

ON THE OCCURRENCE OF *EMPLECTOPTERIDIUM* *ALATUM* KAWASAKI FROM THE SHANSI SERIES OF SOUTHEASTERN SHANSI

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(with 3 plates)

Among the plant fossils collected by Messrs. K. C. Yang, S. Wang and S. F. Peng during the geological investigation in southeastern Shansi in 1954, there are some considerable well-preserved specimens of *Callipteridium*-like frond which appear referable to the present genus. Most of the specimens were found from the Shansi Series at several localities: Changtsun, Shihkutsun, and Chaochiakou of Luanhsien, a few very fragmentary specimens have also been gathered from Wuhsianghsien, S. E. Shansi.

The genus *Emplectopteridium* was established by Kawasaki⁽¹⁾ in 1931, as a monotypic plant, for two fragmentary specimens derived from the upper part of the Jido Series in Chosen (Korea). He founded this genus chiefly on the ground that it is of *Callipteridium* type in the shape of the frond and pinnules, and is characterized by a more or less lonchopteroid aspect of the venation. The genus, so far as we are aware, is only known in Chosen. The discovery of many good preserved specimens of this plant in North China is therefore of interest.

The present material consists of more than forty specimens, which give a good idea of the large size and great variation of the frond of this species. A new amplified diagnosis is therefore given below:

Emplectopteridium alatum Kawasaki, emend.

Frond very large, much divided, tripinnate. Main rachis probably very thick, attaining at least a breadth on the impression of 6 mm at the upper portion of the frond, longitudinally striated and very sparsely punctuated, always provided with a kind of especially-developed intercalated pinnules or much reduced pinnae attaching to the upper surface of the rachis. Penultimate pinnae large, over 19 cm long, alternate, just touching or slightly overlapping each other at their margins, generally forming an open angle with the main rachis; their rachis moderate

thick, very finely striated and sparsely punctuated, and often laterally winged by decurrent lamina of the intercalated pinnules. Ultimate pinnae with stout rachis, comparatively narrow and long, linear, pinnatifid or roundly lobed, gradually narrowing to the acute or somewhat pointed apex, varying in size, alternate or subopposite, forming an angle of about 80° with the penultimate pinnae-rachis. Pinnules closely set, always confluent at the bases and much varying in shape and size even in the same pinna: those in the large pinnae of the lower portion of the frond or at the proximal part of the ultimate pinnae, oblong-ovate, more or less falcate, with obtuse or rounded apex, attaching to the pinna-rachis at a wide angle, generally of the pecopteroid or *Callipteridium*-type in outline; others in the small pinnae of the higher portion of the frond or at the distal part of the ultimate pinnae, often united one another, and separated only by a shallowly lobed sinus; still others in the apex of all the pinnae or towards the top of the frond, appearing only as slight undulations and merging into one another to form a long crenate or entire terminal pinnule. Anadromous pinnule or the basal pinnule on the anterior side of each ultimate pinna slightly reduced in size, while the one on the catadromous angle, i.e., the intercalated pinnule, being larger, broader in base and flatly deltoid in shape, this pinnule being strongly decurrent, and in most cases, borne directly on the upper surface of the rachis just a little below the immediately higher ultimate pinna and distinguishably uniting with the next lower anadromous pinnule. The same is the case in the main rachis, but the intercalated pinnules between each two of the penultimate pinnae, being instead of a sort of much reduced, abnormal pinnae or especially-developed intercalated pinnules which are generally two in number; and in the space between the two reduced pinnae themselves as well as between the lower, larger one and the precedingly normal penultimate pinna, there also occurring the same state of intercalated pinnules as those prevailing on the rachis of the penultimate pinnae. Lamina moderate thick and the pinnules often with recurved margins. Venation distinct, varying in considerable degree; midrib of the large pinnules, fairly distinct, not decurrent or slightly flexuous, dissolving a little below the apex, whereas that of the small ones, often not much thicker than the lateral veins; lateral veins arising from the midrib at an acute angle, and some of them entering each pinnule directly from the pinna-rachis, often anastomosing to form 1-3 rows (mostly 2 rows) of elongated polygonal meshes close to the midrib or within a distance of 2 mm from their origins, but most freely branching to meet the margin oblique-

ly; venation of the less divided, crenate or entire, pinnules, similar to that of the large ones, excepting the midrib being very inconspicuous or lacking; the same venation may be met both in the intercalated pinnules and in the intercalated reduced pinnae. Fructifications unknown.

