STUDIES ON THE CENOZOIC PLANTS OF HOKKAIDÔ AND KARAHUTO*

I. FERNS FROM THE WOODWARDIA SANDSTONE OF HOKKAIDÔ

By

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With 5 Plates

(Contribution from the Department of Geology and Mineralogy, Faculty of Science, Hokkaidô Imperial University, Sapporo; No. 277)

The name "*Woodwardia* Zone" was first used in 1901 by Professor H. YABE, at the time of his stratigraphical study of the Ikusyumbetu and the Yûbari coal-mine districts in the Isikari coal-field, for a thin plant bed occupying an upper part of the thick complex consisting of hard, compact, somewhat flinty sandstones and light gray shales in alternation with subordinate layers of marls and coaly shales. The whole complex contains plant fossils in several horizons and has been called "*Woodwardia* Sandstone" by Dr. H. IMAI(1). According to the recent stratigraphical study of the junior author in the Bibai coal mine, near Bibai, the thickness of the *Woodwardia* Sandstone is ca. 250 m. and the *Woodwardia* Zone is 5–20 m. in the Isikari coal-field.

(*) Studies on the Cenozoic plants of Hokkaidô and Karahuto are now in progress with the collaboration of Mr. K. HUZIOKA. The present paper is the first item concerning the thesis here referred to and papers will appear hereafter according to the progress of the study. The expense for the present study is being met by a grant from the Japan Society for the Promotion of Scientific Research to whom I wish to express my sincere thanks. Cordial thanks are also due to many graduates of the Department of Geology and Mineralogy, Faculty of Science, Hokkaidô Imperial University, who has offered many valuable specimens collected during their field geological surveys as graduate theses; many such specimens form the subject of the present study. S. ÔISHI.

(1) H. IMAI: Stratigraphical Studies of the Coal-bearing Tertiary of the Isikari Coal-Field, the Isikari Series (in Japanese) Journ. Geogr. Soc. Tôkyô, Vol. XXXVI, 1924.

IMAI's subdivision of the Palaeogene deposits (the Isikari Series of Professor YABE) in the Isikari coal-field is as follows (in descending order) :

XI. Asibetu Coal-bearing Group
X. Upper Corbicula Bed
IX. Ikusyumbetu Coal-bearing Group
VIII. Woodwardia Sandstone
VII. Lower Corbicula Bed
VI. Bibai Coal-bearing Group
V. Wakkanabe Shell Bed
IV. Wakkanabe Shale
III. Yûbari Coal-bearing Group
II. Horokabetu Shale
I. Noborikawa Coal-bearing Group

Professor T. NAGAO(1) divided the Isikari Series into three parts from the view point of the palaeogeography and orogeny of Hokkaidô; I–III in IMAI's subdivision, which are terrestrial, form the lower; IV and V, which are marine the middle and VI–XI which are again terrestrial are the upper parts, respectively.

Dr. ENDÔ(2) already discriminated fifty-seven distinct types of plant fossils from the *Woodwardia* Sandstone in the Isikari coal-field, but they have never been described, and only a few species of them have been illustrated. ENDÔ's list of plant fossils includes a considerable number of species common with the Eocene plants of North America, and this is the chief reason for his reaching the conclusion that the plant beds are of the Eocene age. According to the recent palaeontological as well as stratigraphical studies of the Palaeogene deposits of the Isikari Series in the Isikari coal-field by Professor T. NAGAO(1), the Wakkanabe Beds (IMAI's Wakkanabe Shale and Wakkanabe Shell Bed) contain a characteristic marine pelecypod, *Crassatellites yabei* NAGAO var. *ezoensis* NAGAO and ÔTATUME which is closely allied to *C. yabei* from the Asiya

(1) T. NAGAO: Tertiary Orogeny of Hokkaidô. Journ. Fac. Sci., Hokkaidô Imp. Univ., Ser. IV, Vol. IV, Nos. 1–2, 1938.

(2) S. ENDÔ: The Cenozoic Floras. Iwanami's Geol. and Pal. Series, 1931, p. 8.

(3) T. NAGAO: The Palaeogene (The Older Tertiary). Iwanami's Geol. and Pal. Series, 1928, p. 33.

Group in Kyûsyû which Professor NAGAO attributed to the Lower Oligocene age. If this view were accepted, then the flora of the *Woodwardia* Sandstone can not be older than the Older Oligocene[1]. As to the chronology of the Palaeogene deposits of Hokkaidô chiefly based upon palaeobotanical evidences an opinion may be given by the present writers in the near future dependent upon the progress of their studies of the Cenozoic floras of Hokkaidô and Karahuto.

In the present note the writers have treated the ferns only which characterise the *Woodwardia* Zone: they are as follows:

Osmunda japonica THUNBERG *fossilis* subsp. nov.
Athyrium delicatulum sp. nov.
Dennstaedtia nipponica sp. nov.
Onoclea sensibilis L. *fossilis* NEWBERRY
Woodwardia Endoana sp. nov.
Woodwardia decurrens sp. nov.

At this place the writers wish to express their cordial thanks to Dr. S. ENDÔ who was so kind as to send them his own materials for the writers' study and for generous permission to illustrate his specimens in the present paper. The writers' sincere thanks are also due to Prof. T. NAGAO from whom they have received valuable suggestions on the stratigraphy of the Isikari Series and to Messrs. K. ÔTATUME and T. SIMOGAWARA for the loan of the many specimens which they had collected.

DESCRIPTION

OSMUNDACEAE

Genus *Osmunda* L.

Osmunda japonica THUNBERG *fossilis* subsp. nov.

Pl. XXXIX (I), figs. 1–4, 4a, 5–8.

1931. *Osmunda* sp. Endô: The Cenozoic Floras. Op. cit., p. 8.

(1) During the preparation of this note, the writers received a suggestion from Prof. NAGAO as to his recent view on the Palaeogene stratigraphy of this country. According to him the Wakkanabe Beds of Hokkaidô appear likely to be older than the Asiya and probably are attributable to the Upper Eocene. Therefore, Prof. NAGAO holds now the opinion that the *Woodwardia* Sandstone roughly corresponds in age to the Upper Eocene and may not be younger than the Lower Oligocene at the youngest.

Description of specimens: Pl. XXXIX (I), fig. 1 shows a portion of sterile pinna more than 4.5 cm. long traversed by a slender axis bearing linear lanceolate pinnules about 2.7 cm. long, and 0.8 cm. broad in their proximal parts; they are oblique to the axis, set closely and provided with acuminate apices. The nervation is distinct and densely crowded; the midnerve persists to the tip of the pinnules; the secondary nerves are acute to the midnerve and then arching, generally twice or thrice dichotomously branched except the lower basal one which is generally more than thrice forking. The margin is finely serrated. Figs. 4–7 represent detached pinnules; one in fig. 4 shows the nervation very clearly (see fig. 4a). Fig. 2 shows a specimen determined by ENDÔ as *Osmunda* sp. It consists of a terminal pinnule with subacute apex and two smaller pinnules attached oppositely to a thin axis close to the base of the former. The margin is finely serrated. It is highly probable that the specimen represents an apical part of a pinna and not of a frond because in the latter the terminal pinnule is usually lobed or auriculate at their proximal portion. Fig. 8 shows part of a pinna with pinnules similar in shape to that in fig. 5. Fig. 3 represents probably a terminal pinna, which is crenulated at the proximal part.

