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NOTES ON SOME MESOZOIC PLANTS FROM LO-TZU-KOU, PROVINCE CHIENTAO, MANCHOUKUO

By

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With 3 Plates

(Contribution from the Department of Geology and Mineralogy,
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The collection of fossil plants dealt with in this paper was made by Mr. Z. IWAI, one of the geologists of the South Manchuria Railway Co., from the oil shale bearing strata of Lo-tzu-kou, Wang-ching Hsien, Prov. Chientao⁽¹⁾. The result of his geological survey of the district has not yet been brought to publication, but he has kindly informed the present writer as to the geology of the district. According to him the order of succession of strata developed in the named district is as follows:

	Diluvial deposits	Sands and gravels	
			--unconformity--
Lower Cretaceous Lo-tzu-kou Series	Upper	Shales, sandstones and conglomerates in alternation	50 m.
		Oil shales, shales and sandy shales in alternation	.. 140 m.
	Middle	Oil shales, shales and sandy shales in alternation	.. 55 m.
		Oil shales, shales, sandy shales and tuffaceous shales in alternation	40 m.
		Tuffaceous shales with oil shales in the upper part	30 m.
	Lower	Oil shales, sandy shales and tuffaceous shales in alternation	45 m.
Oil shales, sandy shales, and tuffaceous shales in alternation		?	

The lower limit of the Mesozoic complex is unknown. Of these strata, plant remains are contained in several horizons throughout

(1) 滿洲國間島省汪清縣羅子溝

the whole complex, but are mostly concentrated in each upper, middle and lower division, from where the present collection has chiefly been made by Mr. IWAI.

The following is the list of species recognised in the collection:

Upper:

Cladophlebis exiliformis (GEYLER)

C. sp. b.

Middle:

Gleichenites nipponensis ÔISHI

Cladophlebis sp. a.

Sphenopteris sp.

Elatocladus (Elatides) curvifolia (DUNKER)

Pityophyllum sp.

Lower:

Pityites Iwaiana sp. nov.

Sphenolepidium Sternbergianum (DUNKER)

Brachyphyllum sp.

Besides these fossil plants, *Estheria middendorfi* R. JONES are by far the most abundant in the middle and the lower divisions, while fish remains specifically identical with those from Ta-la-tzu, Ho-lung Hsien, Prov. Chientao⁽¹⁾ on which K. SAITÔ⁽²⁾ founded a new genus and species, *Manchurichythis Uwatokoi* SAITÔ, are rather common in the lower division.

It is especially noteworthy that *Manchurichythis Uwatokoi* has not yet been found to occur in association with *Lycoptera davidi* (SAUVAGE), the occurrence of the former being confined as far as present knowledge is concerned, to the strata younger than those equivalent to the coal bearing Fuhsin Series⁽³⁾ (Upper Jurassic in age), while on the contrary *Lycoptera davidi* occurs always from the strata below the Fuhsin Series. This relation can also be ascertained from the viewpoint of palaeobotany: fossil plants which

(1) 滿洲國間島省和龍縣大拉子

(2) K. SAITÔ: Mesozoic Leptolepid Fishes from Jehol and Chientao, Manchuria. Rep. 1st Sci. Exp. Manchoukou, Sect. II, Pt. III, 1936, p. 11, Pl. V, figs. 1-4 and text-figure.

(3) 阜新統

occur in association with *Lycoptera* are *Czekanowskia rigida* HEER, *Schizolepis jeholensis* YABE and ENDÔ, etc., which are not rare in the flora of the Fuhsin Series and its equivalents, while the flora from *Manchurichythys* beds differs considerably in its constituents from this and displays a strong vegetative affinity to the Lower Cretaceous flora as is indicated by the Lo-tzu-kou plants described in this paper.

As listed above, the Lo-tzu-kou plants comprise 9 different types, of which 4 are specifically identical with known species, one is a new species, while the remaining 4 are specifically hardly determinable. Of four, specifically determined, *Cladophlebis exiliformis* (GEYLER) is one of the most common elements of the Tetori and Ryôseki floras of Japan, *Gleichenites nipponensis* ÔISHI is also common in these two floras mentioned above, while *Elatocladus* (*Elatides*) *curvifolia* (DUNKER) and *Sphenolepidium Sternbergianum* (DUNKER) are characteristic Wealden species, though similar types have also been reported from the Upper Jurassic strata of Scotland. *Pityites Iwaiana* sp. nov. is related to *P. Solmsi* SEWARD from the Wealden, while *Brachyphyllum* sp. is also rather Wealden in type. Thus the Lower Cretaceous affinity of the Lo-tzu-kou plants is in no small degree strong.