One of the most remarkable and beautifully preserved specimens is figured in pl. 1, fig. 1 and a portion of it is enlarged twice in pl. 2, fig. 1. This is an impression of the lower surface of the frond which displays fairly the general habit of the frond, and the characteristic anastomosing nervation and also reveals the much reduced intercalated pinnae (or the especially well-developed intercalated pinnules) and the intercalated pinnules both on the main rachis and on the rachis of the penultimate pinnae. There is a considerable variation either in size or in shape of the pinnae and of the pinnules. The longest penultimate pinna preserved in this specimen measures at least 19 cm in length, without being complete, and is 7-8 cm in breadth; the ascending ones, only decreasing gradually in size towards the upper portion, are all attached alternately to the upper surface of the main rachis. The mode of attachment both of the penultimate pinnae and of the ultimate pinnae, though indistinct in most specimens, is rather well preserved in the upper part of this specimen which is more clearly shown in the enlarged figure in pl. 2, fig. 1. From this specimen both the base of the pinnae and the decurrent lamina of the accompanying intercalated pinnules are found obviously to be attached to the upper surface of the rachis; and the same state is recognized in another specimen shown in pl. 3, fig. 5. The ultimate pinnae of this largest specimen, showing a comparatively uniform in size, are only 3-4 cm long and seldom exceed 1 cm wide. The form of the pinnules or the degree of the dissection of the ultimate pinnae usually varies with the position on the frond. They are more or less shallowly divided or undulate in its lower part, becoming gradually almost entire towards the summit.

The specimen in pl. 2, fig. 3, at the first glance, appears to have a somewhat different aspect in comparison with the just mentioned specimen (pl. 1, fig. 1) which is rather complete and is considered to be the most typical of the present plant. In this specimen (pl. 2, fig. 3) the ultimate pinnae are larger, the pinnules are rather deeply divided and the midrib is more distinctly marked in all of its pinnules, even nearest to the apex. A closer examination shows, however, that there is no important difference between this specimen and the longest penultimate pinna of the above-mentioned largest specimen though certain distinctions between

the former and the upper portion of the latter is pronounced. But these differences, as remarked in the diagnosis, are probably due to the fact that the ultimate pinnae as well as the venation of the pinnules may be varying much according to the position of the frond. It is therefore not unreasonable to suppose that the specimen shown in pl. 2, fig. 3 might belong to the penultimate pinnae of the more lower portion of the frond.

An interesting specimen seen in pl. 2, fig. 2 was collected from another locality of the same district, the frond is of much smaller size with more delicate habit. It gives a first impression of being imperfectly developed frond of a distinct species. In regard to the shape of the pinnules and the pattern of venation (pl. 2, fig. 2a), this specimen differs in no essential respect with the other specimens. This specimen belongs certainly to the same species and also represents a penultimate pinnae derived from the lower portion of the frond.

The venation of all the specimens is characterized by the sparsely anastomosing elongated meshes as well as by some veinlets or lateral veins arising directly from the pinnae-rachis. Judging from the outline of the pinnules and from its very conspicuous midrib, the specimen figured in pl. 3, figs. 6 and 6a might be a fragment of the penultimate pinnae belonging to the lower portion of the frond, and the venation of this specimen is perhaps the most common type of this plant. Another type of venation is shown by the specimen in pl. 3, figs. 3, 3a and 4, which are more or less comparable to certain forms referred to *Desmopteris*. The almost undivided ultimate pinnae strongly suggest that they ought to be the upper or the uppermost portion of the frond. All the lateral veins are dividing most freely into fascicles, and the characteristic elongated meshes, however, can be clearly seen near the axis and near the pinnae-rachis. The venation of an intermediate aspect, i. e., a transitional type between the above two types is illustrated in pl. 2, fig. 1. This figure is enlarged from a portion of the specimen in pl. 1, fig. 1. It is noteworthy that a somewhat inconspicuous midrib is present in the more or less developed pinnules.

