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Mesozoic Plants from the Yatsushiro Formation (Albian), Kumamoto Prefecture, Kyushu, Southwest Japan.

By

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Introduction

In 1952, Professors T. MATSUMOTO and K. KANMERA of Kyushu University collected the Albian fossil plants from the Yatsushiro Formation, Kumamoto Prefecture. The material was kindly offered by them for my study. This is the first record of the youngest fossil plants without Angiosperms in Japan.

Geology

In the Yatsushiro district, Southwest Japan, the Cretaceous strata are widely exposed. According to the detailed study by T. MATSUMOTO, K. KANMERA, T. TAKAHASHI and K. FUJII (in MATSUMOTO, 1953), the Cretaceous System in this area might be summarised as follows in descending order;

Tomochi Formation (Cenomanian-Turonian), 660 m thick; contains marine shells in the lower member.

—unconformity—

Yatsushiro Formation (Albian, an equivalent of the upper half of the Upper Monobegawa Formation), ca 580 m thick; contains plants and brackish mollusks in the upper member, shallow sea and littoral animals in the middle member, and plants in the lower member (main plant bed).

—unconformity—

Hinagu Formation (Aptian, an equivalent of the lower half of the Upper Monobegawa Formation), 800 m thick; fossiliferous limestone yielding ammonites, echinoids and other marine shells, and brackish mollusks at the base.

Hachiryuzan Formation (Hauterivian-Barremian, an equivalent of the Lower Monobegawa Formation), 350 m thick; contains ammonites, echinoids and other marine shells.

Kawaguchi Formation (Berriasian-Valangian, an equivalent of the Ryoseki Formation), 400 m thick; contains brackish mollusks and such plants as *Adiantites toyoraensis* OISHI, *Cladophlebis exiliformis* (GEYLER), *C.* sp., *Zamiophyllum buchianum* (ETTINGSHAUSEN), *Nageiopsis* cfr. *zamioides* FONTAINE, *Nilssonia* sp. and *Podozamites lanceolatus* (L. & H.) ?

—fault or unconformity—

Permian System

The Yatsushiro Formation is subdivided into Lower, Middle and Upper members. The Middle member yields a rich marine fauna consisting of bivalves, ammonites, brachiopods, echinoids, crinoids and corals, among which the ammonites comprise Albian species. Fossil plants occur mainly in the type area of the Upper member together with brackish mollusks.

The type locality of the Yatsushiro Formation is in the higher part of the mountainous area along the boundaries of Kawamata-mura, Taneyama-mura, Shimomatsukuma-mura, Kakisako-mura and Kuriki-mura, all the villages belonging to Yatsushiro-gun, Kumamoto Prefecture. For further details of stratigraphy and fauna, see "The Cretaceous System in the Japanese Islands" compiled by the Cretaceous Research Committee (Chairman, T. MATSUMOTO) (1953).

Composition and Characteristics of Yatsushiro Flora

Material: The plant remains described in this paper have been graphitised or have lost the carbonaceous substance, and so while showing their form and venation clearly, they are not suitable for the preparation of spores or cuticles. The specimens here described are all deposited at the National Science Museum, Tokyo.

Composition: The collection includes the following identifiable genera and species;

Lycopodiales: *Lycopodites* sp.

Filicales: Gleicheniaceae: *Gleichenites sachalinensis* (KRYSHTOFOVICH) n. comb., *G. zippei* (CORDA) SEWARD

Unclassified ferns: *Cladophlebis acutipennis* OISHI, *C. elegantissima* OISHI, *C.* ex gr. *exiliformis* (GEYLER) OISHI, *C. geyleriana* (NATHORST) YABE, *C.* (*Teilhardia*?) *kanmerai* KIMURA sp. nov., *C. matsumotoi* KIMURA sp. nov., *C. undulata* OISHI, *Sphenopteris goepperti* DUNKER, *S. yokoyamai* YABE, *Onychiopsis elongata* (GEYLER) YOKOYAMA

Caytoniales: *Sagenopteris inequilateralis* OISHI

Bennettitales: *Ptilophyllum* sp., *Zamites buchianus* (ETTINGSHAUSEN) SEWARD, *Cycadolepis*? sp.

Cycadales: *Nilssonia* ex gr. *orientalis* HEER, *N.* ex gr. *schaumburgensis* (DUNKER) NATHORST

The composition is somewhat different from the Ryoseki and the Monobegawa floras of the type area, Kochi Prefecture. I call the plant assemblage listed above the Yatsushiro Flora.

Characteristics of Yatsushiro Flora: This flora, like the Aptian-Albian floras of Japan, is less rich in genera and species than the coeval floras of Western Canada and Southern Primorye, and also the Neocomian floras of Japan.

1) Ferns unclassified are prominent, and most have fronds pinnately divided three or more times and have small pinnules mostly with lobed margins and strongly convex surface. Such new types of ferns as *Cladophlebis* (*Teilhardia*?) *kanmerai*, n. sp., *C. matsumotoi* n. sp., and *Sphenopteris yokoyamai* flourished. Only classified genus is *Gleichenites* which is more abundant than in the underlying floras.

2) *Sagenopteris inequilateralis* is peculiar to Japan, but it occurs only in Albian and Aptian floras.

3) The only abundant cycadophyte is *Zamites buchianus* which has hitherto been called *Zamiophyllum buchianum*. *Nilssonia* leaves are mostly small-sized. *Ptilophyllum* leaves are less common than in the underlying floras in the Outer Zone of Japan.

4) The collection includes no ginkgoalean, broad-leaved conifer nor other conifer leaves.

5) Though this flora is somewhat different in composition from the underlying floras of the Outer Zone of Japan, it is clearly a member of the Outer Zone Palaeofloristic Province of Japan (KIMURA, 1961, 1975a, b; KIMURA & HIRATA, 1975; KIMURA & SEKIDO, 1963), because it contains such indicators characterising this province during the late Jurassic to early Cretaceous as *Zamites buchianus, Nilssonia* ex gr. *schaumburgensis* and *Ptilophyllum* sp. of Outer Zone-type.

6) Judging from the stratigraphical and the palaeontological facts mentioned before, the geological age of this flora is undoubtedly Albian. Nevertheless, it is remarkable that no Angiosperm is found in the collection. The coeval floras in Southern Primorye, Northern Alaska, Western Canada and also Siberia contain a considerable number of Angiosperms.

From the Japanese Lower Cretaceous strata, merely two types of fossil remains with some affinity to Angiosperm are known; one is a pollen grain, *Tricolpopollenites* sp. (TAKAHASHI, 1972) from the Albian Tanohata Conglomerate Member, the lower part of the Shimohei Formation, Miyako Group, Iwate Prefecture, and the other is a petrified wood, *Tetracentronites japonica* NISHIDA, 1962 from the Aptian bed of the Choshi Peninsula, Chiba Prefecture.

Comparison with Coeval Floras

A) Comparison with the Wealden-type floras

1) Comparison with the Upper Monobegawa floras (Aptian-Albian) in the Outer Zone Palaeofloristic Province of Japan.

In Kochi Prefecture, the type area of the Upper Monobegawa Formation, the following plants were recorded (M. HIRATA, 1972; KIMURA & HIRATA, 1975): *Gleichenites nipponensis* OISHI, *Adiantites sewardi* YABE, *A. toyoraensis* OISHI, *A.* spp., *Onychiopsis elongata* (GEYLER), *Cladophlebis acutipennis* OISHI, *C. argutula* (HEER), *C. denticulata* (BRONGNIART), *C. distans* (HEER), *C. exiliformis* (GEYLER), *C. hukuiensis* OISHI, *C. lobifolia* (PHILLIPS), *C. takezakii* OISHI, *C. undulata* OISHI, *Sagenopteris inequilateralis* OISHI, *Ptilophyllum* ex gr. *pecten* (PHILLIPS), *Zamiophyllum buchianum* (ETTINGSHAUSEN), *Nilssonia orientalis* HEER, *N. schaumburgensis* (DUNKER), *Podozamites lanceolatus* (L. & H.), *Brachyphyllum expansum* (STERNBERG). In addition to the above KIMURA & HIRATA (1975) described *Taeniopteris* sp. cfr. *Nilssoniopteris rhitidorachis* (KRYSHTOFOVICH) KRASSILOV.

The geological age of the Upper Monobegawa Formation extends over the Aptian to Albian and this formation has not yet been subdivided into upper and lower members. We have no detailed information about the stratigraphical distribution of the above plants. Apart from the doubtful record of *Podozamites lanceolatus*, however, the Upper Monobegawa Flora is undoubtedly similar to the Yatsushiro Flora in composition.

The florule of the Aptian Hoji (or Boji) Formation, Tokushima Prefecture, consists of *Cladophlebis acutipennis, C. exiliformis, C. geyleriana, C. hukuiensis, C. nathorsti,* *Sphenopteris yokoyamai, Onychiopsis elongata, Zamiophyllum buchianum, Nilssonia schaumburgensis* and *Brachyphyllum japonicum* (YOKOYAMA, 1894; YABE, 1922, 1927b; OISHI, 1940). There is no marked distinction between the Yatsushiro Flora and this florule.

NISHIDA (1960) described the following species from the Aptian bed of the Choshi Peninsula, Chiba Prefecture. Judging from the illustrations, however, the specimens are very small fragments and I am unconvinced by the determinations marked with asterisk. If these questionable ones are excluded, the flora agrees with the Yatsushiro Flora fairly well.

Equisetites sp., *Coniopteris burejensis**, *Cladophlebis acutipennis, C. exiliformis, C. nihei-takagii* NISHIDA, *C. parvula, C. raciborskii*?*, *Adiantites sewardi, Onychiopsis elongata, Otozamites* sp.*, *Ptilophyllum pecten, Nilssonia orientalis, N. schaumburgensis* var. *parvula, Czekanowskia rigida**, *C.* sp.*, *Sphenobaiera furcata*?*, *Nageiopsis longifolia**, *Podozamites lanceolatus**, *Frenelopsis hoheneggeri, Carpolithus* sp.

Recently I examined the material collected by M. MATSUKAWA from the Aptian Sebayashi Formation, Gumma Prefecture, Kwanto Mountainland, and identified the following genera and species (KIMURA & MATSUKAWA, MS): *Lycopodites*? sp., *Cladophlebis acutipennis, C. nathorsti, C.* (*Osmunda*) *takezakii, C.* spp., *Sphenopteris* ex gr. *goepperti, Acrostichopteris* sp., *Onychiopsis elongata, Ptilophyllum* ex gr. *pecten, Zamites buchianus, Nilssonia* cfr. *canadensis, N.* ex gr. *schaumburgensis, Nageiopsis*? spp., *Cyparissidium japonicum*.

Except for *Nageiopsis*? spp. and *Cyparissidium japonicum*, this florule is not essentially different from the Yatsushiro Flora in composition. The above locality is the same as Kagahara called by YOKOYAMA (1894).

In the Outer Zone of Japan, the Albian flora is close to the Aptian floras in com position, except for the abundant occurrence of coniferous wood in the Aptian bed of the Choshi Peninsula (NISHIDA, 1962, '65, '66, '67a, b, '72, '73), but both are somewhat different in composition and number of species from the late Neocomian Lower Monobegawa and early Neocomian Ryoseki floras.

NISHIDA states that there are 26 distinct types of coniferous wood mainly from the conglomerate of the Choshi Peninsula, but unfortunately their corresponding shoots or leaves are not known.

2) Comparison with the Albian flora of Southern Primorye

The early Cretaceous floras of Southern Primorye were studied in detail by KRASSILOV (1967). The Lower Cretaceous strata bearing plant remains are distributed mainly in two areas. In the southeast, mainly along the Sutschan River, the Lower Cretaceous System is divided into the Taukhin (mainly Berriasian), the Kljuchev (mainly Valangian), the Starosutschan (Lower Sutschan, Barremian), the Severosutschan (Upper Sutschan, Aptian) and the Frentzev (Albian) Formations. In the southwest, mainly along the Sujfun River, the Lower Cretaceous System is divided into the Ussuri (Barremian), the Lipovetz (Aptian) and the Galenkov (Albian) Formations. These, apart from the Taukhin and the Kljuchev Formations, constitute the

Nikan Group. The Albian flora from the Frentzev and the Galenkov Formations is shown below.

Southeastern area (Frentzev Formation); *Isoetes* sp.*, *Equisetites* sp., *Ruffordia goepperti**, *Coniopteris burejensis, Onychiopsis psilotoides, Vargolopteris rossica*, Ussuriopteris rossica?, Cladophlebidium dahuricum*, Pelletieria ussuriensis, Cladophlebis frigida, C. novopokrovskii, Cycadites* cfr. *Pseudocycas dicksonii*, Ginkgo pluripartita, Paramopyle florinii*, Athrotaxopsis expansa, Elatides asiatica, E.* ex gr. *curvifolia, E. obtusifolius*, Brachyphyllum* ex gr. *obesum*, Sassafras ussuriensis*, Aralia lucifera*, Sapindopsis* cfr. *Artocarpidium* sp.*, *Cissites* sp.* (Species with asterisk have not been found from the other area).

