026, 029, 043, 048 (Shinadani).

Description: Five broken leafy shoots were obtained. They are represented possibly by ultimate part of twigs, and are simple, slender, dropped with their leaves still attached. The axis is slender, up to 1 mm wide, bearing closely set alternate leaves on all sides, but the leaf-bases bend and twist to bring each lamina into the horizontal plane at a wide angle. The leaves are elongate-oblong or oblanceolate in outline with rounded apex, typically 0.7 cm long and 1-1.5 mm wide at the widest portion. The contracted leaf-base is continued as a decurrent leaf-cushion onto the axis as shown in Text-fig. 8c. The leaf-margins are entire. The midrib is prominent and persisting to the tip. Cuticle is not preserved.

Distribution and occurrence: Elatocladus sp. A is rarely known only from the Shinadani Formation.

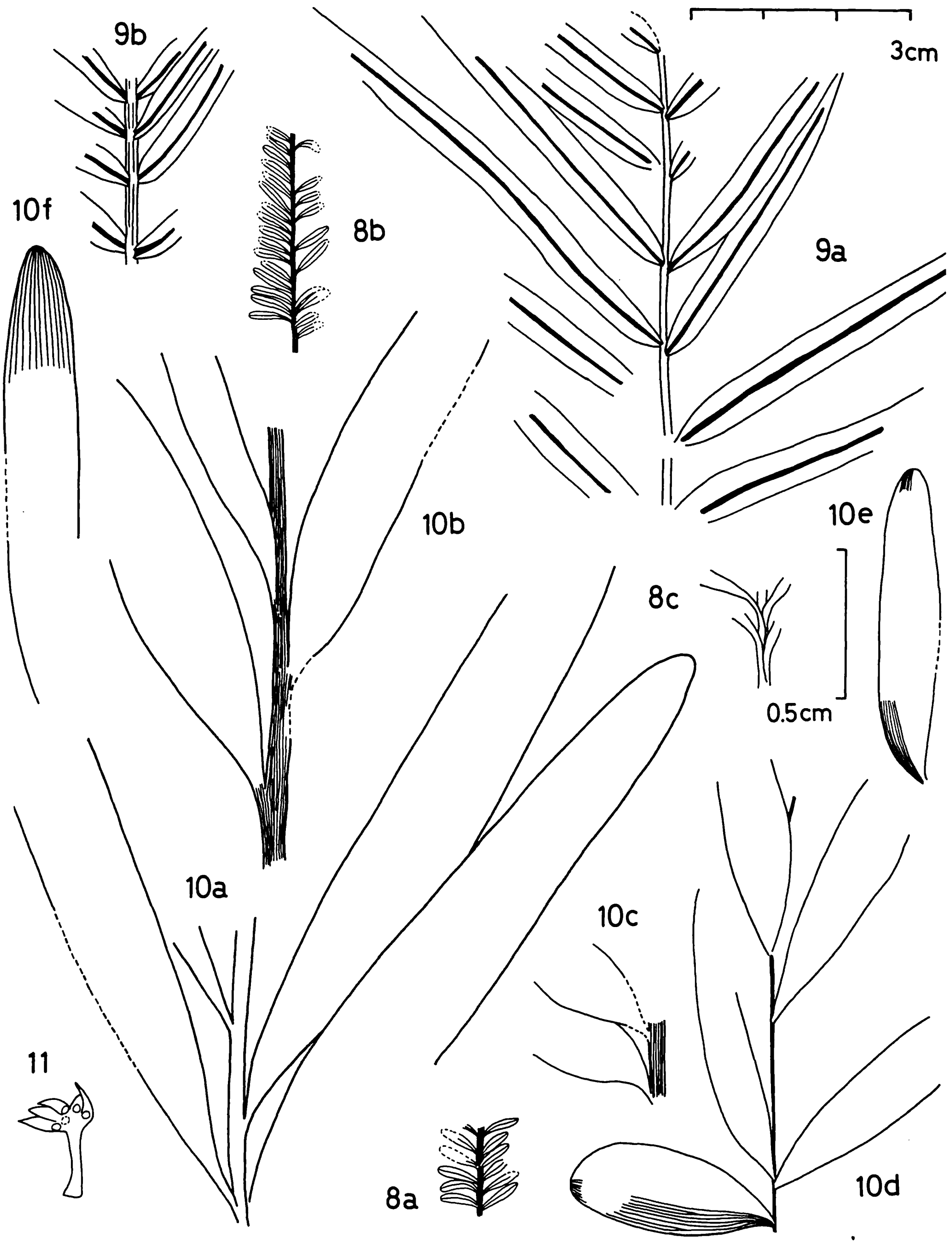
Remarks: Our leafy shoots cannot be placed in a natural genus on the present evidence. We place them in *Elatocladus* sp. A, as used by Harris (1979). No similar leafy shoot to ours has been recorded from the Mesozoic plant-beds in Japan, Korea and China, nor are any of the species described by Harris (1935).

Elatocladus sp. B

Elatocladus sp.: Oishi, 1931, p. 253, pl. 18, fig. 8.

Distribution and occurrence: Only a single leafy shoot. Its exact locality is uncertain.

Remarks: Oishi (1931) described a single broken leafy shoot as *Elatocladus* sp. from an erratic at the upper course of the Dairagawa (belonging possibly to the Negoya Formation). It differs from our *Elatocladus* sp. A in its thick axis (2 mm wide) bearing the leaves which are falcate and broadest at the base.



Text-figs. 8—11 (all natural size except 8c).

8a—c. *Elatocladus* sp. A: 8a (SHI-018, Pl. 56, Fig. 8), 8b (SHI-029), 8c. Showing the leaf-bases and decurrent leaf-cushions, drawn partly from 8a.

9a—b. *Storgaardia spectabilis* Harris: 9a (NEE-070, Pl. 56, Fig. 7), 9b (NNW-238).

10a—f. *Podozamites* ex gr. *distans* ((Presl) Braun: 10a (TOB-048A, Pl. 56, Fig. 9), 10b (TOB-017B, Pl. 56, Fig. 10), 10c (NEE-188), 10d (Kr-073, Pl. 55, Fig. 9), 10e (NEE-105), 10f (NEG-188).

11. *Swedenborgia* sp. A: (A-2040, redrawn from Kimura, 1959a, pl. 8, fig. 5).

Genus *Storgaardia* Harris, 1935: 58

Storgaardia spectabilis Harris

Pl. 54, Fig. 10; Pl. 56, Fig. 7; Text-figs. 9a—b

Storgaardia spectabilis Harris: Harris, 1935, p. 58, pl. 11, fig. 17; pl. 12, figs. 7—8; pl. 16, figs. 1—2; text-figs. 24—26 (Liassic of Greenland): 1937, p. 60 (ditto): Doludenko and Orlovskaja, 1976, p. 82, pl. 38, fig. 1; text-figs. 48, 49a—e (Upper Liassic of Karatau).

Cfr. *Storgaardia spectabilis* Harris: Oishi and Huzioka, 1938, p. 96, pl. 12, fig. 3; text-fig. 7 (Upper Triassic Nariwa Group: Oishi, 1940, p. 412 (remarks).

?*Pityophyllum longifolium* (Nathorst): Oishi, 1931, p. 252, pl. 17, fig. 7 (Tsuchizawa et al., Kuruma Group).

Material: NEE-070 (Higashi-Neiridani), NNW-237, 318, 385 (Nishi-Neiridani).

Description: The shoots are more than 14 cm long, bearing the leaves oppositely at intervals of 0.5—1.3 cm and at an angle of 45—60 degrees to the slender rachis. The leaves are very shortly stalked, elongate-lanceolate in outline, typically 4.5—6.5 cm long and about 1 cm wide at middle portion, narrowing abruptly at base and gradually towards the acute apex; margins are entire. The leaf-pairs are possibly decussate but all leaves are brought into the horizontal plane and some show twisting of the basal stalk. The midrib is prominent, but no other veins are present. Cuticle is not preserved.

Distribution and occurrence: Rather rare. The specimens safely referable to this species are at present known only from the Negoya Formation.

Remarks: Our shoots agree closely with the original ones described by Harris (1935) from the Liassic of Greenland in all macroscopic features.

Oishi and Huzioka (1938) described similar shoots from the Upper Triassic Nariwa Group. But they refrained from its full identity with *Storgaardia spectabilis* because their shoots had more crowded leaves which contracted at base less abruptly and some leaf-pairs appeared to be subopposite. However, so far as the macroscopical form of them is concerned, we think their shoots are conspecific with Harris' species and their mode of insertion of leaves to the rachis appearing to be subopposite is due to the twisting of the basal stalk like those of ours.

Storgaardia hissarensis originally described by Gomolitzky (1963) based mainly on its leaf-cuticle from the Middle Jurassic of the south-western branches of Gissar Range, is an another known species of the genus. But it is difficult to make its macroscopical comparison with ours, because *Storgaardia hissarensis* is represented by several detached leaf-fragments.

'*Podocarpites*' *mentoukouensis* Stockmans and Mathieu (in Sze et al., 1963) from the Lower—Middle Jurassic Mentougou Group near Peking (Beijing), China is similar in leaf-form to ours. But according to Sze et al. (1963, p. 307), its leaves are said to be not decussate but distichous or looking so and to be opposite or subopposite and occasionally alternate.

Several detached leaves described by Oishi (1931) as *Pityophyllum longifolium* (Nathorst) from Tsuchizawa, Shimodera and south of Kuruma (all belonging to the Kuruma Group) may belong to *Storgaardia spectabilis*. If so, Oishi's figure (pl. 17, fig. 7) is upside down.

Genus *Podozamites* Braun
in Münster, 1843: 36

Podozamites ex gr. *distans* (Presl) Braun

Pl. 55, Fig. 9; Pl. 56, Figs. 9—10; Text-figs. 10a—f

Japanese specimens:

Podozamites lanceolatus (Lindley and Hutton): Yokoyama, 1891, p. 245, pl. 34, figs. 3—4 (Yamanoi): 1905, pp. 8, 13, pl. 1, fig. 6 (ditto); pl. 3, fig. 5 (Nariwa): Oishi, 1931, p. 254, pl. 17, fig. 6 (Tsuchizawa, Shimodera and Kuruma, Kuruma Group): 1932a, p. 363, pl. 32, fig. 2; pl. 52, figs. 6—9 (Nariwa): 1932b, p. 13, pl. 3, fig. 13; text-fig. 1 (Shitaka): 1932c, p. 66 (Kusaigawa, Momonoki, Yamanoi and Michiichi): Kimura, 1959a, p. 27, pl. 11 (in association with *Czekanowskia* ex gr. *rigida*; Iwamuro): 1959b, p. 74, pl. 2, fig. 8 (Kotaki Coal-Field).

Podozamites sp. cfr. *P. griesbachi* Seward: Kimura, 1959b, p. 74, text-fig. 1 (Kotaki Coal-Field).

Material: A-0411 and other 29 specimens (Iwamuro), Kr-072 and other 3 (Tsuchizawa), NEE-116 and other 9 (Higashi-Neiridani), NNW-267 and other 3 (Nishi-Neiridani), NEG-013 and other 3 (Negoya), TOB-017A and other 3 (Tobiiwadani), SS-1A, 4982305 and other 2 (Kotaki Coal-Field).

Description: Many leafy shoots and detached leaves were obtained, but none of our shoots is complete. The axis is 0.5—3 mm wide, not hairy, bearing spirally arranged leaves. The leaves are evidently twisted so as to lie in the horizontal plane, except a shoot shown in Text-fig. 10d. The leaves are elongate-oblong in outline, with obtuse or rounded apex, varied in form and size; the thick axis bears large leaves, 9.6 cm long and 1.5 cm wide at middle (Text-fig. 10a) and the thin axis bears small leaves. The ratio of leaf-length to maximum leaf-width (L/W) is 2.5—6.8. The large leaves are shortly petiolate but the small leaves are sessile. The proximal leaves on a shoot are often oblong or oval in outline with rounded or obtusely pointed apex as shown in Text-fig. 10d. The veins are slender, simple or once forked in the basal half of leaf to give about 11—20 in number (6—10 per cm) in each leaf, converging slightly towards the apex, but some of them ending in the distal margins. No interstitial is visible. Cuticle is not preserved.

Distribution and occurrence: Podozamites ex gr. *distans* is common in the Kuruma Group and Iwamuro Formation.

Remarks: It is difficult to classify *Podozamites* leafy shoots and detached leaves specifically on macroscopic features. Most of our leaves are elongate-oblong in form, but a few are lanceolate. Our leaves differ from those of *Lindleycladus lanceolatus* (Lindley and Hutton) Harris (formerly *Podozamites lanceolatus*) of Yorkshire (Harris, 1979) in the ratio (L/W); the ratio (L/W) in ours is 2.5—6.8 as mentioned above, but that in Yorkshire species is 9—16.4 measured on the leaves illustrated by Harris (1979).

In the Japanese specimens having regarded as *Podozamites lanceolatus* from the Upper Triassic-Lower Jurassic plant-beds as cited above, this ratio (L/W) is 2.8—7.1 and is quite similar in numerical value to ours.

This ratio (L/W) is rather similar to that of *Podozamites distans* known extensively from the older Mesozoic plant-beds in Europe. Thus we here separate these Japanese leaves from *Lindleycladus lanceolatus* and in the meantime regard them as *Podozamites* ex gr. *distans.* But it would be most probable that our *Podozamites* ex gr. *distans* is a mixture consisting of more than one natural species.

So far as we know, there is no leaf referable in form to *Lindleycladus lanceolatus* in the late Triassic—early Jurassic floras in Japan. In Korea, many *Podozamites* leafy shoots and detached leaves were described by Kawasaki (1925, '26, '39) from the Daedong Supergroup (mainly Upper Triassic) as *P. schenki*, Cfr. *P. gracilis*, *P. reinii*, *P. distans* and *P. lanceolatus.* Apart from his *Podozamites schenki*, *P. reinii*, Cfr. *P. gracilis* and a particular example (his 1925, pl. 33, fig. 92), the ratio (L/W) is 3.3—8.3 which is quite similar in numerical value to that of ours and other Japanese leaves cited above. Thus in the Daedong flora there is no leaf safely referable to those of *Lindleycladus lanceolatus* of Yorkshire.

From the Upper Triassic—Lower Jurassic plant-beds in China, many *Podozamites* leaves were identified as *Podozamites lanceolatus* and its varieties instituted by Heer, but their ratios (L/W) fall into 2.5—7.5 apart from one described by Sze (1956, pl. 53, fig. 1) from the Upper Triassic Yanchang Formation. Thus most of Chinese leafy shoots and detached leaves regarded as *Podozamites lanceolatus* may rather be included in our *P.* ex gr. *distans* than in *P. lanceolatus.*

Kon'no (1961) described three types of *Podozamites* leafy shoots as *P. distans* var. *osawae*, *P. distans* var. *nagatoensis* and *P. agardhianus* var. *acuminatus*. The first was from the Lower Carnic Nakatsuka Formation and the rest from the Middle Carnic Momonoki Formation. His first and second varieties are distinguished from ours by their small-sized oblong leaves with small number of veins (6—7 and 7—13 in each leaf respectively). His third variety is also distinguished from ours by its small-sized lanceolate leaves with small number of veins (8-9 in each leaf).

Kon'no (1961) also illustrated four broken leaves without description as *Podozamites* sp. cfr. *astartensis* from the Ladino-Carnic Hiramatsu Formation. They are similar in form, size and venation to ours, and may be included in our *Podozamites* ex gr. *distans*.

There are many *Podozamites* species having been described with their cuticles from the older Mesozoic plant-beds in Europe and Soviet Union. Some of them are macroscopically similar or partly similar in leaf-form, size and venation to ours, but we here do not compare them with ours, because it is difficult to make a precise comparison with geographically distant leaves depending only on the macroscopical features, especially with such *Podozamites* leaves.

Two detached leaves regarded by Kimura (1959b) as *Podozamites* sp. cfr. *P. griesbachi* from the Kotaki Coal-Field may be proximal ones on a shoot like that shown in Text-fig. 10d.

Podozamites sp. A

Text-figs. 12a—b

Problematicum B (Broad leave conifer ?): Kimura, 1959a, p. 30, pl. 10, fig. 1 (Iwamuro).

Material: A-0401, 7001 and many other detached leaves.

Description: The rachis is rather thick, 2.5—4 mm wide, covered evenly by hairs on its surface; the hairs are perpendicular to the surface of rachis, appearing to be rigid, up to 5 mm long and 1 mm wide at base, gradually narrowing to the acuminate apex. The leaves are spirally arranged at intervals of 0.75—1 cm and at wide angle to the rachis, more than 5.2 cm long but total length is unknown and 1.5 cm wide at the widest portion near the base, not petiolate; the base is 1—1.5 mm wide and the basal part preserved is mostly bent and twist to bring each leaf into the horizontal bedding plane. The veins are numerous, simple or dichotomously forking near the base, 23 in number at the middle of leaf. The leaf-apex is not known. Cuticle is not preserved.

Distribution and occurrence: Podozamites sp. A is rare and known only from the Iwamuro Formation.

Remarks: A broken shoot labelled A-7001 was once regarded by Kimura (1959a) as Problematicum B (Broad leave conifer ?). Since then similar shoots, though all broken, were obtained from the Iwamuro Formation. Their macroscopical features lead us to place our shoots in *Podozamites*. Their most characteristic feature is the hairy shoot. Hairy *Podozamites* shoots have been described by Kon'no (1961) in his *P. distans* (Presl) var. *nagatoensis* from the Middle Carnic Momonoki Formation and by Stanislavsky (1971) in his *P.* sp. 3 from the Upper Triassic of Donbass. In Kon'no's variety the acicular appendages covering the main axis are very crowded and minute, 2.7 mm long and its leaves are clearly distinguished from ours by their small-size and small number of veins (7—13 in each leaf). Staniskavsky's *Podozamites* sp. 3 is also distinguished from ours in its long and slender leaves.

Podozamites sp. B

Text-fig. 13

Podozamites sp.: Kimura, 1959a, p. 27, pl. 8, fig. 1 (Iwamuro).

Material: A-7002 (Iwamuro) and many detached and broken leaves.

Description: The axis is 2 mm wide and longitudinally striated. The leaves are sessile, and appear to be attached oppositely to the axis at an angle of 35 degrees. None of our leaves is complete, but the leaf is probably oblong or short-lanceolate, with abruptly narrowed base; the widest part is 1.15—1.40 cm. The veins are numerous, dichotomously forked near the base or in the lower half of leaf, 26 in number (23 per cm) at the middle of leaf. Cuticle is not preserved.

Distribution and occurrence: Rare, only known from the Iwamuro Formation.

Remarks: The present leafy shoot is characterized by the oppositely disposed leaves.

Unfortunately it is not clear whether they are decussate or not, because in our Text-fig. 13, the lower pair of leaves is broken at their joint.

The present leafy shoot is distinguished from *Podozamites* ex gr. *distans*, *P.* sp. A and *P.* (*Cycadocarpidium* ?) sp. C here described together by its oppositely disposed leaves. its glabrous axis and its leaf with denser veins respectively. Thus we at present regard it as *Podozamites* sp. B.

Podozamites (*Cycadocarpidium* ?) sp. C

Pl. 56, Fig. 11; Text-figs. 14a—e

Material: A-3080, 7540 (Iwamuro), NNW-324, 393, 851 (Nishi-Neiridani).

Description: Obtained are all detached leaves. The leaves are varied in form. A leaf shown in Text-fig. 14e is elongate-oblong, narrowing gradually towards the base to merge its long petiole, its apex is missing; the veins are partly visible, simple, 10 in number at the widest part (0.7 cm). A leaf shown in Text-fig. 14d, though its basal part is missing, is similar in form to that shown in Text-fig. 14e, but larger in size, probably 3.3 cm long (including the length of petiole) and at most 1.05 cm wide, its apex is rounded; the veins on its apical half are visible, simple, 13 in number, not converging but ending at apical margin. The broken leaves shown in Text-figs. 14b and 14c are apical ones which are small-sized, with rounded apex; the veins are 11 and 9 in number respectively. A detached leaf shown in Text-fig. 14a is in association with that shown in Text-fig. 14d on the same slab and differs in form and venation from the others here described. Its form, though its petiole is missing, is crookedly oblong, 1.05 cm long and at most 0.75 cm wide, with 8 veins, one of which is once forked at the middle. No interstitial between veins is observed. Cuticle is not preserved.

Distribution and occurrence: Podozamites (*Cycadocarpidium* ?) sp. C is rare, and only known from the Iwamuro and Negoya Formations.

Remarks: We think our leaves, though one shown in Text-fig. 14a is fairly different in form and venation, belong to one and the same *Podozamites* species. Our leaves are characterized by their small-size and small number of veins (8—13 in each leaf), and differ in leaf-form and vein-density from *Podozamites* ex gr. *distans*, *P.* sp. A and *P.* sp. B here described together.

It is undeniable that our leaves, such as shown in Text-figs. 14d and 14e resemble closely in form, size and venation the bracts of *Cycadocarpidium nagatoense* described by Kon'no (1961) from the Momonoki Formation. According to Kon'no (1961), *Podozamites distans* (Presl) var. *nagatoensis* and triovulate *Cycadocarpidium nagatoense* might most probably belong to one and the same plant. Unfortunately we could not recognize any traces of fertile organs at the base of our leaves. Thus we regard our leaves as *Podozamites* (*Cycadocarpidium* ?) sp. C.

Podozamites (*Cycadocarpidium* ?) sp. C resembles in leaf-form and size *P. distans* (Presl) var. *osawae* Kon'no from the lower part of Nakatsuka Formation (Lower Carnic), but is distinguished by its number of veins (8-13 in each leaf), instead of 5—8 in each leaf in Kon'no's variety.

Podozamites (*Cycadocarpidium* ?) sp. C is indeed indistinguishable in leaf-form, size and number of veins from *P. distans* (Presl) var. *nagatoensis* described by Kon'no. But at present we refrain its identity, because this Kon'no's variety is further characterized by that the surface of the leaf-bearing stem is densely covered by minute stiff acicular appendages and such a stem has not been recognized in our material.

Genus *Swedenborgia* Nathorst, 1876: 60

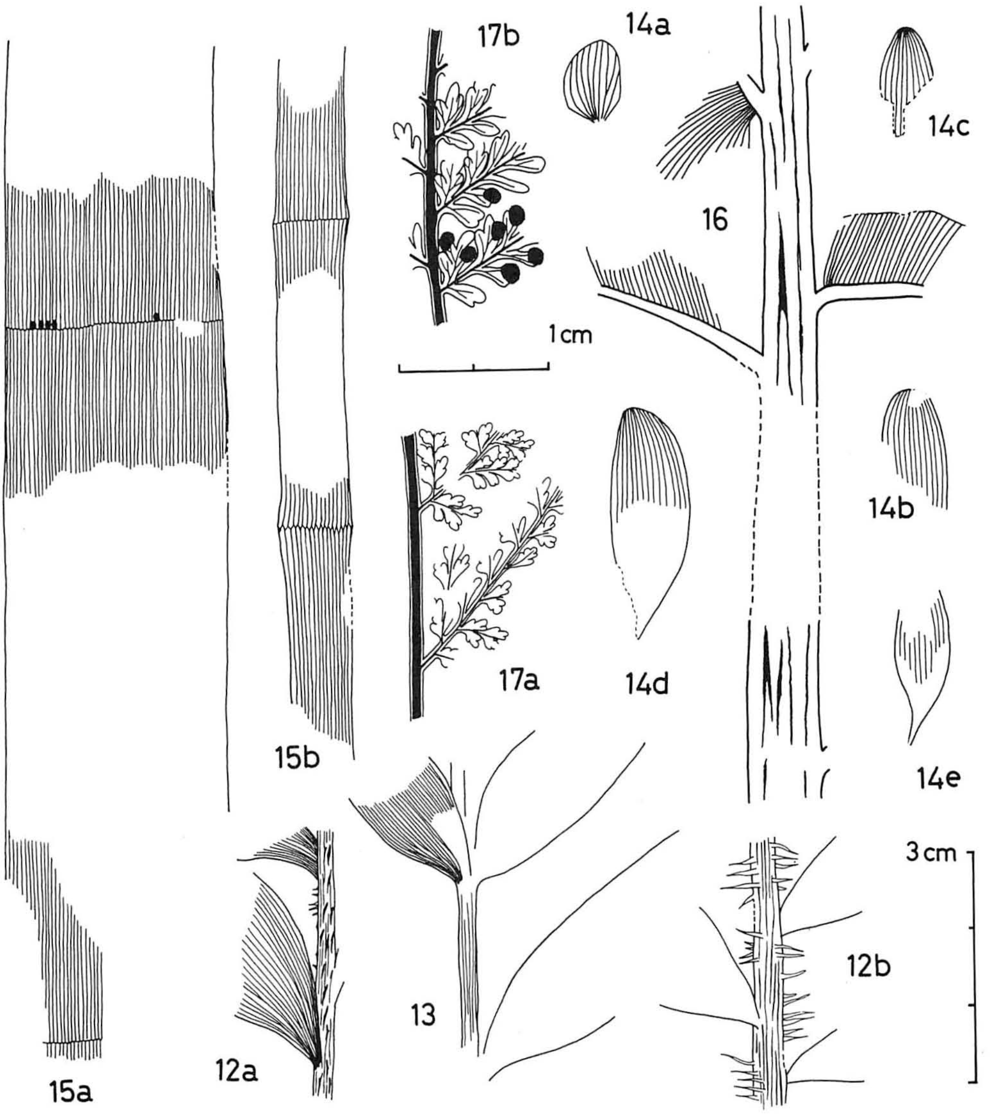
Swedenborgia sp. A

Text-fig. 11

Swedenborgia cryptomerioides Nathorst: Kimura, 1959a, p. 28, pl. 8, fig. 4—5 (Iwamuro).