An illustration supposing to be the rachis of a penultimate pinna of this species afforded by the specimen in pl. 3, fig. 2, this specimen was found from the same locality with the specimens shown in pl. 2, figs. 3-4 and in pl. 3, fig. 1, etc. It has a very thick rachis with distinctly punctate markings. At least 8 basal parts of the ultimate pinnae-rachis are still attaching to the left side (only 2 preserved in the right side) of the rachis. This specimen might also belong to the lower

portion of the frond.

Except the largest specimen figured in pl. 1, fig. 1, all the specimens here described agree in the general habit of the frond, in the shape and size of the pinnules as well as in the peculiar anastomosing nervations, and almost in every respect with the typical representatives of this species described and illustrated by Kawasaki from the Jido Series of Chosen, and there is no doubt as to their specific identity. The original material from Chosen is very meagre and poorly preserved, thus the whole habit of the plant was rather obscure. The present material has shown more clearly the general habit and the great variation of the frond. We know that the original specimens of Kawasaki represent only two fragments of the penultimate pinnae of this species.

The relations of *Emplectopteridium* to other known forms has been dealt with by Kawasaki in the discussion of the genus. Kawasaki has pointed out that this interesting plant closely resembles *Callipteridium* in the habit of the frond and in the shape of the pinnules, and has a type of peculiar venation intermingled with that of *Emplectopteris*, *Lonchopteris*, *Palaeoweichselia* and *Callipteridium*. He also noted that among all the allied plants, the present species is most comparable to the two oriental forms known as *Emplectopteris triangularis* Halle and *Callipteridium koraiense* (Tokunaga). It differs easily from *Lonchopteris* (including *Lonchopteridium*) and *Palaeoweichselia* in having the intercalated pinnules winged strongly on the upper surface of the pinna-rachis, and from *Emplectopteris*, chiefly in that the nervation of the present form is, in most cases, with a marked midrib and some lateral veins always entering the base of the pinnules direct from the pinna-rachis, while in *Emplectopteris*, as stated by Halle, the midrib is often indistinct and no lateral veins arising directly from the pinna-rachis; *Emplectopteridium* is also distinguished from *Callipteridium* by the characteristic anastomosing venation.

In 1935, Jongmans and Gothan⁽²⁾ have instituted a new genus *Dictyocallipteridium* that strongly recalls the present form. As pointed out by Jongmans and Gothan, the Sumatra plant differs from Kawasaki's genus in the absence of the intercalated pinnules and in the more loose anastomosing venation. The same authors state that even after a careful study of the published photographs by Kawasaki, the anastomosis of the Chosen specimens cannot be observed. The *Emplectopteridium alatum* from Chosen is thus considered by them as a "Homolog-Form" of the *Callipteridium mengkarangense* Jongmans et Gothan. It is interest-

ing that the discovery of a more rich material of our locality confirms that the descriptions of Kawasaki are fairly correct. The question of identity between the genera *Emplectopteridium* and *Dictyocallipteridium* must, however, be left open for the present, since no characteristic intercalated pinnules have yet been known in the Sumatra specimens.

Comparison should also be made with the plant first described by Lesquereux⁽³⁾ as *Neuropteris moorii* and subsequently proposed by Schimper⁽⁴⁾ as the type of the new genus *Lescuropteris*. The venation of the type-specimens of the American species, according to both the illustration by Lesquereux and Schimper's diagnosis, is quite different from either that of *Emplectopteris* or that of the present genus. Prof. Halle⁽⁵⁾ is of the opinion that the diagrammatic drawings of Lesquereux's original work perhaps do not represent the venation quite correctly. Halle believes also that the essential characters of *Lescuropteris* are generally not different from those of *Emplectopteris*. These two genera are latter considered respectively by Darrah⁽⁶⁾ (see Darrah 1939, p. 172, 186) and Arnold⁽⁷⁾ (see Arnold 1947, p. 166, 234 & 246) to be probably generic identity. It is clear that *Emplectopteridium* can also be separated from *Lescuropteris* through the more pectopteroid form of pinnules and the characteristic nervation.