Southwestern area (Galenkov Formation); *Equisetites* sp., *Pelletieria ussuriensis, Coniopteris burejensis, Onychiopsis psilotoides, Adiantopteris sewardi*, Teilhardia tenella*, Acrostichopteris pluripartita*, Cladophlebis frigida, C. novopokrovskii, Sagenopteris mantelli*, Neozamites denticulatus*, Sphenozamites* sp.*, *Pterophyllum pterophylloides*, Cycadites sulcatus*, Cycadospadix* sp.*, *Nilssonia densinervis*, N.* ex gr. *orientalis*, N.* ex gr. *brongniarti*, Ginkgo pluripartita, Baiera manchurica*, Sphenobaiera* sp.*, *Podozamites tenuinervis*, Pityospermum prynadae*, Athrotaxopsis expansa, Elatides asiatica, E.* ex gr. *curvifolia, Brachyphyllum* ex gr. *expansum*, Sujfunophyllum dichotomum*, Hydropterandium* sp. B*, *Samalopsis* sp. B*, *Cercidiphyllum sujfunense*, Laurophyllum* sp.*, *Dicotylophyllum* sp. (Species with asterisk have not yet been found in the Southeastern area).

It is noteworthy that the floral composition is fairly different between the two areas, and that such Siberian elements as *Neozamites, Baiera, Sphenobaiera* and *Podozamites* appear to be restricted in the southwestern area only.

The Albian flora of Southern Primorye shown above separately, is fairly rich in genera and species and contains several Angiosperms, though they are not abundant. The smaller number of genera and species in the Yatsushiro Flora makes a precise comparison with the Albian flora of Southern Primorye difficult. Possibly the poorer Yatsushiro Flora grew in a less favourable climate.

3) Comparison with the Albian flora in Western Canada

BELL (1956) recorded the following species in Albian flora of Western Canada:

Isoetites horridus, Equisetites lyelli, Cladophlebis virginiensis, C. frigida, C. alberta, C. oerstedi, Onychiopsis psilotoides, Gleichenites giesekianus, G. nordenskioldi, Cladophlebis (Gleichenites) munda, C. (G.?) sp., *Sphenopteris (Gleichenites?) erecta, S. newberryi, S. mclearni, S.* spp., *Phyllites asplenioides?, Sagenopteris elliptica, Pterophyllum validum?, Pseudocycas* sp. cfr. *unjiga, P.* sp. B (cfr. *unjiga*), *Zamites tenuinervis, Williamsonia? recentior, Nilssonia schaumburgensis?, N. canadensis, Elatocladus brevifolia, Pityophyllum* sp., *Sequoia condita, Geinitzia? jenneyi?, Cyparissidium? gracile?, Pagiophyllum ambiquum, P.* sp. B, *Brachyphyllum crassicaule, Podozamites lanceolatus?, Desmiophyllum (Podozamites?)* sp., *Podozamites? stenopus?, Salix inaequalis?, Populites dawsoni, Ficus ovatifolia, F. fontainii?, Trochodendroides (Cercidiphyllum?) potomacensis, Menispermites reniformis, M. potomacensis, M.* sp., *M.?* sp., *Nelumbites* sp., *Magnolia?* sp., *Cinnamomoides ovalis, C.* sp., *Capparites?* sp., *Platanus* sp., *Celastrophyllum acutidens, Rhamnites* sp., *Myrtophyllum boreale, Sapindopsis angusta, S. belviderensis, Fontainea grandiflora, Araliaephyllum westoni, Dicotylophyllum* sp., *Antholithes* sp.

Excluding Angiosperms and conifers, the Yatsushiro Flora seems to be close to the Albian flora in Western Canada in general composition. Abundant conifers in Western Canada suggest a somewhat different environment.

B) Comparison with the Tamodani Flora (Aptian) in the Inner Zone Palaeofloristic Province of Japan.

In 1975, I described the Tamodani Flora, which was the youngest one among the early Cretaceous floras of the Inner Zone of Japan (KIMURA, 1975a). The Tamodani Flora consists of the following genera and species; *Osmundopsis*? sp., *Gleichenites* aff. *porsildii, Arctopteris* sp., *Jacutopteris* sp., *Adiantites* sp. A, *Cladophlebis* ex gr. *denticulata, C.* cfr. *pseudolobifolia, Sphenopteris kochibeana, Sphenobaiera*? sp., *Ginkgoidium*? sp., *Podozamites* sp. cfr. *P. eichwaldi, Pityophyllum* sp., *Conites* sp. In addition to the above, M. MATSUKAWA recently collected *Nilssonia* sp.

The Yatsushiro Flora is quite different in composition from the Tamodani Flora which is a member of the Inner Zone Palaeofloristic Province of Japan.

C) Comparison with the Albian floras in the Siberian Palaeofloristic Area.

There are many Albian floras in the Lena, the Kolyma River, the Bureja Basins and Torom Lowland and also in North Alaska. One of them, the flora of West Priokhotie recently described by LEBEDEV (1974) is taken here for comparison. This flora is very rich, consisting of three types of mosses, four types of horsetails, twenty-four types of ferns including *Osmunda, Ruffordia, Coniopteris, Lobifolia, Birisia, Onychiopsis, Arctopteris, Asplenium, Acrostichopteris, Cladophlebis, Ochotopteris* and *Sphenopteris*, nine forms of *Nilssonia*, three types of *Taeniopteris*, twelve types of ginkgoaleans, two types of Czekanowskiales, twenty-two types of conifers including *Pagiophyllum, Pseudolarix, Pityophyllum, Schizolepis, Sequoia, Parataxodium, Athrotaxites, Athrotaxopsis, Elatocladus, Cephalotaxopsis* and *Podozamites*, two types of unknown seeds and five forms of Angiosperms.

Needless to say, the Albian floras of the Siberian Palaeofloristic Area is quite different in composition from the Yatsushiro Flora. According to VAKHRAMEEV, the Siberian floras grew under the humid and tempertate climates, differing from those of the Indo-European Palaeofloristic Area under more arid climates.

As mentioned repeatedly by me, the Outer Zone Palaeofloristic Province of Japan during late Jurassic to early Cretaceous age, is included into the Indo-European Palaeofloristic Area.

Brief Comparison with the Neocomian Floras of the Outer Zone of Japan

In the type area of the Lower Cretaceous strata in the Outer Zone of Southwest Japan, we have two rich floras, the early Neocomian Ryoseki (s. str.) and the late Neocomian Lower Monobegawa floras. The constituents of both floras were mentioned previously by KIMURA and HIRATA (1975) in detail.

The main difference between the Yatsushiro and these Neocomian floras are briefly mentioned below.

1) The Yatsushiro Flora and the Upper Monobegawa floras (Aptian-Albian) of the Outer Zone of Japan have generally a smaller number of genera and species than the Neocomian floras.

2) Fairly abundant Matoniaceous ferns characterising the Neocomian floras of the Outer Zone of Japan have not been found in the Yatsushiro Flora.

3) Gleicheniaceous ferns are rather less common in the Neocomian floras.

4) Cycadophytes are fairly varied and abundant in the Neocomian floras, but they are less varied and fewer in the Yatsushiro Flora. *Ptilophyllum* is common in the Neocomian floras, but is much decreased in the Yatsushiro Flora. *Taeniopteris* leaves possibly belonging to *Nilssoniopteris* are common in the Neocomian floras, but have not been found in the Yatsushiro Flora.

5) Conifers are fairly varied and common in the Neocomian floras, but have not been found in the Yatsushiro Flora.

We can not yet judge whether the Yatsushiro Flora is characteristic of only this locality or it will be found equally in other localities. If its occurrence would be limited, it could suggest an unfavourable environment.

Preliminary Notes on the Origin of the Early Cretaceous Floras in the Outer Zone of Japan

Among the species of the early Cretaceous floras in the Outer Zone of Japan, no species of older Mesozoic type has been found so far. Even the oldest species does not go back to the Liassic in age. New species that appeared in the early Cretaceous are restricted in the Outer Zone. On the other hand, most of species of the coeval floras in the Inner Zone are of the older Mesozoic type. Of course, a good number of new species appeared in the early Cretaceous, but most of them are similar to the ones of the Siberian early Cretaceous and are restricted in the Inner Zone of Japan.

In the Japanese Islands, the stratigraphical boundary between the older Mesozoic and the younger Mesozoic floras might correspond to that between the Higashinagano Formation (Hettangian-Sinemurian) and the Nishinakayama Formation (Pliensbachian-Toarcian) in Yamaguchi Prefecture.

The floras of the Nishinakayama Formation and its superjacent Utano Formation (Toarcian-Callovian?) contain elements of both older and younger Mesozoic floras. But in later ages, most of younger elements and their descendants were concentrated in the Outer Zone to form the Outer Zone Palaeofloristic Province of Japan, while most of the older elements and their allies still survived in the Inner Zone to form the Inner Zone Palaeofloristic Province of Japan.

In Southern Primorye and Western Canada, the Albian floras, which include Angiosperms and rich and varied conifers, are considerably different in composition and character from the underlying early Cretaceous floras. In the Outer Zone of Southwest Japan, however, the floral change over this period was slighter and suggests a more constant environment during the Neocomian to Albian.

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Systematic Description

Lycopodiales

Genus *Lycopodites* LINDLEY & HUTTON, 1933: 170

Lycopodites sp.

(Pl. 1, fig. 7; Pl. 3, figs. 6, 7; Pl. 4, fig. 6)

Description: Complanate foliage consisting of lateral leaves and rather small appressed dorsal and ventral leaves. Lateral leaves crowded, often overlapping, spreading or laterally appressed, attached longitudinally with a slightly contracted upper margin and a decurrent lower margin. The disposition of lateral leaves probably alternate or subopposite. Spreading lateral leaves (Pl. 1, fig. 7; Pl. 3, fig. 6; Pl. 4, fig. 6), 1 mm long and 0.5 mm wide, nearly parallel-sided, often falcate and attached at a wide angle; apex bluntly pointed and often curving forwards; margins entire.

Appressed lateral leaves (Pl. 3, fig. 7) at first spreading at right angle, then curving forwards; apex mostly curving inwards. Dorsal and ventral leaves (partly known in Pl. 3, fig. 7) small, deltoid in outline, attached to the axis but free at apex, 0.75 mm long and 0.5 mm wide at base. Venation not visible.

Remarks: The specimens available are all ill-preserved small fragments of sterile foliage only on a single slab. The phyllotaxis is not clear enough, no specimen is branched, and there is nothing to suggest a cone. It is thus possible that the shoots might belong to a *Sellaginella* (or *Sellaginellites*), a bryophyte or a conifer.

Occurrence: Rare.

Specimen: PP7051 (one slab only).

Filicales

Gleicheniaceae

Genus *Gleichenites* GOEPPERT, 1836: 172

Gleichenites sachalinensis (KRYSHTOFOVICH) n. comb.

(Pl. 3, fig. 4; Pl. 4, fig. 1; Fig. 1 a, b)

Similar specimens:

Gleichenites sp.: KRYSHTOFOVICH, 1918, p. 29 (Upper Cretaceous of Sakhalin); KRYSHTOFOVICH, 1920, p. 480 (Ditto).

Gleichenia sachalinensis KRYSHTOFOVICH: 1933, p. 132, pl. 12, fig. 2 (Ditto); 1937, p. 43, pl. 1, fig. 5; pl. 3, figs. 1–3; pl. 4; pl. 5, fig. 3; pl. 6, fig. 2 (Ditto); BAIKOVSKAJA, 1956, pp. 73, 74, 109, pl. 1, fig. 4 (Ditto).

Description: Frond probably tripinnate. Penultimate pinnae set closely, with stout rachis, 2 mm thick. Ultimate pinnae set closely, more than 2.5 cm long, nearly parallel-sided, about 5 mm wide, tapering gradually towards the acuminated apex, inserted perpendicularly or nearly so to the penultimate pinna axis. Sterile pinnules set closely, attached by their whole bases, surface convex; acroscopic pinnules often semi-circular in form with obtusely pointed apex; basiscopic pinnules often triangular or deltoid in form with acutely pointed apex, directed forwards, about 2.2 mm long and 1.8–2.0 mm wide at base of pinnules. Midnerve ditinct, persisting to the tip (but secondaries not visible).

Fertile pinnules also set closely, similar in form to the sterile. Sori fairly large, circular, about 1 mm in diameter, one or two on each basal side of midnerve. (The details of sori not visible.)

Pl. 4, fig. 1 (PP7053) shows a part of sterile penultimate pinna with comparatively stout rachis. Pl. 3, fig. 4 (PP7052) shows a part of fertile penultimate pinnae. Fig. 1a shows form of fertile pinnules, while Fig. 1b (drawn from PP7055) shows fertile pinnules, sori of which are somewhat smaller in size.

Remarks: Though no divaricating branching of frond and arrested bud have yet been found in the collection, the present specimens agree closely with those originally illustrated by KRYSHTOFOVICH and later by BAIKOVSKAJA under the name of *Gleichenia sachalinensis* from the Gyliakian Series of Sakhalin in external appearance and large sorus-like depressions on each pinnule. However, because in the present and even the original fertile specimens of this species the form and the structure of sorus and sporangium have not been made decidedly clear, it is difficult to distinguish the present species from such allied ones as *Gleichenia otrubensis* BAYER illustrated by VELENOVSKY and VINIKLAR (1927, p. 29, pl. 15, figs. 1–3) from the Lower Cretaceous of Bohemia, except for its rather broadly deltoid or rhomboidal pinnules, and *Gleichenia optabilis* described by HEER (1880, p. 5, pl. 1, figs. 13, 13b) from the Kome Shale, Greenland.