Material: A-2040, 2040B (counterpart).

Description: The cone-scale is 1.5 cm in total length, consisting of palm above and stalk below. The scale-stalk is well defined, 1.0 cm long and 1.5 mm wide at middle and 1.2 mm below. The stalk-limb is mostly missing, leaving its



Text-figs. 12—17 (all natural size except 17b).

12a—b. *Podozamites* sp. A: 12a (A-7001), drawn from Kimura, 1959a, pl. 10, fig. 1), 12b. Details of hairs on the rachis (A-0401).

13. *Podozamites* sp. B: Drawn from Kimura, 1959a, pl. 8, fig. 1 (A-7002).

14a—e. *Podozamites* (*Cycadocarpidium*?) sp. C: 14a, d (A-7540), 14b (NNW-851), 14c (NNW-393), 14e (A-3080, Pl. 56, Fig. 11).

15a—b. *Neocalamites* sp. A: 15a (Kr-122), 15b (Kr-146).

16. *Marattia asiatica* (Kawasaki) Harris: (NNW-826).

17a—b. *Coniopteris* sp. A: (SHI-662).

short piece on one side of the stalk-base. The scale-stalk is expanded distally, 5 mm wide at the widest portion and divided palmately into five almost equal lobes. The lobe-proximal below the widest part is broad and short; the lobe-distal is elongated, narrowing gradually towards the acutely pointed apex, 3.8—4.8 mm long; the width of broadest part is 1.6 mm. The seed-scar is at the upper surface of broadest part of each lobe and nearly circular or short-oblong in outline, 1.25 mm (major) and 1 mm (minor) in diameter. The seeds are not preserved. Further details of cone-scale and seed-scar are not known. Cuticle is not preserved.

Distribution and occurrence: Only a single cone-scale and its minor fragments were obtained from the Iwamuro Formation.

Remarks: The present cone-scale is characterized by its medium-size, very short lobe-proximal and nearly circular or short-oblong seed-scar. But at present we regard it as *Swedenborgia* sp. A, because it is represented by an insufficiently preserved single specimen.

In 1959, the senior author (Kimura) thoughtlessly identified it as *Swedenborgia cryptomerioides* Nathorst. But in our opinion it is at present distinguished from European *Swedenborgia cryptomerioides* by its longer and narrower lobe-distal.

Oishi and Yamasita (1935) described a lax cone, detached cone-scales and detached seeds as *Swedenborgia cryptomerioides* from the Upper Triassic Nariwa Group. But their cone-scales are rather similar in having larger and narrower lobes to ours than those of European *Swedenborgia cryptomerioides.*

Based on his rich material from the Daedong Supergroup in the Pyeongyang Coal-Field, North Korea, Kon'no (1944) newly described in detail *Swedenborgia attenuata, S. coreanica, S. lata, S. onoyamai, S. rigida* and *S. rigida* var. *acuminata.* Apart from the propriety of his identification, our cone-scale resembles in form and size Kon'no's *Swedenborgia coreanica* and *S. rigida* var. *acuminata,* but it is distinguished from *S. coreanica* by its nearly circular or short-oblong seed-scars instead of markedly elongate-oblong ones, and from *S. rigida* var. *acuminata* by its more thicker scale-stalk and gradually narrowing lobe-distal instead of narrower scale-stalk and more acuminate lobe-distal.

Harris (1935) originally described *Swedenborgia major* and *S. minor* from the Liassic of Greenland. *Swedenborgia major* is distinguished from ours by its larger cone-scale and elongated lobe-distal, and *S. minor* is also distinguished from ours by its smaller cone-scale.

Swedenborgia longifolia originally described by Stanislavsky (1971) from the Upper Triassic of Donbass is characterized by its markedly elongated scale-lobes. Incidentally we may mention that most characteristic are *Swedenborgia megasperma* and *S. tuttosperma* described also by Stanislavsky (1976) from the Upper Triassic of Donetz Basin, because they have trilobed cone-scales with larger seeds.

In China *Swedenborgia* cones and detached cone-scales similar in form to ours were described from the Upper Triassic Yanchang Formation (Sze, 1956) and the Lower-Middle Jurassic Xiangxi Formation (Sze, 1949; Wu et al., 1980) as *S. cryptomerioides.* An incomplete cone was recorded by Sze (1959) from the

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Explanation of Plate 54
(all natural size)

Figs. 1—3. *Ginkgo* ex gr. *sibirica* Heer: 1 (Kr-060), 2 (A-0406), 3 (A-0425).
Figs. 4—5. *Sphenobaiera* cfr. *eurybasis* Sze: 4 (NNW-053), 5 (NEE-207).
Fig. 6. *Sphenobaiera nipponica* Kimura and Tsujii sp. nov.: A divided (bilobed) leaf (NEG-095).
Figs. 8—9. *Phoenicopsis* ex gr. *angustifolia* Heer: 8 (SHI-060), 9 (SHI-120).
Fig. 10. *Storgaardia spectabilis* Harris: (NNW-237).

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Liassic Hongliugou Group as ?*Swedenborgia cryptomerioides.*

Most authors think *Swedenborgia* is one of the female reproductive organs of some *Podozamites* species of late Triassic—early Jurassic age. In East Asia, too, *Swedenborgia* species are known from the Upper Triassic to the Lower Jurassic strata in association with several types of *Podozamites* leafy shoots, but none of them has been found in organic connection with *Podozamites* shoots.

Supplementary description

Equisetales

Genus *Neocalamites* Halle, 1908: 6

Neocalamites sp. A

Text-figs. 15a—b

Neocalamites hoerensis (Schimper): Oishi, 1931, p. 229, pl. 16, figs. 2—3 (Tsuchizawa): 1940, p. 187 (pars) (remarks): Kimura, 1959a, p. 8, pl. 1, figs. 7—10 (Iwamuro).

Neocalamites carrerei (Zeiller) Halle: Kimura, 1959b, p. 66, pl. 1, figs. 2, 6; pl. 2, fig. 3 (Kotaki Coal-Field).

Neocalamites sp. cfr. *N. hoerensis* (Schimper) Halle: Kimura, 1959b, p. 67, pl. 1, fig. 1 (Kotaki Coal-Field).

Neocalamites ? sp.: Kimura, 1959b, p. 68 (Kotaki Coal-Field).

Material: A-3074 and other 17 specimens (Iwamuro), 4961801 and other 8 (Kotaki Coal-Field), Kr-106 and other 9 (Tsuchizawa).

Distribution and occurrence: Locally very abundant in the Iwamuro Formation and Kuruma Group, but they are mostly represented by pith-casts of aerial stems.

Remarks: It is now difficult to identify *Neocalamites* pith-casts specifically. Many *Neocalamites* pith-casts were described as *N. carrerei*, *N. hoerensis* and other names as cited above by Oishi (1931, '40) and Kimura (1959a, b) from the Kuruma Group and Iwamuro Formation.

Halle (1908) mentioned that in *Neocalamites carrerei*, the internode is generally shorter in comparison with the breadth of the stem than in *N. hoerensis*, and the leaves are mostly shorter, narrower and more in number than in *N. hoerensis*.

Kimura and Kim observed *Neocalamites carrerei*-community *in situ* extensively preserved for 3 km long in the lower horizons of Upper Triassic Daedong Supergroup, Chungnam Coal-Field, Korea (Kimura et al., 1982) and collected vast number of leafy stems, rhizomes and a few cones. According to our observation of them, the length of internodes is quite variable, usually shorter below and longer above (range noted from 2.4 cm to 8.5 cm even in the same leafy stem) and the width is broader below and narrower above (range noted from 8 cm to 0.4 cm in the same leafy stem). Thus it is difficult to distinguish between *Neocalamites carrerei* and *N. hoerensis* depending only on the ratio (L/W) of internode. In Korean *Neocalamites carrerei*, leaves are not shorter but more than 20 cm long and are not so generally narrower but many of them reaching 2 mm wide (range noted from 0.5 mm to 2 mm). Thus it is also difficult to distinguish between both species depending only on the fragmentarily preserved leaves as shown by Oishi (1931, pl. 16, fig. 2 from Tsuchizawa).

Under the circumstances, we refrain from the specific identity of *Neocalamites* pith-casts and detached leaves from the Kuruma Group and Iwamuro Formation without the aid of further material.

Filicales

Marattiaceae

Marattia asiatica (Kawasaki) Harris

Text-fig. 16

Marattia asiatica (Kawasaki) Harris: Kimura and Tsujii, 1980b, p. 449, pl. 54, fig. 1; pl. 55, figs. 1—3; text-figs. 1a—j. For further references, see Kimura and Tsujii, 1980b, p. 449.

Additional material: NNW-826 (821, counterpart) (Nishi-Neiridani).

Additional description and remarks: Newly obtained is a main rachis bearing sessile *Marattia* pinnae which are, though broken, referable fully to *M. asiatica* in all respects.

The main rachis is thick, 1 cm wide below and 0.55 cm above, more than 10.4 cm long with longitudinal striations (a part was already shown in Kimura and Tsujii, 1980b, text-fig. 1b), giving laterally off pinnae suboppositely at intervals of 3—3.5 cm and at a wide angle below and obliquely above as shown in Text-fig. 16.

Judging from the dimension of partly preserved main rachis, the leaves of *Marattia asiatica* are supposed to be fairly large in size, possibly reaching 1 m in length.

Dicksoniaceae

Genus *Coniopteris* Brongniart, 1849: 26

Coniopteris sp. A

Text-figs. 17a—b

Material: SHI-062, 104 (Shinadani).

Description: The leaves obtained are medium-sized and partly fertile, but all are broken. Text-fig. 17a shows a sterile part of leaf which is at least tripinnate with main rachis, 1.8 mm wide with a marked median furrow above, giving alternately off penultimate pinnae at intervals of 2 cm at an angle of 40—60 degrees. The ultimate pinnae are more than 1.3 cm long and 0.5 cm wide in the proximal ones, bearing 3—5 alternate pairs of closely set pinnules in katadromic order at an angle of 55 degrees. The pinnules are varied in size according to their position, generally larger in size on the proximal and basal parts of a leaf, typically 0.5 cm long; its margins are regularly or often irregularly lobed into 1—3 alternate pairs of lobes; each lobe ending at rounded apex, but occasionally not lobed but entire. The veins are weak; the midnerve is distinct but not persisting to the tip, sending off simple or once forked lateral veins; each lobe receives one lateral vein which does not persist to its tip. The sori (or indusia) are larger in size, nearly circular in form, 2.5 mm in diameter, produced at the tip of each lobe on the large-sized pinnules as shown in Text-fig. 17b which possibly shows a part of basal penultimate pinna. Unfortunately the details of sori are not known.

Distribution and occurrence: Coniopteris sp. A is rare, and only known from the Shinadani Formation.

Remarks: Our leaves clearly agree with the Dicksoniaceae in the form of their pinnules and a marginal sorus, but as we have no details of the sorus we make no precise generic identification. However, the name *Coniopteris* has been widely used for leaves with such sori, no better known than ours.

A good many of these ill-known fossils have been given specific names, particularly *hymenophylloides*, but such names are scarcely useful. We make no specific comparisons, but no such leaf with large marginal sori is known from the older Mesozoic of Japan. Elsewhere the dicksoniaceous ferns become common in the Middle Jurassic.

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Explanation of Plate 55

(all natural size)

Figs. 1—4. *Sphenobaiera nipponica* Kimura and Tsujii sp. nov.: Undivided (entire) leaves. 1 (NNW-602, Paratype), 2 (NNW-345, Paratype), 3 (NEE-283, Paratype), 4 (NNW-217).

Figs. 5—6. *Sphenobaiera* cfr. *ophioglossum* Harris: 5 (NEG-021), 6 (NEE-123).

Figs. 7—8. *Phoenicopsis* ex gr. *angustifolia* Heer: 7 (SHI-060), 8 (SHI-106).

Fig. 9. *Podozamites* ex gr. *distans* (Presl) Braun: (Kr-073).


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Explanation of Plate 56

(all natural size)

Figs. 1—2. *Ginkgo* ex gr. *sibirica* Heer: (A-0354).

Figs. 3—4. *Sphenobaiera nipponica* Kimura and Tsujji sp. nov.: Divided (bilobed) leaves. 3. (NNW-627, Holotype), 4 (NNW-632, Paratype).

Fig. 5. A. *Sphenobaiera* cfr. *ophioglossum* Harris: B. *Czekanowskia* ex gr. *rigida* Heer: (NEE-279).

Fig. 6. *Phoenicopsis* ex gr. *angustifolia* Heer: (SHI-144).

Fig. 7. *Storgaardia spectabilis* Harris: (NEE-070).

Fig. 8. *Elatocladus* sp. A: Shown partly from SHI-018.

Figs. 9—10. *Podozamites* ex gr. *distans* (Presl) Braun: 9 (TOB-048A), 10 (TOB-017B).

Fig. 11. *Podozamites* (*Cycadocarpidium*?) sp. C: (A-3080).


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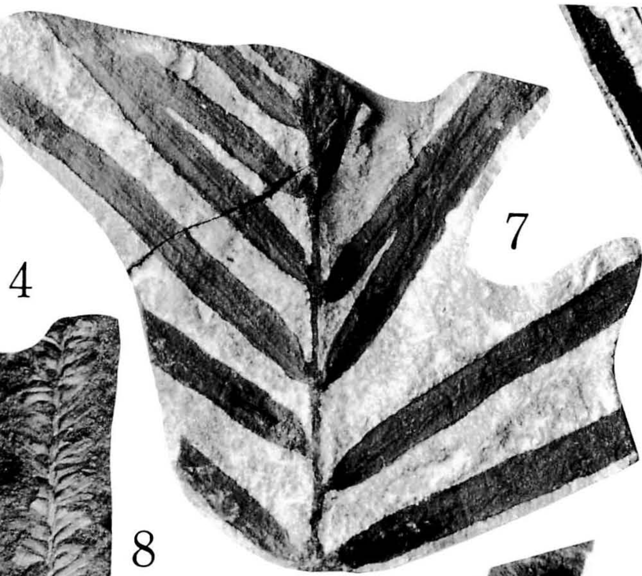
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Geographical names in Japan:
Akaiwa 赤岩, Asahi-machi 朝日町, Dairagawa 大平川, Hokogase 箱ケ瀬, Higashi-Neiridani 東寝入谷, Hiramatsu 平松, Itoshiro 石徹白, Iwamuro 岩室, Kiyosue (Kiyosué) 清末, Kotaki 小滝, Kuruma 来馬, Kusaigawa 草井川, Kuwashima 桑島, Michiichi 道市, Momonoki 桃ノ木, Nakatsuka 中塚, Nariwa 成羽, Negoya 似虎谷, Nishi-Neiridani 西寝入谷, Shimodera 下寺, Shinadani 榀谷, Tobiiwadani 飛岩谷, Tsuchizawa (Tsunzawa) 土沢, Yamanoi 山野井。
Geographical names in China:
Chaidamu 柴達木, Daanshan 大安山, Hongliugou 紅柳溝, Jiaohe 蛟河, Jilin 吉林, Mentougou 門頭溝, Qinghai 青海, Xiangxi (Hsiangchi) 香渓, Xinjiang 新疆, Yanchang 延長。
Geographical names in Korea:
Chungnam 忠南, Daedong 大同, Pyeongyang 平壌。

日本の初期ジュラ紀植物化石。その 6: 前編につづき，来馬層群および岩室累層からつぎのイチョウ，チエカノフスキアおよび球果目に属する化石および補足としてシダ植物3種を記載した。

イチョウ目: *Ginkgo* ex gr. *sibirica* Heer, *Sphenobaiera* cfr. *eurybasis* Sze, *S. nipponica* Kimura and Tsujii sp. nov., *S.* cfr. *ophioglossum* Harris and Millington, *Ginkgoidium* ? sp.

チエカノフスキア目: *Czekanowskia* ex gr. *rigida* Heer, *Phoenicopsis* ex gr. *angustifolia* Heer.

球果目: *Elatocladus* sp. A, *E.* sp. B, *Storgaardia spectabilis* Harris, *Podozamites* ex gr. *distans* (Presl) Braun, *P.* sp. A, *P.* sp. B, *P.* (*Cycadocarpidium* ?) sp. C, *Swedenborgia* sp. A.

シダ植物（補足）: *Neocalamites* sp. A, *Marattia asiatica* (Kawasaki) Harris, *Coniopteris* sp. A.

以上のうち *Sphenobaiera* 属は日本で最初の記載である。Cuticle が保存されていないため，以上について完全な同定ができなかったが，いずれも日本の初期ジュラ紀植物群の重要な構成要素であり，当時の植物地理を論ずる上で重要な資料となる。 木村達明・辻井正則

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 133, pp. 288—299, pls. 57—60, April 30, 1984

774. CRETACEOUS NAUTILOIDS FROM HOKKAIDO — IV
PART 4. AN INTERESTING NAUTILOID SPECIES FROM THE CENOMANIAN OF HOKKAIDO*

TATSURO MATSUMOTO[1], TAKEMI TAKAHASHI[2],
IKUWO OBATA[3] and MASAO FUTAKAMI[4]

Abstract. This paper consists of sections A and B. In section A, *Anglonautilus japonicus* Matsumoto et Takahashi, 1982, from the Lower Cenomanian Zone of *Mantelliceras japonicum* in the Ikushumbets area, central Hokkaido, is described in more detail. It is distinguished from *A. undulatus* (Sowerby), the type species, by its broader whorl which has a shallow median ventral groove on the adoral part, weaker and less distant ribs which tend to be approximated on the last part, and somewhat more sinuous sutures. Its characters suggest the relationships of *Anglonautilus* with certain subgroups of *Cymatoceras* on one hand and *Paracymatoceras* on the other.

In section B, the ontogeny, especially an individual allometry, of the same species is examined in detail on the early whorl. An observation of the spiral growth in early stage on *Anglonautilus japonicus* has confirmed the existence of two critical points, i.e. 1.2π and 2π in total rotation angle from the axis. The nepionic constriction is recognized at a point between the two critical points. As to the septal interspace three growth stages are noticed in the early whorl: the first and the second chambers are small, the third to the seventh large, and the eighth and the successive chambers again small in total rotation angle from axis. Thus the pattern of septal growth on the early whorl in the present species has some similarity with that in *Nautilus pompilius*. *Anglonautilus japonicus*, which has an adult shell of about 90 mm in diameter, shows a great changes of the growth pattern near the nepionic constriction (D = 15 mm). Thus the end of the embryonic stage of the species can be defined at about 15 mm in diameter. Accordingly, the egg diameter of *Anglonautilus japonicus* is presumed to be smaller than that of the living *Nautilus*.

Introduction

An interesting nautiloid species from the Cenomanian of Hokkaido, which we are going to deal with in this paper, has been nomenclatorially established by the first two authors (Matsumoto and Takahashi, 1982). That report was, however, so brief that the description in more details is given in this paper.

The present study is based on a number of well preserved specimens obtained mostly by the second author (T. T.), sometimes with the first (T. M.), during the field works for years. The specimens of Takahashi's collection are marked as TTC, in this paper. Most of them occurred in the Lower Cenomanian Zone of

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Mantelliceras japonicum at one and the same locality (loc. Ik 1100) and a few at other localities in the same zone. They include the specimens of various growth-stages. Therefore, we have attempted to examine the ontogeny as well as the variation in addition to the routine taxonomy.

The results are described below in the following two sections:

A. Taxonomic Description by T. Matsumoto and T. Takahashi

B. Ontogeny by I. Obata and M. Futakami

A. TAXONOMIC DESCRIPTION

(T. Matsumoto and T. Takahashi)

Family Cymatoceratidae

Genus *Anglonautilus* Spath, 1927

Type species:—Nautilus undulatus J. de Sowerby (original designation).

Remarks:—See Kummel (1956, p. 431), Matsumoto and Takahashi (1982, p. 297) and Matsumoto and Miyauchi (1983, p. 226) for the generic diagnosis and the relationships with *Cymatoceras* and *Paracymatoceras.*

Anglonautilus japonicus Matsumoto et Takahashi

Pl. 57, Fig. 1; Pl. 58, Fig. 1; Pl. 59, Figs. 1, 2; Pl. 60, Figs. 1—6; Text-fig. 1

1982. *Anglonautilus japonicus* Matsumoto et Takahashi, *Proc. Japan Acad.*, vol. 58, ser. B, p. 295, figs. 1—3.

Material:—Holotype TTC. 390715 (Pl. 1, Fig. 1; Text-fig. 1A), adult specimen, internal mould for the most part but for the last ventral part where a portion of the test is preserved. Paratype 1, TTC. 500413 (Pl. 58, Fig. 1; Text-fig. 1B), another adult example in which the test is better preserved but the sutures are not so well shown as in the holotype.

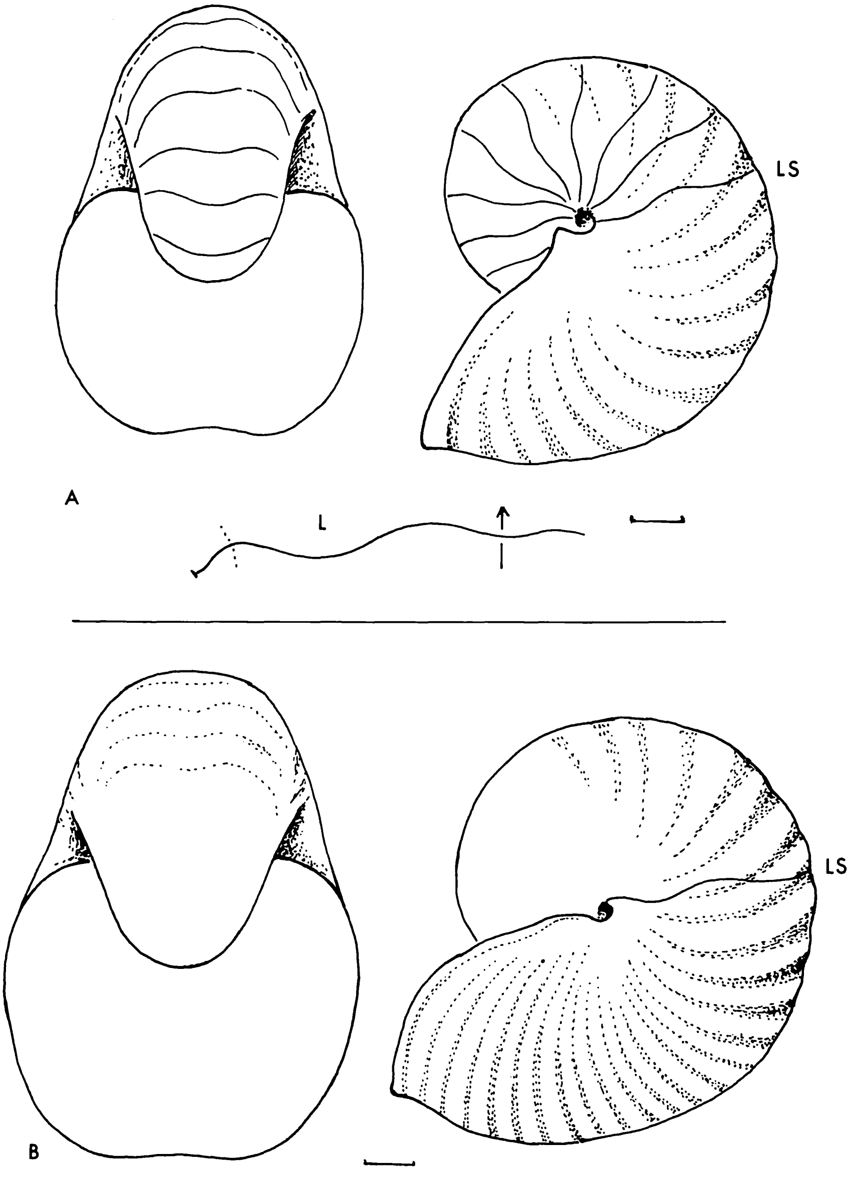
Other 18 paratypes are smaller than the above two, representing immature stages. The majority of them is TTC. (400606, 390419, 380414, 390726-3, 410710, 390717-1, 400530, 390726-1, 390726-2, 400516, 391102, 370524, 390917-2, 370717, 410723, 500900) and 2 others are in Kyushu University Geological Collection (GK. H 5568 and GK. H. 5930 obtained by M. Suda and T. Takahashi respectively, both presented through T. Matsumoto).