Remarks: In spite of the scantiness of material now at hand the writers venture to identify the present specimens to one of the living species of *Osmunda*, *O. japonica* THUNB., now living in the temperate zone of the Japanese Islands from Hokkaidô as far as Kyûsyû. Unfortunately there is available no fertile example of the fossil materials, but the tolerable resemblance of the vegetative parts in the fossil and the living types renders the reference of the fossil example to *Osmunda japonica* most probable. If it may be permitted to make a distinction between them, the writers would suggest that in the fossil form the pinnules are more or less narrower than those in the living species, though otherwise almost indistinguishable.

Comparison and discussion: Detached fossil examples of pinnules similar in general habit to the present specimens have been reported from several parts of the world under the names *Osmunda affinis* LESQ.[1], *Pteris subsimplex* LESQ.[2], *P. erosa* LESQ.[3], *Asple-*

(1) L. LESQUEREUX: Contribution to the Fossil Flora of the Western Territories. Pt. II, The Tertiary Flora. Rep. U. S. Geol. Surv. Terr., Vol. VII, 1878, p. 60, pl. IV, fig. 1.

(2) L. LESQUEREUX: Ibid., p. 52, pl. IV, figs. 5–7.

(3) L. LESQUEREUX: Ibid., p. 53, pl. IV, fig. 8.

nium hurleyensis BERRY[1], *Osmunda Heeri* GAUDIN[2], etc. The first named species was described by LESQUEREUX based on very imperfect pinnules from the Denver and the Fort Union Series of North America. They resemble indeed the present form, but are said to have had an almost entire margin. If that is certainly so, there exists a distinction between the American and the present form, in regard to the nature of the margin of the pinnules, unless they were subjected to the secondary shrinkage of the margin. *Pteris subsimplex* and *Pteris erosa* have been so named on the basis of some imperfect pinnules from the Eocene rocks of Colorado, but they may be distinguishable from the present specimens in that the pinnules taper towards the proximal portion and in that the secondary nerves are less crowded. *Asplenium hurleyensis* BERRY from the Lower Eocene of North America shows a certain resemblance to the present form, but the secondary nerves fork only once and there is certainly a difference in the shape of pinnules. Though BERRY adopted the genus *Asplenium* for the American specimens, there is no adequate ground whatever for referring his specimens to the living genus.

Occurrence:

Takikawa, Sorati-gun; coll. T. SIMOGAWARA; common.
Naé-gawa, Sorati-gun; coll. K. HUZIOKA; common.
Tyasinai, Sorati-gun; coll. K. HUZIOKA.
Sannosawa near Miruto; Sorati-gun; coll. H. IMAI.
Syakôno-sawa, Yûbari coal-mine, Yûbari-gun; colls. M. MINATO and T. MAKI.

POLYPODIACEAE

Genus *Athyrium* ROTH.

Athyrium delicatulum sp. nov.

Pl. XXXIX (I), Fig. 9; Pl. XL (II), Fig. 6.

(1) E. W. BERRY: The Lower Eocene Floras of Southeastern North America. U. S. Geol. Surv., Prof. Paper, Vol. 91, 1916, p. 168, pl. X, fig. 1.

(2) O. HEER: Die fossile Flora der Polarländer. Flora Fossilis Arctica, Bd. 1, 1868, p. 88, pl. I, figs. 6–11; pl. VIII, fig. 15b.

Description of specimen: In Pl. XXXIX (I), fig. 9 is shown part of an elegant fern frond which is at least tripinnate and traversed by a rachis about 2 mm. across measured on the compressed surface; it bears a longitudinal median ridge probably indicating the vascular course. The penultimate pinnae are more than 5.5 cm. long, narrowing distally and attached to the rachis at a wide angle. The ultimate pinnae are oblong to lanceolate, set closely, subopposite or alternate and are almost perpendicular to the pinna-axis. The pinnules are small, ovate, 5–7 in number on each side of the pinna-axis, and provided with rounded apices. The nervation is delicate but distinct, the midnerve giving off on each side 2–3 secondary nerves in the same strength and occasionally forking once.

Remarks: Though the present specimen is represented by part of a sterile frond, there is no fossil species identical with, or even comparable to it. Among the living ferns, there is a considerable number of comparable species among the genus *Athyrium* in respect to the morphology of the sterile parts. Therefore, taking into consideration the striking resemblance of the sterile parts in both fossil and recent ferns the writers wish provisionally to call the present specimen *Athyrium delicatulum* sp. nov.

Occurrence: Bannosawa, near Bibai coal-mine, Sorati-gun; coll. K. HUZIOKA; rare.

Genus *Dennstaedtia* BERNH.

Dennstaedtia nipponica sp. nov.

Pl. XXXIX (I), Figs. 10–14; Pl. XL (II), Figs. 1–5, 5a, 7–8.

Diagnosis: Sterile frond at least tripinnate; frond or penultimate pinna slender; its axis thin and narrow, smooth; ultimate pinnae lanceolate, at an angle of 50°–70° to the axis, subopposite, generally 1–5 cm. long; pinnules oblong to deltoid, 2–5 mm. long, at a wide angle to the pinna-axis, shallowly lobed except the lowest one which is rather deeply cleft at the margin generally into 3–4 lobes with rounded apices and attached to the axis by a part of the base; nervation delicate, slender but distinct; midnerve, which takes a zigzag course, sends off secondary nerves which are sometimes dichotomously branching. Fertile frond similar to the sterile but apparently more slender, the lamina being somewhat reduced, with round sori about 0.5 mm. in diameter at the top of each lobe.

Description of specimens: Pl. XXXIX (I), figs. 10–14 show parts of frond, of which the one in fig. 10 indicates that this fern is at least tripinnate. In fig. 13 the distal portion is fertile; Pl. XL (II), figs. 1 and 2 show parts of ultimate pinnae bearing oblong to deltoid pinnules lobed at the upper margin. Some fertile fragments are shown in figs. 3, 4 and 5 in the same plate; round terminal sori are clearly seen in the enlarged figure (fig. 5a).

Remarks and comparison: Sterile and fertile examples are examined, but in neither case is the internal structure of the sori available. They did not occur in organic connection, but in close association more or less frequently in certain localities almost without other fossils, therefore the writers believe they represent the same fern.

Comparable species are *Dennstaedtia americana* KNOWLTON[1] from the Fort Union formation of North America and *D. scabra* MOORE living in temperate Japan and tropical Asia. In the former, however, the frond is rather stronger and the pinnules are larger and broader. It is more difficult to distinguish the present specimens from the living species, *D. scabra*. In comparing the fossil example with the living species, the writers incline even to refer the fossil to the living species. However, in comparing more closely, the writers found that in the fossil type the ultimate pinnae are generally longer and narrower and present a rather slender aspect.