DESCRIPTION OF SPECIMENS

Genus *Gleichenites* GOEPPERT

Gleichenites nipponensis ÔISHI

Pl. XXXVII (II), Figs. 1, 2, 2a.

1940. *Gleichenites nipponensis* ÔISHI: The Mesozoic Floras of Japan. Journ. Fac. Sci., Hokkaidô Imp. Univ., Ser. IV, Vol. V, Nos. 2-4, p. 202, Pl. III, figs. 2, 3, 3a.

Pl. XXXVII (II), fig. 1 shows portion of a frond (?) with very thick and strong axis to which penultimate pinnae are attached alternately. The thickness of the axis is about 1.5 cm. measured on the compressed impression. The penultimate pinnae are about 2.5 mm. thick and at an angle of approximately 45° with the axis; their whole length is unknown because their distal portions are missing. The ultimate pinnae are linear, nearly parallel sided, about

3.5 cm. long and 4 mm. broad and attached more or less remotely to the axis of the penultimate pinnae at a wide angle, the distance being 5-7 mm. on each side of the axis. The pinnules are set closely, small, semicircular or shortly ovate, with broadly or sometimes obtusely rounded apices and attached by their whole bases nearly at a right angle. The nervation is unfortunately indistinct. Another specimen in fig. 2 on the same plate shows also a portion of a frond (?) which agrees essentially with the former.

The original specimen of this species was derived from the Tetori Series of Central Japan. Although the generic name *Gleichenites* has been adopted for the Japanese specimens to which the present specimens were identified, there is no adequate reason for asserting the Gleicheniaceae affinity of the specimens other than that they resemble in their general habit, especially in regard to the size and form of pinnules, certain specimens described under the generic name *Gleichenites* some of which are known from their sori.

G. nipponensis ÔISHI appears to be a very large fern; it is not uncommon in the Tetori flora of the Japanese Islands and the same type of fern possibly identical with those from the Tetori Series has also been found in the Ryôseki flora of the Islands and the Rakutô Bed of Tyôsen⁽¹⁾.

Horizon: Middle Division

Genus *Cladophlebis* BRONGNIART

Cladophlebis exiliformis (GEYLER)

Pl. XXXVI (I), Fig. 4.

1940. *Cladophlebis exiliformis* ÔISHI: The Mesozoic Floras of Japan. Op. cit., p. 261, Pl. XII-XIV; Pl. XV, figs. 2, 2a, 3.

For further references, see ÔISHI, 1940, op. cit.

The specimen in Pl. XXXVI (I) fig. 4 is probably identical with *Cladophlebis exiliformis* (GEYLER), one of the commonest elements of both the Tetori and the Ryôseki floras in the Japanese Islands.

The specimen is represented by a portion of a bipinnate sterile frond more than 17 cm. long and 12 cm. broad. The pinnae are linear,

(1) S. ÔISHI: The Mesozoic Floras of Japan. Op. cit., pp. 203-204.

about 12 cm. broad, set closely and at an angle of about 45° with a comparatively thick axis. The pinnules are 7 mm. long and 3 mm. broad, straight or slightly falcate, with obtuse apices, set closely and attached to the pinna-rachis at a wide angle. The pinna-axis appears to be rigid. The nervation is unfortunately indistinctly impressed; the midnerve is distinct, the secondary nerves are oblique to, and about six in number on each side of, the midnerve and appear to be mostly once forking.

Fern fragments from the Tetori and the Ryôseki Series which have been known among the Japanese geologists under such names as *Cladophlebis Browniana* (DUNKER), *C. Geyleyana* (NATHORST), *Pecopteris exiliformis* GEYLER and *P. exilis* YOKOYAMA (non PHILL.) are all in most probability specifically identical and GEYLER's name which was the earliest should be applicable substituting the generic name *Cladophlebis* for *Pecopteris*. The general habit, especially the shape and size of pinnules of the present specimen agree well with *C. exiliformis* as re-defined by the present writer⁽¹⁾.