Description:—The adult shell is of moderate size, about 90 mm in diameter in the holotype and 95 mm in the paratype 1. The body-chamber occupies about 150° — 170°, slightly less than a half whorl.

The adult body-chamber is subrounded-subquadrate in section. It is somewhat broader than high, with the proportion of B/H about 1.18 to 1.20, being broadest somewhat below the middle of the whorl-height. In its last part (for about 110° — 130°) where its coiling deviates from normal spire, its venter is broadened, somewhat flattened and provided with a shallow median groove. It has a rounded venter in the preceding part. Its ventrolateral parts are well rounded, flanks are gently convex and inflated, umbilical shoulders are abruptly rounded, passing to a steeply inclined umbilical wall. The umbilicus is very narrow, about 6 per cent of the diameter on the internal mould. The adult shell is somewhat scaphitoid (clioscaphitoid) in aspect by a deviation from the normal spiral coiling for the last 110° in the holotype and 130° in the paratype 1.

In the phragmocone, the whorl is more rounded in section, with a well rounded ventral part and convex flanks. It is somewhat broader than high, with the maximum breadth near the umbilical shoulder.

The shell formed in the mature stage, i.e. the body-chamber and the last 75° (±10°) of the phragmocone, is ornamented with low and broad ribs or undulations, which are distinct on the outer part of the whorl but weakened and fading away as they approach the umbilicus. They are fairly distant for each 90° or so before and after the last suture, about 5 or 6 being counted per quarter whorl. In the paratype 1, they become more approximated on the last part of the body-chamber, numbering about 15 in the last 120°. In the holotype the distant



Text-fig. 1. Diagrammatic sketch of *Anglonautilus japonicus*. A: TTC. 390715 (Holotype); B: TTC. 500413 (Paratype 1). Frontal and lateral views, with sutures in A and the last suture (LS) only in B. Scale bar is 10 mm. (T. Matsumoto *delin.*)

ribbing persists for a longer period and the ribs tend to be gradually approximated on the last part, but they are not so dense and so numerous as in the corresponding part of the paratype 1 (about 9 in the last 120°). The ribs or undulations in the mature stage are so coarse that they are not only distinct on the surface of the shell but also well marked on the internal mould, except near the umbilical area. They show a convex curvature on the flanks and a considerably backward sinus on crossing the venter.

In the late part of the immature shell, with diameters of 45 – 55 mm, the ribs on the external surface of the shell are fairly dense but

Table 1. Measurements (in mm) of *Anglonautilus japonicus.*

Specimen		Diameter	Umbilicus	Height	Breadth	B/H
Holotype	(end)	88.0 (1)	5.4 (.06)	51.0 (.58)	64.0 (.73)	1.19
,,	(–110°)	75.1 (1)	5.1 (.07)	45.0 (.60)	53.0 (.71)	1.18
,,	(–145°)*	64.0 (1)	–	39.0 (.61)	46.0 (.72)	1.18
,,	(–180°)	57.0 (1)	–	34.0 (.60)	40.0 (.70)	1.18
Paratype 1	(end)	93.0 (1)	3.2 (.03)	57.0 (.61)	68.5 (.73)	1.20
,,	(–120°)	75.0 (1)	4.4 (.06)	46.0 (.61)	55.0 (.73)	1.20
,,	(–170°)*	64.0 (1)	–	39.0 (.61)	47.0 (.73)	1.20
Paratype 2		70.0 (1)	3.0 (.04)	43.0 (.61)	53.0 (.76)	1.23

*end of phragmocone

weak. In still earlier stages they are almost imperceptible. There are fine lirae in parallel to the ribs. Their curvature is similar to that of the ribs on the adult shell. On the well preserved smaller shell (less than 17 mm in diameter) spiral lirae are also discernible, showing a finely reticulated pattern by combination with the radial ones. The surface of the internal mould is smooth in the immature stages.

The suture is moderately sinuous, with a shallow ventral lobe, a low asymmetric saddle at the ventrolateral shoulder, a shallow but distinct lateral lobe on the flank and a smaller saddle at about the umbilical shoulder. The sinuosity of the suture varies to some (but not to a great) extent with growth and also between individuals. The well exposed sutures on the holotype represent the moderate state. The last suture of the paratype 1 is a comparatively less sinuous example. The sutures of the paratype 2, (TTC. 400606)(Pl. 59, Fig. 2), which is of middle growth-stage, are fairly sinuous, showing a prominent saddle at about the umbilical shoulder.

The siphuncle crosses septa at a point somewhat ventrad from the center, about two fifths of the ventro-dorsal distance from the venter.

Remarks:—The details of the ontogenetic change in early immature stages will be described in section B of this paper by Obata and Futakami.

Among numerous specimens from loc. Ik 1100, there are two specimens which deviate from the above descriptions. One is small and probably immature, but distinct from others in having a compressed whorl (H > B); the other is a distorted specimen of moderate size, but unlike others of the corresponding size it has the ribbing of *Cymatoceras* type. These two specimens are excluded from the material of the present species, although we hesitate to give them a definite specific name.

Comparison and discussion:—As there are fold-like major ribs which are distinct on the outer part of the adult whorl but weakened and disappearing toward the umbilicus, this species is undoubtedly referred to *Anglonautilus.* The holotype of the present species is indeed similar to the topotype of *A. undulatus* (Sowerby), from the Lower Greensand of England (Kummel, 1956, p. 430, pl. 20, figs. 1, 2; text-fig. 26), with respect to the major ribs and the subquadrate section of the adult whorl, but the former has lower and somewhat more numerous ribs, a more inflated and broader whorl and more sinuous suture with a small but distinct saddle at about the umbilical shoulder. The shallow ventral groove, approximation of the ribs on the adoral part and somewhat scaphitoid coiling of the body-chamber are characteristic of the present species.

Any of the specimens of *A. japonicus* representing various growth-stages is different from the illustrated specimens of *A. undulatus* from the Cenomanian of England (Sharpe, 1953, p. 15, pl. 5, figs. 4a-c) and the northern Caucasus (Shimansky, 1960, pl. 7, fig. 1) by its more inflated broader whorl and weaker, less distant fold-like ribs. It is, however, noted that an exceptional specimen (TTC. 400516) in our population somewhat approaches to the British Cenomanian form, as will be explained in more detail in section B.

As one of us (T. M.) has mentioned in Part 2 of this serial publication (Matsumoto *in* Matsumoto and Muramoto, 1983), the pattern of suture varies between species of *Cymatoceras*, but the majority of the species has somewhat sinuous sutures which range between those of *Cenoceras* and *Kummeloceras*. A few species show more sinuous sutures in which a small but distinct saddle is developed at about the umbilical shoulder. This pattern is similar to that of *A. japonicus*. In *A. japonicus*, however, there is some extent of variation in the sinuosity of sutures and the most sinuous example approaches to, if not so strongly folded as, the suture of *Paracymatoceras asper* (Oppel) or *P. texanum* (Shumard) (see Miller and Harris, 1945, pls. 3-5, text-figs. 3A, B).

The paratype 1 of *A. japonicus* somewhat resembles the holotype of *Paracymatoceras tunghaicum* Matsumoto et Amano (1964, p. 175, pl. 26, fig. 1; text-figs. 2, 3), from the Lower Cenomanian of western Kyushu, in having the subquadrate whorl-section, the ventral groove and the *Cymatoceras* type ribs which are shown in the last stage not only on the surface of shell but also on the internal mould. The angle of the ventral sinus in the former is not so sharp and so small as in the latter.

Although the latter is imperfectly preserved, it has no fold-like ribs in the preceding main part of the mature shell. The whorl of the former has more inflated flanks. The strongly folded suture in *P. tunghaicum* is the prime distinction.

A. japonicus is similar to *A. mamiyai* Matsumoto et Miyauchi (1983, p. 226, pl. 50, fig. 1), from the Campanian of northern Hokkaido, in the subrounded-subquadrate section of the body-chamber and the shallow ventral groove on the adoral part, but is distinguished by much weaker ribs, narrower almost closed umbilicus and less sinuous sutures of the latter species.

Occurrence:—The holotype and 16 other specimens occurred in the sandstone of loc. Ik 1100, Katsurazawa pit (now abandoned), on the right side of the main stream of the Ikushumbets, central Hokkaido. The silty fine-grained sandstone of the pit belongs to the Zone of *Mantelliceras japonicum*, upper Lower Cenomanian. A few other specimens were obtained from the same zone in the Torii-zawa (=Shimo-ichi-no-sawa), a tributary to the Ikushumbets and in the Onko-no-sawa, a branch of the Pombets. See Matsumoto, 1965 and Matsumoto *et al.*, 1969 for the location of Ik 1100.

B. ONTOGENY

(I. Obata and M. Futakami)

Material and Method

Twenty specimens, which were collected mainly by T. Takahashi, of *Anglonautilus japonicus* are used for this study. As to the details of material see section A of this paper by Matsumoto and Takahashi. All the localities belong to the *Mantelliceras japonicum* Zone, upper Lower Cenomanian.

As the first step to examine the biometry, we have measured the shell-diameter, the whorl-

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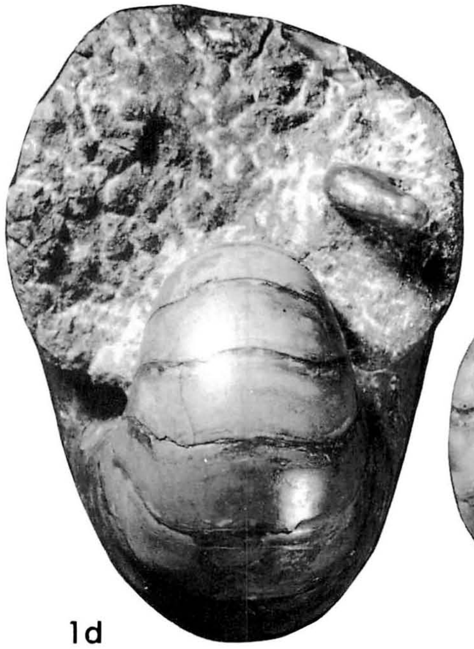
Explanation of Plate 57

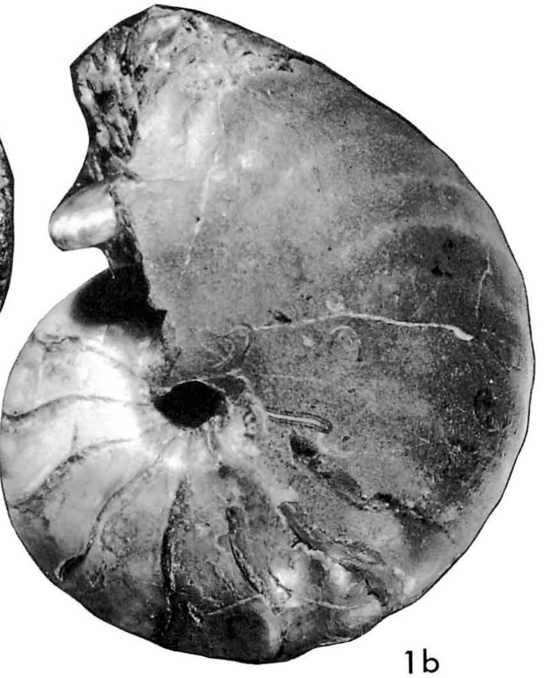
Fig. 1. *Anglonautilus japonicus* Matsumoto et Takahashi . . . . Page 289
Holotype, TTC. 390715, from loc. Ik 1100, Katsurazawa Pit, Ikushumbets area.
Left (a) and right (b) lateral, back (c) and frontal (d) views, x1.

Photos in Pls. 57—59 all by courtesy of Dr. M. Noda.


1a


1c


1d


1b

height and the whorl-breadth of each individual by means of calipers and discussed on the average relative growth of the species. We also have prepared polished cross-section (TTC. 390917-1) and longitudinal ones (i.e. TTC. 380414 and TTC. 400530), which have been examined by means of the profile projector (V-16D, Nippon Kogaku Co.) and the WILD microscope.

Observation of Variation

Adult stage:—The specific diagnosis of the present species has been described in detail in section A by Matsumoto and Takahashi. According to them, the fold-like ribbing is characteristic of the adult stage (e.g. TTC. 390715 and TTC. 500413) and a shallow median groove is formed in the adoral part.

The ribs are thick and widely interspaced in the main part of the adult stage but gradually approximated in the last part.

Middle stage:—The middle stage is here defined as being from the appearance of nepionic constriction to that of distinct ribs. Eighteen specimens have been examined. A variation is recognized in the shell form: the ratio of whorl-breadth (B) to whorl-height (H) varies from 1.10 to 1.40, that of whorl-height (H) to shell diameter (D) from 0.53 to 0.71, and that of whorl-breadth (B) to shell diameter (D) 0.67 to 0.81.

The whorl-section is generally semi-circular in outline, being rounded on the venter and the ventro-lateral margin, except for TTC. 400516 which has a rather subquadrate to subrounded cross-section. In TTC. 400516, the venter is more gently arched, and the flanks are flattened and slightly convergent to the subrounded or subquadrate ventro-lateral margin. TTC. 400516 shows, however, a pattern of suture-line similar to that of the other specimens, a similar value of B/H and was obtained from the same locality with most of them. Thus TTC. 400516 can be included within the scope of variation of this species.

So far as the examined specimens (TTC. 390419, TTC. 390726-3, TTC. 400530) are concerned, the position of siphuncle clearly

Table 2. Measurements of the middle-aged and the earlier individuals in diameter, whorl-height and whorl-breadth.

Specimen	D	H	H/D	B	B/D	B/H
TTC. 390419 (−180°)	62.2	43.9	0.71	48.1	0.77	1.10
TTC. 380414 (−180°)	43.6	(27.5)	(0.63)	32.4	0.74	(1.18)
TTC. 390726-3 (−180°)	45.5	26.7	0.59	—	—	—
TTC. 410710	47.8	32.6	0.68	38.2	0.80	1.17
TTC. 390917-1 (−180°)	42.6	26.4	0.62	34.0	0.80	1.29
TTC. 400530 (−180°)	42.1	27.8	0.66	32.1	0.76	1.15
TTC. 390726-1	27.8	15.4	0.55	19.7	0.71	1.28
TTC. 390726-2	39.0	23.9	0.61	(30.1)	0.77	1.26
TTC. 400516	30.4	(18.4)	(0.61)	21.6	0.71	(1.17)
TTC. 391102	29.9	17.5	0.59	22.7	0.76	1.30
TTC. 370524 (−180°)	23.4	13.7	0.59	18.9	0.81	1.38
TTC. 390917-2 (−180°)	22.5	11.9	0.53	(16.1)	(0.72)	(1.35)
TTC. 370717	27.2	15.6	0.57	21.9	0.81	1.40
TTC. 410723	22.0	13.5	0.61	16.0	0.73	1.19
TTC. 500900	19.3	11.0	0.57	13.0	0.67	1.18
GK. H 5568	52.0	33.5	0.64	40.0	0.77	1.19
GK. H 5930	30.0	18.5	0.62	23.2	0.77	1.25

deviates from the median, longitudinal plane to the left side. Among them TTC. 390726-3 is an extreme example.

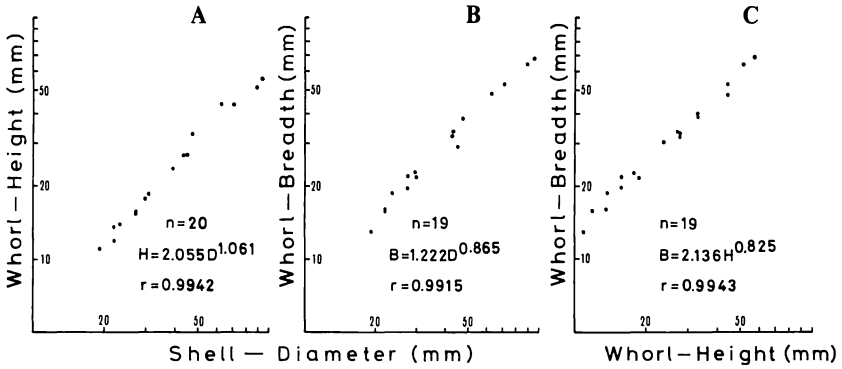
Ontogenetic Development

Average relative growth:—The allometric equation of coiled cephalopods is represented as follows (e.g. Obata, 1959): $y = \beta X^{\alpha}$, where β is initial growth index, and α is growth ratio. We calculated the constant values of allometric equation of *Anglonautilus japonicus* Matsumoto et Takahashi on the average relative growth (Table 2). The result is that the whorl-height (H) shows a positive allometry against the shell-diameter (D), being $H = 2.055D^{1.061}$ and the whorl-breadth (B) shows a negative allometry against the shell-diameter (D) and the whorl-height (H) respectively, being $B = 1.222D^{0.865}$ and $B = 2.136H^{0.825}$ (Text-fig. 2).

Individual spiral growth:—For measurements of spiral growth on the venter in the longitudinal section we regard a straight line which connects the cross-point of first septum to ventral wall and that to dorsal inner wall as a standard axis. The other axis is defined as the perpendicular line, which passes through the latter point, to the standard line. The radius (R) against the total rotation angle (S) is shown on the Text-figs. 3, 4.

The result of measurements by means of the profile projector (Nikon) illustrated in Text-figs. 5, 6 is based on Table 3. Two critical points are recognized at 1.2π and 2π, in the total rotation angle, respectively (Text-fig. 6). Thus the distinguished spiral stages are represented as an equation, $r = ae^{k\theta}$ (Obata, 1960). Some previous authors (e.g. Hirano, 1977; Hirano and Obata, 1979; Hirano *et al.*, 1980) have studied the biometric characteristics of the recent *Nautilus*. The spiral growth of the examined specimens of Cretaceous *Anglonautilus japonicus* can be expressed thus:

	TTC. 400530	TTC. 380414
1st stage	$R=2.535e^{0.267\theta}$ $\omega=74.72^{\circ}$	$R=2.477e^{0.272\theta}$ $\omega=89.94^{\circ}$
2nd stage	$R=4.808e^{0.115\theta}$ $\omega=83.46^{\circ}$	$R=4.592e^{0.104\theta}$ $\omega=84.10^{\circ}$
3rd stage	$R=3.304e^{0.168\theta}$ $\omega=80.40^{\circ}$	$R=3.914e^{0.159\theta}$ $\omega=80.93^{\circ}$



Text-fig. 2. Average relative growth on the shell-diameter, the whorl-height and the whorl-breadth.

Explanation of Plate 58

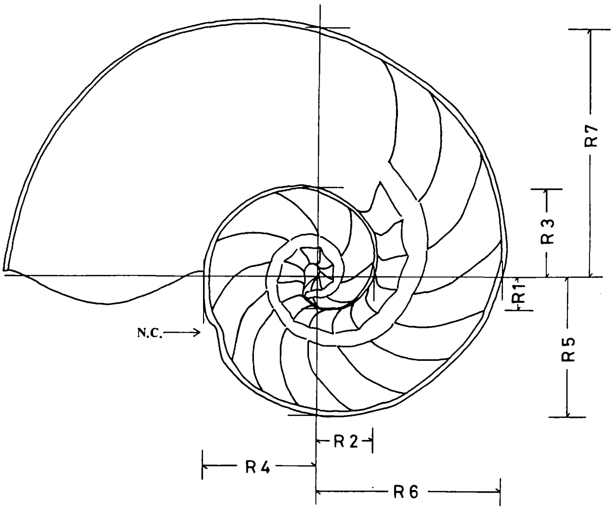
Fig. 1. *Anglonautilus japonicus* Matsumoto et Takahashi . . . . Page 289
Paratype 1, TTC. 500413, from loc. Ik 1100. Lateral (a), adorally ventral (b), back (c) and frontal (d) views, x1.

1a

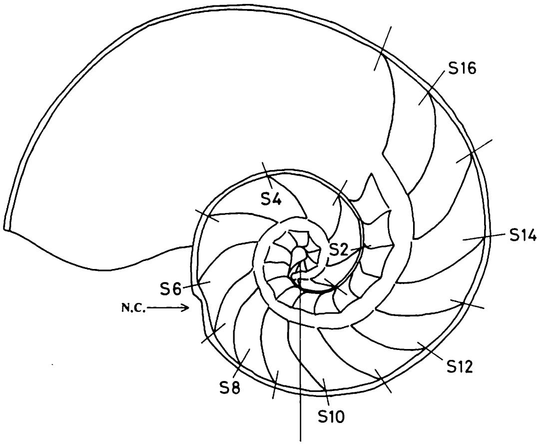
1c

1b

1d



Text-fig. 3. Illustration of the longitudinal section showing the radius (R1—R7) from the axis. N.C.: Nepionic constriction.



Text-fig. 4. Illustration of the longitudinal section showing the total rotation angle (S1—S17) from the axis. N.C.: Nepionic constriction.

The growth ratio of the second stage is minimum amongst the ratios. In TTC. 400530 the nepionic constriction is detectable at 1.7π in the second stage. To know the growth pattern in detail we examine the value of radius (R) between R4 and R5 by each 10° in the total rotation angle (Text-fig. 7).

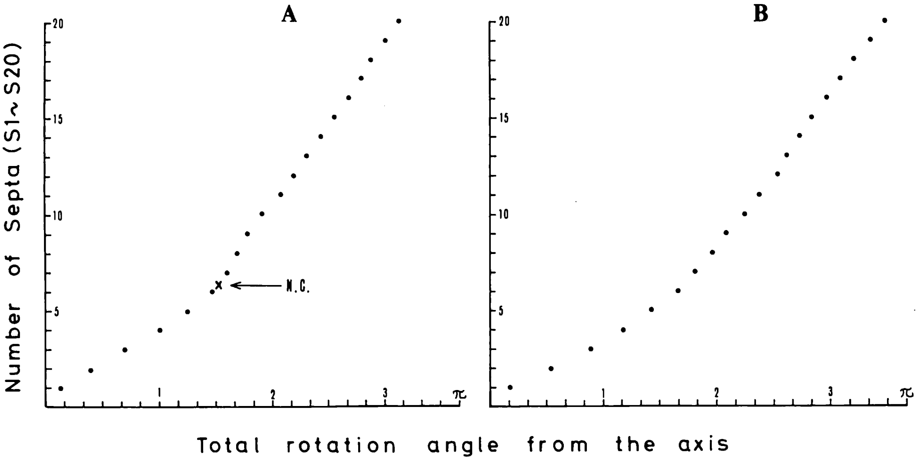
If we ignore the dropping of radius caused by the shape of nepionic constriction, the relation between R and θ may be almost linear (Text-figs. 7, 8). Thus the second stage of spiral growth represents a slow transitional one between the rapid first and the moderate third ones (Text-fig. 6) in the early whorl.