Gleichenia comptoniaefolia (DEBEY & ETTINGSHAUSEN) HEER illustrated by HEER (1875, p. 49, pl. 11, figs. 1–2; 1882, p. 8, 36, pl. 44, fig. 1; pl. 46, figs. 25, 25b) from the Cretaceous of Greenland and also from the Cretaceous of Bohemia and Western Kazakhstan, *Gleichenia gracilis* HEER (1875, p. 52, pl. 10, figs. 1–11; 1882, p. 36, pl. 7, fig. 3) from the Cretaceous of Greenland and also from the Cretaceous of Canada, Germany and United States, and *Gleichenia rewahensis* FEISTMANTEL, a sterile pinna fragment illustrated by SURANGE (1966, p. 101, figs. 64A–D) which was regarded as being conspecific with *Gleichenia gleichenoides* (OLDHAM & MORRIS) by BOSE & SAH (1968, p. 21), are also allied species to the present one.

The present specimens, however, differ from *Gleichenia comptoniaefolia* and *G. gracilis*, in which pinnae and pinnules are strongly directed forwards and bear small sori, and from *G. rewahensis*, in which pinnae are remotely set and pinnules are small and triangular in form.

The occurrence of this species is the first record in Japan.

Occurrence: Rather rare.

Specimens: PP7052–PP7055.

Gleichenites zippei (CORDA) SEWARD

(Pl. 1, fig. 6; Pl. 2, fig. 1; Pl. 3, figs. 1–3; Fig. 2 a, b)

Similar specimens:

Gleichenia zippei (CORDA) HEER: 1868, p. 79, pl. 43, fig. 4 (Cretaceous of Northern Greenland); 1875, p. 44, pls. 4–5; pl. 6, figs. 1–3; pl. 7, fig. 2; p. 90, pl. 25, figs. 1–3; p. 97, pl. 26, figs. 10–13 (Lower Cretaceous Kome Shale and Upper Cretaceous of Greenland); 1876, p. 49, pl. 32, figs. 6, 7 (Cretaceous of Svalbard); 1882, p. 7, 36, pl. 3, fig. 2 (Upper Cretaceous of Greenland); KRYSHTOFOVICH, 1918, p. 27 (Upper Cretaceous of Sakhalin); 1937, p. 46, pl. 2, figs. 3, 4; pl. 3, fig. 4; pl. 4; pl. 5, fig. 1; pl. 6, fig. 3 (Ditto); BAIKOVSKAJA, 1956, pp. 71, 74, 96, 97, 106, 109, 142, 145, 158, 159, 161, pl. 1, figs. 5, 6; pl. 2, fig. 3 (Ditto).

Gleichenia rinkiana HEER: 1868, p. 80, pl. 43, fig. 6 (Cretaceous of Northern Greenland).

Gleichenites zippei (CORDA) SEWARD: 1910, p. 354, fig. 262D (HEER's specimen); KRASSILOV, 1967, p. 109, pl. 9, fig. 5 (Lower Cretaceous of Southern Primorye).

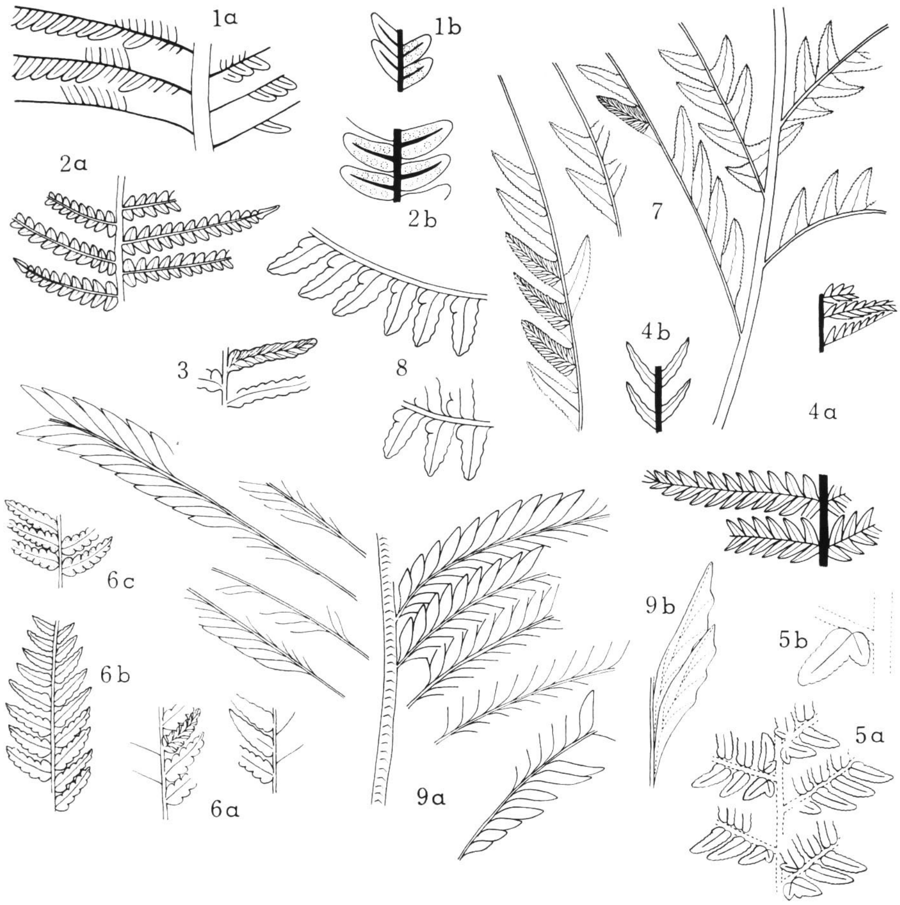
Description: Frond probably tripinnate. Penultimate pinnae set closely, elongate-oblong in form, more than 6.5 cm long and 6 cm wide at the widest portion, attached to the thick rachis at a wide angle, often nearly perpendicular. Ultimate pinnae set closely, touching each other laterally, 1.5–2.5 cm long and 4 mm wide, nearly parallel-sided, tapering to the acuminate apex, attached alternately to the penultimate pinna axis at a wide angle or nearly perpendicular. Pinnules katadromic in order, set closely, 7–12 on each side, semi-circular or deltoid in form, about 2 mm long and 1 mm wide, attached to the pinna axis by their whole bases at a wide angle or sometimes directed forwards, surface convex; midnerve distinct (but secondaries not visible).

Fertile pinnules like sterile ones or more elongated. Sori circular, 0.9 mm in diameter, 2–4 on each side of midnerve. (The details of sporangium not visible.)

Many specimens obtained agree generally with the diagnosis of this species given by HEER (1868) excepting tripinnate feature. Pl. 2, fig. 1 (PP7056) shows three penultimate pinnae of a certain tripinnate frond which is probably fairly large in size. Pl. 1, fig. 6 shows the form of pinnules enlarged from PP7056, in which some of pinnules are fertile bearing a single row of indistinct sori on each side of midnerve. Fig. 2a shows general outline of sterile pinnules. Pl. 3, fig. 1 (PP7069) shows sterile pinna fragments below and fertile ones above bearing one large circular sori, 1.3 mm in diameter on each basal side of midnerve as shown in Pl. 3, fig. 2 enlarged partly from PP7069. Pl. 3, fig. 3 (PP7062) shows a pinna fragment with elongated fertile pinnules bearing a single row of faintly preserved sori, 0.9 mm in diameter, 3–4 in number on each side of midnerve as shown in Fig. 2b.

Remarks: No specimen in the present collection shows the branching of the frond or the arrested bud, characteristics of the Gleicheniaceae. Moreover, despite much effort, the details of the sori and sporangia have not been made clear.

The Cretaceous specimens described under the following names are somewhat like the present ones; *Gleichenites argentinica* BERRY described by HERBST (1962, p. 144, pl. 2, figs. 6–10), *G.* cfr. *argentinica* by ARCHANGELSKY (1965, p. 248, figs. 1–4),



Figs. 1–9 (unless otherwise referred to, all in natural size); 1. *Gleichenites sachalinensis* (KRYSHTOFOVICH): 1a. showing the outline of fertile pinnules (PP7052); 1b. showing sori, one or two on each side of midnerve (PP7055), ×2. 2. *Gleichenites zippei* (CORDA) SEWARD: 2a. showing general outline of sterile penultimate pinna and pinnules (PP7056); 2b. showing fertile pinnules with row of sori on each side of midnerve (PP7062), ×2. 3. *Cladophlebis acutipennis* OISHI, showing the outline of pinnules and venation (PP7171). 4. *Cladophlebis elegantissima* OISHI; 4a. showing an apical part of penultimate pinna, bearing sterile pinnules with entire margins (PP7078), ×2; 4b. fertile pinnules? with shallowly lobed margins (PP7073), ×2. 5. *Cladophlebis geyleriana* (NATHORST) YABE; 5a. showing the outline of pinnules on apical part of penultimate pinna (PP7089); 5b. basal basiscopic pinnule with distinctly bilobed apex enlarged from PP7089, ×2. 6. *Cladophlebis* (*Teilhardia*?) *kanmerai* KIMURA, sp. nov.; 6a–b. showing the outline of pinnules (PP7092, PP7091); 6c. fertle pinnules with a sorus on each lobe (PP7090). 7. *Cladophlebis matsumotoi* KIMURA sp. nov., showing general outline of pinnules and venation (PP7093). 8. *Cladophlebis undulata* OISHI, showing the outline of pinnules (PP7114), ×2. 9. *Sphenopteris yokoyamai* YABE: 9a. showing varied forms of pinnules on a ultimate pinna (PP7116); 9b. lanceolate pinnules enlarged from PP7116, ×2.

Gleichenia longipennis HEER (1875, p. 46, pl. 6, figs. 4–6; pl. 8, figs. 1–3; 1882, p. 7, pl. 2, fig. 5), *G. micromera* HEER (1875, p. 55, pl. 10, figs. 14, 15; 1882, p. 9), *G. nordenskiolidi* HEER (1875, p. 50, pl. 9, figs. 6–12; 1882, p. 8, pl. 1, fig. 1), by FONTAINE (1889, p. 119, pl. 21, fig. 11; 1905 in WARD, p. 231, pl. 65, figs. 24–29), by BERRY (1922, p. 208, pl. 47, fig. 1), by BELL (1956, p. 62, pl. 15, fig. 2; pl. 16, fig. 3; pl. 18, figs. 1, 3, 7; pl. 19, fig. 7; pl. 20) and by BAIKOVSKAJA (1956, pp. 73, 74, 109, pl. 2, fig. 2).

The present specimens, however, differ from *Gleichenites argentinica* which has larger sori, from *Gleichenia longipennis* which has larger and longer penultimate and ultimate pinnae, from *G. micromera*, most pinnules of which are basally contracted, and from *G. nordenskioldi*, in which ultimate pinnae are mostly set remotely and their pinnules basally contracted.

Both *Gleichenia rotula* HEER (1875, p. 48, pl. 8, figs. 4, 5; pl. 9, figs. 1–4; 1882, p. 37, pl. 30, figs. 7–16) and *G. obtusata* HEER (1882, p. 37, pl. 30, figs. 7–16) are also allied form to the present species, but the present species differs from *G. rotula*, in which pinnules are oblong, and from *G. obtusata*, in which pinnules are broadly deltoid in form respectively. The occurrence of this species is the first record in Japan.

Occurrence: Common.

Specimens: PP7056–PP7070.

Unclassified ferns

Form-genus *Cladophlebis* BRONGNIART, 1849: 105

Cladophlebis acutipennis OISHI

(Fig. 3)

Thyrsopteris sp.: YOKOYAMA, 1894, p. 213, pl. 23, fig. 3 (Fujikawa, Tokushima Prefecture, an equivalent of the Upper Monobegawa Formation).

Pecopteris cfr. *virginiensis* FONTAINE: YOKOYAMA, 1894, p. 220, pl. 24, fig. 1 (Ditto).

Cladophlebis acutipennis OISHI: 1940, p. 249, pl. 9, figs. 4–6 (Ditto and Yuasa Formation, Wakayama Prefecture, an equivalent of the Ryoseki Formation).

Only one pinna fragment with four pinnules as shown in Fig. 3 referable to this species is found in the collection. The present pinnules are somewhat different from the type specimen (OISHI, 1940, pl. 9, fig. 6) in having a larger basal acroscopic lobe than the others.

Occurrence: One specimen only.

Specimen: PP7071.

Cladophlebis elegantissima OISHI

(Pl. 2, fig. 3; Pl. 4, fig. 2; Fig. 4 a, b)

Cladophlebis elegantissima OISHI: 1940, p. 260, pl. 11, figs. 1, 1a, 1b (Hiromura, Yuasa Formation).

Description: Frond probably small, three or more times pinnate. Ultimate pinnae opposite, rather remotely set at a wide angle or nearly perpendicular to the very slender penultimate pinna axis, narrowing gradually towards the acuminate apex, typically 2.5 cm long and 0.5 cm wide. Pinnules katadromic in order, small, long and narrow, or elongate-triangular in form, 4.5–5 mm long and 1 mm wide, set closely or less remote, slightly decurrent basiscopically, directed forwards, 35–45 degrees to the pinna axis, apex acuminate, larger pinnules often falcate; margins finely dentate, lobed or entire. Nerves indistinct; midnerve persisting to the tip, giving off 4–5 pairs of simple secondaries. (Fructification not known.)