Like the genus *Emplectopteris*, the present plant is most probably not a Fern but a Pteridosperm, though nothing is at present known about the productive organs.

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The generalized columnar section of the Changtsun region, Luanhsien given by Mr. S. Wang (text-fig. 1 in Chinese text, p. 179) shows the essential lithological character of this formation and the position of the beds from which the most specimens here described were collected. In addition, the following account has been informed by Mr. Wang:

"The mentioned specimens of *Emplectopteridium*, marked by the field number LOFO 50, LOFO 51, and LOFO 53, are most abundantly coming from the yellowish grey shaly-sandstone beds lying only 3-15 m above a main workable coal seam of the Shansi Series (sens. restr.), which can be correlated with the Upper Yuenkou Series of Central Shansi. Doubtful remains (LOFO 47) of the same species occurs also in a higher horizon which is at about 6 m below the base of the Lower Shihhotze Series."

The age of the *Emplectopteridium*-bearing beds is thus most probably upper

Stephanian or Permo-Carboniferous⁽⁵⁾. The plant-association of these horizons shows, however, that it seems to be corresponding to the Lower Shihhotze Series or the Lower Permian. It contains the following species:

- Calamites cisti* Brongniart
- Sphenophyllum thonii* Mahr
- Pecopteris arcuata* Halle
- Asterotheca (Pecopteris) hemitelioides* Brongn.
- Alethopteris* (?) cf. *ascendens* Halle
- Cladophlebis* cf. *nystroemii* Halle
- Taeniopteris nystroemii* Halle
- Cordaites principalis* (Germ.)
- Carpolithus* spp. etc.

All these forms occur most commonly in the Shihhotze Series in Central Shansi as well as in the equivalents in other parts of North China. The presence of *Sphenophyllum thonii* Mahr in this Series is notable, since it is usually considered to be one of the characteristic elements of the Lower Permian though it has also very rarely been recorded in the Stephanian*. On comparing this florule with that from the upper part of Jido Series in Chosen, we find that they are approximately of the same composition. The upper part (bed D) of the Jido Series which contains also coal seams, and from which the type-specimens of *Emplectopteridium alatum* were derived is held by many authors^(4,7) to be corresponding roughly, but not precisely, to the Lower Shihhotze Series of Central Shansi, and it is generally regarded as Lower Permian. Accordingly, it would seem better to consider the *Emplectopteridium*-bearing formation, i.e., the Shansi Series in South-eastern Shansi, to be contemporaneous with that of the Jido Series, being also Lower Permian in age.

The most serious objection to placing the *Emplectopteridium*-bearing formation of S.E. Shansi in the Lower Shihhotze Series is the fact that, according to field observations of the collectors, this formation is most probably equivalent to the Shansi Series of Central Shansi (see the columnar section in the Chinese text, p.179). It should be considered as Stephanian-Permian at the present.

In Kaiping coal field of the Hopei province, the lower part of the Chaoko-

* Sze, H. C., 1934. Ueber die Palaeozoische Flora der Provinz Suiyuan. Bull. Geol. Soc. China, p. 597; & Halle⁽⁴⁾, p. 261.

chwang Series contains also coal seams with both some Permian elements such as *Taeniopteris multinervis* Weiss, *Tingia carbonica* (Schenk) etc. which are very characteristic plants of the Lower Shihhotze Series and the typical Stephanian species *Neuropteris pseudovata* Gothan et Sze, being only known from the Yumenkou Series of North China. Mathieu and Stockmans⁽⁹⁾ assigned these intermediate horizons also to Stephano-Permian.

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