As to the pattern of the septal formation (Table 3) the following three stages are distinguished:

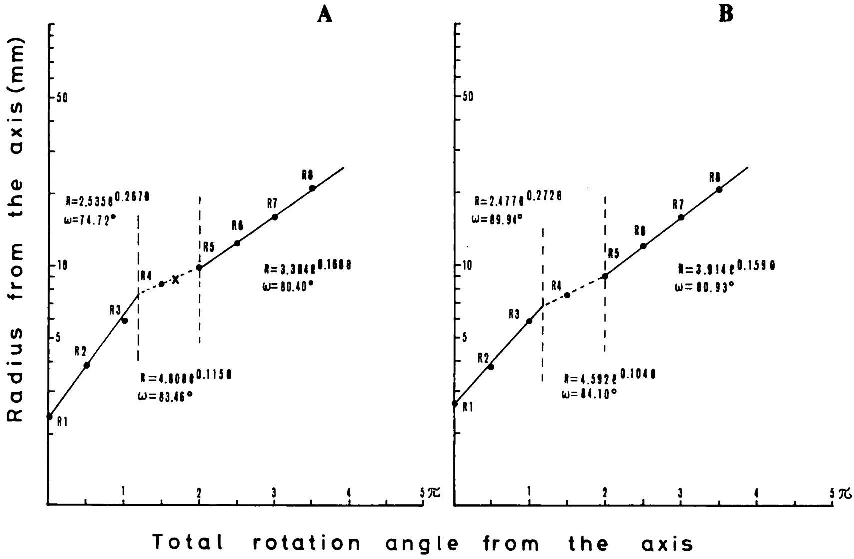
1st stage	
1st and 2nd chamber	S (degree) is small
2nd stage	
3rd to 7th chamber	S (degree) is large
3rd stage	
8th to 21st chamber	S (degree) is small

The nepionic constriction is just situated at the anterior side of the seventh chamber (Text-figs. 3, 4). In other words, the formation of nepionic constriction seems to be related to the formative velocity of periodic septum.

Naef (1921—1923) has already pointed out the similar tendency of ontogenetic change in the septal interspace on a living *Nautilus*: the interspace of the first to third chamber is narrow, that of the fourth to seventh is wide, and that of the eighth and the successive chambers is again narrow. Shimanskiy (1948) also observed an ontogenetic difference of the septal interspace on some Paleozoic orthocerids.



Text-fig. 5. Relation of the septum number (S1—S20) and the total rotation angle from the axis. A: TTC. 400530; B: TTC. 380414. N.C.: Nepionic constriction.



Text-fig. 6. Relation of the radius and the total rotation angle from the axis. Equation of the spiral growth is shown. A: TTC. 400530; B: TTC. 380414.

Explanation of Plate 59

Figs. 1, 2. *Anglonautilus japonicus* Matsumoto et Takahashi . . . . Page 289

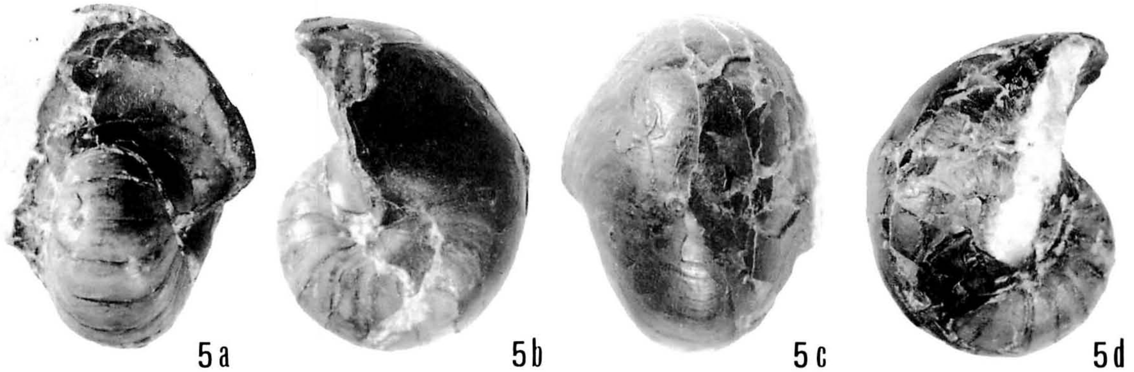
1. GK. H 5568, from loc. Ik 1100. Two lateral (a, b), frontal (c) and back (d) views of an immature example, x1.
2. TTC. 400606, from loc. Ik 1100. Two lateral (a, b) and back (c) views of a middle-aged example, showing fairly sinuous sutures, x1.

1a 1b 1c

3

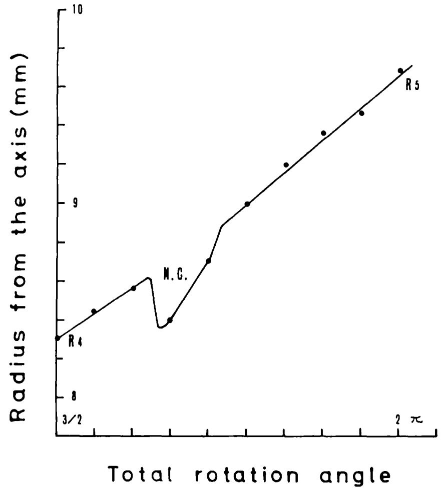
2a 2b 2c 2d

4

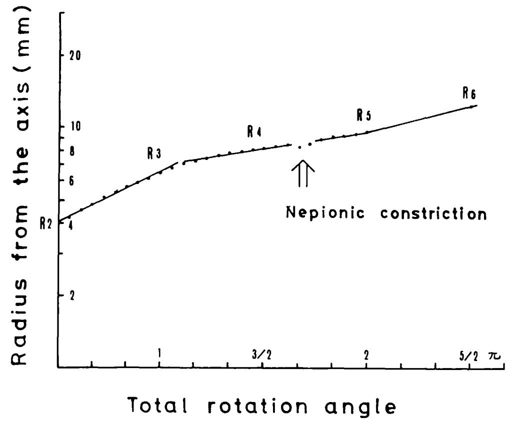


5a 5b 5c 5d

6a 6b 6c 6d



Text-fig. 7. Relation of the radius (R4 to R5) and total rotation angle from the axis on TTC. 400530. N.C.: Nepionic constriction.



Text-fig. 8. Relation of the radius (R2—R6) and the total rotation angle from the axis on TTC. 400530.

Table 3. Measurements on the spiral growth in radius from the axis (R), total rotation angle from the axis (S) and the septum number.

	TTC. 380414		TTC. 400530	
Septum	R (in mm)	S (degrees)	R (in mm)	S (degrees)
1	1.999	34°43′	2.383	26°20′
2	4.252	63°35′	3.851	49°35′
3	5.813	52°08′	5.878	55°04′
4	7.571	62°45′	8.275	53°40′
5	8.953	45°51′	9.910	45°24′
6	12.160	40°30′	12.367	37°31′
7	15.866	27°34′	15.924	22°50′
8	20.114	27°35′	20.974	16°00′
9		23°20′	25.480	19°18′
10		27°12′		22°26′
11		25°15′		29°40′
12		22°30′		20°30′
13		21°13′		21°22′
14		19°40′		21°32′
15		20°56′		21°54′
16		21°56′		23°36′
17		21°15′		22°18′
18		23°00′		14°19′
19		24°20′		23°00′
20		23°35′		19°47′

Concluding Remarks

1. An observation of the spiral growth in early stage on *Anglonautilus japonicus* from the Cenomanian of Hokkaido has confirmed the existence of two critical points, i.e. 1.2π and 2π in total rotation angle from the axis. The nepionic constriction is recognized at a point between the two critical points.
2. As to the septal interspace three growth stages are noticed in the early whorl. In other words, the first and the second chambers are small, the third to the seventh large, and the eighth and the successive chambers again small in total rotation angle from the axis.
3. Thus the pattern of septal growth on the early whorl in *Anglonautilus japonicus* has some similarity with that in *Nautilus pompilius.* However, the latter differs from the former in that the first three septa are close together, the third to the seventh septa are the most widely spaced, from the seventh septum on they are fairly close together again (Stenzel, 1964).
4. *Anglonautilus japonicus*, which has an adult shell of about 90 mm in diameter, shows a great changes of the growth pattern near the nepionic constriction (D=15 mm). Thus the end of the embryonic stage of the species can be defined at about 15 mm in diameter. On the other hand, the nepionic constriction of *Nautilus pompilius*, a living nautilus which has an adult shell of about 200 mm in diameter, is at about 25 to 27 mm in diameter (Naef, 1921—1923) and is regarded as the end of the embryonic stage (Stenzel, 1964; Cochran *et al.*, 1981; *non* Eichler and Ristedt, 1966). On *Nautilus macromphalus* the egg is estimated as 45 mm in diameter (Stenzel, 1964). Accordingly, the egg diameter of *Anglonautilus japonicus* is presumed to be smaller than that of the living *Nautilus.*

References Cited

(For brevity the references listed in Parts 1—3 are not repeated here.)

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Explanation of Plate 60

Anglonautilus japonicus Matsumoto et Takahashi

Fig. 1. Frontal (a), lateral (b) and ventral (c) views of TTC. 370717 from loc. Ik 7758 p, the Onko-no-sawa, a branch of the Pombets.

Fig. 2. Frontal (a), lateral (b, d) and ventral (c) views of TTC. 391102 from loc. Ik 1100, Katsurazawa Pit, Ikushumbets.

Fig. 3. A longitudinal section of TTC. 400530 from loc. Ik 1100.

Fig. 4. A cross-section of TTC. 390917-1 from loc. Ik 1100.

Fig. 5. Frontal (a), lateral (b, d) and ventral (c) views of TTC. 390726-3 from loc. Ik 1100.

Fig. 6. Frontal (a), lateral (b, d) and ventral (c) views of TTC. 410710 from loc. Ik 1100.

All specimens were collected by Takemi Takahashi and photographed by Masao Futakami.


1a

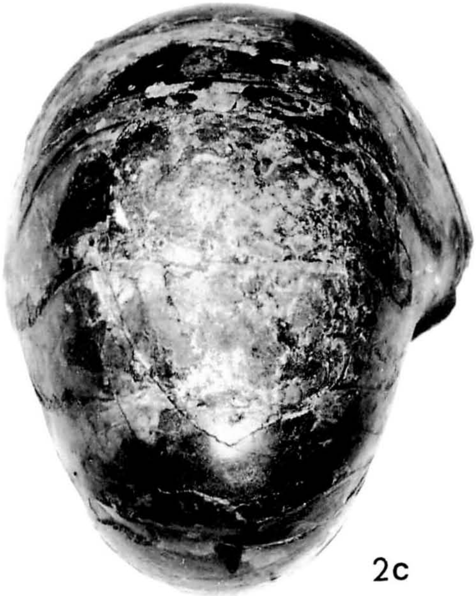
1c


1b


2a


1d


2b


2c

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Ikushumbets [Ikushunbetsu] 幾春別, Katsurazawa 桂沢, Onko-no-sawa オンコの沢, Pombets [Ponbetsu] 奔別, Shimo-ichi-no-sawa 下一の沢, Torii-zawa 鳥居沢

北海道産白亜紀オウムガイ類—IV. その 4. 北海道のセノマニアン産の興味ある1種: A. 分類。幾春別地方の下部セノマニアン *Mantelliceras japonicum* 帯産の好資料に基づき *Anglonautilus japonicus* を記載した。本種は模式種 *A. undulatus* (Sowerby) に比し，肋が弱く間隔が狭く，住房最終部で密になっていくこと，螺環の幅が広く，最終部外面中央に浅い凹帯があること，縫合線の波曲がより著しいことなどで区別される。同時にその性状には，*Cymatoceras* はもとより，*Paracymatoceras* とも関連を示す点があり興味深い。

(松本達郎・高橋武美)

B. 個体発達，上記種の個体群につき，個体変異および個成長などを検討した。その結果，とくに螺環成長様式では，殻半径の成長回転角が 1.2π および 2π 付近にそれぞれ変移点が認められ，その間に nepionic constriction が存在する。また隔壁の形成様式にも3つの成長期が識別され，現生オウムガイ類との共通点と相違点が認められる。 (小畠郁生・二上政夫)

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 133, pp. 300—312, pl. 61, April 30, 1984

775. EARLY CARBONIFEROUS (VISEAN) BRACHIOPODS FROM THE HIKOROICHI FORMATION OF THE KITAKAMI MOUNTAINS, NORTHEAST JAPAN*

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Abstract. A brachiopod fauna from the upper 105 m of the Hikoroichi Formation of the southern Kitakami Mountains suggests a Late Visean age for that part of the formation. It matches well with the fact that the Hikoroichi Formation is overlain conformably by the Upper Visean Onimaru Formation. The fauna includes the following species: *Schizophoria resupinata*, *Rhipidomella* sp., *Orthotetes* sp., *Pustula* cf. *pustulosa*, *Karavankina* sp., *Cleiothyridina* sp., *Spirifer* sp., *Choristites bisulcatus* and *Tomiopsis* sp.

Introduction

The Lower Carboniferous sequence, excluding the uppermost limestone unit, of the Hikoroichi district (Fig. 1), southern Kitakami Mountains, northeast Japan has long been famous because it contains fossiliferous marine strata of earliest Carboniferous age. This sequence was first introduced in 1948 by Minato and Okubo as the Hikoroichi Series, and subsequently defined lithostratigraphically as the Hikoroichi Formation (Onuki, 1956).

Stratigraphy of the Hikoroichi Formation became more firmly established by Minato (1950), Okubo (1951b), Minato *et al.* (1953), Onuki (1956, 1969), Saito (1968) and Haga (in Minato *et al.*, 1979). The following species have hitherto been described from this formation: 1 rugose coral (Kato, 1959), 1 conularid (Sugiyama, 1938, 1942), 21 bryozoans (Sakagami, 1962), 16 brachiopods (Minato, 1951, 1952; Minato and Kato, 1977), 1 pelecypod (Minato, 1951), 10 trilobites (Sugiyama, 1944; Okubo, 1951a; Endo and Matsumoto, 1962; Araki and Koizumi, 1968; Kobayashi and Hamada, 1980) and 2 crinoids (Minato, 1951). These authors assigned the Hikoroichi Formation or its

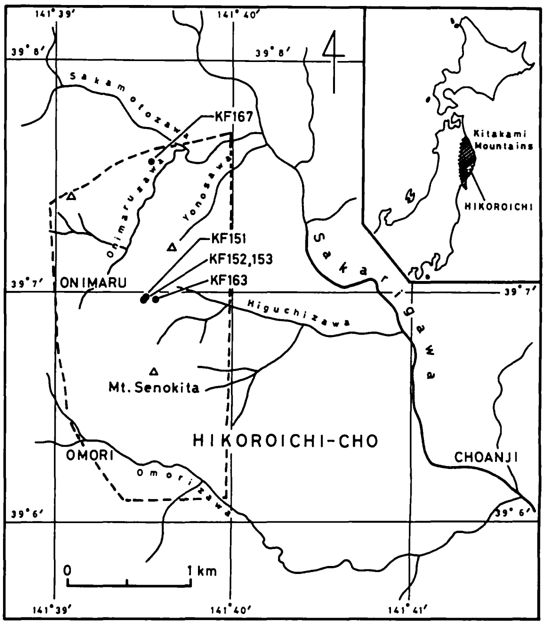

Fig. 1. Map showing the fossil localities and the Hikoroichi district.

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fossil fauna to a Tournaisian age. Also, it was considered that there was a log hiatus between the Hikoroichi Formation and the overlying Upper Visean Onimaru Formation (*e.g.* Minato, 1955a, 1966; Minato *et al.*, 1953, 1979).

In recent years, Mori and Tazawa (1980) found some Visean rugose corals and brachiopods in the upper part of the Hikoroichi Formation of the type locality, and regarded the stratigraphic relationship between these two formations as highly probably conformable. Further occurrences of rugose corals indicating a Visean age were reported by Kawamura, Niikawa and Kato (1981), Kawamura and Kato (1982) and Niikawa (1982), from the upper Hikoroichi Formation. But these fossils have remained undescribed.

In this paper brachiopods from the upper part (upper 105 m) of the Hikoroichi Formation of the Hikoroichi district, previously only listed as species (see Mori and Tazawa, 1980, p. 143), plus newly identified forms, are described, and the age of the fauna is discussed. The specimens are stored in the Institute of Geology and Paleontology, Faculty of Science, Tohoku University.

Stratigraphy

A thick sequence of marine Tournaisian and Visean carbonates, clastics and pyroclastics is present in the Hikoroichi district. The Lower Carboniferous rocks are exposed in the Sakamotozawa, Yonosawa, Higuchizawa and Onimarusawa Valleys, forming a syncline plunging gently to the north (Fig. 2). They have been divided lithologically into two units: the Hikoroichi Formation and the Onimaru Formation.

The Hikoroichi Formation overlies, with angular unconformity, the Middle Devonian Nakazato Formation (*e.g.* Okubo, 1951b; Minato *et al.*, 1979), and is in turn overlain conformably by the Onimaru Formation. It consists mostly of sandstone, with a basal conglomerate and intercalations of shale, acidic to intermediate tuffs and limestone, 560 m in total thickness (Fig. 3). A rather thick (40—90 m), greyish green, dacitic to andesitic tuff is developed at the middle horizon, about 250 to 300 m above the base of the formation. Fossils are generally sparse, but in the lower part it contains highly fossiliferous sandstone and shale beds. Brachiopods are predominant among various invertebrates represented.

The brachiopods treated in this paper were collected from localities KF151, 152, 153, 163 and 167. The geographic and stratigraphic location and the host rock types are as follows (Figs. 1, 3):

KF151: Grey, fine-grained, calcareous sandstone, the top of the Hikoroichi Formation, at 590 m N of the peak of Mt. Senokita, eastern slope facing the upper Higuchizawa Valley (Lat. 39°6′58″N, Long. 141°39′31″E).

KF152: Grey, fine-grained sandstone, 2 m below the top of the Hikoroichi Formation, at 15 m SW of KF151.

KF153: Grey, fine-grained, calcareous sandstone, the top of the Hikoroichi Formation, at 20 m SW of KF151.

KF163: Grey, oolitic limestone, 80 m below the top of the Hikoroichi Formation, at 50 m SE of KF151.

KF167: Grey, fine-grained sandstone, 105 m below the top of the Hikoroichi Formation, at 280 m SW of the junction of the Sakamotozawa and Onimarusawa Valleys, eastern slope facing the lower Onimarusawa Valley (Lat. 39°7′34″N, Long. 141°39′32″E).

Age of the Fauna

The brachiopod fauna described here includes the following species:

Schizophoria resupinata (Martin)
Rhipidomella sp.
Orthotetes sp.
Pustula cf. *P. pustulosa* (Phillips)
Karavankina sp.
Cleiothyridina sp.
Spirifer sp.
Choristites bisulcatus (Sowerby)
Tomiopsis sp.

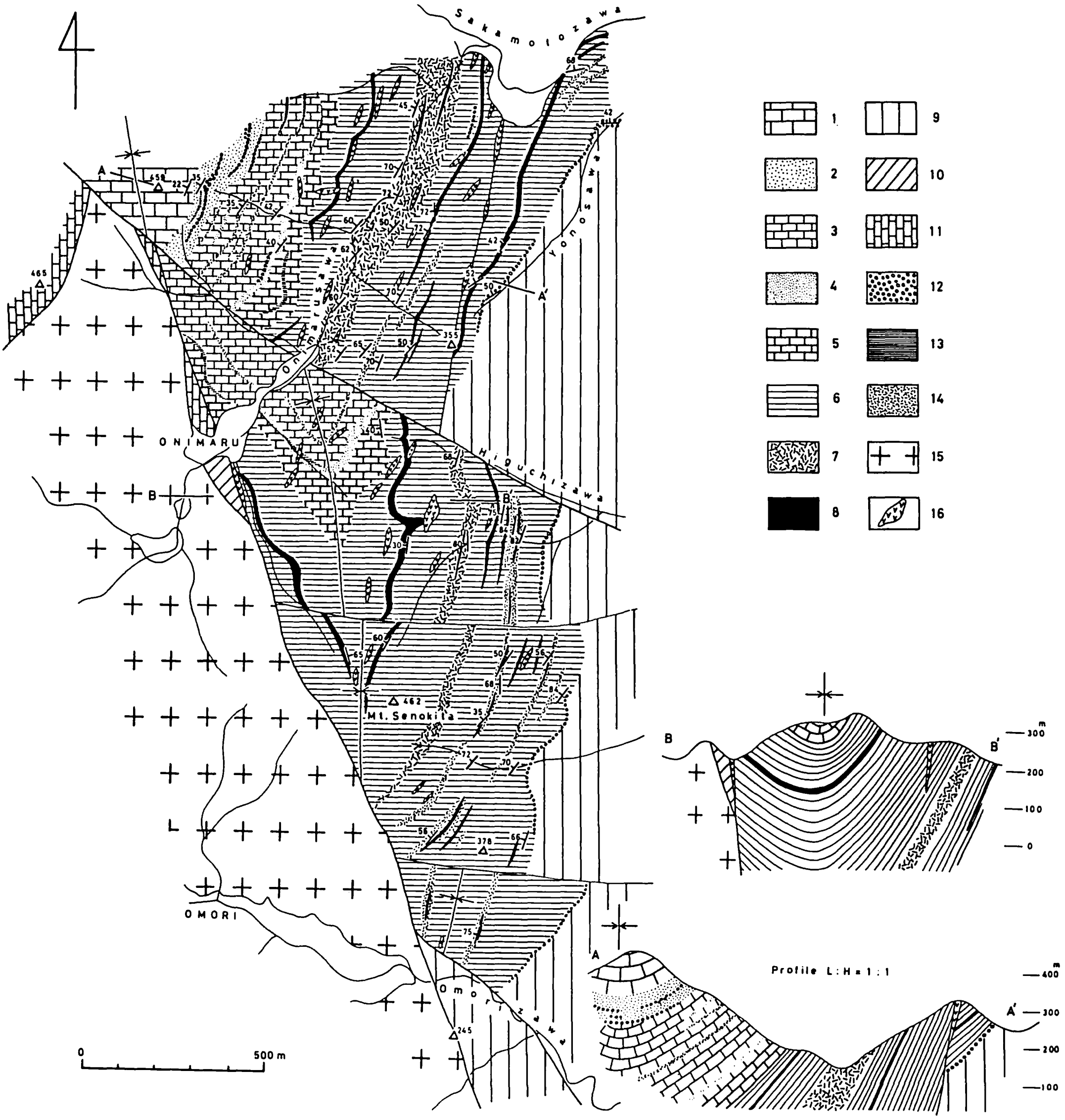

Fig. 2. Geologic map of the Hikoroichi district. 1, 2: Sakamotozawa Formation (Lower Permian; 1: Limestone; 2: Sandstone); 3, 4: Nagaiwa Formation (Lower to Middle Carboniferous; 3: Limestone; 4: Sandstone); 5: Limestone of the Onimaru Formation (Lower Carboniferous); 6—8: Hikoroichi Formation (Lower Carboniferous; 6: Sandstone and shale; 7: Tuff of the upper part; 8: Limestone); 9: Nakazato Formation (Middle Devonian); 10: Ono Formation (Lower Devonian); 11: Kawauchi Formation (Middle to Upper Silurian); 12: Conglomerate of the Hikoroichi, Nagaiwa and Sakamotozawa Formations; 13: Shale of the Onimaru, Nagaiwa and Sakamotozawa Formations; 14: Tuff of the lower part of the Hikoroichi Formation and the Nagaiwa Formation; 15: Granitic rocks (Hikami Granite); 16: Dyke rocks.