Many specimens were examined. Pl. 2, fig. 3 (PP7078) shows probably apical portion of a penultimate pinna, in which pinnules are rather shorter and with entire margins. Fig. 4a shows an outline of pinnules enlarged from PP7078. Pl. 4, fig. 2 (PP7072) shows probably a basal portion of a penultimate pinna, in which pinnules are long and narrow with finely dentate or shallowly lobed margins. Fig. 4b shows an outline of pinnules enlarged from PP7073.

The pinnules with dentate or lobed margins may be fertile because each lobe has a depression which possibly makes a sporangium or sorus.

Remarks: The present specimens closely resemble the original specmiens from the Yuasa Formation, Wakayama Prefecture. Unfortunately I could not make the characters of the possible reproductive organ clear, in spite of my various trials including the balsam transfer.

Occurrence: Common.

Specimens: PP7072–PP7083.

Cladophlebis ex gr. *exiliformis* (Geyler) Oishi

(Pl. 4, fig. 3)

Similar specimens:

Pecopteris exilis Yokoyama: 1889, p. 35, pl. 1, figs. 8–10 (Kuwashima, Oguchi Formation).

Pecopteris browniana (Dunker): Yokoyama, 1894 (pars), p. 218, pl. 24, figs. 2, 3 (Fujikawa).

Cladophlebis browniana (Dunker): Yabe, 1913, p. 4, pl. 1, figs. 6–9, 10? (Omoto, Iwate Prefecture, an equivalent of the Ryoseki Formation); 1922 (pars), p. 5, pl. 1, figs. 9, 10 (Kuwashima and Kaisekiyama, Ryoseki Formation); Oishi, 1931, p. 3, pl. 1, figs. 2–4 (Takata, Yuasa Formation).

Cladophlebis exiliformis (Geyler) Oishi: 1940 (pars), p. 216, pl. 13, fig. 1; pl. 14, figs. 2, 3 (Kuwashima); Kimura, 1958b, p. 21, pl. 1, fig. 5; pl. 4, figs. 3, 4 (Wakogo, Upper Jurassic Kuzuryu Group).

Description: Sterile frond large, tripinnate or more, with thick rachis. Penultimate pinnae alternate, crowded. Ultimate pinnae set closely, alternate or subopposite, narrowly linear, tapering gradually towards acuminate apex, attached to the penultimate pinna axis at a wide angle. Pinnules set closely, linear to oblong, straight or slightly falcate, obtusely pointed at apex, attached to the pinna axis by their whole bases at a wide angle, variable in form according to the position on the frond; margins entire or shallowly lobed; midnerve distinct, persisting to the tip, sending off indistinct and once forking secondaries (Fructification not known).

Pl. 4, fig. 3 (PP7084) shows one of the fragments of penultimate pinnae found in the collection.

Remarks: Sterile fern fronds like these are very common in the Japanese Upper Jurassic to Lower Cretaceous plant beds. In the present specimens referred by me to this comprehensive species, basal basiscopic pinnules are not specialized but usual in form. The present specimens may be confused in gross form with sterile leaves of *Gleichenites sachalinensis* or *G. zippei* here described together. But the present specimens are distinguished in the form of pinnules from the *Gleichenites* species by careful examination.

OISHI (1940) included *Cladophlebis geyleriana* (NATHORST) into this comprehensive species. But now I believe that *C. geyleriana* is distinct, because its basal basiscopic pinnules are broadly deltoid or distinctly bilobed apically.

In 1967 KRASSILOV combined *Gleichenites nipponensis* and *Cladophlebis exiliformis* illustrated by OISHI (1940) and include them in his Cyatheaceous *Alsophilites nipponensis* (OISHI) KRASSILOV mainly on the basis that fertile pinnae in OISHI's illustration (pl. 13, fig. 2; pl. 15, fig. 2) and his explanation, which seemed to be so close to *Gleichenites nipponensis* in general appearance, were in close association in occurrence with the sterile ones of *Cladophlebis exiliformis*.

However, I believe that this association is accidental and, so far as the Japanese specimens are concerned, both are distinct from each other.

Occurrence: Common.

Specimens: PP7084–PP7086 and many small fragments.

Cladophlebis geyleriana (NATHORST) YABE

(Pl. 5, fig. 2; Pl. 6, fig. 4; Fig. 5 a, b)

Pecopteris geyleriana NATHORST: 1890 (pars), p. 48, pl. 4, fig. 1; pl. 6, fig. 1 (Kataji, Ryoseki Formation); YOKOYAMA, 1894, p. 219, pl. 21, fig. 12(?); pl. 23, figs. 1, 1a(?); pl. 28, fig. 5 (Yuasa Formation, Fujikawa and Kaisekiyama).

Cladophlebis geyleriana (NATHORST): YABE, 1922 (name).

Cladophlebis exiliformis (GEYLER) OISHI: 1940 (pars), p. 261, pl. 12, fig. 1; pl. 14, fig. 1 (Oguchi and Yuasa Formations).

Description: Frond unknown in size, probably tripinnate. Ultimate pinnae set closely, subopposite or alternate, narrowly linear, tapering gradually towards acuminate apex and attached at an angle of about 50 degrees to the penultimate pinna axis, more than 4.5 cm long and about 1 cm wide at base. Pinnules set closely, linear to oblong, straight or slightly falcate, obtusely pointed at apex, attached to the pinna axis by their whole bases at a wide angle. Basal basiscopic pinnules broadly deltoid in form and often distinctly bilobed at apex; margins entire or shallowly lobed; midnerve well-defined but secondaries indistinct. Basal margin of pinnules often asymmetrically lobed possibly because of the presence of a sorus.

Several sterile penultimate pinna fragments were found in the collection. Pl. 5, fig. 2 (PP7089) and Fig. 5a show an apical part of a penultimate pinna which agrees closely with the original specimens of this species (NATHORST, 1890) from the Ryoseki Formation. Pl. 6, fig. 4 and Fig. 5b show a bilobed basal basiscopic pinnule enlarged from PP7089.

Remarks: Tripinnate sterile fern fronds with thick rachises like these are often encountered in the Upper Jurassic to Lower Cretaceous plant beds in the Japanese Islands and their adjacent areas. They had been called *Pecopteris exiliformis* (GEYLER, 1877), *P. exilis* (YOKOYAMA, 1889), *P.* (or *Cladophlebis*) *geyleriana, P.* (or *Cladophlebis*) *browniana* and *Cladophlebis dunkeri*. They were included as synonyms by OISHI (1940) into his comprehensive species, *C. exiliformis*.

As mentioned above, I conclude that *Cladophlebis geyleriana* is distinct, because its basal basiscopic pinnules are broadly deltoid in form and distinctly bilobed at apex without exception.

Occurrence: Not rare.

Specimens: PP7087–PP7089.

Cladophlebis (*Teihardia*?) *kanmerai* KIMURA, sp. nov.

(Pl. 1, figs. 1–5; Figs. 6a–c)

Diagnosis: Frond probably tripinnate, large in size, whole shape unknown. Penultimate pinnae, more than 9 cm long and 10 cm wide with stout rachis, 5 mm thick below and slender and flexible, 1.5 mm thick above. Ultimate pinnae set closely, touching or overlapping each other laterally, more than 6 cm long and 1.2–2.0 cm wide, nearly parallel-sided, apex unknown, attached to the penultimate pinna axis perpendicularly below and about 60 degrees above. Sterile pinnules set closely, attached to the pinna axis at a wide angle by their whole bases. Sterile pinnules on the distal part of frond or penultimate pinnae elongate-deltoid in shape with shallowly lobed or crenulated margins, ending acutely or obtusely pointed apex, 0.8 cm long and 0.35 cm wide at base of pinnules. Sterile pinnules on the basal part of frond or penultimate pinnae long and narrow, 1.2 cm long and 3 mm wide, often falcate, deeply divided into rectangular fine lobes with rounded or obtusely pointed apex.

Fertile pinnules similar in form to the sterile ones on the basal portion of frond or penultimate pinnae. Sorus-like depressions at the centre of each lobe. Lamina of each lobe slightly reduced.

Midnerve distinct, persisting to the tip, secondaries indistinct, obliquely arising at an angle of 60 degrees, remote, mostly simple, basal ones often branching once; each lobe receiving one secondary nerve.

Description: Two sterile penultimate pinnae and one small pinna with six fertile pinnules are found in the collection. Pl. 1, fig. 1 (PP7091, holotype) shows an apical part of a penultimate pinna with shallowly lobed or crenulated margins. Pl. 1, fig. 2 (PP7092) shows the basal part of a penultimate pinna with a thick rachis, sending perpendicularly off ultimate pinna with long and narrow and deeply and finely lobed pinnules. Pl. 1, fig. 3 and fig. 4 and Fig. 6a–b are partly enlarged from PP7092 and PP7091, respectively, to show the forms of varied pinnules. Pl. 1, fig. 5 (PP7090, paratype) and Fig. 6c show a pinna fragment with fertile pinnules.

Remarks: Though the soral and sporangial characters in the present fertile pinnules are not clear, the present fertile pinnules resemble closely in general form the fertile ones of *Teilhardia tenella* (PRYNADA) illustrated by KRASSILOV (1967, p. 126, pl. 22, figs. 3–7) from the Lower Cretaceous of Southern Primorye. This is the only reason why I referred the present specimens with some doubt to *Cladophlebis* (*Teilhardia*?).

Teilhardia was originally instituted by SEWARD (1913, p. 96) for the Wealden material without definite soral and sporangial characters. The present sterile pinnules differ from those of both *Teilhardia valdensis* from the English Wealden (SEWARD, pl. 11, figs. 7a–9b) and of *T. tenella* (KRASSILOV, pl. 22, figs. 1, 2, 9–11), and for this reason I institute the new species. It is named after Prof. K. KANMERA of Kyushu University.
Occurrence: Rare.
Specimens: PP7090 (paratype), PP7091 (holotype), PP7092.

Cladophlebis matsumotoi KIMURA sp. nov.

(Pl. 2, fig. 2; Pl. 5, fig. 3; Fig. 7)

Diagnosis: Frond probably bipinnate, unknown size, with a thin and delicate rachis, 1 mm thick, alternately sending off flexible pinnae at an angle of about 40 degrees. Pinnae set closely, 2 cm distant, overlapping each other laterally, directed strongly forwards, linear, elongate-triangular in form, acuminate at apex, 7.5 cm long and 1.5 cm wide at the widest portion. Pinnules katadromic in order, linear, long and narrow, elongate-triangular in form, strongly directed forwards, attached to the pinna axis by their whole bases at an angle of about 30 degrees, slightly falcate, ending acuminate at apex, set closely, continuous with next pinnules at base; distal half of margins or most of margins dentate, slightly decurrent basiscopically; the largest pinnule, 1.1 cm long and 0.3 cm wide at base. Nerves distinct, midnerve persisting to the tip, secondaries directed forwards, mostly once dichotomously forking, 10–12 on each side of the midnerve. (Fructification not known.)
Description: Many fragments of fronds were examined. Pl. 2, fig. 2 (PP7093, holotype) and Fig. 7 show the largest one, probably representing an apical portion of frond, on which above diagnosis mainly based. Pl. 5, fig. 3 (PP7109, paratype) shows the detail of outline and nervation of pinnules.
Comparison and *remarks*: As pointed out by OISHI (1940), this type of frond belonging to the large group of fronds called *Cladophlebis denticulata* BRONGNIART. But it is certain that the present form differs at least from the type specimen of *C. denticulata* (BRONGNIART, 1828, pl. 98, figs. 1, 2) and from such specimens as described under the name of *C. denticulata* from the Japanese Islands by NATHORST (1890), YOKOYAMA (1894), YABE (1905, 1922), OISHI (1931, 1932, 1940), OISHI and TAKAhashi (1936), KIMURA (1959a), etc.

Cladophlebis matsumotoi has linear, elongate-triangular pinnules which are strongly directed forwards instead of being broader and shorter as in *C. denticulata*. *Cladophlebis matsumotoi* resembles *C. toyoraensis* OISHI from the Upper Jurassic Kiyosue Formation, Yamaguchi Prefecture (OISHI, 1940, p. 291, pl. 23, figs. 4, 5, 5a), in the form, size and venation of its pinnules, but *C. toyoraensis* differs in having a thick rachis and its pinnules are attached at a wide angle and the pinnae themselves are linear-lanceolate rather than linear-triangular.

The new species is named in honour of Professor T. MATSUMOTO of Kyushu University.

Occurrence: Abundant.
Specimens: PP7093 (holotype), PP7094–PP7108, PP7109 (paratype), PP7110–PP7113.

Cladophlebis undulata OISHI

(Fig. 8)

Cladophlebis undulata OISHI: 1940, p. 294, pl. 21, figs. 1–3; pl. 22, figs. 3, 4 (Nishinotani, Ryoseki Formation).

Description: Frond unknown in size and form. Ultimate pinnae set closely, attached at a wide angle to the rachis. Pinnules alternate, obovate, narrowing toward obtusely rounded apex, attached at a wide angle to the rachis, upper surface strongly convex, 4 mm long and 1.5 mm wide at middle. Margins undulating, acroscopic basal edge prominent and lightly contracting and decurrent basiscopically. Midnerve distinct (but secondaries not visible). Fertile pinnules similar in form to the sterile ones with 1–4 round sorus-like depressions on each side of midnerve. Fig. 8 (PP7114) shows outline of pinnules.