ENDÔ[2] listed *D. americana* KNOWLTON in his list of fossil plants from the *Woodwardia* Sandstone of Hokkaidô. The writers have not yet had the opportunity of examining the original specimens on which ENDÔ based his determination, but recently they received information from him that his material was fructified specimens hardly distinguishable from *D. americana* figured by KNOWLTON. Therefore, it may be suggested that two distinct types of *Dennstaedtia* are represented in the *Woodwardia* Sandstone of Hokkaidô in the Palaeogene age.

Suggestion: In examining the present fossil, the writers were struck by the striking simliarity of the fossil with a well known Mesozoic fern referred to Cyatheaceae and called under the name

(1) F. H. KNOWLTON: Description of Fossil Ferns from the Mesozoic and Cenozoic of North America. I. Smithonian Inst. Misc. Coll., Vol. LII, pt. 4, 1910, p. 492, pl. XLIII, fig. 4; pl. XLIV, figs. 3–5.

(2) S. ENDÔ: The Cenozoic Floras. Op. cit., 1931, p. 8.

Coniopteris burejensis (ZAL.)[1]. In *C. burejensis* the internal structure of the characteristic terminal sori is not yet known, but from the undeniable resemblance of the fertile and sterile examples in respect to the general habit of the frond, SEWARD suggested the Cyatheaceous affinity of *C. burejensis* taking into consideration the resemblance with another well-known Cyatheaceous fern *C. hymenophylloides* (BRONGN.). Unfortunately the soral character of the fossil now in question is uncertain, and there is no adequate ground for referring the specimens to Cyatheaceae. Therefore, the writers believe it more appropriate to compare the present specimens to a Polypodiaceous fern *Dennstaedtia* to which references have already been made by certain authors for Older Tertiary ferns.

Occurrence:

Naié, Sorati-gun; coll. K. HUZIOKA; abundant.
Bannosawa, near Bibai coal-mine, Sorati-gun; coll. K. HUZIOKA; abundant.
Environs of Bibai Town, Sorati-gun; coll. K. HUZIOKA; rare.
Yûbari coal-mine, Yûbari-gun; coll. K. ÔTATUME; common.
The bank of the river Sihorokabetu of Yûbari, Yûbari-gun; coll. K. ÔTATUME; common.
Kakuta near Yûbari coal-mine, Yûbari-gun; coll. K. HUZIOKA; abundant.

Genus *Onoclea* LINNE

Onoclea sensibilis L. *fossilis* NEWBERRY

Pl. XLI (III), Figs. 1, 1a, 2, 2a, 3, 4.

1851. *Filicites* ? *hebraidicus* FORBES: Note on the Vegetative Remains from Ardtun Head. Qurt. Journ. Geol. Soc. London, Vol. VII, p. 103, pl. II, figs. 2a, 2b.
1868. *Woodwardites arcticus* HEER: Die fossile Flora der Polarlaender. Op. cit., p. 86, pl. I, fig. 16; pl. XLV, fig. 2c; pl. XLVIII, fig. 9.
1822. *Onoclea hebraidica* GARDNER and ETTINGSHAUSEN: British Eocene Flora. Vol. I. Pal. Soc. London, p. 68, pl. XIII, figs. 5–6.
1883. *Onoclea sensibilis* HEER: Die fossile Flora Groenlands. II. Die tertiäre Flora von Groenland. Flora Fossilis Arctica, Bd. VII, p. 48, pl. LXX, fig. 6.

(1) A. C. SEWARD: Jurassic Plants from Amurland. Mém. Com. Géol. St.-Pétersburg, N.S., Liv. LXXXI, 1912, p. 22, pl. I, figs. 1–5; pl. III, figs. 18–21.

1898. *Onoclea sensibilis fossilis* NEWBERRY: The Later Extinct Floras of North America. U. S. G. S. Mon., Vol. XXXV, p. 8, pl. XXIII, fig. 3; pl. XXIV, figs. 5–6.
1931. *Onoclea hebraidica* ENDÔ: The Cenozoic Floras. Op. cit., p. 8.
1936. *Onoclea sensibilis* HOLLICK: The Tertiary Floras of Alaska. U. S. G. S. Prof. Paper, 182, p. 35, Pl. II, figs. 2–4.

Description of specimens: On Plate XLI (III), fig. 2 shows a specimen determined by ENDÔ (op. cit.) as *Onoclea hebraidica*. It is a portion probably of the middle of a frond. Two pinnules are seen on the right hand side of the thin axis, alternating with a pinnule on the left; they are 7 cm. long and taper gradually from the base towards the acuminate apex. The midnerve is thin but distinct and sends off secondary nerves at a narrow angle, which branch frequently forming a reticulum consisting of elongate meshes. The margin is somewhat wavy. Fig. 1 shows the distal portion of a frond consisting of a slender rachis to which pinnules are attached sub-oppositely at a wide angle. The pinnules are set closely and the lamina is confluent laterally. The lateral nerves are quite similar to those of the living species. In this specimen the apical portion of the pinnules is missing, and the margin appears to be entire. Fig. 3 represents the apical end of a frond; the margin is wavy or lobed each lobe being provided with rounded apex. The specimen in fig. 4 differs somewhat from others described above; it is at least 8 cm. long and the margin is regularly lobed each lobe being provided with a rounded apex. The secondary nerves in this specimen are peculiar, a well-defined secondary nerve entering each lobe first at an acute angle and then arching and sending off finer tertiary ones which form with each other a reticulate nervation consisting of polygonal meshes. This specimen is in both shape and nervation identical with the proximal pinnules of the frond in the living species and it may probably represent the corresponding portion in the fossil species. Fertile specimen is not known.

Remarks: Fragments of some sterile examples are examined. It is highly probable that they are identical in many respects with the living species, *Onoclea sensibilis*. FORBES first described this fern as *Filicites ? hebraidicus*. Later GARDNER and ETTINGSHAUSEN adopted FORBES' name for some fragments from the British Eocene strata and described them as *Onoclea hebraidica*. HEER identified a fossil form from Greenland to the living species and named it *O.*

sensibilis including also his *Woodwardites arcticus* into its synonymy. NEWBERRY figured some splendid specimens of sterile fronds from the Fort Union Series of North America, and called them under the name *Onoclea sensibilis fossilis*. FORBES' *Filicites ? hebraidicus* and the living *Onoclea sensibilis*, are, so far as sterile examples are concerned, hardly distinguishable from each other. Therefore it is advisable to treat them under one specific group, *O. sensibilis fossilis*, as NEWBERRY suggested.