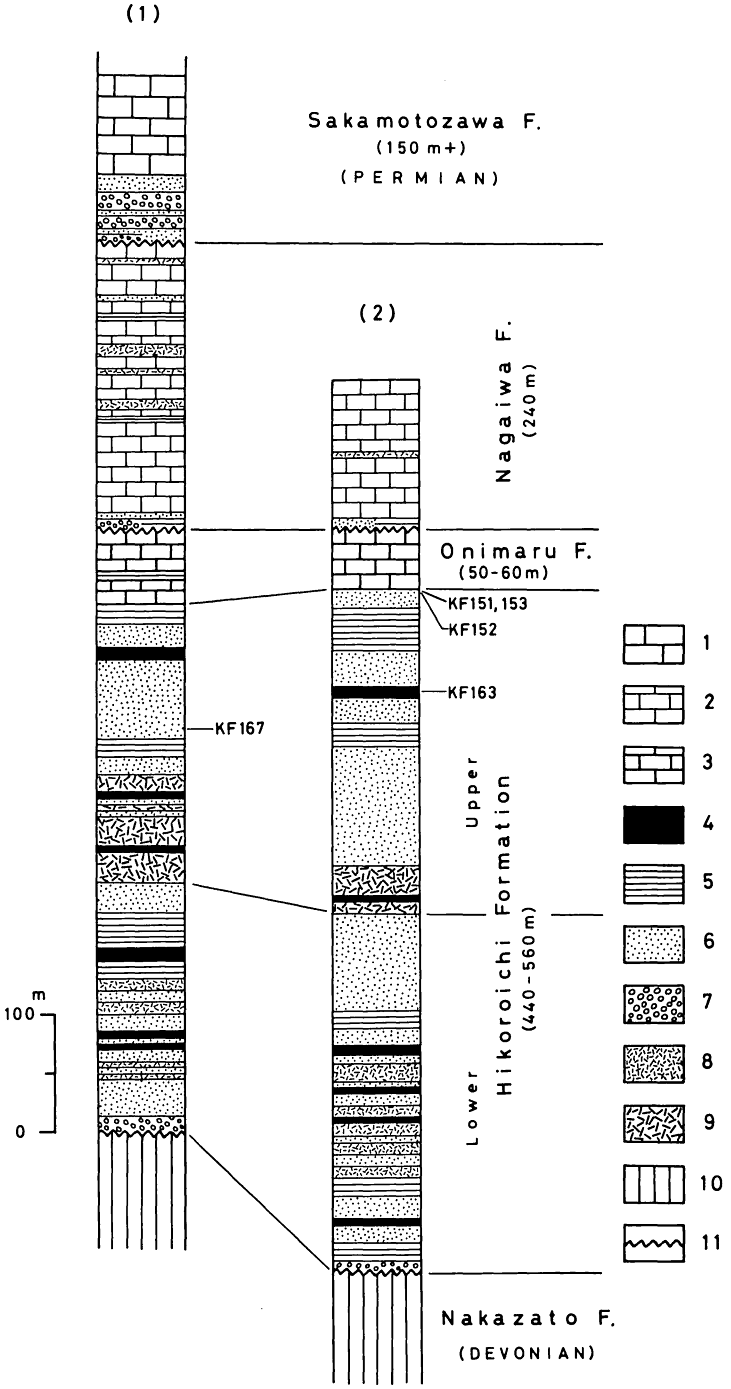

Fig. 3. Columnar sections of the Carboniferous and Permian in the northern area (1) and the southern area (2) of the Hikoroichi district, showing the stratigraphic positions of the fossil localities shown on the index map, see Fig. 1. 1—4: Limestone; 5: Shale; 6: Sandstone; 7: Conglomerate; 8, 9: Tuff; 10: Nakazato Formation; 11: Stratigraphic discontinuity.

Each of the species listed above is represented by a single specimen, except for four *Rhipidomella* sp. specimens and two *Tomiopsis* sp. specimens.

Among these species, *S. resupinata* is a long ranging species, which occurs in the Tournaisian to Visean. *C. bisulcatus* has been known from the Visean and Namurian of Europe, Asia and Australia. *Orthotetes* sp. closely resembles *O. australis* Campbell, 1957 from the Upper Visean of New South Wales. *Pustula* cf. *pustulosa* is compared with shells of *P. pustulosa* (Phillips, 1836), described or figured from the Visean of western Europe and the Soviet Union. *Karavankina* sp. most resembles *K. jizodoensis* Tazawa, 1980 from the Upper Visean of the Nagasaka district, southern Kitakami Mountains. *Spirifer* (s.s.) sp. is close to *S. liangchowensis* Chao, 1929 from the Visean of Gansu, South China.

The genus *Karavankina* Ramovs, 1969 has not been found below the Upper Visean (Winkler Prins, 1982). On the other hand, the upper age limit of this fauna is assigned to Late Visean from its stratigraphic level directly below the Upper Visean (*e.g.* Minato, 1955b; Okimura, 1966) Onimaru Formation. Therefore, *Karavankina* sp., collected from the lowest fossil horizon (KF167), appears to have value in correlation.

The brachiopod fauna is considered to be of Early Carboniferous, Late Visean age. This conclusion agrees with the opinion (Kawamura and Kato, 1982) based on rugose corals, and matches well with the stratigraphic data suggesting that the Hikoroichi Formation is overlain conformably by the Upper Visean Onimaru Formation.

Description of Species

Order Orthida Schuchert and Cooper, 1932

Suborder Orthidina Schuchert and Cooper, 1932

Superfamily Enteletacea Waagen, 1884

Family Enteletidae Waagen, 1884

Subfamily Schizophoriinae Schuchert and Le Vene, 1929

Genus *Schizophoria* King, 1850

Schizophoria resupinata (Martin, 1809)

Pl. 61, Figs. 9a, 9b

1809 *Conchyliolithus* (*Anomites*) *resupinatus* Martin, pl. 49, figs. 13, 14.
1952 *Schizophoria resupinata* (Martin): Minato, p. 150, pl. 5, fig. 3; pl. 6, fig. 4.
1968 *Schizophoria resupinata* (Martin): Pocock, p. 80, pl. 18, figs. 7a, 7b; text-figs. 13–15.
1979 *Schizophoria resupinata* (Martin): Tazawa and Katayama, p. 169, pl. 11, figs. 8–14.
1979 *Schizophoria resupinata* (Martin): Minato (in Minato *et al.*), pl. 22, figs. 1, 2.
1980 *Schizophoria resupinata* (Martin): Mori and Tazawa, text-fig. 3.3.
1981 *Schizophoria resupinata* (Martin): Tazawa, Itabashi and Mori, pl. 1, figs. 4–6.
1981 *Schizophoria resupinata* (Martin): Tazawa, p. 67, pl. 5, figs. 3–5.

Material:—One specimen, internal mould of a pedicle valve with the posterior portion of the brachial valve attached, from locality KF167, IGPS coll. cat. no. 97898.

Descriptive remarks:—The single specimen from Hikoroichi is referred to *Schizophoria resupinata* (Martin, 1809) on account of its large, elliptical, flat pedicle valve and the ventral internal structure, *viz.* a large, flabellate muscle field, long, subparallel dental plates, high, strong median septum and a pair of long vascular markings. The dimensions of the pedicle valve are as follows: length about 45 mm, width about 70 mm, width of the hinge line about 32 mm. The ventral muscle field is faintly sculptured with several radial ribs on the anterior portion, and is bounded anteriorly by an accessory ridge and postero-laterally by dental plates. The median septum is low and thin on the posterior portion, becomes high and strong anteriorly, extends to but not projects beyond the anterior margin of the muscle field. The vascula media occurs just anterior to the muscle field, first slightly diverging, then converging anteriorly.

In the Lower Carboniferous of the southern Kitakami Mountains *S. resupinata* has been described or figured from the Arisu Formation (Minato, 1952, 1979 in Minato *et al.*), Odaira Formation (Tazawa and Katayama, 1979), Karoyama Formation (Tazawa, Itabashi and Mori, 1981; Tazawa, 1981) and Hikoroichi Formation (Mori and Tazawa, 1980).

Family Rhipidomellidae Schuchert, 1913

Genus *Rhipidomella* Oehlert, 1890

Rhipidomella sp.

Pl. 61, Figs. 5—7

1979 *Rhipidomella* sp. Tazawa and Katayama, p. 170, pl. 11, figs. 1—7.
1980 *Rhipidomella* sp. Mori and Tazawa, text-figs. 3.4—3.6.

Material:—Four specimens, from locality KF163: (1) two pedicle valves showing the internal structures, IGPS coll. cat. nos. 97899, 97900; (2) internal moulds of two brachial valves, IGPS coll. cat. nos. 97901, 97902.

Remarks:—These specimens are assigned to the genus *Rhipidomella* Oehlert, 1890 on the basis of their small (length 25 mm, width 19 mm in the largest specimen, IGPS coll. cat. no. 97902), suboval shells, with the internal structure consisting of a large, flabellate ventral muscle field, a large cardinal process, a pair of strong brachiophores and a quadripartite dorsal muscle field.

The Hikoroichi species appears to be conspecific with *Rhipidomella* sp., described and figured by Tazawa and Katayama (1979, p. 170, pl. 11, figs. 1—7) from the Odaira Formation of the Yokota district, southern Kitakami Mountains because of similarities in size and shell outline.

Order Strophomenida Öpik, 1934

Suborder Strophomenidina Öpik, 1934

Superfamily Davidsoniacea King, 1850

Family Orthotetidae Waagen, 1884

Subfamily Orthotetinae Waagen, 1884

Genus *Orthotetes* Fischer, 1829

Orthotetes sp.

Pl. 61, Figs. 11a, 11b

Material:—One specimen, external and internal moulds of a brachial valve, from locality KF167, IGPS coll. cat. no. 97903.

Description:—Brachial valve gently and evenly convex in lateral profile; length about 59 mm, width uncertain but probably over 80 mm.

External ornament of the brachial valve consisting of numerous costellae, fine radial lirae, irregular, strong concentric or oblique rugae and very fine growth lines. Costellae with many intercalations, slightly sinuous anteriorly; 7—8 costellae in 5 mm width near the anterior margin of the valve; 1 or 2 lirae occurring in the intercostal troughs. Rugae strongly developed on the anterior half of the valve, mostly concentric, a few of them oblique; 3—5 rugae within 20 mm of the anterior valve margin.

Brachial valve interior with a pair of long, straight vascula media extending to the midvalve. Other internal structure not observed.

Remarks:—This specimen agrees with *Orthotetes australis* (Campbell, 1957, p. 45, pl. 11, figs. 1—7) from the upper part of the lower Burindi Group (=Upper Visean Merlewood Formation, after Roberts, 1975, p. 13) of Watts, Babbinboon, New South Wales in shape and external ornament of the brachial valve, especially the density of lirae in the intercostal troughs.

In size and external ornament, the Hikoroichi specimen somewhat resembles *Orthotetes* sp. from the Lower Namurian of Akiyoshi, southwest Japan (Yanagida, 1965, p. 120, pl. 27, figs. 9—14), and also *Orthotetes* cf. *australis* from the Upper Visean Karoyama Formation of the Nisawa district, southern Kitakami Mountains (Tazawa, 1981, p. 69, pl. 5, figs. 8a, 8b). But the poor preservation of the present material makes accurate comparison difficult.

Suborder Productidina Waagen, 1883

Superfamily Productacea Gray, 1840

Family Echinoconchidae Stehli, 1954

Subfamily Echinoconchinae Stehli, 1954

Genus *Pustula* Thomas, 1914

Pustula cf. *P. pustulosa* (Phillips, 1836)

Pl. 61, Fig. 8

1980 *Pustula* cf. *P. pustulosa* (Phillips): Mori and Tazawa, text-fig. 3.2.

Material:—One specimen, external mould of a brachial valve, from locality KF152, IGPS coll. cat. no. 97904.

Descriptive remarks:—The brachial valve from Hikoroichi may have originally been about 80 mm wide, although the right half of the valve has been broken off. The valve has a low and broad fold, and is ornamented by numerous, quincuncially arranged, elongate spine bases and regular, concentric rugae on the external surface; 6—9 spine bases in 10 mm width, 6 rugae in 10 mm length at about the midvalve.

In size and external ornament, the Hikoroichi specimen resembles shells of *Pustula pustulosa* (Phillips, 1836), described or figured from the Visean of Britain (Phillips, 1836, p. 216, pl. 7, fig. 15; Thomas, 1914, p. 261, pl. 17, figs. 24—28; pl. 18, fig. 1; Muir-Wood and Cooper, 1960, pl. 84, figs. 1—7; pl. 85, figs. 6—10), Belgium (Muir-Wood and Cooper, 1960, pl. 59, fig. 4), Germany (Paeckelmann, 1931, p. 138, pl. 13, figs. 2, 3) and the Soviet Union (Sarytcheva and Sokolskaja, 1952, p. 106, pl. 19, fig. 127; Gubareva, 1964, p. 161, pl. 3, figs. 6—9; Kalashnikov, 1974, p. 51, pl. 10, figs. 6—9; pl. 11, figs. 1—2; pl. 13, figs. 4—5; pl. 30, fig. 6; Volgin and Kushnar, 1975, p. 45, pl. 3, figs. 10—12).

Pustula sp., described by Minato (1952, p. 155) from the Odaira Formation of the Yokota district, southern Kitakami Mountains, is close to *P. pustulosa* in shape of the pedicle valve. It is a possible that Minato's *Pustula* sp. is a synonym of the present form.

Pustula cf. *P. tenuipustulata* (Thomas, 1914) from the Arisu Formation of the Yokota district (Minato, 1952, p. 154, pl. 11, fig. 7) is clearly distinguished from the present form by its irregular and more closely arranged spine bases on the pedicle valve.

Family Buxtoniidae Muir-Wood and Cooper, 1960

Subfamily Karavankininae Ramovs, 1969

Genus *Karavankina* Ramovs, 1969

Karavankina sp.

Pl. 61, Figs. 2a, 2b

Material:—One specimen, external and internal moulds of a brachial valve, from locality KF167, IGPS coll. cat. no. 97905.

Description:—Brachial valve elongate subrectangular in outline, flat on visceral disc, slightly concave near the anterior and lateral margins of the valve. Hinge line straight, a little less than the greatest width of the valve; the latter occurring at about three-quarters of the length of the valve. Umbo narrow, strongly concave, not projecting behind hinge line. Ears rather large, flat, trigonal, not clearly delimited from visceral disc. Dimensions of the brachial valve: length about 19 mm, width about 17 mm, width of hinge line 13 mm.

External surface of the brachial valve ornamented by regular, concentric, lamellose bands bearing numerous, quincuncially arranged, elongate spine bases; 7—9 bands in 10 mm length at the anterior half of the valve.

Internally, brachial valve with a median septum and a pair of buttress plates; median septum being 6.3 mm long, not fusing with cardinal process, low and thin on the posterior portion, becoming high and strong anteriorly; buttress plates elongate, trigonal, 4.2 mm long, situated on both sides of median septum.

Remarks:—The fragmentary external mould of brachial valve described here is slightly indented at the mid portion, but this concavity may not be original. The dorsal external ornament is badly preserved, except for the concentric, lamellose bands. The internal structure is also poorly preserved; both the cardinal process and lateral ridges cannot be observed in the present material.

In spite of the ill state of preservation, this specimen is assigned to the genus *Karavankina* Ramovs, 1969 on the basis of its small, subrectangular brachial valve, the external ornament of concentric, lamellose bands and quincuncially arranged spine bases and the presence of buttress plates in the brachial valve.

Karavankina jizodoensis Tazawa (1980, p. 362, pl. 41, figs. 8–16; pl. 42, fig. 14; text-fig. 2) from the top of the Karaumedate Formation of the Nagasaka district, southern Kitakami Mountains, resembles the present form in the density of concentric bands on the brachial valve (8–9 bands in 10 mm length in *K. jizodoensis*; 7–9 bands in 10 mm length in *Karavankina* sp). Unfortunately the preservation of the Hikoroichi specimen does not permit comparison with *K. jizodoensis.*

Karavankina praepermica Ramovs (1969, p. 258, 265, pl. 3, figs. 1–6) from the Upper Carboniferous (Orenburgian) of the Karavanken, Yugoslavia, is small in size like *Karavankina* sp., but the former is distinguished from the latter by its thin, more widely divaricated buttress plates in the brachial valve.

Order Spiriferida Waagen, 1883

Suborder Athyrididina Boucot, Johnson and Staton, 1964

Superfamily Athyridacea Davidson, 1881

Family Athyrididae Davidson, 1881

Subfamily Athyridinae Davidson, 1881

Genus *Cleiothyridina* Buchman, 1906

Cleiothyridina sp.

Pl. 61, Fig. 3

Material:—One specimen, external mould of a valve fragment, from locality KF167, IGPS coll. cat. no. 97907.

Remarks:—One fragmentarily preserved specimen from Hikoroichi, having the characteristic external ornament of concentric lamellae, the edges of which are fringed with numerous flattened spines. It can be assigned to the genus *Cleiothyridina* Buckman, 1906.

Externally, this specimen somewhat resembles the lectotype (BM(NH)BB58678) of *Cleiothyridina fimbriata* (Phillips, 1836) from the Upper Visean of Ireland; the latter was selected and figured by Brunton (1980, p. 228, figs. 19a, 19b). But the Hikoroichi specimen is too poorly preserved for specific determination.

Suborder Spiriferidina Waagen, 1883

Superfamily Spiriferacea King, 1846

Family Spiriferidae King, 1846

Subfamily Spiriferinae King, 1846

Genus *Spirifer* Sowerby, 1816

Spirifer sp.

Pl. 61, Figs. 1a–1c

Material:—One specimen with valves conjoined, from locality KF151, IGPS coll. cat. no. 97908.

Descriptive remarks:—An imperfect specimen from Hikoroichi, lacking the anterior portion of the pedicle valve and most of the brachial valve, is wider than long, subquadrate in outline, with rounded cardinal extremities; length presumably about 35 mm, width about 55 mm. Numerous bifurcating costae are developed on the sulcus and each ventral lateral slope. Intercalations of costae often occur on the lateral slopes.

This specimen is assigned to the genus *Spirifer* s.s. on the basis of its size, shape and external ornament of the pedicle valve, particularly in having rounded cardinal extremities, a sulcus with numerous bifurcating costae and lateral slopes ornamented by numerous, freely bifurcating and intercalating costae.

The Hikoroichi specimen superficially resembles *Spirifer liangchowensis* Chao (1929, p. 6, pl. 1, figs. 1–7; text-fig. 1) from the Visean of Gansu, South China.

Family Choristitidae Waterhouse, 1968

Genus *Choristites* Fischer, 1825

Choristites bisulcatus (Sowerby, 1825)

Pl. 61, Figs. 4a, 4b

1836 *Spirifer bisulcatus* Sowerby: Phillips, p. 218, pl. 9, fig. 14.
1858 *Spirifera bisulcata* (Sowerby): Davidson, p. 31, pl. 5, fig. 1; pl. 6, figs. 6—16 only.
1908 *Spirifer bisulcatus* Sowerby: Gröber, p. 222, 239, pl. 26, figs. 3a—3c, 8—10; text-figs. 3, 4.
1916 *Spirifer bisulcatus* Sowerby: Frech, p. 252, pl. 8, fig. 7.
1918 *Spirifer bisulcatus* Sowerby: Yanishevsky, p. 82, pl. 6, figs. 1, 15 only.
1920 *Spirifera bisulcata* (Sowerby): Benson and Dun, p. 347, pl. 21, fig. 1.
1922 *Spirifer bisulcatus* Sowerby: Hayasaka, p. 63, pl. 3, figs. 8—9.
1924 *Spirifer bisulcatus* Sowerby: Grabau, fig. 152.
1931 *Choristites bisulcatus* (Sowerby): Grabau, fig. 6.
1932 *Choristites bisulcatus* (Sowerby): Grabau, pl. 2, fig. 13.
1938 *Spirifer bisulcatus* Sowerby: Demanet, p. 88, pl. 8, figs. 17—19.
1970 *Spirifer* ex gr. *bisulcatus* Sowerby: Abramov, p. 142, pl. 22, fig. 8.
1980 *Choristites bisulcatus* Sowerby): Mori and Tazawa, text-figs. 3.1a, 3.1b.

Material:—One specimen, external mould and cast of a pedicle valve, from locality KF153, IGPS coll. cat. no. 97909.

Description:—Shell small size for the genus, wider subtrigonal in outline, the maximum width at hinge line, length 28 mm, width 34 mm.

Pedicle valve strongly and unevenly convex in lateral profile, with the greatest convexity at the umbonal region. Cardinal extremities blunt, produced. Sulcus moderately deep, angular, having a pair of simple primary costae, 1 or 2 simple costae on outside the primary costae. External surface of ventral lateral slopes ornamented by numerous rounded costae; costae mostly simple, a few of them bifurcated near the anterior margin of the valve, with narrow intercostal grooves; 9 costae on one side of the lateral slope. Shell substance thick at umbonal region.

Remarks:—Bipartite development of sinal costae, which characterized the Carboniferous spiriferids, can be observed in the pedicle valve specimen of Hikoroichi.

This specimen is referred to *Choristites bisulcatus* (Sowerby, 1825) on account of its size, shape and external ornament of the pedicle valve. The Hikoroichi specimen superficially most resembles the pedicle valve figured by Demanet (1938, pl. 8, fig. 18) as *Spirifer bisulcatus* Sowerby from the Upper Visean of Belgium.

Concerning the generic assignment of Sowerby's *Spirifer bisulcatus*, I follow Grabau's opinion (Grabau, 1931, p. 26), in which the species is regarded as a simplest form of *Choristites*. This species has been known from the Visean and Namurian of Britain, Belgium, Siberia, Asia Minor, Central Asia, South China, Japan and eastern Australia.

C. bisulcatus differs from *Choristites mosquensis* (Fischer, 1825) in having a smaller, more transverse shell, with less complicated sinal costae and less bifurcated lateral costae.

Suborder Delthyrididina Ivanova, 1972

Superfamily Martiniacea Waagen, 1883

Family Martiniidae Waagen, 1883

Subfamily Ingelarellinae Campbell, 1959

Genus *Tomiopsis* Benediktova, 1956

Tomiopsis sp.

Pl. 61, Figs. 10a, 10b

Material:—Two specimens, internal moulds of two pedicle valves, with the external moulds of the posterior portion attached, from locality KF163, IGPS coll. cat. nos. 97910, 97911.

Remarks:—These two specimens appear to belong to the genus *Tomiopsis* Benediktova, 1956, because of their straight hinge line, rounded cardinal extremities, clearly developed ventral interarea and shallow sulcus, and the presence of long, subparallel dental plates in the pedicle valve.

The Hikoroichi specimens cannot be identified with any previously known species of *Tomiopsis*, because of the lack of information about the ventral external ornament and the dorsal external and internal features.

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Akiyoshi 秋吉, Arisu 有住, Higuchizawa 樋口沢, Hikami 氷上, Hikoroichi 日頃市, Karaumedate 唐梅館, Karoyama 加労山, Kawauchi 川内, Kitakami Mountains 北上山地, Mt. Senokita セノキタ山, Nagaiwa 長岩, Nagasaka 長坂, Nakazato 中里, Nisawa 荷沢, Odaira 大平, Onimaru 鬼丸, Onimarusawa 鬼丸沢, Ono 大野, Sakamotozawa 坂本沢, Setamai 世田米, Sumitacho 住田町, Yokota 横田, Yonosawa ヨーノ沢

北上山地の日頃市層より産出した前期石炭紀（ビゼー期）腕足類：南部北上山地，日頃市地域（岩手県大船渡市日頃市町）に分布する日頃市層の上部層（上部 105 m）から，後期ビゼー期の腕足類化石が産出した。このことは，日頃市層が上位の上部ビゼー階鬼丸層に整合的に覆われる野外事実と符合する。この腕足類化石動物群は，次の種を含む：*Schizophoria resupinata* (Martin), *Rhipidomella* sp., *Orthotetes* sp., *Pustula* cf. *P. pustulosa* (Phillips), *Karavankina* sp., *Cleiothyridina* sp., *Spirifer* sp., *Choristites bisulcatus* (Sowerby) および *Tomiopsis* sp.

田沢純一

Explanation of Plate 61

(Natural size unless otherwise indicated)

Figs. 1a—1c. *Spirifer* sp.
1a, 1b, 1c. Ventral, dorsal and internal views of a specimen, with an almost decorticated brachial valve, IGPS coll. cat. no. 97908.