Horizon: Upper Division.

Cladophlebis sp. a.

Pl. XXXVI (I), Figs. 1, 1a, 2, 2a.

The specimens in Pl. XXXVI(I), figs. 1 and 2 represent portions of ultimate pinnae more than 1.5 cm. long. The one in fig. 1 narrows gradually towards an acute apex, while the other tapers less gradually and ends in a subacute apex. The pinnules are similar in the two specimens; they are finger-shaped with obtuse apices and are directed forwards. The nerves are distinct in the two specimens; in the one in fig. 1 the secondary nerves are once forked, while in the other they appear to be simple.

The specific determination is very difficult in such small fragments of fern pinnae. The probability is that they may be fragments of *Cladophlebis exiliformis* (GEYLER), but this must await confirmation until better specimens enabling comparison have been discovered.

Horizon: Middle Division.

(1) S. ÔISHI: The Mesozoic Floras of Japan. Op. cit., p. 261, Pls. XII-XIV; Pl. XV, figs. 2, 2a, 3.

***Cladophlebis* sp. b.**

Pl. XXXVI (I), Figs. 5, 5a.

The specimen in Pl. XXXVI(I), fig. 5 appears to represent a new species, but unfortunately it is too imperfect to warrant a new name. It is represented by portions of three pinnae possibly arranged in their natural growing position; they are linear, more than 6 cm. long and about 1.5 cm. broad, overlapping each other laterally and each is traversed by a pinna-axis which appears to be more or less rigid. The pinnules are at a wide angle to the pinna-axis and narrow gradually towards the subacute apex. As they are attached to the axis by their whole base which is somewhat expanded, they are slightly spaced laterally. The nervation is distinctly impressed as relief; the midnerve is straight or slightly curved according to the shape of the pinnules; the secondary nerves are first at an acute angle to the midnerve and then curve outwards forking once or twice. The lower basal secondary nerve is given off so close to the pinna-axis that it seems as if it were given off direct from the pinna-axis. The margin of the pinnules is undulated or shallowly lobed.

Little is known of ferns belonging to *Cladophlebis* or allied genera which have a habit or nervation as seen in the present specimen. If additional material bearing diagnostic value should be collected, the specific determination may be possible.

Fern fragments which HALLE⁽¹⁾ figured from Patagonia under the name *Cladophlebis* cf. *Browniana* (DUNKER) resemble ours more or less, but the Patagonian specimens are too imperfect to admit of comparison.

Horizon: Upper Division.

Genus *Sphenopteris* BRONGNIART***Sphenopteris* sp.**

Pl. XXXVI (I), Fig. 3.

The specimen in Pl. XXXVI(I), fig. 3 has been figured at this place as it shows, though fragmentary, a type of pinnae somewhat

(1) T. G. HALLE: Some Mesozoic Plant-bearing Deposits in Patagonia and Tierra del Fuego and Their Floras. Kgl. Svensk. Vet.-Akad. Handl., Bd. LI, No. 3, 1913, p. 27, pl. IV, figs. 1-5 (non 6 and 7).

different from those usually met with. The specimen shows a distal part of an ultimate pinna with long and narrow pinnules. The pinnules narrow gradually towards the apex and the margin is shallowly crenulated or lobed. Part of the pinna-axis is seen in the distal end of the specimen, but it is almost concealed beneath a fragment of *Pityophyllum* leaf (P.). The nervation is faintly visible; a number of lateral nerves are given off obliquely from the midnerve, each branching several times to form a bundle of finer nerves which correspond to a single marginal lobe of the pinnules.

The specific identification of the present specimen is hardly possible, being only a single fragment of a fern possibly of the distal portion of a pinna. Even the generic identification can not be said to have been done correctly, but the manner of branching of the lateral nerves in each pinnule is rather of *Sphenopteris* type than of *Cladophlebis* type. The specimen is likely to be a portion of that described as *Cladophlebis* sp. b. in this paper, however, in that the pinnules appear to be attached to the pinna-axis more remotely.