Onoclea sensibilis fossilis appears to be not uncommon in the Older Tertiary strata of Japan, North America and Europe. Similar specimens have been described also from the Cretaceous of North America under several names such as *Onoclea ? fecunda* (LESQ.)[1], *O. minima* KNOWLTON[2], *O. neomexicana* KNOWLTON[3], etc. HOLLICK[4] figured some fertile examples of *Onoclea* from the Magothy Formation as *Caulinites inquirendus* HOLLICK which he[5] later reclassified in the genus *Onoclea*.

Onoclea sensibilis L. is a monotypic species now living in Hokkaidô, Honsyû and Kyûsyû. Outside Japan, it exists also in Amurland, Manchoukuo, the United States of America and Canada.

Occurrence:

Upper course of the Naé-gawa, Sorati-gun; coll. K. HUZIOKA; common.
Naié, Sorati-gun; coll. K. HUZIOKA; common.
Bibai, Sorati-gun; coll. K. HUZIOKA; common.
Poronai, Sorati-gun; coll. R. SAITÔ; rare .
Yûbari, coal-mine, Yûbari-gun; coll. K. HUZIOKA; common.
Kakuta, near Yûbari coal-mine, Yûbari-gun; coll. S. ENDÔ and K. HUZIOKA; common.

(1) L. LESQUEREUX: Contribution to the Fossil Flora of the Western Territories. Op. cit., p. 101, pl. XIV, figs. 1–3.

(2) F. H. KNOWLTON: Fossil Flora of the Yellowstone National Park. U. S. G. S. Mon., Vol. XXXII, Pt. 2, 1899, p. 656, pl. LXXVII, figs. 11–15.

(3) F. H. KNOWLTON: Flora of the Fruitland and Kirtland Formations. U. S. G. S. Prof. Paper, 98, 1916, p. 332, pl. LXXXIV, figs. 1–2.

(4) A. HOLLICK: Additions to the Palaeobotany of the Cretaceous Formation in Long Island. No. II. New York Bot. Gard. Bull., Vol. III, 1904, p. 406, Pl. LXX, fig. 3.

(5) A. HOLLICK: The Cretaceous Flora of Southern New York and New England. U. S. G. S. Mon., Vol. L, 1906, p. 32. Pl. I, figs. 1–7.

Genus *Woodwardia* SM.

A considerable number of sterile and fertile specimens are examined. Some are excellently preserved, but they are generally fragmentary. In studying the present material the writers found that there are two types specifically distinctive from each other, and they were named under the new names *Woodwardia Endoana* sp. nov. and *W. decurrens* sp. nov. Dr. S. ENDÔ[1] once named a certain specimen of *Woodwardia* from Simizusawa in the Yûbari-gun as *W. ezoana* ENDÔ, but the description has not yet been published. Through the courtesy of Dr. ENDÔ the present writers had the opportunity to examine the paratype of *W. ezoana* which was kindly sent at their request. However, neither the paratype nor the type-specimen illustrated by ENDÔ shows the characteristic nervation and the basal characters of the pinnae on which the essential criteria of specific distinction of the Japanese *Woodwardia* are based. Therefore the name *W. ezoana* must be used only when some essential morphological difference distinctive specifically from *W. Endoana* and *W. decurrens* described below is found in ENDÔ's type specimens of *W. ezoana*.

Woodwardia Endoana sp. nov.

Pl. XLI (III), Figs. 5, 6; Pl. XLII (IV), Figs. 1, 2, 2a, 3, 3a, 5, 6.

General description: Frond is at least bipinnate probably attaining considerable dimensions in its complete state. The pinnae are attached alternately to the axis at an angle of about 50°, linear, generally more than 9 cm. long, about 2.5 cm. broad and narrow gradually towards the distal end. The pinna-axis is strong with a distinct longitudinal median groove on its upper side. The pinnules are rather variable in respect to shape, varying from narrow and long to short and broadly triangular in outline; they are usually slightly falcate and are acutely pointed at their apices. There is a characteristic basal lobe (*Aphlebia*-like ?) deltoid to oblong in shape in each basal pinnule. The margin is almost entire or lightly undulating. The midnerve is distinct, with a single series of small, elliptical to oblong areoles on each side, and parallel to, the midnerve; the secondary nerves are given off from the areoles,

(1) S. ENDÔ: The Cenozoic Floras. Op. cit., 1931, p. 9, fig. 5.

generally 3–4 to each basal areole becoming less in number towards the apical areoles, and as far as can be seen always simple. The sori linear to oblong, slightly oblique to the midnerve, 1–1.5 mm. long, generally 4 on each side of the midnerve, one occupying a single areole.

Remarks: The presence of small lobes at the basal pinnules of each pinna is the characteristic feature of this species. This feature is clearly seen in the detached pinnae shown in Pl. XLII (IV), figs. 1–3. A part of frond, though it is badly preserved, is shown in Pl. XLI (III), fig. 5.

Comparison: A comparable species is *Woodwardia Maxoni* KNOWLTON[1] from the Fort Union Formation of North America, however, the new species differs from it in having pinnules with subacute apices and almost entire to lightly undulating margin instead of the latter's pinnules with obtuse to rounded apices and finely serrate margin.

Occurrence:

Otinumbetugawa, near Nokanan, Asibetu-mura, Sorati-gun; coll. T. ÔSIMA; common.

Takinosawa and Bannosawa, near Bibai coal-mine, Sorati-gun; coll. K. HUZIOKA; common.

Neighbourhood of the Kami-Sunagawa coal-mine, Sorati-gun; coll. T. SIMOGAWARA; common.

The Naé-gawa, Sorati-gun; coll. T. SIMOGAWARA and K. HUZIOKA; common.

The Naié-gawa, Sorati-gun; coll. K. HUZIOKA; common.

Environs of Bibai Town, Sorati-gun; coll. K. HUZIOKA; abundant.

Bibai Coal-mine, Sorati-gun; coll. K. HUZIOKA; common.

Kakuta near Yûbari coal-mine, Yûbari-gun; coll. K. HUZIOKA; common.

Several localities in the Yûbari coal-mine, Yûbari-gun; coll. K. ÔTATUME and K. HUZIOKA; common.

Wakkanabe, Simizusawa and Kanegahuti near Yûbari coal-mine, Yûbari-gun; coll. K. ÔTATUME, R. SAITÔ and K. HUZIOKA; common.

(1) F. H. KNOWLTON: Description of Fossil Plants from the Mesozoic and Cenozoic of North America. I. Smith. Misc. Coll., Vol. LII, pt. 4, 1910, pl. LXIII, fig. 3; pl. LXIV, figs. 1 and 2.

Woodwardia decurrens sp. nov.

Pl. XLII (IV), Figs. 4, 4a; Pl. XLIII (V), Figs. 1–3, 3a, 4, 5.

Description: Frond bipinnate, more than 15 cm. long; rachis 1.5 mm. across measured on the compressed surface in the proximal broken end of the specimen; pinnae alternate or subopposite, set closely, linear, long and narrow, narrowing very gradually towards the apex and attached to the rachis at an angle of about 40°; pinna-axis bears a single series of long and low areoles on each side; pinnules triangular in shape, with acuminate apices, slightly falcate; basal pinnules in each pinna decurrent strongly below; midnerve distinct, with a series of low areoles generally 6–7 in number or less on each side; secondary nerves which are given off from the areoles simple or once forking; margin almost entire; sori 5–7 in number on each side of the midnerve, their structure unknown.