Figs. 2a, 2b. *Karavankina* sp.
Rubber casts of a brachial valve exterior and interior, IGPS coll. cat. no. 97905. Fig. 2b is × 2.

Fig. 3. *Cleiothyridina* sp.
Rubber cast of a valve exterior, IGPS coll. cat. no. 97907.

Figs. 4a, 4b. *Choristites bisulcatus* (Sowerby)
4a. Ventral view of a partly decorticated pedicle valve, 4b. Rubber cast of a pedicle valve exterior, IGPS coll. cat. no. 97909.

Figs. 5—7. *Rhipidomella* sp.
5. Rubber cast of a pedicle valve interior, IGPS coll. cat. no. 97900, 6, 7. Internal moulds of two brachial valves: 6. IGPS coll. cat. no. 97902, 7. IGPS coll. cat. no. 97901.

Fig. 8. *Pustula* cf. *P. pustulosa* (Phillips)
External mould of a brachial valve, IGPS coll. cat. no. 97904.

Figs. 9a, 9b. *Schizophoria resupinata* (Martin)
Internal mould of a pedicle valve and the rubber cast, IGPS coll. cat. no. 97898.

Figs. 10a, 10b. *Tomiopsis* sp.
Internal mould of a pedicle valve and the rubber cast, IGPS coll. cat. no. 97910.

Figs. 11a, 11b. *Orthotetes* sp.
11a. Rubber cast of a brachial valve exterior, 11b. Internal mould of a brachial valve, IGPS coll. cat. no. 97903.


1a


1c


2a


2b


1b


3


7


5


4b

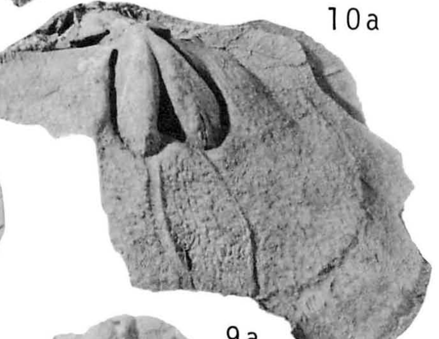

6


4a

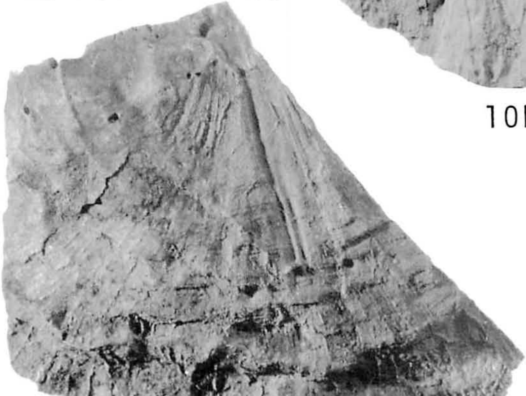

8

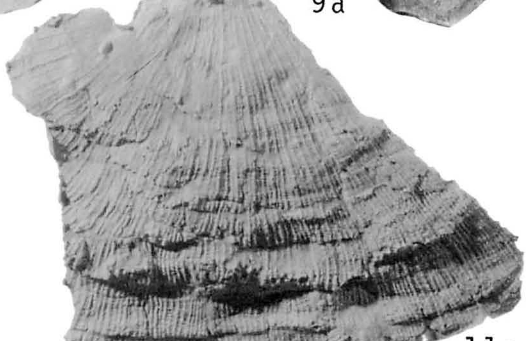

10a


9b


9a


10b


11b


11a

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776. PALYNOLOGICAL INVESTIGATION OF THE POSTGLACIAL DEPOSITS IN LAGOON KAHOKU-GATA, KANAZAWA, CENTRAL JAPAN*

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Abstract. The palaeovegetational and palaeoclimatic changes during the last 20,000 years in and around Lagoon Kahoku-gata, Kanazawa, Central Japan are analysed from the viewpoint of pollen analysis. The palaeoclimatic change is inferred as follows:

The last 1,500 years (Pollen Subzone A-d): mild and wet (the last 500 years . . . . . mild as climate of the present-day, 500—1,500 years . . . . . more or less warm);

1,500—5,000 years ago (Pollen Subzone A-c): cool and slightly dry (1500—3,500 years . . . . . cool or slightly cool);

5,000—8,000 years ago (Pollen Subzone A-b): warm and wet;

8,000—11,000 years ago (Pollen Subzone A-a): more or less cold and slightly wet;

11,000—12,000 years ago (Pollen Subzone B-d): cool and slightly wet;

12,000—14,000 years ago (Pollen Subzone B-c): more or less cold and slightly dry;

14,000—16,500 years ago (Pollen Subzone B-b): cold and slightly dry;

16,500—21,000 years ago (Pollen Subzone B-a): cold or slightly cold and dry.

The pollen zones from Lagoon Kahoku-gata may be correlated with the divisions in Northwestern Europe as follows:

Subzone A-d may be correlated with the Subatlantic, Subzone A-c with the Subboreal, Subzone A-b with the Atlantic, Subzone A-a with the Preboreal and the late Younger Dryas, Subzone B-d with the early Younger Dryas — Alleröd — Older Dryas, Subzone B-c with Bölling — the late Oldest Dryas, Subzone B-b with the early Oldest Dryas, and Subzone B-a with age before the Oldest Dryas respectively.

Introduction

After the last glaciation called the Würmian Glacial Age in the Middle Europe, the Weichselian Glacial Age in the Northwestern Europe, a large transgression confirmed over the world had begun. This transgression has been internationally called the Flandrian Transgression, and it has been called Yurakucho Transgression in the Japanese Islands, and also the later part of the transgression has been named the Jomonian Transgression. Though an ancient inlet called the Ko-kahoku-irie had existed during the transgressional age, the inlet had been changed a lagoon by the formation of large

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coastal sand dunes in the small regression during the stage of the middle Jomonian to the late Yayoian Age, and the environment as a lagoon has been kept since the Yayoian Age (Fuji, 1975; Fuji *et al.*, 1981). Therefore, the present writer infers that all of the deposits throughout the latest Quaternary deposits called the Postglacial deposits have been distributed beneath this lagoon. If this inference is correct and a boring will be drilled at the lagoon, all of the deposits after the last glacial age may be collected. If the deposits are obtained, palaeovegetational and palaeoclimatic changes in and around the lagoon during about 20,000 years since the last glacial age may be ascertained.

The present writer has obtained many core samples from the two drilled wells, about 15-m and about 85-m borings, and these core samples have been studied from the viewpoint of palynological investigation.

This article consists of three parts of descriptions of the stratigraphy of the Postglacial period around and in Lagoon Kahoku-gata, the palynological study on the last Quaternary deposits, and the palaeovegetational and palaeoclimatic significance during the last 20,000 years.

The present writer takes this opportunity to express his deepest gratitude to the late Dr. Naoto Kawai, former Professor of Osaka University, for his continuous encouragement and supervision. Thanks are due to Assistant Professor Tadashi Nakajima of Fukui University, and Professor Kimio Hiro'oka of Toyama University for their advice on the palaeomagnetism of the present core samples. Finally, the writer expresses his deep appreciation to the Ministry of Education of the Japanese Government for grants from the Science Expenditure Funds during the period 1977 to 1979, and also to the Japan Society for the Promotion of Science for grants during the period 1978 to 1979.

1. Topography and Geology

Lagoon Kahoku-gata is located in the central part of Ishikawa Prefecture, facing the Japan Sea of Central Japan. The coastal sand dunes which were formed during the middle and late Holocene Epoch have been distributed in front of the simple coastal region of the Japan Sea. The alluvial lowland areas around this lagoon were formed during the period since the Flandrian Transgression. This lagoon is the second largest lagoon on the Japan Sea side, and had been an old inlet called Ko-kahoku-irie during the Flandrian Transgression age. In the middle Holocene Epoch, the lagoon was changed from a marine condition to a brackish condition. The change of palaeoenvironment as mentioned above agrees chronologically with the relative small regression age. The ancient inlet was isolated from the Japan Sea by the formation of the coastal sand dunes and by a lowering of sea-level during this regression age, and changed to a lagoon (Fuji, 1975; Fuji *et al.*, 1981; Fuji, 1982a; Fuji, 1982b).

The deposits beneath the Kanazawa Plain including Lagoon Kahoku-gata are stratigraphically divided into two parts: the lower and the upper parts. The lower part is composed mainly of hard Neogene strata and loose Pleistocene deposits, and the upper one is composed of the postglacial deposits which are divided into three subparts; the alternation of coarse sand and mud layers in the lower horizon, a loose medium sand layer in the middle horizon, and a mud layer in the upper horizon. A gravel layer, about 5 m to 8 m thick and 50 mm to 100 mm in diameter of gravel, is intercalated between the lower and upper parts, and belongs to the last stage of the last glacial age.

The gravel layer is generally distributed just below the Postglacial deposits of the Holocene alluvial plain developing along the coastal area of the Japan Sea, and called the First Gravel Layer in Japan, and a key bed indicating the boundary between the Postglacial and the last glacial deposits.

2. Palynological Study

2-1) Preparation for Pollen Analyses

Pollen grains in the sediments were concentrated in the laboratory by slight modifications of the process described by Faegri and Iversen (1964).

2-2) Microscopic Examination

Pollen grains and spores mounted on slides were identified and counted by means of a mechanical stage of a microscope. The counting was continued up to more than 300 identifiable arboreal pollen grains. Determination was made with the aid of the key by Faegri and Iversen (1964) and McAndrews (1973), and also in reference to the pollen grains obtainable from the Japanese Islands. Hard-to-identify pollen grains were identified with the aid of a reference collection of about 500 slides for important trees, shrubs, and acquatic herbs of the Japanese Islands in possession of the Institute of Earth Science, Kanazawa University, a reference collection of about 9,000 slides owned by the Limnological Research Center, University of Minnesota, Minneapolis, U.S.A., and also a reference collection of about 5,000 slides owned by the Department of Quaternary Geology, Faculty of Science, University of Uppsala, Uppsala, Sweden.

2-3) Method for Interpretation of Palaeovegetation and Climatic History

The writer depends upon the pollen analyses for the reconstruction of vegetation during a glacial age. For the interpretation of the pollen spectra obtained from the 200-m core samples, he has employed two methods, namely, (1) pollen spectra of the modern samples collected from Lagoon Kahoku-gata and its vicinity, and also from various localities of some climatic zones throughout the Japanese Islands and (2) the warmth index (month-degrees). The methods are described in detail in the present writer's previous paper (1978).

2-4) Pollen Analyses of the 15-m Core Samples

(1) Location of the Boring and Samples

The boring site is situated in a reclaimed land, about −50 cm in the present altitude, near Kurotsubune of Uchinada-machi.

The 15-m core samples are composed mainly of homogeneous dark bluish grey clay. As measured by Kigoshi of Gakushuin University, the ^{14}C dating age of dark bluish grey clay in the 13.60 − 13.70 m horizon of this 15-m core is 3,220 ± 160 years B.P. (Gak-7146).

All of the core samples belong to the late Holocene deposits according to the stratigraphy of this core and ^{14}C dating.

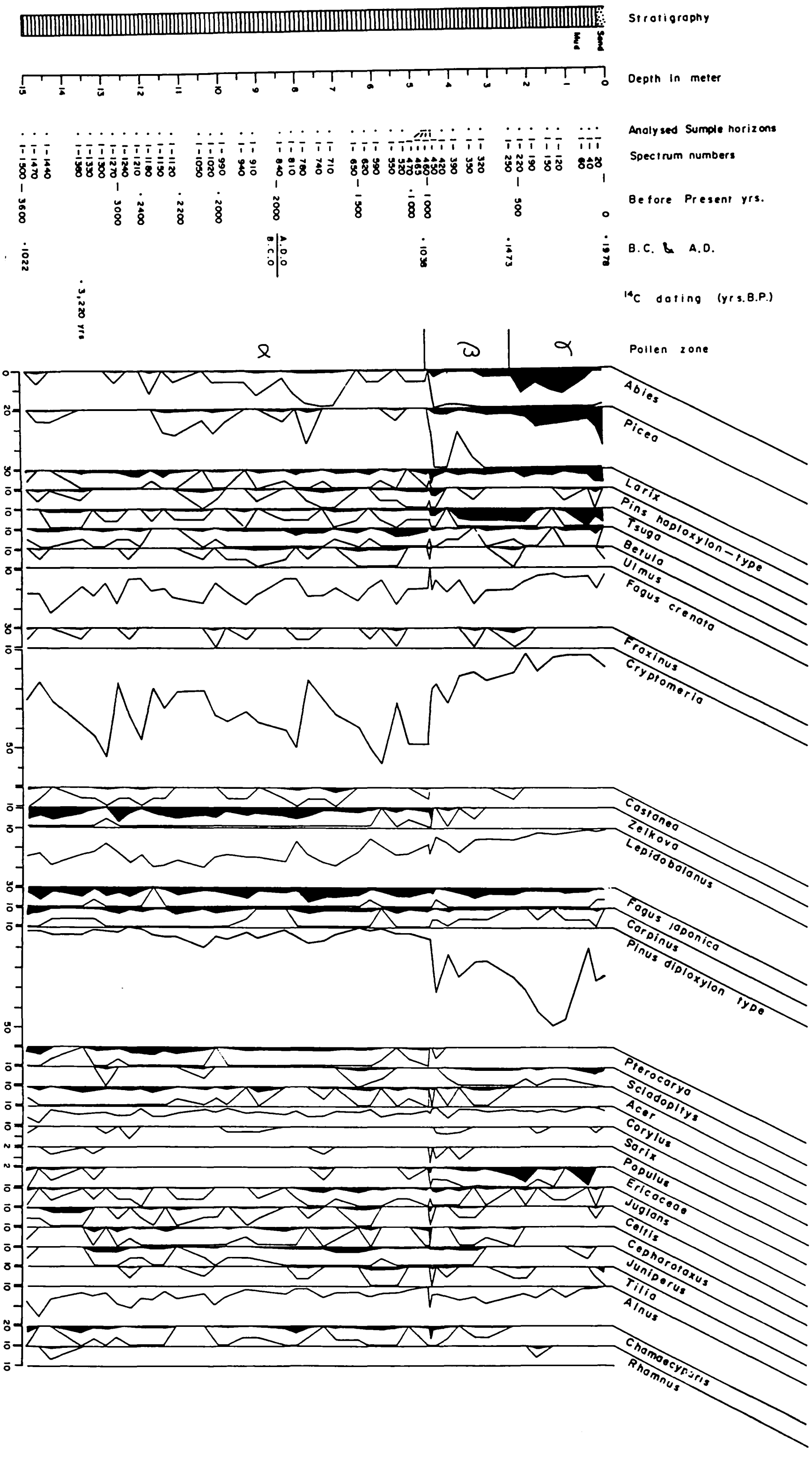
(2) Zoning of Pollen Assemblage and Palaeoclimate based on Palaeovegetation

In order to facilitate their description and discussion, the pollen diagrams are divided into some zones. These zones are based upon conspicuous changes in pollen percentages. Changes in the ratio, Total AP/Total NAP, can be described, while alternation of values of one or two pollen types may also lead to the establishment of pollen zones. Where pollen zones display the same nature characterized by assemblage of pollen grains and spores, the writer has attempted to indicate them under the same letter code in order to facilitate comparison. These pollen zones are restricted to the series of diagrams under discussion. The minor differences of the pollen assemblage in the zones are shown by subzones.

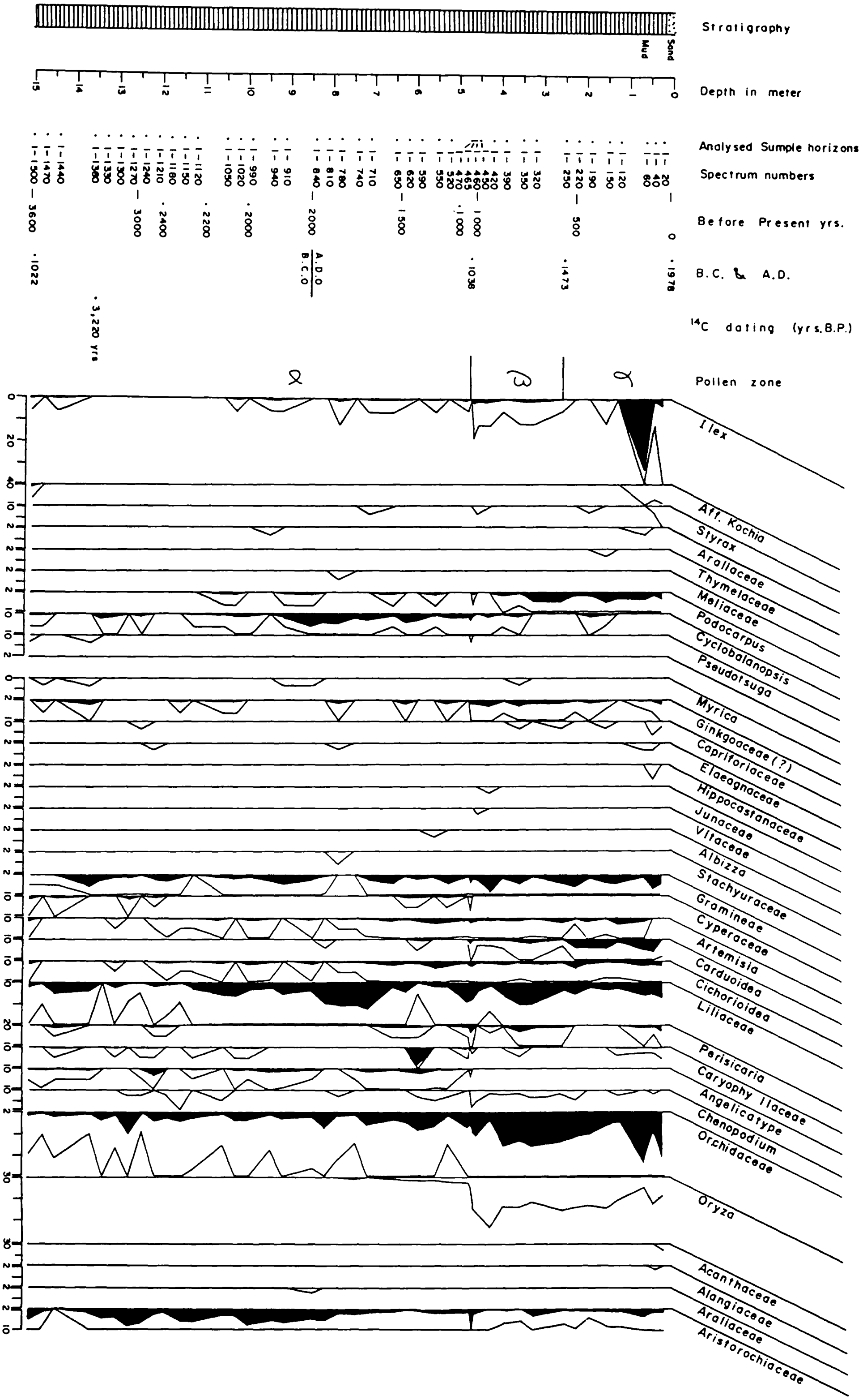
The 15-m core samples are divided into three pollen zones as Zone α, Zone β, Zone γ in an ascending order. They are described as follows:

Zone α, spectra: I-470 to I-1500; depth: 4.7 to 15 m; age: about 1,500 to 3,500 years ago.

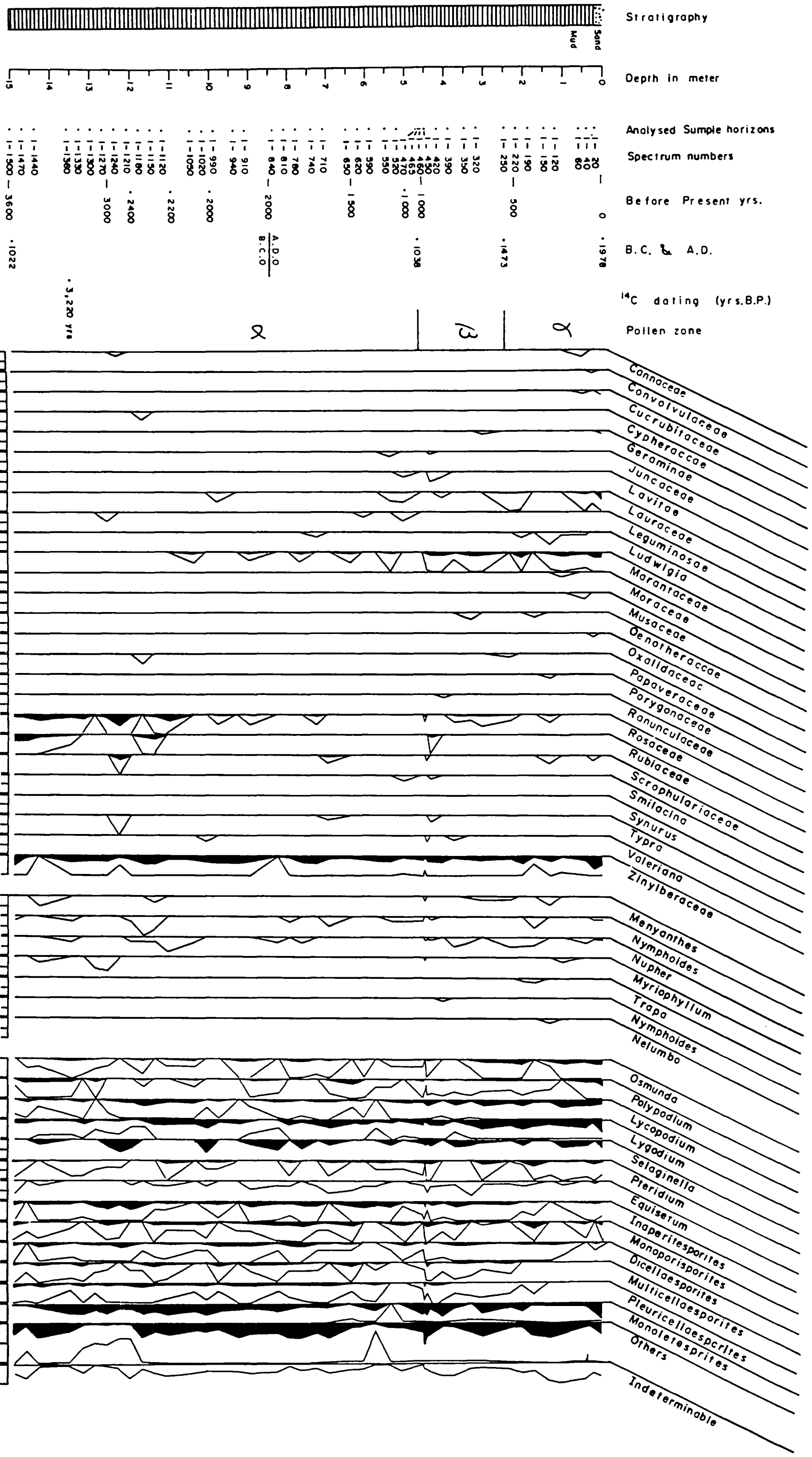
This zone is characterized by a large amplitude and a long duration of every maximum (up to about 60%) or minimum (down to ca. 17%) period in a fluctuation of pollen value of *Cryptomeria*. The percentage of arboreal pollen grains shows the highest value throughout the 15-m boring core. Such plants as *Abies*, *Picea*, and *Tsuga* growing in the Subpolar area reach only 1 to 6% in this zone. Plants adapted to the Cool Temperate climatic zone appear 7 to 24% in the fluctuation of pollen percentage. Among them, *Fagus* large-type which is inferred to be *Fagus crenata* appears about 13% on the average (1% at a minimum and 23% at a maximum). Plants growing in both climatic zones of the Cool Temperate and the Temperate (Warmth-index: 55° to 140°) reach 45 to 72% in pollen value,



Text-fig. 1. Diagram of conifer and arboreal pollen grains found from the 15-m core samples.



Text-fig. 2. Diagram of arboreal and non-arboreal pollen grains found from the 15-m core samples.