Remarks: The present specimens, though incomplete pinna fragments, are referable to this species in outline of pinnules. Unfortunately the internal structure of sorus-like depressions could not be made clear as well as the original specimens described by OISHI.

Occurrence: Rare.
Specimens: PP7114, PP7115.

Form-genus *Sphenopteris* STERNBERG, 1825: 15

Sphenopteris goepperti DUNKER

(Pl. 4, fig. 5, right corner)

Sphenopteris goepperti DUNKER: 1846, p. 4, pl. 1, fig. 6; pl. 9, figs. 1–3. For further references, see OISHI, 1940, p. 238.

Remarks: Such small pinna fragments as shown in the right corner of Pl. 4, fig. 5 (PP7136) referable to this comprehensive species are fairly common in the collection.

Occurrence: Common.
Specimens: PP7136 and many other tiny fragments.

Sphenopteris yokoyamai YABE

(Pl. 6, figs. 1–3; Fig. 9a, b)

Sphenopteris yokoyamai YABE: 1927a, p. 44 (name); 1927b, p. 233, pl. 23, figs. 1–2 (Huruke, Tokushima Prefecture, an equivalent of the Upper Monobegawa Formation).

Description: Frond probably tripinnate. Ultimate pinnae set closely, overlapping each other laterally, opposite, long and narrow, nearly parallel-sided throughout the length, the largest one measuring more than 6 cm and 8 mm wide, attached to the penultimate rachis at an angle of about 45 degrees, then bending outwards. Pinnules set closely, opposite or subopposite, variable in form, the rhomboidal ones (Pl. 6, fig. 2; Fig. 9a) in the proximal part of ultimate pinnae to the lanceolate ones

(Pl. 6, fig. 3; Fig. 9b) in the apical part, obtusely pointed at apex, attenuated below and strongly decurrent at the base; margins entire or wavy. Rhomboidal pinnules 0.7 cm long and 2 mm wide, lanceolate pinnules 0.8–0.9 cm long and 1.5 mm wide, directed forwards. (Venation obscure.).

An incomplete sterile penultimate pinna was found in the collection. Pl. 6, fig. 1 is the counterpart of PP7116.

Remarks: The above description agrees well with the diagnosis of this species originally given by YABE except that the present pinnules are longer than those of the type material. YABE compared this species with *Sphenopteris virginica* FONTAINE from the Potomac Formation of Virginia and with *'Dicksonia' gracilis* HEER from Amurland, which was identified as *Coniopteris saportana* by VAKHRAMEEV (1958, p. 79).

Sphenopteris kochibeana (YOKOYAMA) OISHI known from the Tetori Supergroup, Inner Zone of Japan and from the Lower Cretaceous of Mongolia (JÄNICHEN & KAHLERT, 1972) is similar except for its pinnules, but the present species is distinguishable from *S. kochibeana* in having rhomboidal to lanceolate pinnules. As pointed out by OISHI (1940, p. 247), a fragment of this species is hardly distinguishable from *Onychiopsis elongata* (GEYLER), but in the typical one the distinction is not very difficult to recognize.

Occurrence: Rare.

Specimens: PP7116A, B.

Form-genus *Onychiopsis* YOKOYAMA, 1889: 27

Onychiopsis elongata (GEYLER) YOKOYAMA

(Pl. 5, fig. 1)

Onychiopsis elongata (GEYLER) YOKOYAMA: 1889, p. 27, pl. 2, figs. 1–3, 4a–c; pl. 3, fig. 6d; pl. 12, figs. 9–10. For further references, see KIMURA, 1975a, p. 77.

Remarks: Many small pinna fragments as shown in Pl. 5, fig. 1 were found in the collection. It is difficult to distinguish this species from the elongate pinnules of *Sphenopteris yokoyamai*.

Occurrence: Common.

Specimens: PP7117–PP7123 and many other small fragments.

Caytoniales

Genus *Sagenopteris* PRESL, 1838: 164

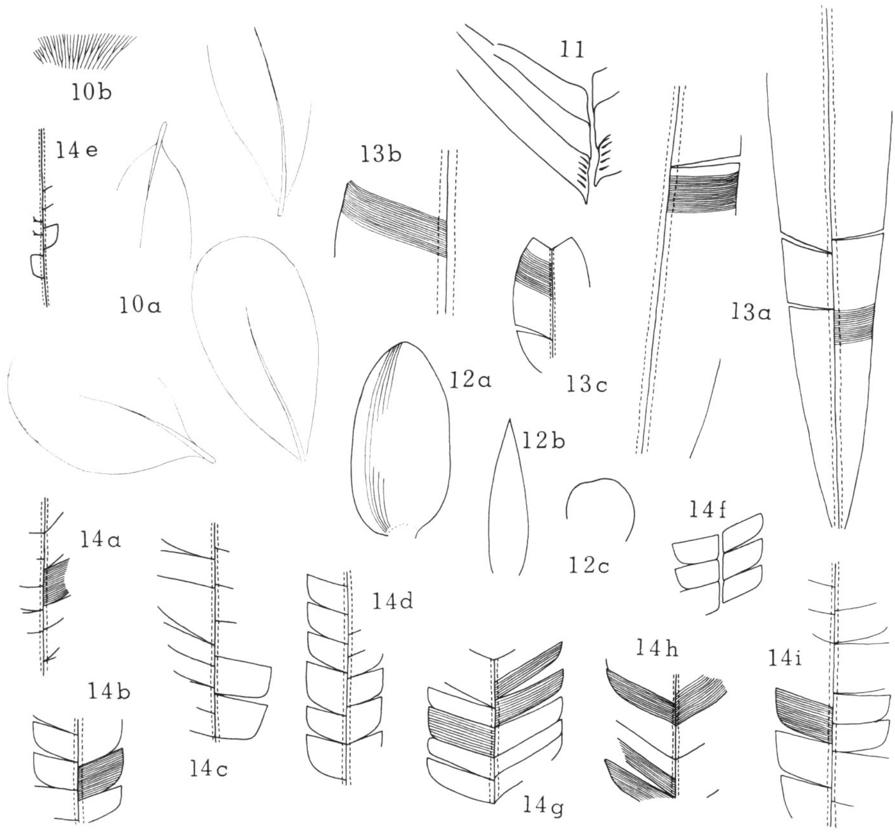
Sagenopteris inequilateralis OISHI

(Pl. 2, fig. 4; Pl. 4, fig. 4; Fig. 10a, b)

Sagenopteris? *inequilateralis* OISHI: 1940, p. 363, pl. 47, figs. 3–5 (Tanzaki, Yuasa Formation).

Description: Isolated *Sagenopteris* leaflets shortly stalked. Lamina fairly varied in form and size, ovate or circular in outline, inequilateral, typically 2 cm long and 1.1 cm wide in their widest portion; margins entire, apex rounded; midnerve distinct except in apical third, lateral nerves indistinct but divergent and dichotomously forking, forming meshes.

Several isolated leaflets are shown in Pl. 4, fig. 4 (PP7128). They are very close to those originally described by OISHI as *Sagenopteris*? *inequilateralis*. Pl. 4, fig. 4 shows five isolated leaflets, and the largest (Pl. 2, fig. 4, PP7127) has a lamina, 3 cm long and 1.5 cm wide. In the specimen shown in Pl. 4, fig. 4, lateral nerves are entirely obscure as they are in the type specimen, probably owing to the coarseness of the matrix. But on three slabs of fine-grained shale, there are several incomplete fragments, in which *Sagenopteris*-type lateral nerves are partly visible as shown in Fig. 10b that possibly represents the apical part of the lamina. Accordingly the present



Figs. 10–14 (unless otherwise referred to, all in natural size); 10. *Sagenopteris inequilateralis* OISHI; 10a. showing leaflet-form (PP7128), ×3/2; 10b. venation on apical part of a leaflet (PP7125). 11. *Ptilophyllum* sp., showing the outline of pinnae, in which nerves are preserved only on their basal parts (PP7129). 12. *Cycadolepis*? sp., showing varied forms of scale leaves (PP7145). 13. *Nilssonia* ex gr. *orientalis* HEER: 13a. elongate-lanceolate leaves (PP7128); 13b–c. showing varied forms (PP7147, PP7150). 14a–i. *Nilssonia* ex gr. *schaumburgensis* (DUNKER) NATHORST, showing varied leaf-forms; a–e, i (PP7151), f (PP7153), g–h (PP7154).

specimens are placed in *Sagenopteris* with confidence. Fig. 10a shows typical leaflets of this species.
Remarks: As was stated by OISHI, this species is characterized by the leaflets which are divided by the midnerve into two unequal halves.
Occurrence: Rare.
Specimens: PP7124–PP7128.

Bennettitales

Genus *Ptilophyllum* MORRIS, 1840: 327

Ptilophyllum sp.

(Fig. 11)

Description: An incomplete *Ptilophyllum* leaf. Pinnae set closely, long and narrow, nearly parallel-sided, 2～4 mm wide at middle portion, length more than 2.5 cm, attached at an angle of 50 degrees by whole breadth of lamina and covering almost completely upper surface of rather thick rachis, upper basal angle rounded and not expanded, lower basal angle distinctly decurrent with narrow decurrent part, often partially concealed by lamina of next pinna below. Nerves indistinct, but coarse.
Remarks: Only one specimen is found in the collection. The present specimen reminds us of *Ptilophyllum pecten* used by OISHI (1940) in more or less comprehensive sense, but according to the emended diagnosis given by HARRIS (1969, p. 64) to *P. pecten*, the type material of Yorkshire, the present specimen is quite different in size of pinnae from *P. pecten*. Thus, the Japanese specimens determined as *P. pecten* should be re-examined.
Occurrence: One specimen only.
Specimen: PP7129.

Genus *Zamites* BRONGNIART, 1828

In 1890, NATHORST instituted *Zamiophyllum* for some large fronds derived from Togodani, a famous fossil-plant locality, Kochi Prefecture, which was thought to be specifically identical with ETTINGSHAUSEN's *Pterophyllum buchianum* from the Lower Cretaceous of Germany. He founded the new genus mainly because the pinnae narrow gradually towards the base somewhat thickened.

Regarding the definition of *Zamites*, SEWARD had traced the history to the origin in detail and included *Zamiophyllum* in his *Zamites* (1917, p. 531).

In 1922, YABE, following Nathorst's generic name, described some specimens from four localities in Japan. Under his detailed observation of many Japanese specimens derived from various localities, OISHI found that the pinnae attached not to the lateral sides as mentioned by NATHORST but to the upper surface of the rachis and emended the diagnosis as follows: "Frond large, pinnate with thick rachis. Pinnae long and narrow, tapering gradually towards the base, and attached to the upper surface of the rachis by more or less concave semi-amplexicaul base with callosity except the upper part of a frond, the plane of the pinnae making an angle with the flank of the rachis, nerves parallel."

Then the generic name *Zamiophyllum* have been referred by DABER (1960) and KRASSILOV (1967). I, however, here adopt *Zamites* for the present material, following SEWARD, instead of *Zamiophyllum*, because there is no particular generic distinction between *Zamites* and *Zamiophyllum* defined by NATHORST and by OISHI.

Zamites buchinus (ETTINGSHAUSEN) SEWARD

(Pl. 4, fig. 5; Pl. 5, fig. 5; Pl. 6, fig. 7)

Similar specimens:

Pterophyllum buchianum ETTINGSHAUSEN: 1852, p. 21, pl. 1, fig. 1 (Lower Cretaceous of Germany).

Zamiophyllum buchianum (ETTINGSHAUSEN) NATHORST: 1890, p. 6, pl. 2, figs. 1, 2; pl. 3; pl. 5, fig. 2; p. 9 (Ryoseki Formation); YOKOYAMA, 1894, p. 223, pl. 20, fig. 1; pl. 22, figs. 1, 2; pl. 23, fig. 6; pl. 28, figs. 1, 2 (not pl. 27, figs. 5a, b) (Ryoseki, Lower and Upper Monobegawa Formations and their equivalents); YABE, 1922, p. 19, pl. 3, figs. 1, 2 (not figs. 3, 4) (Ryoseki Formation and the equivalent of the Upper Monobegawa Formation); OISHI, 1939, p. 213, pls. 12–13 (Ryoseki Formation and its equivalent, and Kiyosué and Utano Formations, Yamaguchi Prefecture); 1940, p. 353; KRASSILOV, 1967, p. 143, pl. 36, figs. 1–3; pl. 38, fig. 5; pl. 39, figs. 4–5 (Lower Cretaceous of Southern Primorye).

Zamiophyllum naumanni NATHORST: 1890, p. 7, pl. 5, fig. 1 (Ryoseki Formation); YOKOYAMA, 1894, p. 225, pl. 22, fig. 3; pl. 26 (Ditto).

Zamiophyllum buchianum (ETTINGSHAUSEN) NATHORST var. *angustifolia* FONTAINE: YOKOYAMA, 1894, p. 224, pl. 25, fig. 5; pl. 28, figs. 8, 9 (not pl. 22, fig. 4) (Ditto).

Zamiophyllum buchianum (ETTINGSHAUSEN) NATHORST var. *pilosulus* SCHUSTER: DABER, 1960, p. 596, pl. 3; pl. 4, figs. 1–4 (Lower Cretaceous of Germany).