Remarks: The above description is chiefly based on the specimens shown in Pl. XLIII (V), figs. 1 and 2. As to the nervation and the sori the observation was chiefly based on the specimens in Pl. XLII (IV), fig. 4 and Pl. XLIII (V), fig. 5. This species is characterised by the basal pinnules in each pinna, in which the laminae are decurrent below and not lobed as in *W. Endoana* and *W. Maxoni*.

Comparison: As the present species differs chiefly from *W. Endoana* sp. nov. in the nature of the basal pinnules, it is hardly possible to distinguish the two named species unless that part is available. However they may be distinguishable in that in the former the areoles are lower and longer than in those of the latter and the secondary nerves are more crowded. In respect to the decurrent lamina of the basal pinnules, the present species is not unlike *W. orientalis* Sw. now living in the temperate and tropical parts of Japan, but there is a distinction in the size of the frond, pinnules, and some other points.

Occurrence:

Sarusihorokabetu, Yûbari-gun; coll. K. Ôtatume.

Panke near Sunagawa Town, Sorati-gun; coll. T. Simogawara.

Several localities in the Bibai coal-mine; coll. K. Huzioka; abundant.

Several localities in the Yûbari coal-mine, Yûbari-gun; coll. K. ÔTATUME and K. HUZIOKA.

Kakuta near Yûbari coal-mine, Yûbari-gun; coll. K. HUZIOKA.

Kanegahuti near Simizusawa, south of the Yûbari coal-mine, Yûbari-gun; coll. K. HUZIOKA.

Simizusawa, Yûbari-gun; coll. R. SAITÔ, K. ÔTATUME and K. HUZIOKA.

LIST OF GEOGRAPHICAL NAMES

(B)

Bannosawa ..... 空知郡美唄町盤ノ澤
Bibai ..... 空知郡美唄町美唄炭山

(I)

Ikusyumbetsu ..... 空知郡三笠山村幾春別

(K)

Kakuta ..... 夕張郡角田炭坑
Kanegahuti ..... 夕張郡夕張町清水澤鐘ケ淵

(M)

Miruto ..... 空知郡栗澤村美流渡

(N)

Naé-gawa ..... 空知郡奈江川
Naié ..... 空知郡奈井江
Nokanan ..... 空知郡蘆別村野花南

(P)

Poronai ..... 空知郡三笠山村幌内炭山

(S)

Sannosawa ..... 空知郡栗澤村美流渡附近三ノ澤
Simizusawa ..... 夕張郡夕張町清水澤
Sunagawa ..... 空知郡砂川町上砂川
Syakôno-sawa ..... 夕張郡夕張町夕張炭山社光ノ澤

(T)

Takikawa ..... 空知郡瀧川町
Takinosawa ..... 空知郡美唄町瀧ノ澤
Tyasinai ..... 空知郡美唄町茶志内

(W)

Wakkanabe ..... 夕張郡夕張町若鍋

EXPLANATION OF THE PLATES XXXIX (I)—XLIII (V)

The figures are in natural size, if not otherwise stated. The specimens in Pl. XXXIX (I), fig. 2 and Pl. XLI (III), fig. 2 are in the Institute of Geology and Palaeontology, Tôhoku Imperial University, Sendai, while the others are in the Department of Geology and Mineralogy, Faculty of Science, Hokkaidô Imperial University, Sapporo.

Plate XXXIX (I)

Fig. 1. *Osmunda japonica* THUNB. *fossils* subsp. nov. Takikawa.
Fig. 2. *Osmunda japonica* THUNB. *fossilis* subsp. nov. Sannosawa, near Miruto.
Figs. 3, 8. *Osmunda japonica* THUNB. *fossilis* subsp. nov. Syakôno-sawa, Yubari coal-mine.
Fig. 4, 4a. *Osmunda japonica* THUNB. *fossilis* subsp. nov. Naé-gawa.
Figs. 5 – 7. *Osmunda japonica* THUNB. *fossilis* subsp. nov. Takikawa.
Fig. 9. *Athyrium delicatulum* sp. nov. Bannosawa, near Bibai coal-mine.
Figs. 10 – 13. *Dennstaedtia nipponica* sp. nov. Kakuta, near Yûbari coal-mine.
Fig. 14. *Dennstaedtia nipponica* sp. nov. Bannosawa, near Bibai coal-mine.

Plate XL (II)

Fig. 1. *Dennstaedtia nipponica* sp. nov. Bibai Town.
Fig. 2. *Dennstaedtia nipponica* sp. nov. Naié.
Fig. 3. *Dennstaedtia nipponica* sp. nov. Fertile frond. Sihorokabetu, near Yûbari.
Figs. 4, 5, 5a. *Dennstaedtia nipponica* sp. nov. Fertile pinnae. Naié.
Fig. 6. *Athyrium delicatulum* sp. nov. Enlargement of a part of Pl. XXXIX (I), fig. 9.
Fig. 7. *Dennstaedtia nipponica* sp. nov. Enlargement of a part of Pl. XXXIX (I), fig. 12.
Fig. 8. *Dennstaedtia nipponica* sp. nov. Enlargement of a part of Pl. XXXIX (I), fig. 13.

Plate XLI (III)