Text-fig. 3. Diagram of non-arboreal pollen grains and spores found from the 15-m core samples.

which is the highest percentage throughout the 15-m core samples. Most of the highest value is taken by *Cryptomeria.* Plants growing in the middle part of the Cool Temperate zone and the Warm Temperate zone (70° to 140°) have a pollen value of 12 to 37%, which is lower than those of Pollen Zones β and γ. Plants of both climatic areas of the South Warm Temperate and Subtropical zones (Warmth-index: 100° to 180°) reach 8% at a maximum value, which is lower than those of Pollen Zones β and γ. The pollen percentage of *Fagus crenata*-type shows a negative interrelation to that of *Cryptomeria.*

On the basis of the above-mentioned description, the palaeoclimate during the sedimentation of the deposits of this zone may have been the same as the climate in the present Cool Temperate area.

Zone β, spectra: I-320 to I-460; depth: 2.5 to 4.7 m; age: about 500 to 1,500 years ago.

This zone is characterized by a large percentage of non-arboreal pollen grains, pollen value of which is about 50%. Boreal conifers growing in the Subpolar and/or Subalpine zones appear as follows; *Abies*: 0 to 4%, *Picea*: 0 to 3%, *Tsuga*: 1 to 7%. Cool Temperate plants of this zone show a value higher than that of Zone γ. Some changes are recognized in the percentage of pollen assemblages. Namely, plants adapted to the Cool Temperate and Temperate zones record a drastic decrease from 64% to 22% because of a drastic decrease (from 49% to 12%) of *Cryptomeria,* especially remarkable at 4.6 m to 4.7 m in depth. In contrast to the above-mentioned phenomenon, plants of the middle area of the Cool Temperate zone and the Warm Temperate zone increase gradually from 32% to 50% due to an increase (6% to 23%) of *Pinus diploxylon*-type. Warm Temperate and Subtropical plants show a pollen percentage (2% to 8%) which is the same as that of Zone γ.

According to palaeovegetation mentioned above, the palaeoclimate during the age of Zone β may have been more or less warm in comparison with the present climate.

Zone γ, spectra: I-20 to I-250; depth: 0 to 2.5 m; age: the present-day to about 500 years ago.

In this zone, arboreal pollen grains occupy about 43% to 63%, being higher than the value of nonarboreal pollen grains. As *Abies* and *Picea* pollen grains are respectively 2% to 12% and 3% to 18%. Subpolar plants show the highest value (21% to 35%) over this zone. Plants growing in the Cool Temperate zone have a low value, which is 4% to 8% in the total percentage. On the other hand plants growing in the Cool Temperate and Warm Temperate zones show the lowest value throughout all of the zones. However, plants growing in the middle area of the Cool Temperate zone and the Warm Temperate zone reach the highest percentage over the boring core samples due to an increase (25% to 49%) of *Pinus diploxylon*-type. Among them, *Ilex* pollen percentage shows a large amplitude, e.g., from 0% to 35%. Warm Temperate and Subtropical plants show a 3 to 7% value in this zone. The percentage of *Oryza* pollen grains records a drastic increase.

Judging from the above-mentioned description, the palaeoclimate during this zone may have been warm as the present climate.

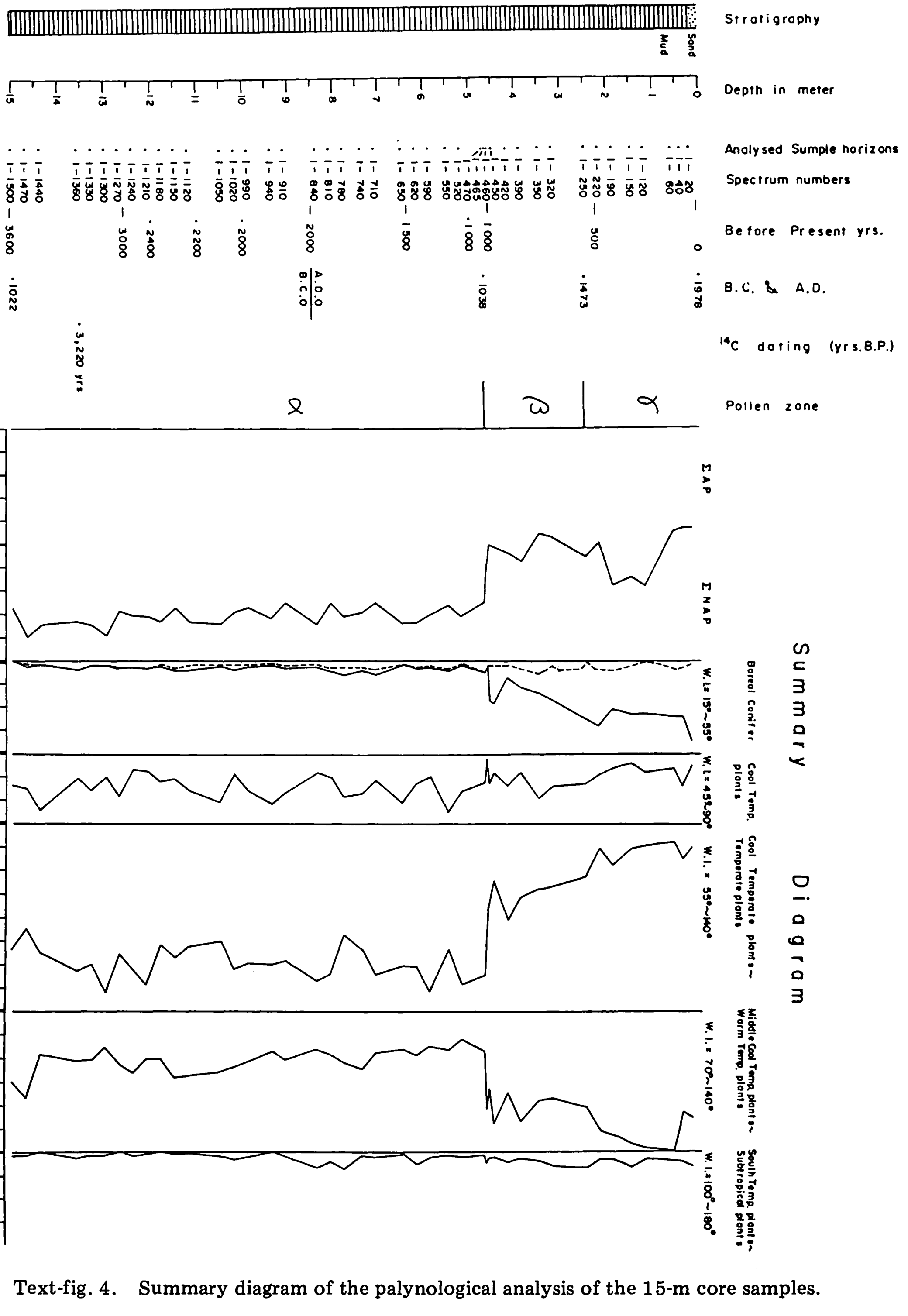
Nakai, Mori and Ohta (1982) studied the stable carbon isotopic composition ratio ($^{13}C/^{12}C$) of sedimentary organic materials in the 15-m core. Judging from the isotopic and pollen analyses, the change of climate on the basis of the pollen analysis is a close agreement to the change of the isotopic composition in a pattern of change.

The frequency of pollen grains of *Oryza* (rice plant) found in Zone γ shows a value larger than those of Zones α and β. This phenomenon reveals the remarkable development of rice-cultivation around Lagoon Kahoku-gata during the time of Zone γ, and this inference is supported by many old documents and pieces of archaeological evidence.

2-5) Pollen Analyses of the 85-m Core Samples

(1) Locality of the Boring and Samples

The 85-m boring site is situated in the bottom of Lagoon Kahoku-gata near Bridge Konan-ohashi, Tsubata, northwest Kanazawa, and about −100 cm in the present altitude. The



Text-fig. 4. Summary diagram of the palynological analysis of the 15-m core samples.

writer can divide the 85-m core samples into seven parts. Fuji, the present writer, calls them Layers A to G in a descending order. They are described as follows (Fuji, 1982b):

Layer A: This layer is distributed locally in a deltaic area near the mouths of the Tsubata, Morimoto and Asano Rivers flowing into Lagoon Kahoku-gata. The layer is composed of loose brown coarse-grained sand. It is about 2 – 5 m thick.

Layer B: This is composed mainly of homogeneous loose dark bluish grey silt intercalated with thin (2 m thick) loose dark bluish grey mud (about 18 to 20 m deep). This layer is about 26 m thick (−2 to −28 m below the present sea-level).

Layer C: This is composed mainly of loose dark yellowish brown silty sand and medium-grained sand, and about 10 m thick (−28 to −37 m below the present sea-level).

Layer D: This is composed of alternation of loose brown-colored sand and dark bluish grey mud or silt, and about 25 m thick (−37 to −62 m below the present sea-level).

Layer E: This is composed of brown-colored gravels, kinds of which are sandstone, homogeneous hard mudstone, hornblende andesite, and pyroxyne andesite, etc. The gravel is 5 to 10 cm in diameter. It is about 4 m thick, and −62 to −66 m in the present altitude.

Layer F: This layer is composed of alternation of dark bluish grey clayey silt and dark bluish grey silty mud. This is about 16 m thick, and −66 to −82 m below the present sea-level.

Layer G: This layer is composed of brown medium- and coarse-grained sand, and −82 to −85 m below the present sea-level.

Layer E to G belong to the latest Pleistocene deposits according to stratigraphy and ^{14}C dating on this core sample (Fuji, 1982a, 1982b).

(2) Zoning of Pollen Assemblage and Palaeoclimate based on Palaeovegetation

The 85-m core samples are divided into two pollen zones as Zones A and B, and eight pollen subzones as Subzones A-d, A-c, ... A-a, B-d, B-c, ... B-a in a descending order as described below. The present palynological study of the 85-m core samples has been made in order to discover, in detail, changes of palaeovegetation and palaeoclimate during the sedimentation of the 85-m core samples.

Zone A, spectra: 0.82 to 39.70; depth: 0 m to 40 m; age: about 10,000 years ago to the present-day.

Zone A is characterized by a dominant percentage of plants growing in the middle area of the Cool Temperate and Warm Temperate zones, and A-a, A-b, A-c, and A-d in an ascending order.

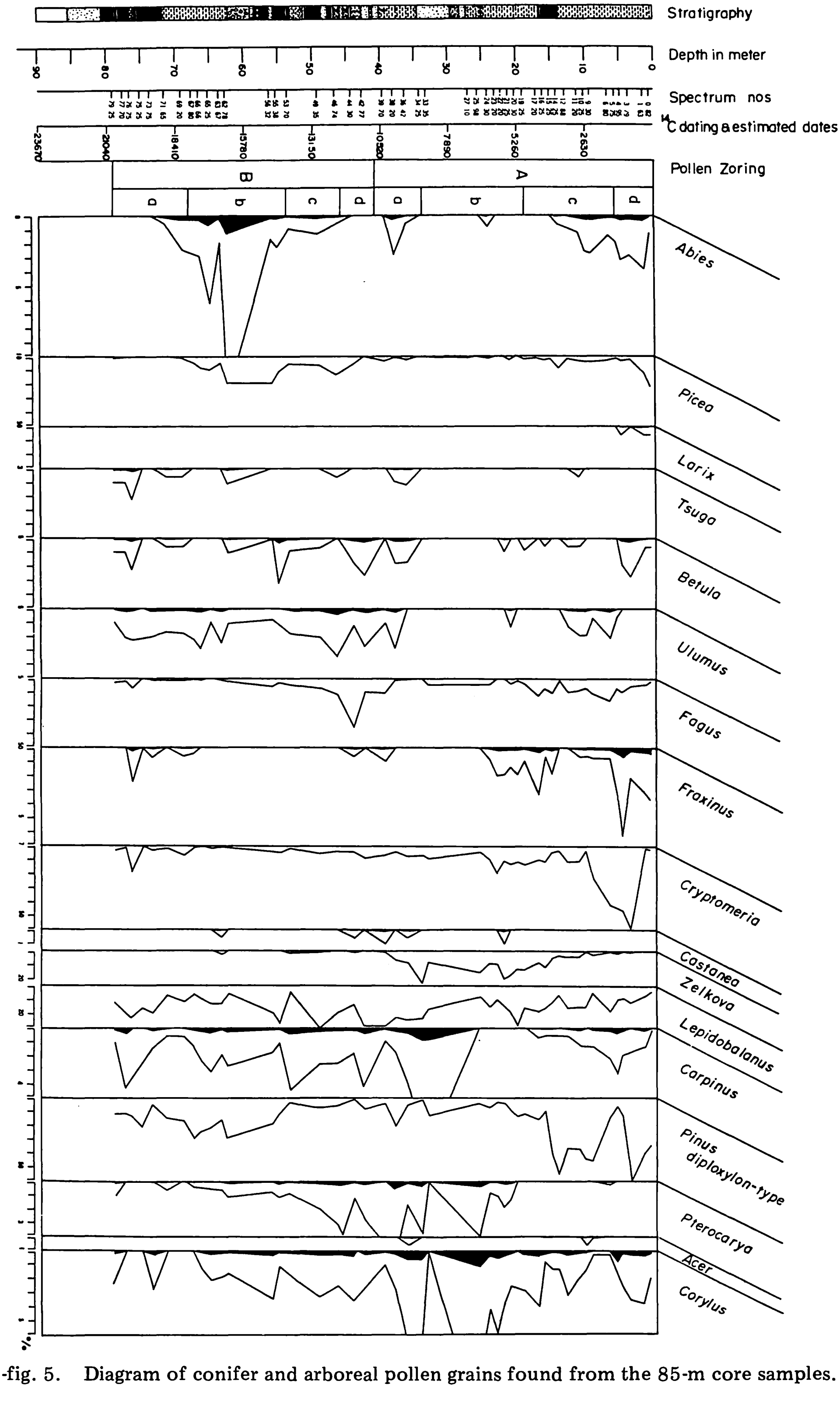
Subzone A-d, spectra: 0.82 to 4.95; depth: 0 m to 5 m; age: 1,500 years ago to the present.

Arboreal grains show up with a total pollen value of 61% to 72%, which is higher than the percentage of non-arboreal pollen grains. Boreal conifers reach about 15% on the average (3% at a minimum and 24% at a maximum), which is influenced by an increase of *Abies*, *Picea*, and *Larix*. Plants growing in the Cool Temperate zone are 11% to 75%, which is influenced by an increase of *Cryptomeria*. Plants growing in the middle part of the Cool Temperate and the Warm Temperate zones show a high percent, 11% to 62%. Among them, *Pinus*'s and *Corylus*'s percentages are respectively 3 to 48% and 2 to 8%. *Oryza* pollen grains are found to be 8.1 to 23%.

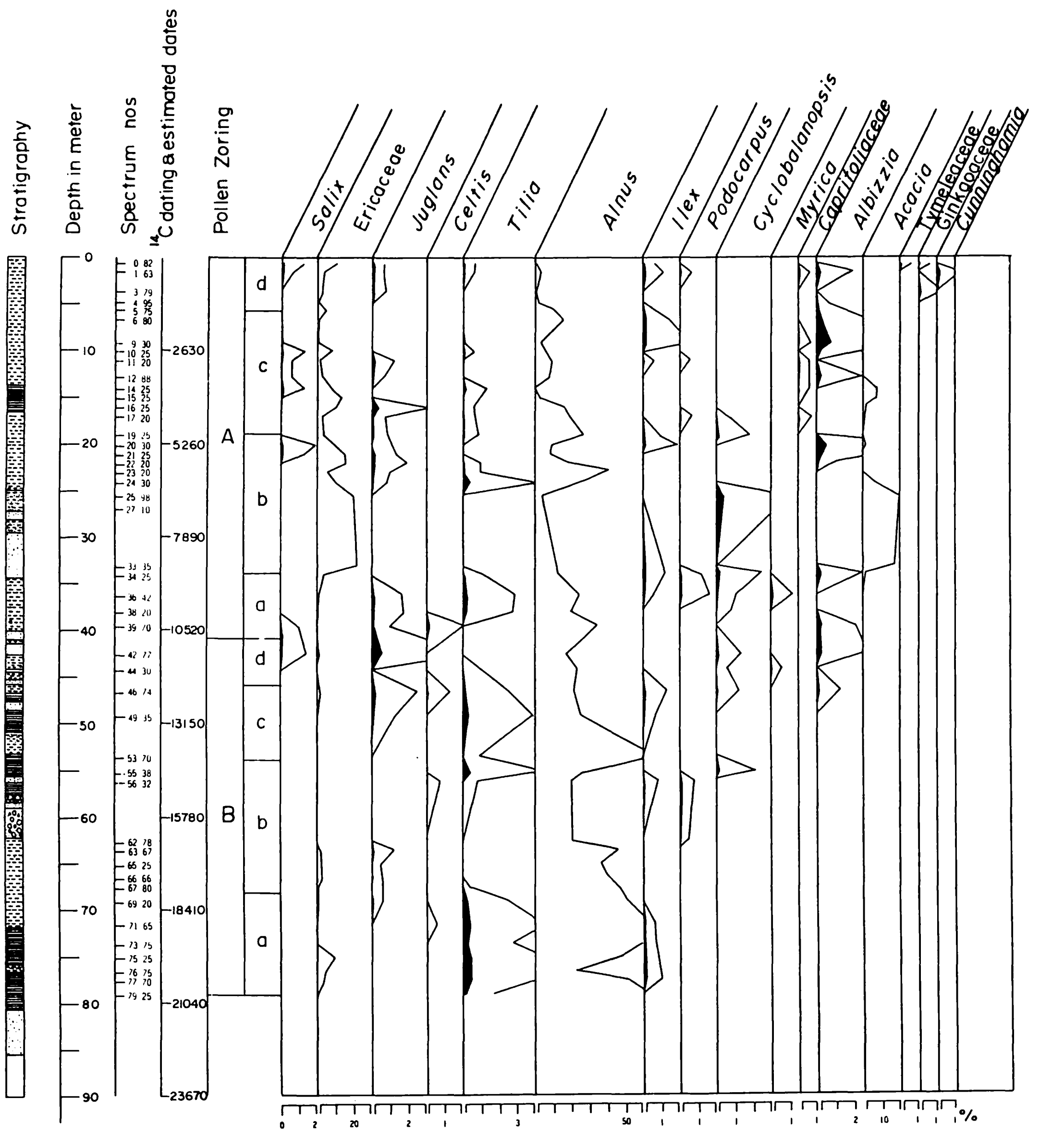
Judging from the above-mentioned pollen assemblage, it is inferred that the palaeoclimate since about 1,500 years ago may have been mild and wet.

Subzone A-c, spectra: 5.75 to 17.70; depth: 5 m to 19 m; age: 1,500 to 5,000 years ago.

Arboreal pollen grains have a large percentage, 65% to 88%, which is the highest one throughout the 85-m core samples under the influence of an increase of *Abies* (about 3%) and *Picea* (1.5 to 8%). Plants adapted to the Cool Temperate and Temperate zones show 14% to 45% due to an increase of *Cryptomeria* pollen grains, though *Zelkova* pollen grains decrease from about 16% to 1%. Plants of the middle Cool Temperate and the Warm Temperate zones reach 30% to 70%. Plants growing in the Warm Temperate



Text-fig. 5. Diagram of conifer and arboreal pollen grains found from the 85-m core samples.



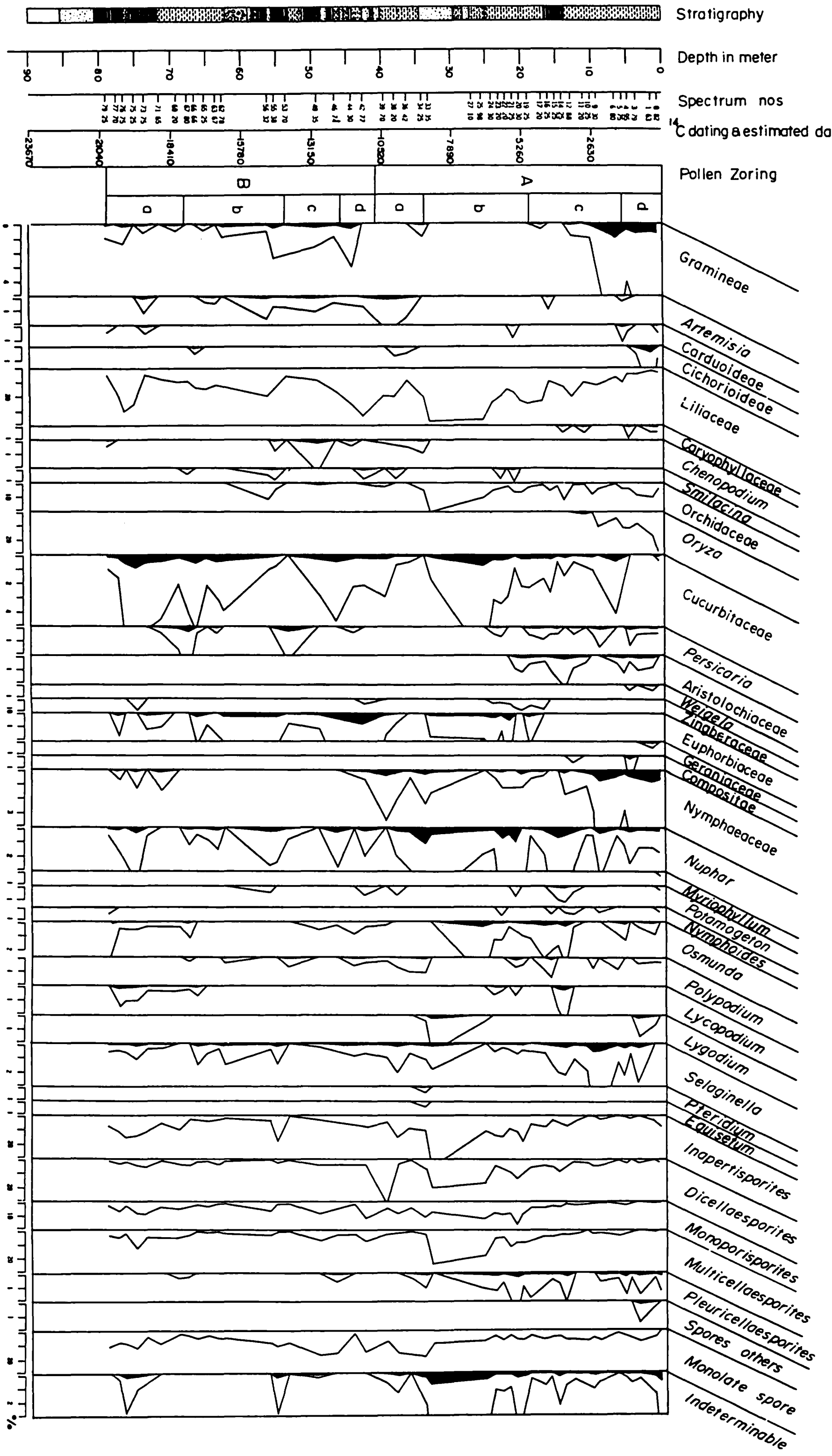
Text-fig. 6. Diagram of arboreal pollen grains found from the 85-m core samples.

and the Subtropical zones are 1% to 9%, which is a decrease as compared to Subzone A-b. *Oryza* pollen grains are found in an upper horizon from this subzone, and the percentage of these grains is 0.5% to 10.2%.

On the basis of the result mentioned above, the palaeoclimate is inferred to have been cooler than those of the present-day, Subzones A-d and A-b.

Subzone A-b, spectra: 19.25 to 33.45; depth: 19 m to 34 m; age: 5,000 to 8,000 years ago.

Arboreal pollen grains have a value of 39% to 73%, lower than those of the other subzones. Therefore, non-arboreal pollen grains increase. Such boreal conifers as *Abies*, *Picea*, *Tsuga*, and *Larix* decrease to 0% or 2.5%, and



Text-fig. 7. Diagram of non-arboreal pollen grains and spores found from the 85-m core samples.

the percentages of their conifers show the lowest value throughout all of the eight subzones. Cool Temperate plants decrease. Plants growing in the Cool Temperate and the Warm Temperate zones show such a high percentage as 28% to 55% because of an increase of *Zelkova* (9% to 20%), *Lepidobalanus* (8% to 28%), and *Cryptomeria* (4% to 20%). Middle Cool Temperate and Warm Temperate plants reach a high value (36% to 58%) of pollen grains due to an increase of *Corylus* (12%). Plants adapting to the Warm Temperate and Subtropical zones have the highest percentage throughout all of the eight subzones.