Horizon: Middle Division.

Genus *Pityites* SEWARD

Pityites Iwaiana sp. nov.

Pl. XXXVIII (III), Figs. 3, 3a.

The specimen in Pl. XXXVIII (III), fig. 3 shows a terminal portion of a coniferous vegetative shoot consisting of a twig to which needle leaves are attached at an acute angle. The leaves are straight, about 1.5 cm. long and less than 1.2 mm. broad, uninerved and sub-acutely pointed at the apices. As the leaves are borne crowded around the twig, the manner of attachment of the leaves to the leaf-bearing twig is not shown with sufficient clearness. Without cones, the actual affinity of the present specimen is not clear, though the general habit of the shoot and the form of the needles offer a close resemblance to Pinaceae, especially to Pinoideae.

The occurrence of the present specimen is somewhat interesting and deserves description as such a coniferous shoot as ours, bearing very thin and delicate needles has not yet been described from the Mesozoic strata of the world. Therefore the present writer wishes to call the specimen under a new specific name *Iwaiana*, adopting

provisionally the generic term *Pityites* founded by SEWARD, though it lacks cones.

Pityites Solmsi SEWARD⁽¹⁾ from the Wealden of England has a similar cluster of leaves, but the leaves are longer and broader.

Horizon: Lower Division.

Genus *Sphenolepidium* HEER

Sphenolepidium Sternbergianum (DUNKER)

Pl. XXXVII (II), Fig. 3; Pl. XXXVIII (III), Fig. 4.

In Pl. XXXVIII (III), fig. 4 is shown a branched sterile shoot with alternate branching. The leaves are rather small, free from the axis except the bases where they are decurrent, spirally arranged and provided with acute apices. It is highly questionable whether this specimen is specifically identical with *Sphenolepidium Sternbergianum* in which cones are known, but it is provisionally assigned to that species as the sterile shoot displays a striking agreement with the vegetative shoots of the type specimen.

The specific distinction by means of sterile shoots between *S. Sternbergianum* and *Elatides curvifolia* is generally not easy. Specimens from Tyôsen which the present writer⁽²⁾ referred to *S. Sternbergianum* are also represented by sterile shoots and the identification is thus only provisional.

Horizon: Lower Division.

Genus *Elatocladus* HALLE

Elatocladus (Elatides) curvifolia (DUNKER) ÔISHI n. comb.

Pl. XXXVIII (III), Figs. 1, 2.

There are two fragments of coniferous vegetative shoots which are hardly distinguishable from the well-known Wealden species *Elatides curvifolia*. One in fig. 1 is more than 7 cm. long and traversed by an axis 3 mm. across. The leaves are uninerved,

(1) A. C. SEWARD: Fossil Plants, Vol. IV, 1919, p. 373, figs. 772, 773. See also SEWARD: Wealden Flora, pt. II, 1895, p. 196, pl. XVIII, figs. 2, 3; pl. XIX.

(2) S. ÔISHI: The Mesozoic Floras of Japan, Op. cit., p. 411.

generally 1.5 cm. long and slightly less than 1 mm. broad, recurved, those in the proximal portion stand at a wide angle to the axis, while those in the distal portion at acuter angle, and are subacutely pointed at apices. The basal portion of each leaf is unfortunately not clearly preserved. Another specimen in fig. 2 on the same plate is similar to the preceding, but the leaves are not recurved. In this specimen the basal portion of the leaves is pretty well preserved: they are decurrent at their bases where they are somewhat expanded and arranged spirally around the axis.

This species was first described by DUNKER⁽¹⁾ from the Wealden strata of north Germany under the name *Lycopodites curvifolius* DUNKER. Later discovery of fertile branches from Spitzbergen by NATHORST⁽²⁾ led him to the adoption of the generic name *Elatides* founded by HEER⁽³⁾. Though the present specimens are represented by sterile shoots only, the existence of this well-known species in the Lo-tzu-kou florule may be almost beyond doubt from the striking resemblance of the sterile shoots in the specimens at hand to those profusely illustrated by NATHORST from Spitzbergen. However, the comprehensive generic designation *Elatocladus* founded by HALLE has been adopted here until better reliable evidence referring to *Elatides* may be acquired.