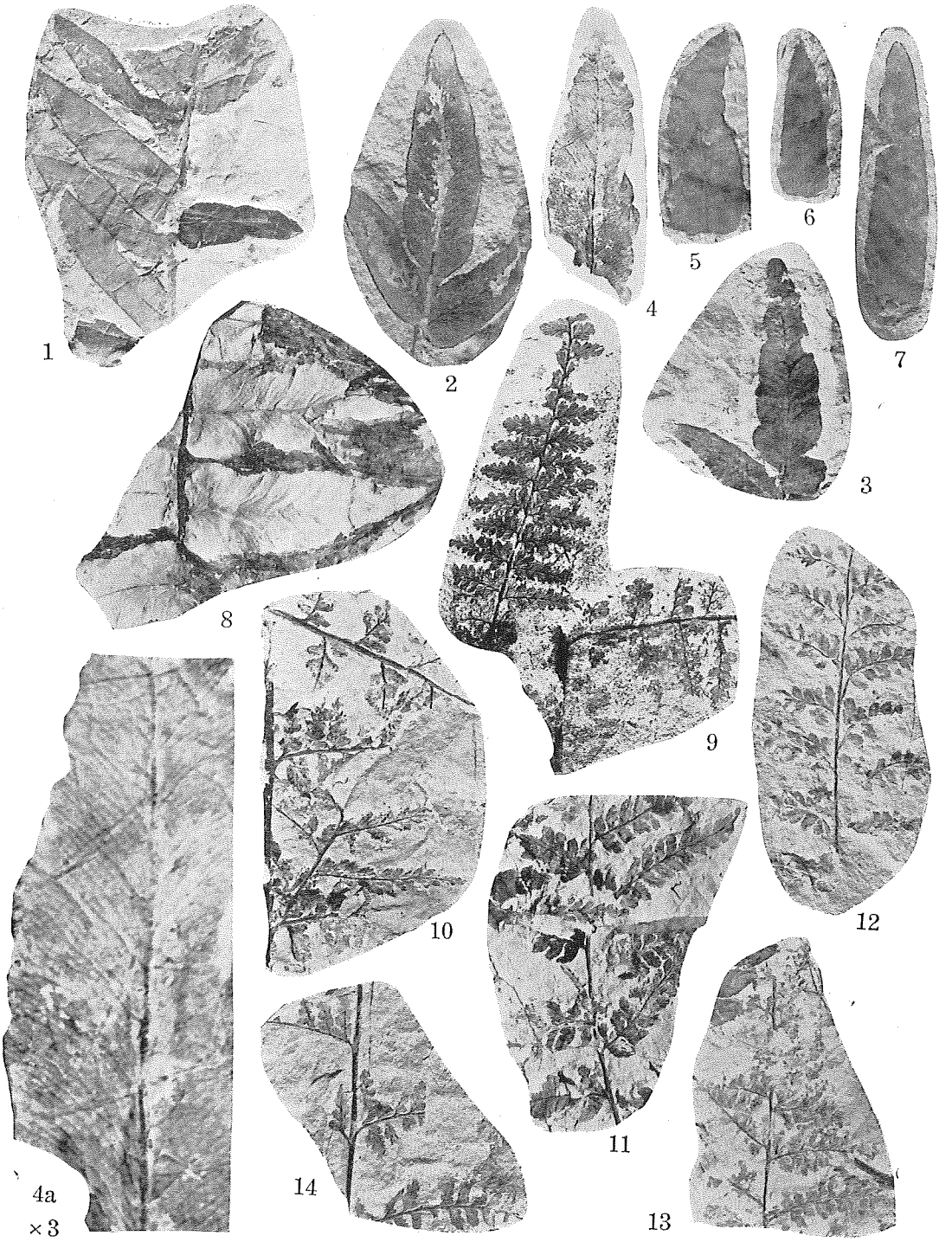
Figs. 1, 1a, 3. *Onoclea sensibilis* L. *fossilis* NEWBERRY. Yûbari coal-mine.
Figs. 2, 2a, 4. *Onoclea sensibilis* L. *fossilis* NEWBERRY. Kakuta, near Yûbari coal-mine.
Fig. 5. *Woodwardia Endoana* sp. nov. Kakuta, near Yûbari coal-mine.
Fig. 6. *Woodwardia Endoana* sp. nov. Simizusawa, near Yûbari coal-mine.

Plate XLII (IV)

Fig. 1. *Woodwardia Endoana* sp. nov. Sin-Yûbari, Yûbari coal-mine.
Figs. 2, 2a. *Woodwardia Endoana* sp. nov. Takinosawa, near Bibai coal-mine.
Figs. 3, 3a. *Woodwardia Endoana* sp. nov. Sihorokabetu, near Yûbari.
Figs. 4, 4a. *Woodwardia decurrens* sp. nov. Naé-gawa.
Fig. 5. *Woodwardia Endoana* sp. nov. Bannosawa, near Bibai coal-mine.
Fig. 6. *Woodwardia Endoana* sp. nov. A sketch of a fertile pinna from Takinosawa.

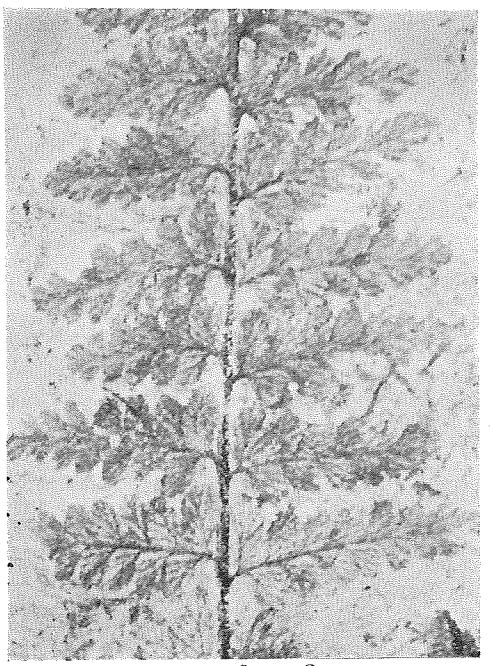
Plate XLIII (V)

Fig. 1. *Woodwardia decurrens* sp. nov. Sarusihorokabetugawa, Yûbari.
Fig. 2. *Woodwardia decurrens* sp. nov. Kakuta, near Yûbari coal-mine.
Figs. 3, 3a, 4. *Woodwardia decurrens* sp. nov. Takinosawa, near Bibai coal-mine.
Fig. 5. *Woodwardia decurrens* sp. nov. A sketch of a specimen from Bannosawa, near Bibai coal-mine.



Kumano photo.

S. Ôishi and K. Huzioka: Ferns from the Woodwardia Sandstone.



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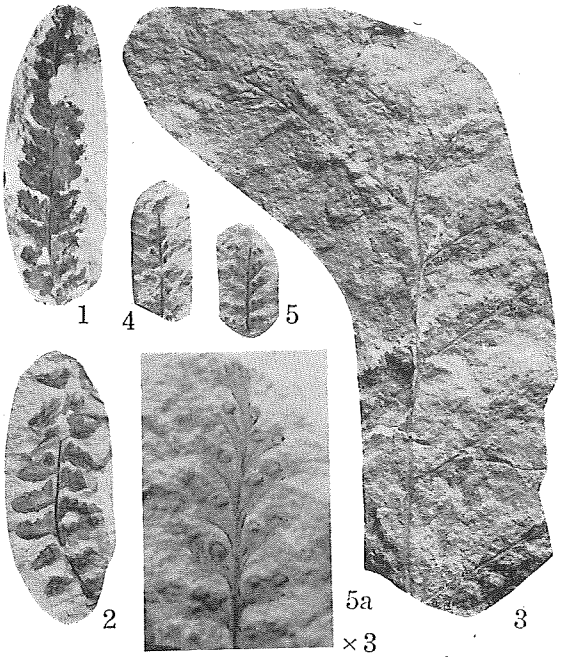
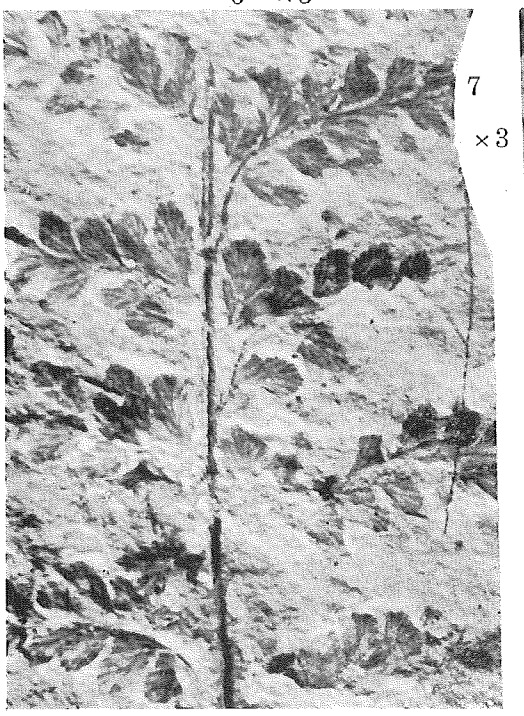