Description: Pl. 4, fig. 5 (PP7136) shows what appears to be the apical portion of a leaf, pinnae of which are somewhat remotely inserted alternately to the upper surface of the rachis but not completely covering it, with 35 degrees by more or less concave semi-amplexicaul base, though they appear to be of lateral insertion at first sight. The basal callosity is inconspicuous. The rachis is 4 mm thick, tapering gradually towards the apex, with a conspicuous median gutter on its upper surface. The nerves are faintly preserved, divergent at the base, simple or dichotomously branched, for the most part parallel to the edges of the lamina.

Specimen PP7137 (Pl. 5, fig. 5) shows the middle part of a leaf. The veins, not visible in the photograph, are at 25 per cm at the broken ends of the pinnae. In this slab the rachis overlies the bases of most of the pinnae, and the plane of the leaf surface exposed so far is by no means flat, as noted by OISHI (1939, p. 214). Pl. 6, fig. 7 (PP7138) shows part of a large leaf. No complete pinna exists in the collection but some broken specimens (*e.g.* PP7133) show an acuminate apex.

Remarks: The present specimens agree with the material of OISHI (1939) described as *Zamiophyllum buchianum*. The rachis in Pl. 4, fig. 5 is not smooth as mentioned by him but has a deep adaxial furrow, possibly caused by collapse. The abaxial surface in Pl. 5, fig. 5 and Pl. 6, fig. 7 has several small ridges (possibly caused by vascular strands).

The specimen shown in Pl. 4, fig. 5 having remotely set pinnae, might not be of posterior portion of a leaf but of apical portion on account of its slender rachis, though OISHI stated that those of the lower portion were set remotely and at wide angle, while those of the upper portion closely and at acute angle.

DABER's *Zamiophyllum buchianum* var. *pilosulus* is a large leaf, more than 26 cm long and 36 cm wide. Its pinnae are entirely preserved, about 28 cm long, narrowing gradually towards the acuminated apex instead of narrowing towards the base in most of the Japanese specimens.

In 1967, KRASSILOV described *Zamiophyllum buchianum* together with *Z. ivanovii* from the Lower Cretaceous of Southern Primorye. His specimens illustrated in pl. 36, fig. 3 and pl. 39, fig. 4 are closely referable to the present ones, but the others in his pl. 36, fig. 1 and pl. 38, fig. 5 are somewhat different from the rest in having the pinnae attached perpendicularly to the rachis, remotely set, and being narrower towards their bases. But his anatomical study showed their cuticular character common in the above-mentioned four specimens.

Dioonites buchianus described by FONTAINE is now reserved for comparison because its mode of insertion of pinnae are not always so close to that of *Zamites*.

This species is a common species in the Upper Jurassic to Cretaceous floras in the Outer Zone of Japan and also in the Middle Jurassic Utano Formation, Yamaguchi Prefecture, but has not been recorded from the Tetori Supergroup, Inner Zone of Japan.

Occurrence: Abundant.

Specimens: PP7130–PP7143.

Genus *Cycadolepis* SAPORTA, 1874: 201

Cycadolepis? sp.

(Pl. 5, fig. 4; Pl. 6, fig. 6; Fig. 12a–c)

Description: Scale leaves varying in size and form, lanceolate to circular, one surface strongly convex, the other concave; margins entire; surface longitudinally striated.

Pl. 6, fig. 6 (PP7144) shows the largest one; oval in form, 2.7 cm long and 1.5 cm wide at the widest portion, rounded at both ends, the scars of attachment are hidden in the matrix, perhaps situated slightly above the base of concave side. The strongly convex surface is ornamented with weak, simple and parallel striations (vein?) at 10–13 per cm.

Pl. 5, fig. 4 (PP7145) shows scale leaves of varied form. Fig. 4a is similar but longer. The concave surface of two scale leaves are seen in fig. 4c. Fig. 4b shows a circular scale leaf, 7 mm across, with a rounded apex. There are five such circular scale leaves on this slab; the smallest one is 4 mm across. All are striated. Fig. 12a–c show the varied forms of scale leaves.

Remarks: Since HARRIS distinguished *Deltolepis*, palaeontological value of scale leaves has been increased. Unfortunately the present specimens are only of impression and none of the organic material is preserved, so that it is impossible to decide whether they attribute to Bennettitalean *Cycadolepis* emended by HARRIS (1953, p. 34) or to Cycadean *Deltolepis* (HARRIS, 1942, p. 573). So I call the present specimens *Cycadolepis*? sp. On the present scale leaves, I could not recognize such wrinkles as said to be a striking feature of many kind of *Cycadolepis* (HARRIS, 1969, p. 102). But, of course, the presence of such wrinkles does not produce a positive proof of the attribution to *Cycadolepis* only by itself.

Judging from their crowded occurrence as shown in Pl. 5, fig. 4, each scale leaf may belong to the same plant organ and the difference in form among them is considered to be due to their natural position; that is, it is presumable that such scale leaves might have formed a series, as was the case in those female *Williamsonia* flowers (HARRIS, 1969, p. 103).

The general outline of *Cycadolepis sixtelae* described by VAKHRAMEEV (in VAKHRAMEEV & DOLUDENKO, 1961, p. 100, pl. 42, fig. 4; pl. 46, figs. 1–4; text-fig. 29) from the Jurasso-Cretaceous of Bureja Basin, is close to that of the largest of the present ones.
Occurrence: Rare.
Specimens: PP7144, PP7145.

Cycadales

Genus *Nilssonia* BRONGNIART, 1825: 200

Nilssonia ex gr. *orientalis* HEER

(Pl. 2, fig. 5; Pl. 6, fig. 5; Fig. 13a–c)

Comparable Japanese specimens:
Nilssonia ozoana YOKOYAMA: 1889, p. 41, pl. 10, figs. 2b, 11–14 (Ozo, Oguchi Formation).
Nilssonia orientalis HEER: OISHI, 1940, p. 307, pl. 26, figs. 2, 3 (Oshima, Miyagi Prefecture, Moné Formation).
Nilssonia cfr. *orientalis* HEER: KIMURA, 1958a, p. 136, pl. 9, figs. 1–4, 7 (Kizaki, Nagano Prefecture, Kuzuryu Group).
Nilssonia tanakai KIMURA: 1959b, p. 110, pl. 1, figs. 5–7 (Ditto).

Description: Frond mostly long and narrow, rarely oblong, elongate-oval or lanceolate in outline, cuneate at base and emarginate at apex, about 8 cm long and typically 1.3–2.5 cm wide at the widest portion. Lamina apparently covering the upper surface of rachis, entire or divided irregular segments. Nerves indistinct, fine, simple, almost perpendicular to the rachis, 20 per cm.

Several fragments of leaves were found in the collection. Pl. 6, fig. 5 (PP7128) shows two lanceolate leaves with cuneate bases, though the basal part of petiole is missing. The lamina irregularly divided into rectangular segments as shown in Fig. 13a. Fig. 13b–c shows two varied forms. Pl. 2, fig. 5 (PP7127) shows an entire lamina.

Remarks: The present specimens resemble those originally described by FONTAINE from the Lower Cretaceous of Oregon under the name of *Nilssonia orientalis* var. *minor* in general form.

Nilssonia orientalis was originally defined by HEER (1878, p. 18, pl. 4, figs. 5–9) as follows (freely translated from German); Leaf entire or rarely segmented, truncated

at apex, rounded at base; veins fine, dense, slightly curved and directed forwards. Specimens agreeing with this diagnosis are known from the Upper Triassic to the Lower Cretaceous of Northern Hemisphere. Studies of cuticle prove that many different species are covered by this definition; see for example HARRIS, 1932 (for the Rhaeto-Liassic of East Greenland). In the Japanese Islands the undivided *Nilssonia* leaves of the older floras (Triassic and early Liassic) are mostly broader than those of the early Cretaceous.
Occurrence: Common.
Specimens: PP7127, PP7128, PP7146–PP7151.

Nilssonia ex gr. *schaumburgensis* (DUNKER) NATHORST

(Pl. 3, fig. 5; Fig. 14a–i)

Similar specimens:
Nilssonia cfr. *schaumburgensis* (DUNKER) NATHORST: 1890, p. 5, pl. 1, figs. 6–9a (Ryoseki, Lower and Upper Monobegawa Formations).
Nilssonia schaumburgensis (DUNKER) NATHORST: YOKOYAMA, 1894, p. 227, pl. 20, figs. 12, 14; pl. 21, fig. 14; pl. 22, figs. 5–7 (Ryoseki, and the equivalent in the Upper Monobegawa Formation); FONTAINE in WARD, 1905, p. 303, pl. 72, figs. 17–21 (Lower Cretaceous of the United States); OISHI, 1940, p. 311, pl. 27, figs. 5–11; pl. 28, fig. 2 (Ryoseki Formation and the Nagdong Group, Korea); SAMYLINA, 1964, p. 73, pl. 14, fig. 9 (Lower Cretaceous of Kolyma River Basin); WATSON, 1969, p. 242, text-figs. 48–52 (Lower Cretaceous of England); KRASSILOV, 1967, p. 170, pl. 57, figs. 3, 4, 6 (Lower Cretaceous of Southern Primorye).

Description: Detached leaves variable in form, typically elongate-oval in form, 5.5 cm long and 1 cm wide at the widest portion, nearly parallel-sided but narrowing gradually towards the base, shortly petioled. Lamina dissected into segments mostly up to the rachis, being unequal in width, rectangluar, both outer and upper margins nearly straight but lower distal edge rounded or often deltoid. Nerves fine, 3–4 per mm.

Pl. 3, fig. 5 (PP7155) shows an almost perfectly preserved leaf, though its apical part is missing. Figs. 14a–i show various leaf fragments in the collection.

Remarks: In 1940 OISHI stated "As the Japanese specimens referable to this species are considerably variable, particularly in the size of frond and in the number of nerves in unit length, it is the best way, the writer believes, provisionally to refer all the specimens as figured in this work to DUNKER's species, although there is a slight difference, as suggested by NATHORST, in the form of the segments which in the Japanese specimens are less rounded in their lower distal corner."

According to my observation, the following three types of leaves are distinguishable among the leaves regarded as *N. schaumburgensis*. The first (Fig. 15a, e, f, l) is, the form referable to *parvula*-type variety originally instituted by YABE (1913, p. 6, pl. 1, figs. 13–16) from an equivalent of the Ryoseki Formation, at Omoto, Iwate Prefecture, in which laminae are almost entire or shallowly lobed, nearly parallel-sided, and the margins of lamina often revolute. The specimens described by FONTAINE as *N. parvula* (HEER) (in WARD, 1905, p. 92, pl. 17, figs. 1–7) from the Lower Cretaceous of Oregon, by TATEIWA (1929, fig. 18) from the Nagdong Group and by KRASSILOV

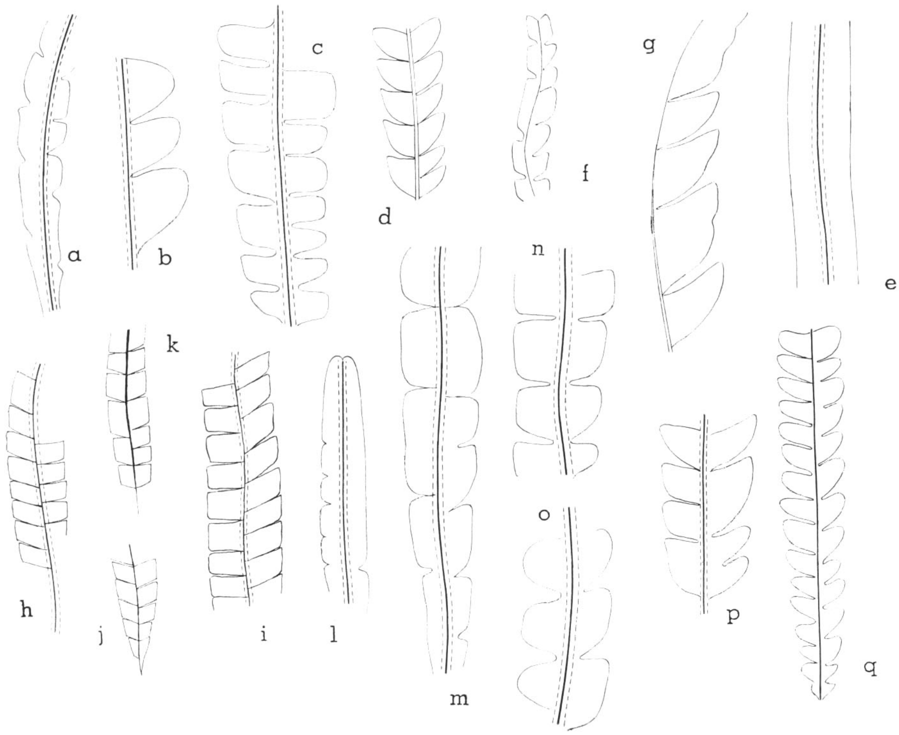


Fig. 15. Varied leaf-forms regarded as *Nilssonia schaumburgensis*; a–c, after OISHI, 1940 (a: pl. 28, fig. 2, Nagdong Group, Korea; b: pl. 27, fig. 8, Hiromura, Yuasa Formation; c: pl. 27, fig. 11, Kobodani, Ryoseki Formation), ×3/4. d–g, after FONTAINE in WARD, 1905 (d: pl. 72, fig. 18; e: pl. 72, fig. 21; f: pl. 72, fig. 20; g: pl. 72, fig. 19, Kootenai Formation), ×3/4. h–k, after NATHORST, 1890 (h: pl. 1, fig. 8; i: pl. 1, fig. 9; j: pl. 1, fig. 6; k: pl. 1, fig. 7, Ryoseki Formation), ×1. 1, after WATSON, 1969 (text-fig. 48, English Wealden). m–o, after KRASSILOV, 1967 (m: pl. 57, fig. 4; n: pl. 57, fig. 3; o: pl. 57, fig. 6, Taukhin Formation, Southern Primorye), ×3/4. p–q, after BELL, 1956 (p: pl. 49, fig. 5; q: pl. 48, fig. 1, Kootenai and Hazelton Formations, Western Canada), ×3/4.