This species is characteristic to the Wealden strata of northern Europe; it is recorded also from the Upper Jurassic rocks of Scotland⁽⁴⁾. NATHORST is of the opinion that *Elatides ovalis*, *parvula*, *falcata* and *Brandtiana* named by HEER⁽⁵⁾ for the Jurassic coniferous branches from Siberia are conspecific with *E. curvifolia*.

Horizon: Middle Division.

(1) W. DUNKER: Monographie der norddeutschen Wealdenbildung, 1846, p. 20, pl. VII, fig. 9.

(2) A. G. NATHORST: Zur mesozoischen Flora Spitzbergens. Kgl. Svensk. Vet.-Akad. Handl., Bd. XXX, No. 1, 1897, p. 35, pl. I, figs. 25-27; pl. II, figs. 3-5; p. 58, pl. IV, figs. 1-18; pl. VI, figs. 6-8.

(3) O. HEER: Beitrage zur Jura-Flora Ostsibiriens und des Amurlandes. Flora Fossilis Arctica, Bd. IV, Abt. 2, 1876, p. 77.

(4) A. C. SEWARD: The Jurassic Flora of Sutherland. Trans. Roy. Soc. Edinburg, Vol. XLVII pt. IV, 1911, p. 684, pl. V, figs. 76, 77; pl. VIII, figs. 22-25, 30; text-fig. 10.

(5) O. HEER: Op. cit.

Genus *Brachyphyllum* BRONGNIART*Brachyphyllum* sp.

Pl. XXXVIII (III), Figs. 5, 5a, 6, 6a, 7, 7a.

In the present collection, there are a number of fragments of coniferous sterile branches of *Brachyphyllum* type, bearing appressed triangular leaves on the axis, but they are hardly specifically determinable. Some of them are figured in Pl. XXXVIII (III), figs. 5, 6 and 7; specimens in figs. 5 and 6 are badly preserved, while one in fig. 7 is beautifully preserved showing small triangular leaves appressed on the axis bearing branchlets (b) directed forwards in the middle portion of the figure. The leaves are distinctly keeled dorsally.

Plants possessing similar appearance have been described from Jurassic and Lower Cretaceous rocks of foreign countries under such names as *Brachyphyllum obesum* HEER, *B. crassicaule* FONTAINE, *B. expansum* (STERNBERG), etc. However, it is extremely difficult to distinguish specific types among fragments of sterile branches of such species.

Horizon: Lower Division.

EXPLANATION OF THE PLATES XXXVI (I)—XXXVIII (III)

The figures are in natural size, if not stated. The specimens are in the Department of Geology and Mineralogy, Faculty of Science, Hokkaidô Imperial University, Sapporo.

Plate XXXVI (I)