1 4 5 2 5a ×3 3



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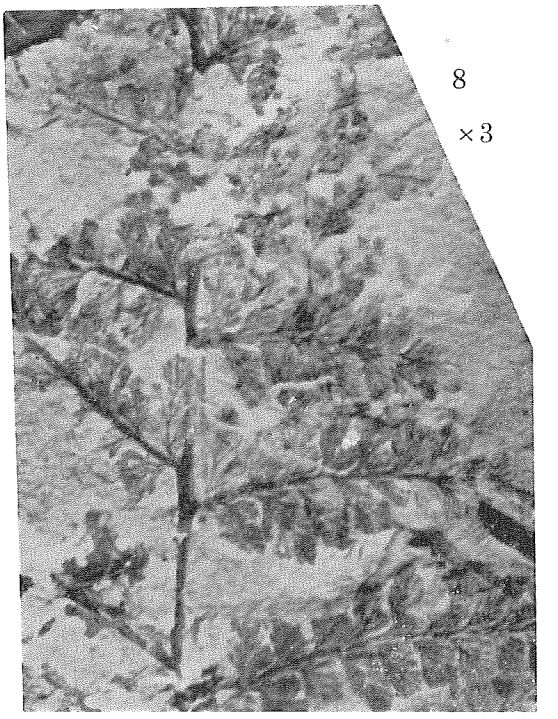

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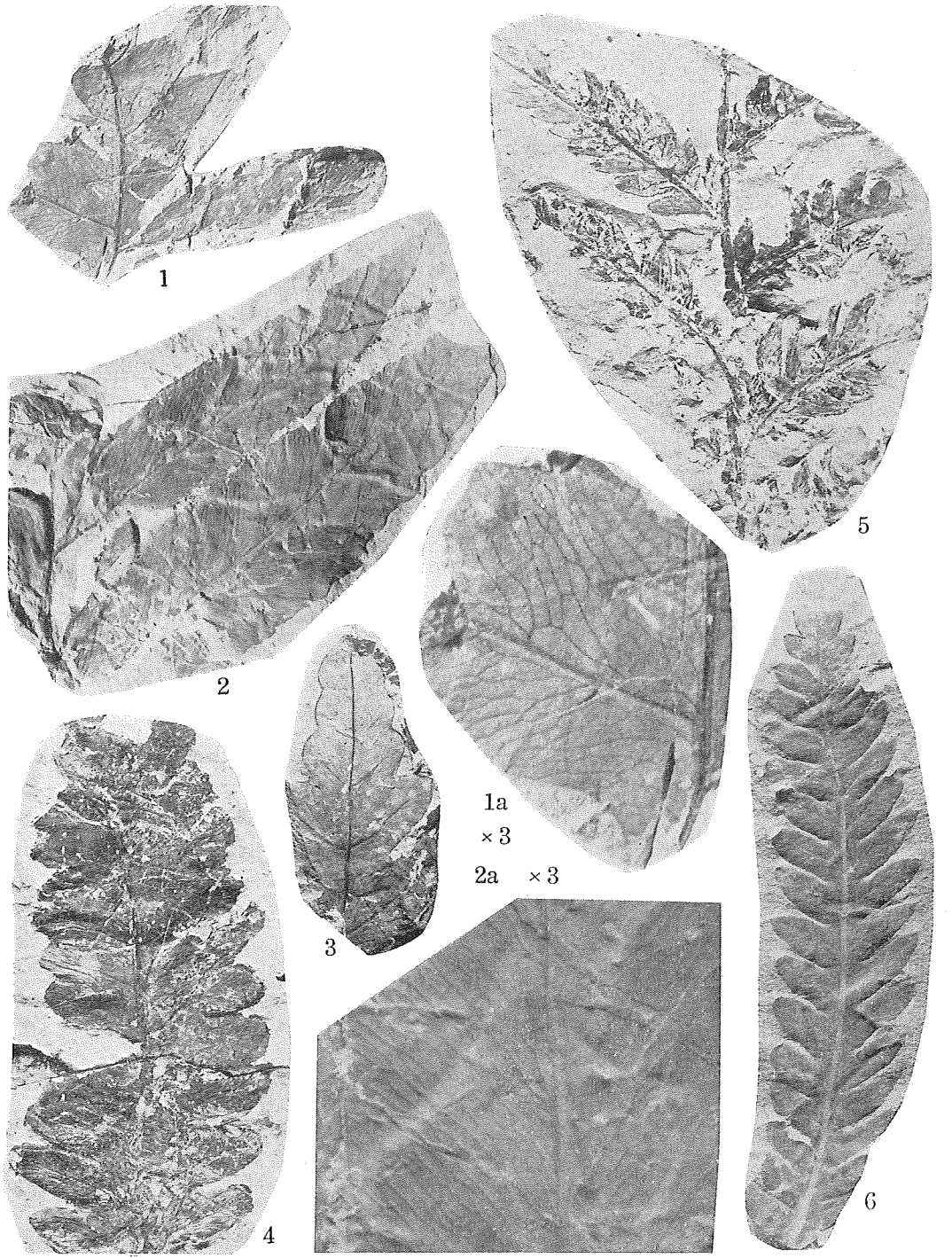
Kumano photo.

S. Ôishi and K. Huzioka: Ferns from the Woodwardia Sandstone.



Kumano photo.