(1967, p. 170, pl. 57, figs. 1, 2, 5, 7) from the Lower Cretaceous of Southern Primorye, belong to this-type form. *N. schaumburgensis* described by WATSON (1969, text-fig. 48) is rather close to var. *parvula*.

The second form (Fig. 15b–d, g. m–q) shows the laminae irregularly dissected into rectangular or deltoid segments up to the rachis, being unequal in width, and with rounded lower distal edge. Most of specimens belong to this-type form, such as those described by YOKOYAMA from Kagahara, Gumma Prefecture (1894, pl. 20, figs. 4, 14) and from Yuasa, Wakayama Prefecture (pl. 21, figs. 6, 7, 14; pl. 22, fig. 5), by FONTAINE (in WARD, 1905, p. 303, pl. 72, figs. 17–19) from the Lower Cretaceous of Oregon, by OISHI from Tennohama, Wakayama Prefecture (1940, pl. 27, fig. 5) and from the Ryoseki Formation (figs. 8, 9, 11), by BELL from the Lower Cretaceous of Western Canada (1956, pl. 49, fig. 5; pl. 48, fig. 1; pl. 51, fig. 5), by SAMYLINA (1964, p. 73, pl. 14, fig. 9) from the Lower Cretaceous of Kolyma River Basin and by KRASSILOV (1967, p. 170, pl. 57, figs. 3, 4, 6) from the Lower Cretaceous of Southern Primorye, together with the present specimens.

The third form (Fig. 15h–k) somewhat differs from the above two types in having the laminae dissected into many quadrilateral segments with nearly straight lower margin. The specimens described by NATHORST (1890, pl. 1, figs. 6–9a) as *N.* cfr. *schaumburgensis*, belong to this form, together with those by OISHI from the same locality (1940, pl. 27, fig. 7) and Otani and Nishinotani, Kochi Prefecture (pl. 27, figs. 6, 10).

Among the specimens concerned here except the third form, it is useless to distinguish different forms giving any taxonomically valid names because they occur together and their morphology varies continuously. Then I here regard the present specimens as *Nilssonia* ex gr. *schaumburgensis.*

Occurrence: Common.

Specimens: PP7151–PP7156.

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Explanation of Plates

Plate 1

Figs. 1–5. *Cladophlebis (Teilhardia?) kanmerai* KIMURA sp. nov.; 1. A penultimate pinna with closely set pinnae bearing pinnules with shallowly lobed margins, probably showing an apical part of a frond (PP7091), ×1. 2. A penultimate pinna with closely set pinnae bearing deeply lobed pinnules (PP7092), probably showing basal portion of a frond, ×1. 3. A part of ultimate pinnae enlarged from PP7092, showing the outline of pinnules, ×2. 4. A part of ultimate pinna enlarged from PP7091, showing the outline of pinnules, ×2. 5. Fertile pinnules (PP7090), ×3.

Fig. 6. *Gleichenites zippei* (CORDA) SEWARD; a part of pinnae, showing the outline of pinnules and partly preserved sori on both sides of midnerve, ×3.

Fig. 7. *Lycopodites* sp.; foliage with spreading lateral and small appressed dorsiventral leaves (PP7051), ×8.

Plate 2

Fig. 1. *Gleichenites zippei* (CORDA) SEWARD; a part of tripinnate frond with three penultimate pinnae (PP7056), ×2.

Fig. 2. *Cladophlebis matsumotoi* KIMURA, sp. nov.; a part of bipinnate frond (PP7093), ×1.

Fig. 3. *Cladophlebis elegantissima* OISHI; a part of penultimate? pinna with remotely set ultimate pinnae (PP7078), ×2.

Fig. 4. *Sagenopteris inequilateralis* OISHI; the largest one (PP7127), ×2.

Fig. 5. *Nilssonia* ex gr. *orientalis* HEER; an entire margined leaf (PP7127), ×2.

Plate 3

Figs. 1–3. *Gleichenites zippei* (CORDA) SEWARD; 1. Fertile and sterile pinna fragments, upper half showing several fragments of remotely disposed pinnae with fertile pinnules (PP7069), ×1. 2. Fertile pinnae set remotely, with fertile pinnules enlarged from PP7069, ×3. 3. Pinna fragment with fertile pinnules (PP7062), ×3.

Fig. 4. *Gleichenites sachalinensis* (KRYSHTOFOVICH) n. comb.; a part of tripinnate frond with closely set penultimate pinnae with fertile pinnules (PP7052), ×1.

Fig. 5. *Nilssonia* ex gr. *schaumburgensis* (DUNKER) NATHORST; almost entire leaf without an apical portion (PP7155), ×2.

Figs. 6–7. *Lycopodites* sp.; 6. Foliage with spreading lateral and small-sized appressed dorsiventral leaves (PP7051), ×8. 7. Foliage with appressed dorsiventral and lateral leaves (PP7051), ×10.

Plate 4

Fig. 1. *Gleichenites sachalinensis* (KRYSHTOFOVICH) n. comb.; a part of penultimate pinna (PP7053), ×2.

Fig. 2. *Cladophlebis elegantissima* OISHI; elongate pinnules with shallowly lobed margins (PP7072), ×2.

Fig. 3. *Cladophlebis* ex gr. *exiliformis* (GEYLER) OISHI; (PP7084), ×3.

Fig. 4. *Sagenopteris inequilateralis* OISHI; (PP7128), ×2.

Fig. 5. *Zamites buchianus* (ETTINGSHAUSEN) SEWARD; an apical portion of a leaf, in association with *Sphenopteris goepperti* DUNKER on the right corner (PP7051), ×1.

Fig. 6. *Lycopodites* sp.; foliage with spreading lateral and small-sized appressed dorsivenral leaves (PP7051), ×8.

Plate 5

Fig. 1. *Onychiopsis elongata* (GEYLER) YOKOYAMA; a sterile fragment of frond (PP7119), ×1.

Fig. 2. *Cladophlebis geyleriana* (NATHORST) YABE; an apical part of penultimate pinna (PP7089), ×1.

Fig. 3. *Cladophlebis matsumotoi* KIMURA, sp. nov.; a part of pinna showing the outline and venation of pinnules (PP7109), ×2.

Fig. 4. *Cycadolepis*? sp.; showing three types (a–c) of scale leaves (PP7145), ×1.

Fig. 5. *Zamites buchianus* (ETTINGSHAUSEN) SEWARD; (PP7137), ×1.

Plate 6

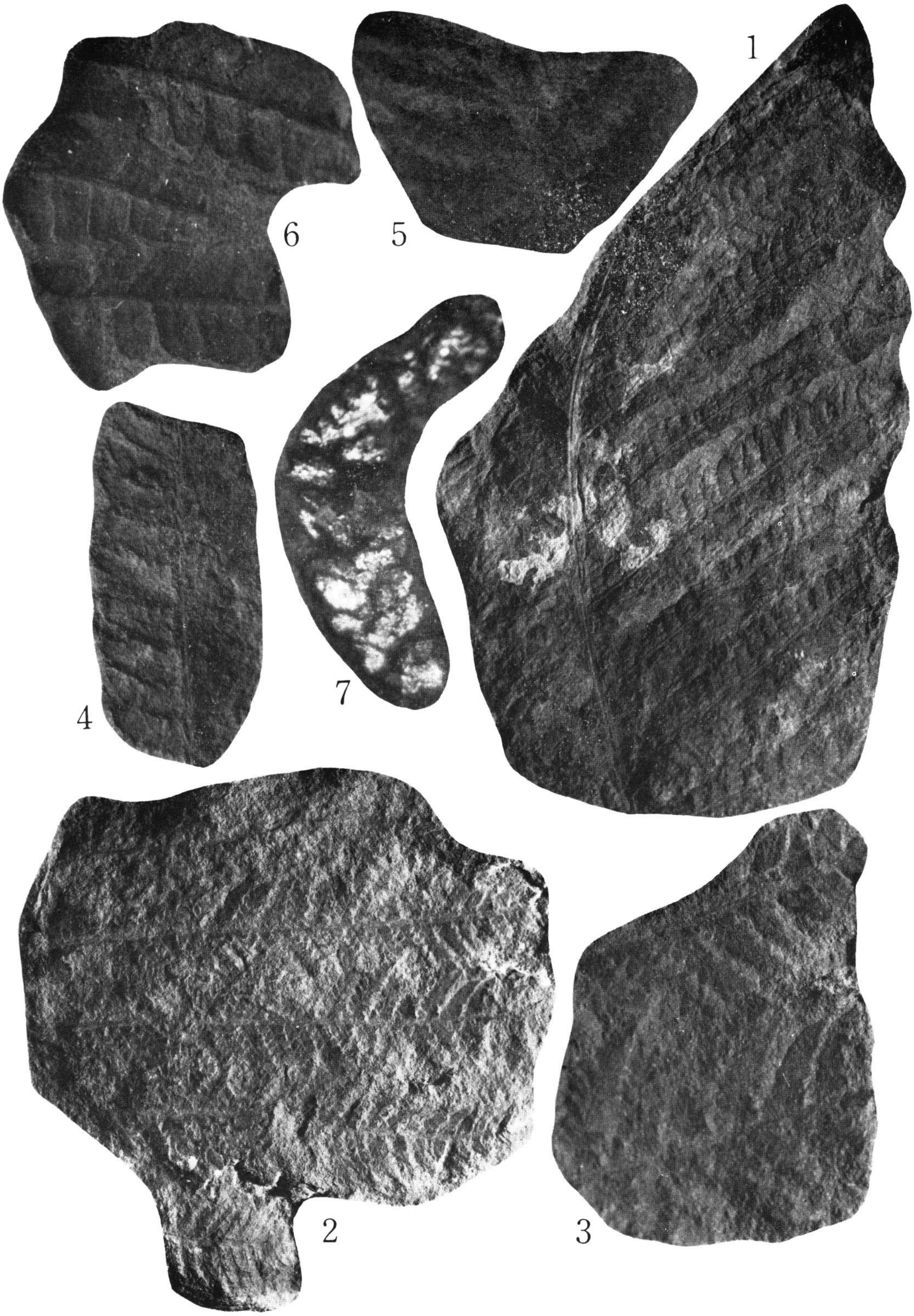
Figs. 1–3. *Sphenopteris yokoyamai* YABE; 1. A part of a frond (PP7116), ×2. 2. A part of frond, showing the outline of pinnules (PP7116), ×2. 3. Showing elongate pinnules enlarged from PP7116, ×2.

Fig. 4. *Cladophlebis geyleriana* (NATHORST) YABE; showing a specialized basal basiscopic pinnule on the left side, enlarged from PP7089, ×2.

Fig. 5. *Nilssonia* ex gr. *orientalis* HEER; (PP7128), ×1.

Fig. 6. *Cycadolepis*? sp.; (PP7144), ×1.