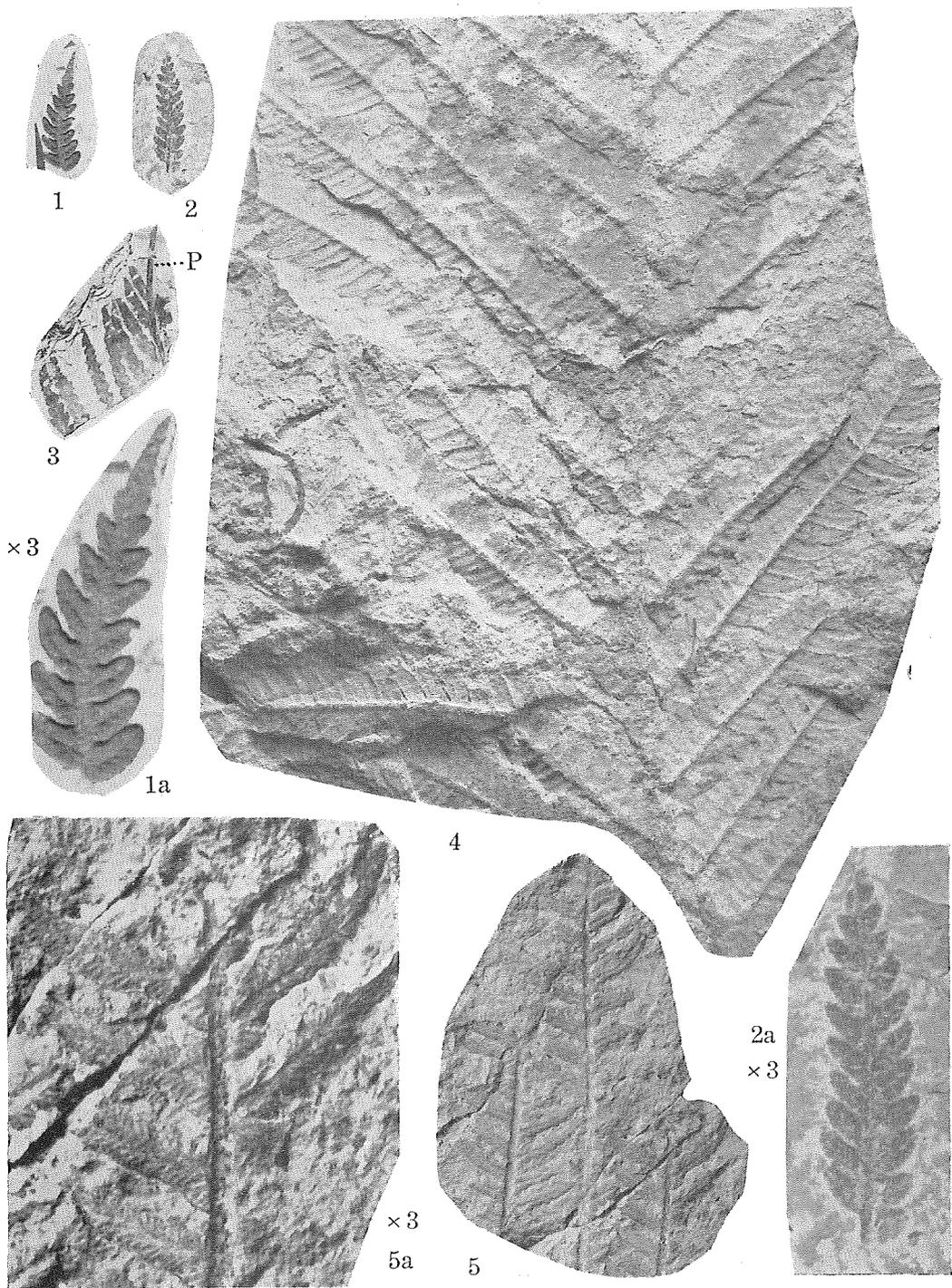
- | | |
|---------------------|---|
| Figs. 1, 1a, 2, 2a. | <i>Cladophlebis</i> sp. a. |
| Fig. 3. | <i>Sphenopteris</i> sp. with <i>Pityophyllum</i> (P). |
| Fig. 4. | <i>Cladophlebis exiliformis</i> (GEYLER). |
| Figs. 5, 5a. | <i>Cladophlebis</i> sp. b. |

Plate XXXVII (II)

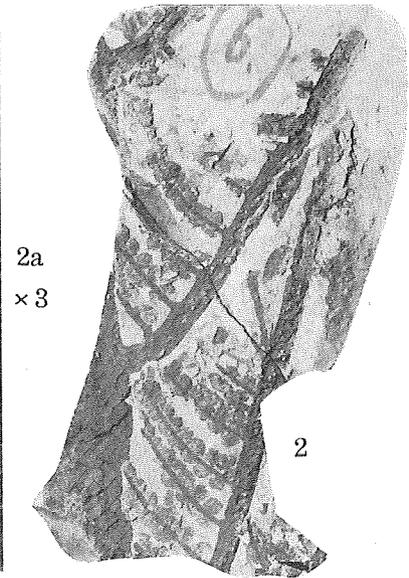
- | | |
|-----------------|--|
| Figs. 1, 2, 2a. | <i>Gleichenites nipponensis</i> ÔISHI |
| Fig. 3. | <i>Sphenolepidium Sternbergianum</i> (DUNKER). |

Plate XXXVIII (III)