S. Ôishi and K. Huzioka: Ferns from the Woodwardia Sandstone.

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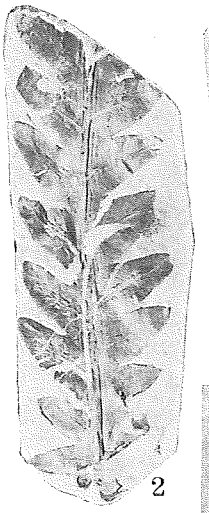

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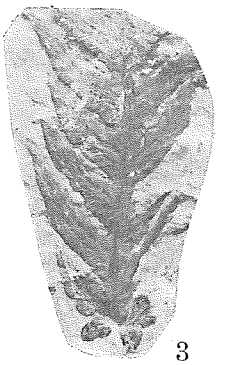

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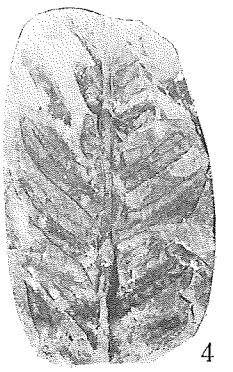
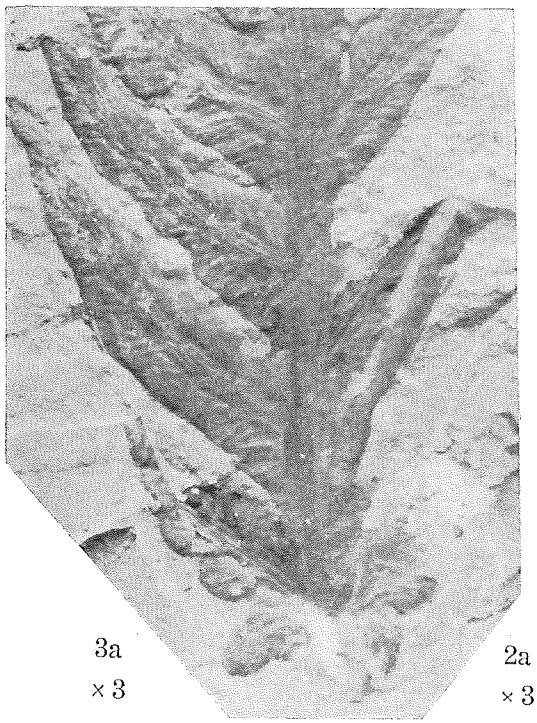


4

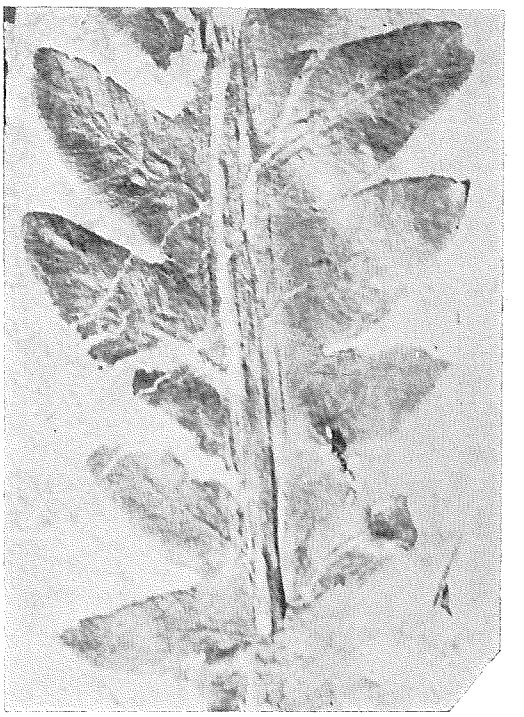
5

6

4a × 3



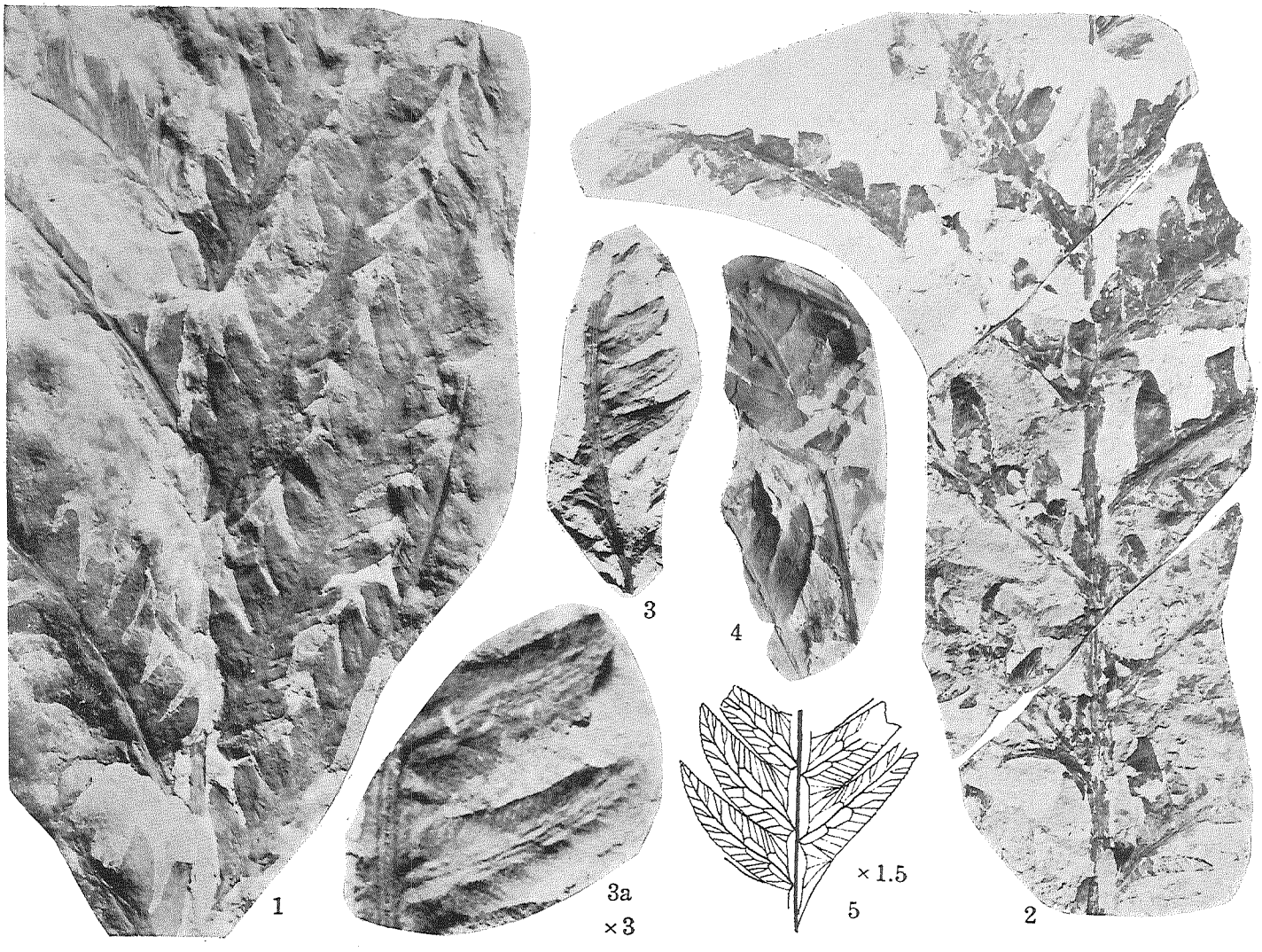
3a
× 3



2a
× 3

Kumano photo.

S. Ôishi and K. Huzioka : Ferns from the Woodwardia Sandstone.



Kumano photo.

S. Ôishi and K. Huzioka: Ferns from the Woodwardia Sandstone.