Fig. 7. *Zamites buchianus* (ETTINGSHAUSEN) SEWARD; (PP7138), ×1.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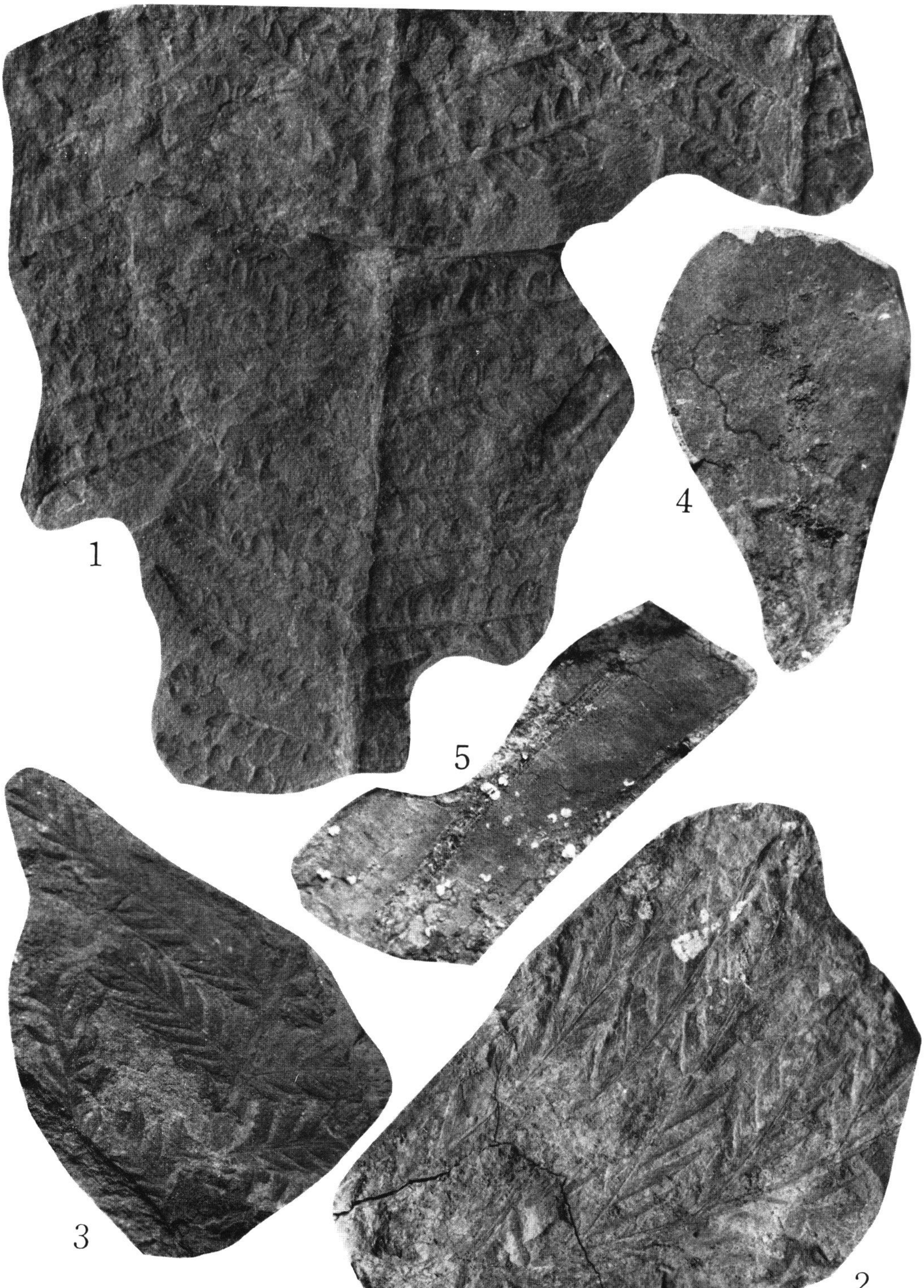
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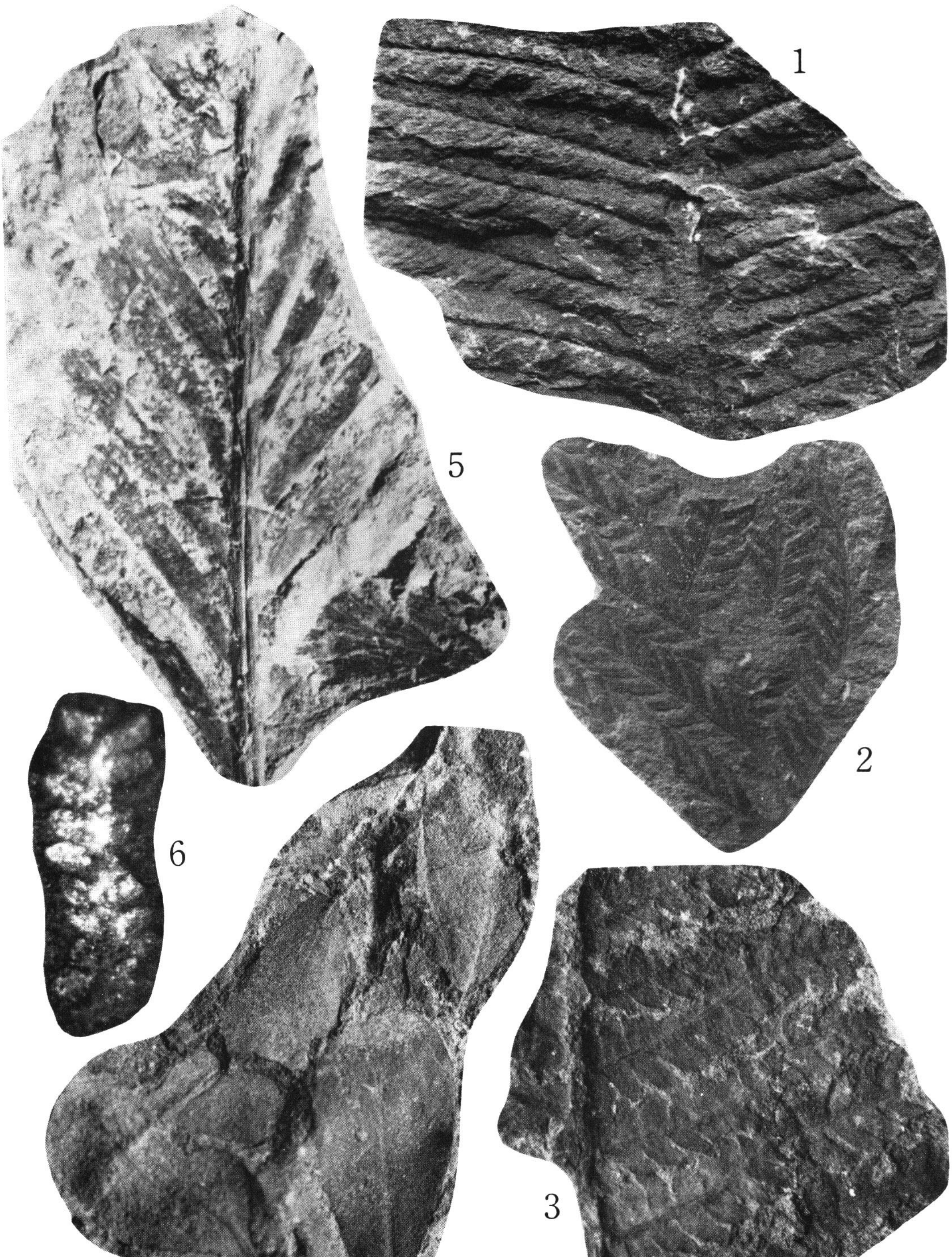
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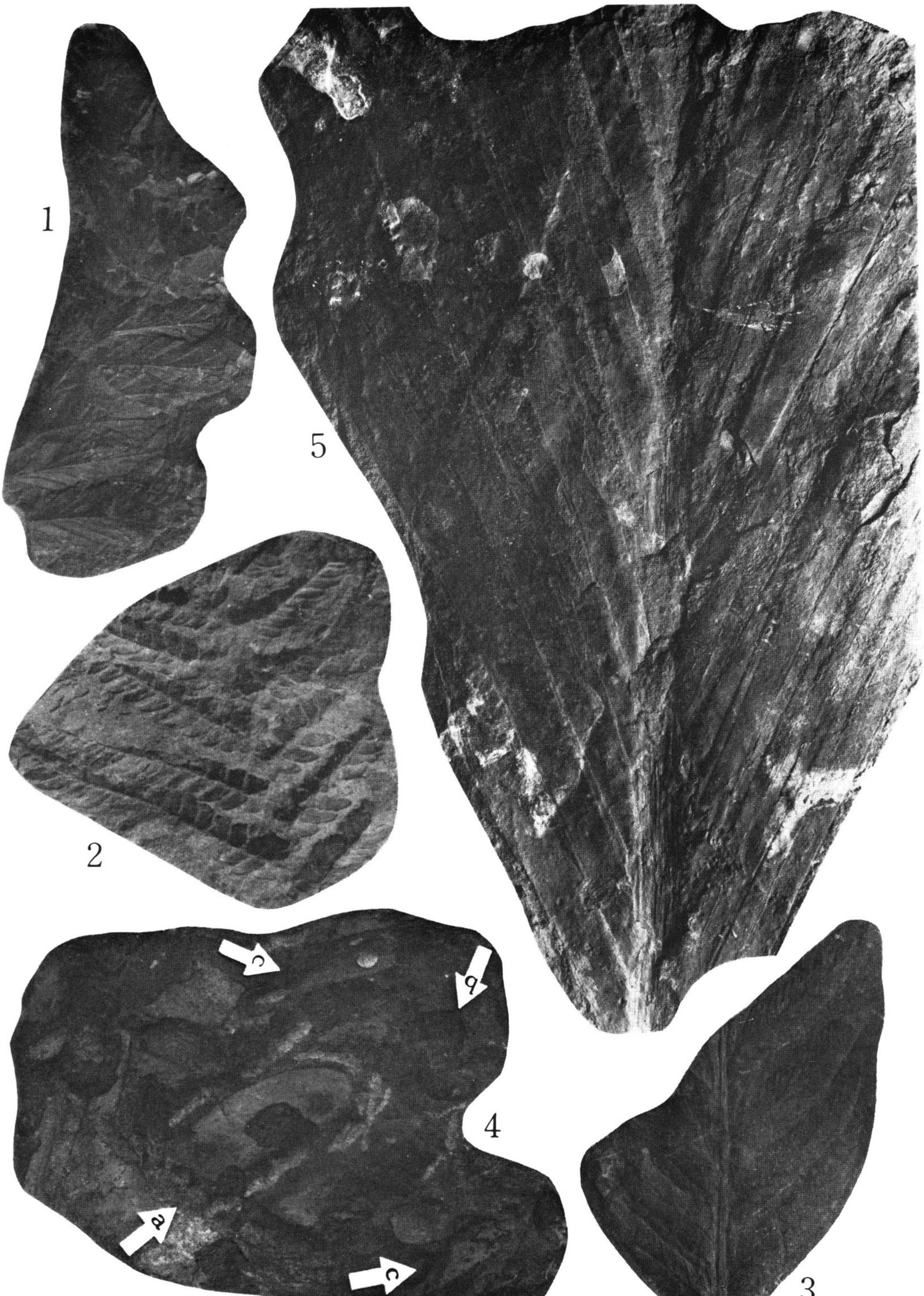
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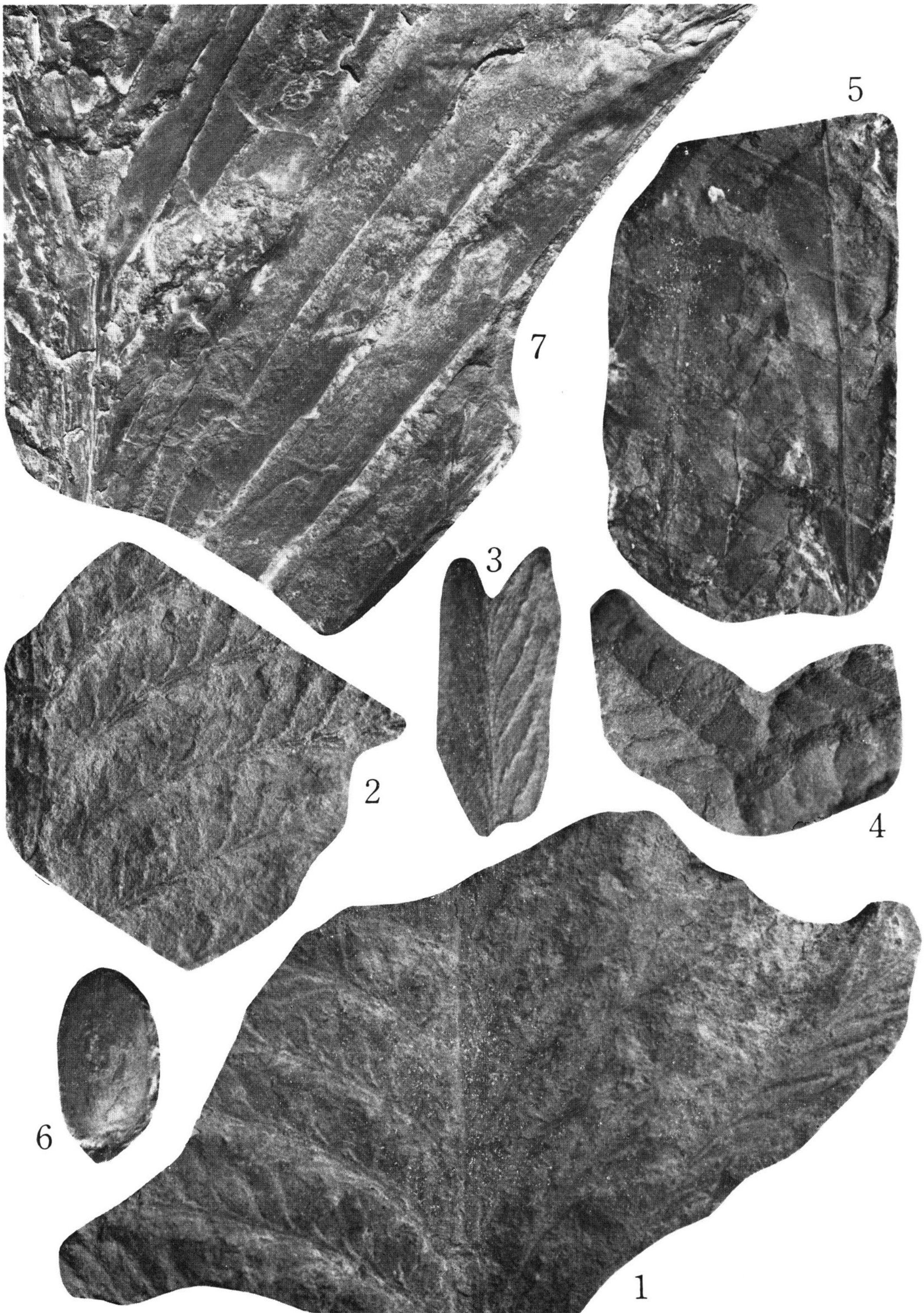
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