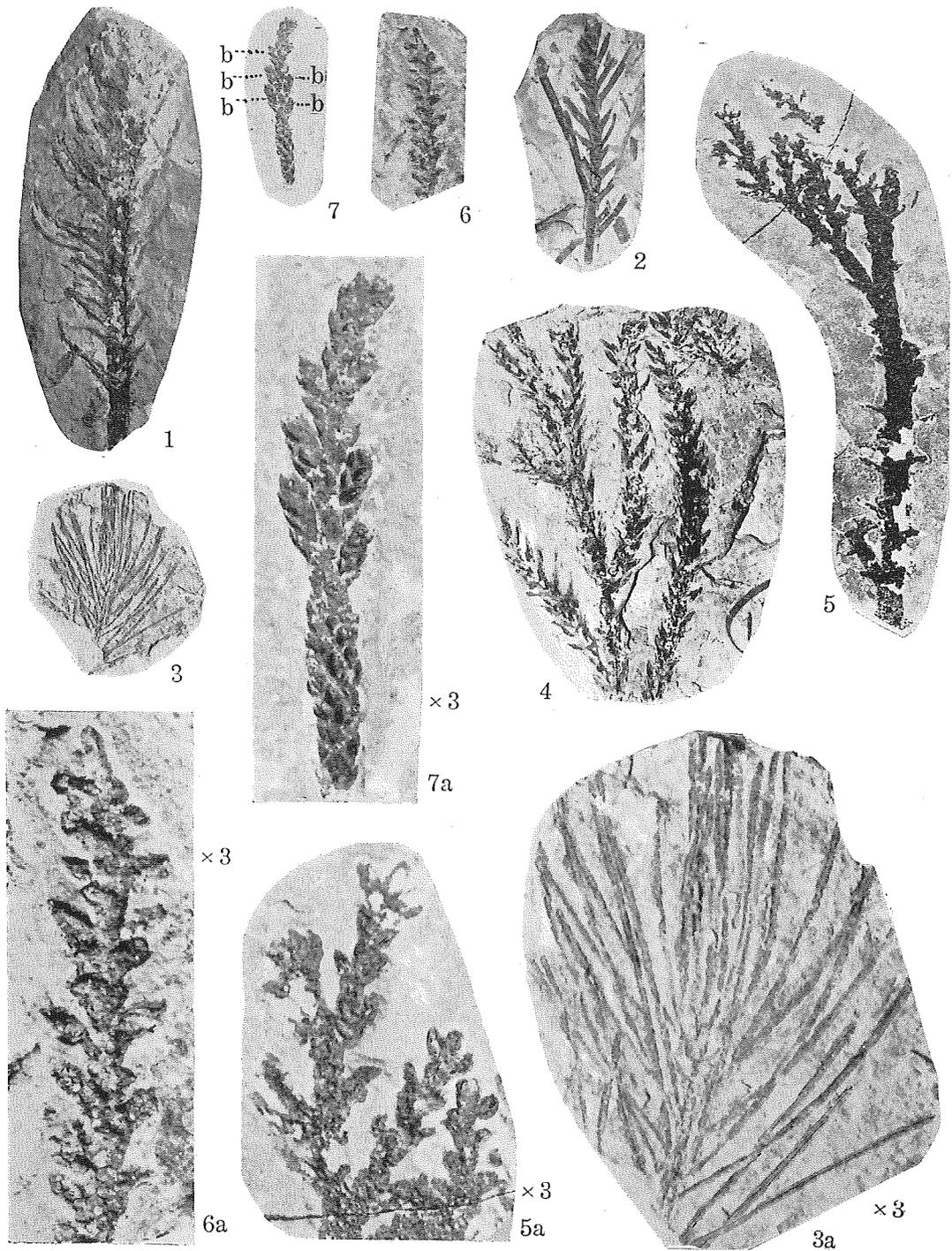
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|----------------------------|--|
| Figs. 1, 2. | <i>Elatocladus</i> (<i>Elatides</i>) <i>curvifolia</i> (DUNKER) ÔISHI n. comb. |
| Figs. 3, 3a. | <i>Pityites Iwaiana</i> sp. nov. |
| Fig. 4. | <i>Sphenolepidium Sternbergianum</i> (DUNKER). |
| Figs. 5, 5a, 6, 6a, 7, 7a. | <i>Brachyphyllum</i> sp. |



Kumano photo.



Kumano photo.



Kumano photo.