Judging from the above-mentioned palynological results, the palaeoclimate during the age of this subzone may have been the warmest over the 85-m core samples.

Subzone A-a, spectra: 34.75 to 39.70; depth: 34 m to 41 m; age: 8,000 to 11,000 years ago.

Arboreal pollen grains show a high percentage of 71% to 87%, and non-arboreal pollen grains have a low percentage. Plants growing in the Subpolar zone reach to a value of about 4.6% at a maximum, which is low. Cool Temperate plants decrease from 11% to 3%. This phenomenon is influenced by a decrease (from 10% to 0%) of *Fagus*. In contrast to this decrease, plants of the Cool Temperate and the Warm Temperate zones increase from 32% of the Subzone B-d to 72% of this Subzone A-a. This increase is influenced by an increase of *Zelkova* (1% to 24%) and *Lepidobalanus* (25% on the average). Warm Temperate and Subtropical plants reach 1% to 7%.

Judging from the above-mentioned pollen assemblage, it is inferred that the palaeoclimate during the Subzone A-a may have been more or less cold.

Subzone B-d, spectra: 42.77 to 44.30; depth: 41 m to 46 m; age: 11,000 to 12,000 years ago.

Arboreal pollen grains are 51% to 62%, and occupy a value more than that of non-arboreal pollen grains. Plants growing in the Subpolar zone are few. Among them, *Abies*, *Tsuga*, and *Larix* pollen grains are lacking, and only 6% of *Picea* grains are included. Cool Temperate plants show a high percentage (15% to 38%); that is, *Betula* grains reach 1.8% to 2.7%, *Ulmus* 1.2% to 2.7%, and *Fagus* 10% to 35%. Plants of the Cool Temperate and Warm Temperate zones increase gradually in contrast to the lower horizon as Subzone B-c. Plants growing in the middle part of the Cool Temperate and Warm Temperate zones are 33% to 40%. The Warm Temperate and Subtropical plants increase from a lower subzone to this subzone; that is, *Myrica* pollen grains are 0.6% on the average, and *Cyclobalanopsis* grains 0.6% to 1.5%.

As mentioned above, this subzone is characterized by the abundance of plants growing in the Cool Temperate zone, and the middle area of the Cool Temperate and the Warm Temperate zones. Also, Warm Temperate and Subtropical plants increase gradually from the lower horizon of this subzone.

The palaeoclimate during the age of the sedimentation of deposits of Subzone B-d had been a cool condition.

Subzone B-c, spectra: 46.74 to 53.70; depth: 46 m to 54 m; age: 12,000 to 14,000 years ago.

Arboreal pollen grains show a high percentage (74% to 90%) throughout the 85-m core samples, and in contrast, non-arboreal pollen grains are very rare. Subpolar plants increase to about 10% on the average. Plants growing in the Cool Temperate and Warm Temperate zones increase to about 25% on the average (12% at a minimum and 39% at a maximum) owing to an increase (31% to 44%) of *Lepidobalanus*. Middle Cool Temperate and Warm Temperate plants decrease from about 62% on the average (77% at a maximum) of Subzone B-b to about 40% of this subzone. This decrease results from a decrease of *Alnus* pollen grains from 67% in lower Subzone B-b to 22% in this subzone. Warm Temperate and Subtropical plants increase, though the increase is a small percentage.

The palaeoclimate at the time of this Subzone B-c may have been a more or less cold condition.

Subzone B-b, spectra: 55.38 to 67.80; depth:

54 m to 68.2 m; age: 14,000 to 16,500 years age.

This subzone is characterized by the abundance of conifers, and by the absence of Subtropical and Warm Temperate plants. Accordingly, Subpolar plants are about 70% on the average, which is influenced by a high value of *Abies* (12% to 18%) and *Picea* (5% to 20%). Cool Temperate plants appear about 4% on the average (1% at a minimum and 7% at a maximum) except *Alnus*. Cool Temperate and Warm Temperate plants change from 10% to 30% in Subzone B-b. The percentage of plants growing in the middle area of the Cool Temperate and Warm Temperate zones shows a high value (46% to 77%), which is influenced by *Alnus* pollen grains (20% to 47%).

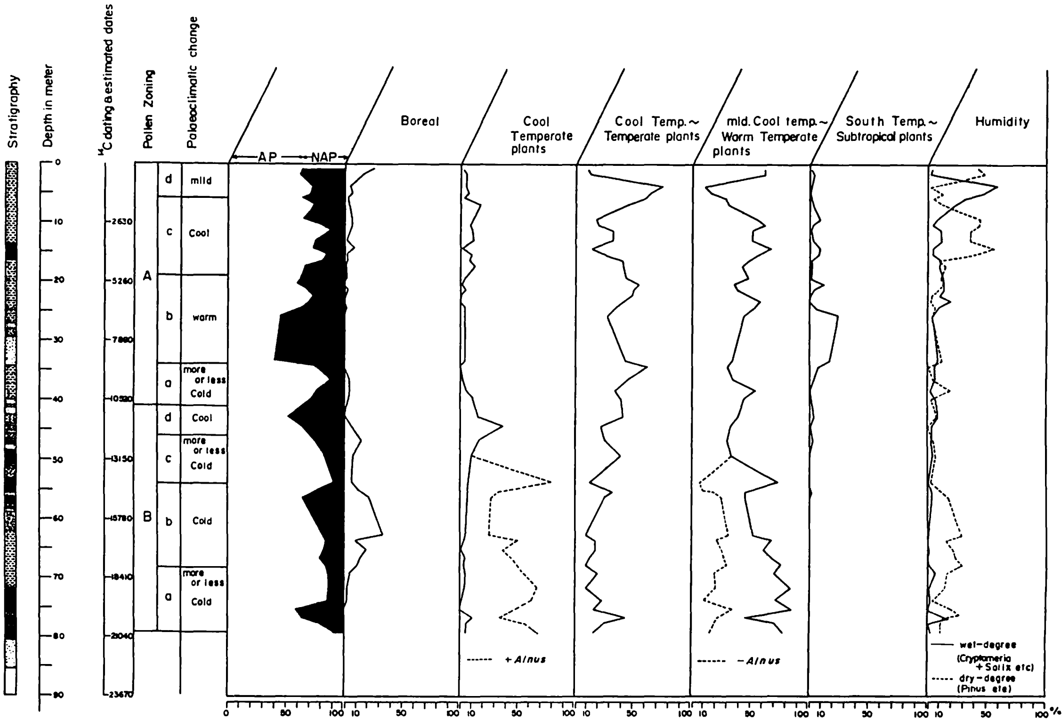
The palaeoclimate in the stage of Subzone B-b may have been a cold condition.

Subzone B-a, spectra: 69.20 to 79.25; depth: 68.2 m to 79.25 m; age: 16,500 to 21,000 years ago.

This subzone is characterized by the abundance of conifers, and by the absence of Subtropical and Warm Temperate plants. Cool Temperate plants appear about 5% on the average (11% at a maximum). Plants growing in the Cool Temperate and Warm Temperate zones show the lowest percentage throughout all of the eight subzones by the influence of the low values of *Cryptomeria* and *Zelkova*. Plants of the middle part of the Cool Temperate and Warm Temperate zones reach 46% (at a minimum) to 85% (at a maximum), which are higher than those of the other subzone in the 85-m core samples.

Judging from the above-mentioned description, the palaeoclimate of Subzone B-a is inferred as having been cold or slightly cold.

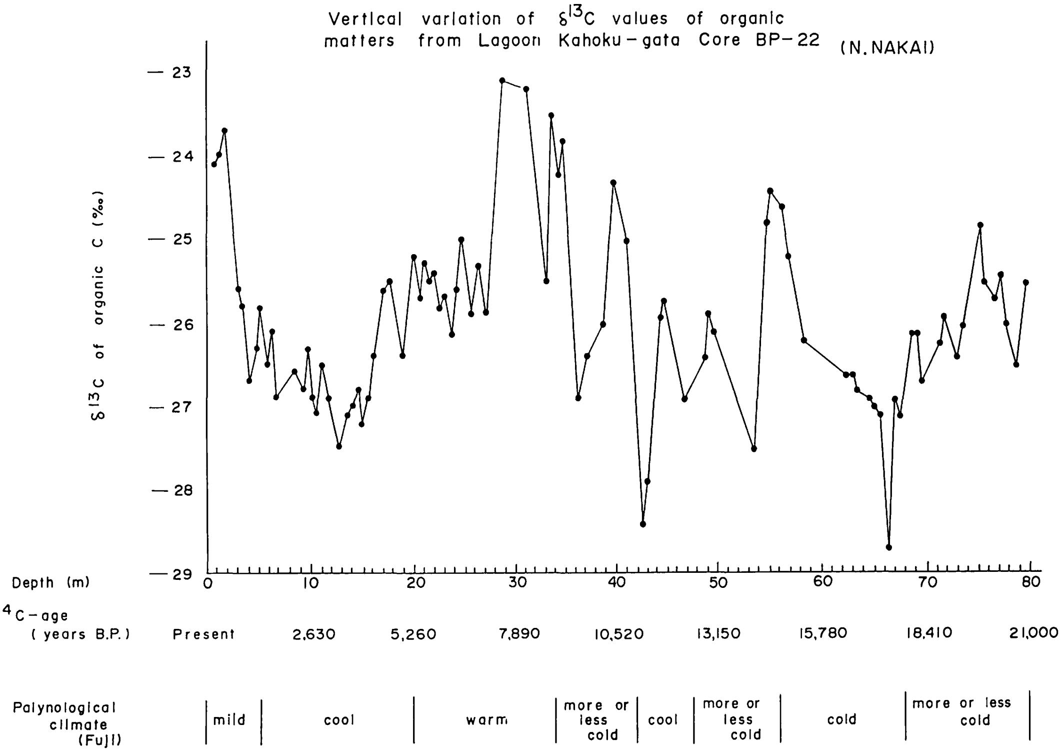
3. The Comparison between the Climatic Changes by the Isotopic and Palynological Studies



Text-fig. 8. Summary diagram of the palynological analysis of the 85-m core samples.

The comparison between the profiles for environmental changes by the isotopic and geochemical studies and the fossil pollen and diatom analyses gave a close agreement to each other (Nakai *et al.*, 1982). According to the studies, it is concluded that the isotopic and chemical records of embayment sediments can be used as useful indicators for the past environment.

To study the environmental changes such as the climatic and sea-level fluctuation in the past geologic time, the 15-m and 85-m core samples were analyzed by N. Nakai for the stable carbon isotopic composition ratio ($^{13}C/^{12}C$) of sedimentary organic materials. Total organic materials in the cores have a $\delta^{13}C$-range from −29 to −23 ‰ relative to PDB-standard. Large ranges of $\delta^{13}C$ values are due to the past depositional history affected primarily by the relative contribution of terrestrial- and marine-derived organic materials to the bottom sediments. Besides a difference in the source of organic materials, $\delta^{13}C$ value is affected by the sedimentary environment and temperature conditions. From the fluctuation pattern of $\delta^{13}C$, the present writer can find the following feature indicating the sea-level and the climatic (temperature) changes during the end of the last glacial age, Würmian or Wisconsinian glacial age, and the Holocene. A cold climate can apparently be seen at the lower horizon of the core in the ^{14}C-age of 9,000 to 14,000 years B.P. According to the investigation based on diatom analysis (Fuji *et al.*, 1981), a sea-level at that time was about −50 to −5 m in the studied area. After that period, the sea-level rose gradually, and the high sea-level and climatic optimum appeared in the ^{14}C-age of 8,000 to 4,000 years B.P. corresponding to "the Jomonian Transgression". This warm and high sea-level period is followed



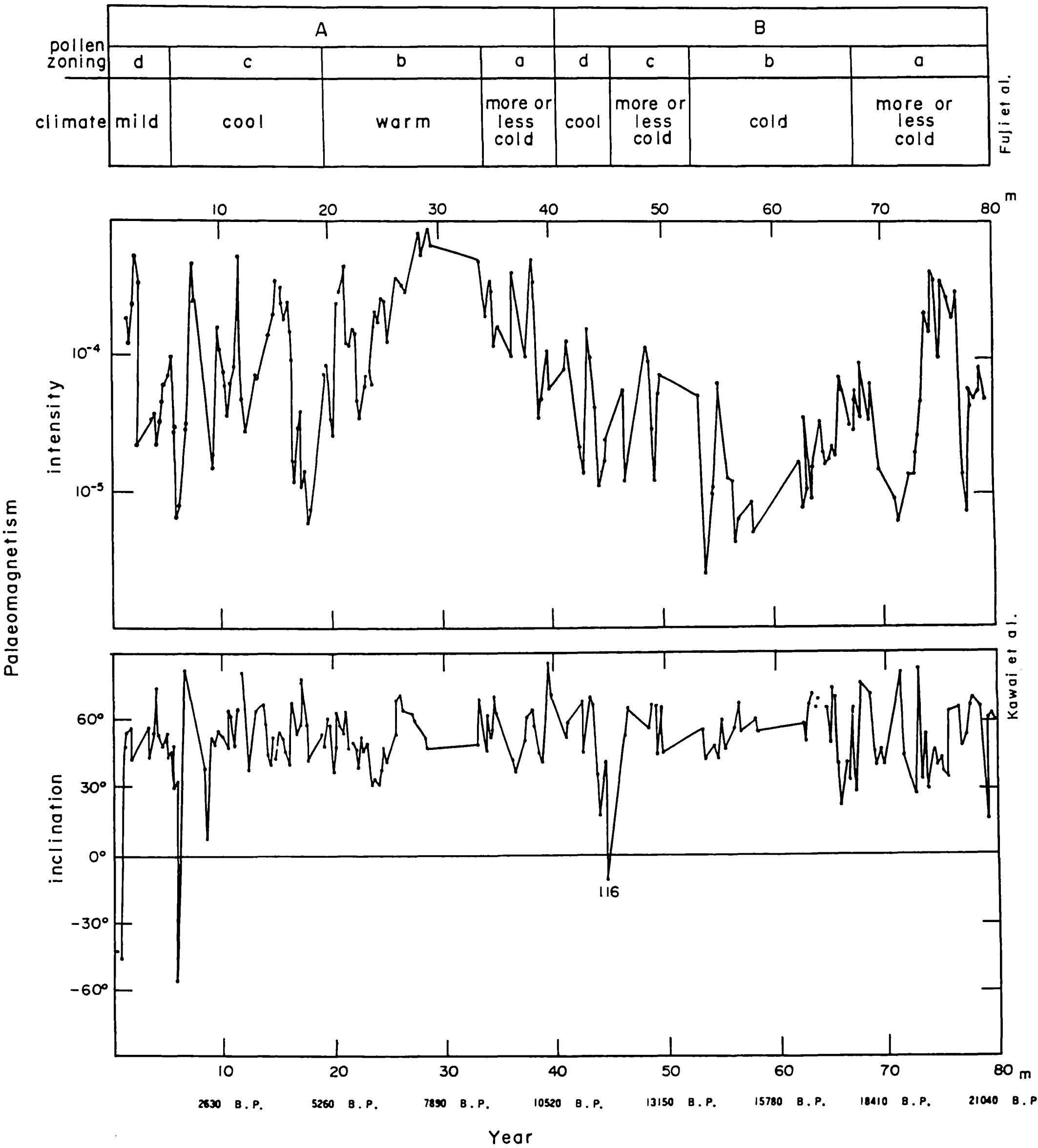
Text-fig. 9. Vertical variation of $\delta^{13}C$ values of organic matters found from the 85-m core samples (after Nakai, Mori and Ohta, 1982).

by a low sea-level and a cool climate corresponding to a small scale regression called "the Yayoian Regression" in Japan and correlated internationally with "a little ice age". After the small scale regression, about 1,500 years B.P., the sea-level rose again gradually toward the present sea-level.

The climatic change by the isotopic analysis above-mentioned gives a close agreement to the climatic change based on the palynological study as shown in Text-fig. 9.

4. The Comparison between Changes of the Palaeoclimate and Palaeomagnetism

The palaeomagnetic study of the 85-m core



Text-fig. 10. Diagram showing the changes of the palaeomagnetism and the palaeoclimate based on the palynological anlysis of the 85-m core samples (after Kawai & Nakajima, unpubl. data).

samples has been made by the late Dr. Naoto Kawai, former Professor of Osaka University and Assistant Professor Tadashi Nakajima of Fukui University. The result of the palaeomagnetism on the 85-m core is shown in Text-fig. 10. Judging from the results of the palaeomagnetic and palynological studies, it seems to be concluded that when the intensity of the magnetism was weak, the climate was a cold condition, and in contrast, when the intensity was strong, the climate was a warm or mild condition. The relationship between the palaeomagnetism and plaeoclimate as above-mentioned has been found in the long core samples obtained from the bottom of Lake Biwa, Central Japan (Kawai *et al.*, 1975).

5. Correlation

In Northwestern Europe, the Late Glacial Period is divided into five stages on the basis of changes of palaeoclimate, namely, the Oldest Dryas (12,400 to 15,000 years ago), Bölling (12,100 to 12,400 years ago), Older Dryas (11,800 to 12,100 years ago), Alleröd (11,000 to 11,800 years ago), and Younger Dryas (10,350 to 11,000 years ago).

As a detailed dating on the deposits from Lagoon Kahoku-gata has not been measured, the writers cannot correctly state the age of the boundary between some pollen subzones and pollen zones. However, judging from the changes of palaeoclimate based on the palynology and ^{14}C dating and palaeomagnetic stratigraphy of a few horizons, the ages of some pollen subzones are estimated roughly as mentioned already in the description of individual pollen zones.

According to the writer's investigation on the deposits obtained from Lagoon Kahoku-gata, Pollen Subzone A-a (about 8,000 to 11,000 years ago, more or less cold) may be correlated with the Preboreal and the Late Younger Dryas stage; Pollen Subzone B-d (about 11,000 to 12,000 years ago, cool) with the early Younger Dryas — Alleröd — Older Dryas stages; Pollen Subzone B-c (about 12,000 to 14,000 years ago, more or less cold) with Bölling — the late Oldest Dryas; and Pollen Subzone B-b (about 14,000 to 16,500 years ago, cold) with the early Oldest Dryas and the previous age, respectively.

In addition, Pollen Subzone A-b (about 5,000 to 8,000 years ago, warm) may be correlated with the Atlantic stage; Pollen Subzone A-c (about 5,000 to 1,500 years ago, cooler than that of the present-day) with the Subboreal; and Pollen Subzone A-d (the present-day to about 1,500 years ago, mild and wet) with the Subatlantic stage, respectively.

6. Conclusion

(1) The palaeovegetation and palaeoclimate during the last about 20,000 years in and around Lagoon Kahoku-gata are analysed by a palynological investigation.

(2) Judging from the pollen analyses, the palaeoclimate may be inferred as follows:

Subzone B-a: 16,500 — 21,000 years ago; cold or slightly cold, dry;

Subzone B-b: 14,000 — 16,500 years ago; cold and slightly dry;

Subzone B-c: 12,000 — 14,000 years ago; more or less cold, slightly dry;

Subzone B-d: 11,000 — 12,000 year ago; cool, slightly wet;

Subzone A-a: 8,000 — 11,000 years ago; more or less cold, slightly wet;

Subzone A-b: 5,000 — 8,000 years ago; warm and wet;

Subzone A-c: 1,500 — 5,000 years ago; cool and slightly dry;

Subzone A-d: the present-day — 1,500 years ago; mild and wet.

(3) Judging from the palynological investigation of the samples obtained from the 15-m boring core of Lagoon Kahoku-gata, the deposits below this lagoon are divided into three pollen zones as Zones α, β and γ in an ascending order.

Zone α: 1,500 — 3,500 years ago; cool or slightly cool.

Zone β: 500 — 1,500 years ago; more or less warm.

Zone γ: the present-day — 500 years ago;

mild as the present-day.

(4) A change of the Carbon-13 (^{13}C) and Carbon-12 (^{12}C) ratio is shown in Text-fig. 9. The pattern of the change of δ^{13}C corresponds to pattern of the change of δ^{13}C corresponds to the pattern of the change of palaeoclimate. Especially, the boundary between Zones α and β is sharper than the boundary between Zones β and γ.

(5) The frequency of pollen grains of *Oryza* (rice plant) found in Zones β and γ is larger than the value in the Zone α. This phenomenon shows the remarkable development of rice-cultivation around Lagoon Kahoku-gata during the age of Zones β and γ, and this inference is supported by many old documents and pieces of archaeological evidence.

(6) The pollen zones of the core samples below Lagoon Kahoku-gata are correlated with the divisions in Northwestern Europe as follows: Subzone A-d may be correlated with the Subatlantic stage, Subzone A-c with Subboreal, Subzone A-b with Atlantic, Subzone A-a with Preboreal and the late Younger Dryas, Subzone B-d with the early Younger Dryas — Alleröd — Older Dryas, Subzone B-c with Bölling — the late Oldest Dryas, Subzone B-b with the early Oldest Dryas and its previous age, and Subzone B-a with times before the Oldest Dryas, respectively.

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Kohoku-gata 河北潟, Kanazawa 金沢, Jomonian Age 縄文時代, Yayoian Age 弥生時代, Kokahoku-irie 古河北入江, Konan-ohashi 湖南大橋, Tsubata 津幡, Asano River 浅野川, Lake Biwa 琵琶湖, Yurakucho Transgression 有楽町海進

能登半島基部の河北潟底下には，過去2万余年間の，いわゆる有楽町海進によって形成された沖積層が連続して堆積している。ボーリングによって得られたこの地層を花粉分析し，各時代の古植生を復元した結果，次に述べるような結論をえた。

(1) 過去約2万年間の古気候の変化と北欧地域の花粉分帯との対比

最近 1,500 年間（花粉亜帯 A-d）····温和で湿潤，Subatlantic 期に対比
1,500～5.000 年前（花粉亜帯 A-c）····冷涼でやや乾燥，Subboreal 期に対比
5,000～8,000 年前（花粉亜帯 A-b）····温暖湿潤，Atlantic 期に対比
8,000～11,000 年前（花粉亜帯 A-a）····やや寒冷でやや湿潤，Preboreal ～ Younger Dryas 後期に対比
11,000～12,000 年前（花粉亜帯 B-d）····冷涼やや湿潤；Younger Dryas 前期～Older Dryas 期に対比
12,000～14,000 年前（花粉亜帯 B-c）····やや寒冷やや乾燥；Bölling～Oldest Dryas 後期に対比
14,000～16,500 年前（花粉亜帯 B-b）····寒冷でやや乾燥；Oldest Dryas 前期～それ以前に対比
16,500～21,000 年前（花粉亜帯 B-a）····寒冷～やや寒冷で乾燥；Oldest Dryas 期以前

(2) 上述の花粉分析に基づく古気候の変化は，同一ボーリング・コア・サンプルの δ^{13}C 分析（名大・中井信之）より解析して得られた古気候の変化ともよく一致する。

(3) 河北潟周辺での稲作農耕は，放射性炭素測定による年代によると約 **2,400 年前（北陸での縄文晩期頃）**に開始され，顕著な稲作農耕は約 1,000 年前からで，この推定は，当地域の古記録ともよく符合する。

PROCEEDINGS OF THE PALAEONTOLOGICAL SOCIETY OF JAPAN

日本古生物学会1984年年会・総会

日本古生物学会1984年年会・総会が1984年1月21・22日に京都大学理学部を会場として開催された（参会者225名）。

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行事予定

	開催地	開催日	講演申込締切
第133回例会	秋田大学	1984年6月24日	1984年4月24日
1985年 年会・総会	国立科学博物館および東京大学	1985年2月2,3日	1984年10月31日

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おわびと訂正

編集係の不注意により本誌130号および131号に次の重大な誤りがありましたので，おわびして訂正します。

Errata for No, 130

Plates 26 and 27 [Furutani: Middle Paleozoic Radiolaria]
Read Plate 27 *for* Plate 26, and *read* Plate 26 *for* Plate 27.

Errata for No. 131

Back cover, line 8
Read Ostracoda from the Pliocene Ananai Formation, Shikoku, Japan—Description— *for* Ostracoda from the Ananai Formation.

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