NOTES ON SOME JURASSIC PLANTS FROM THE RAJMAHAL HILLS, BIHAR, INDIA

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ABSTRACT

A few interesting plant impressions are described out of an old collection made by the author and his friends in 1934 from the Rajmahal Hills. It includes two new species of *Rhizomopteris* (*R. Sahnii* and *R. rajmahalense*), one new species of *Cladophlebis* (*C. Srivastavai*), one new species of *Cycadeospermum* (*C. indicum*), one new species of *Coniferocaulon* (*C. rajmahalense*), and one new species of *Cycadolepis* (*C. indica*).

Besides an impression of a *Williamsonia* flower some cycadean seeds and stems have been figured. All the fossils are characteristic of the Rajmahal flora.

INTRODUCTION

DURING excursions in the Rajmahal Hills, a large collection of fossil plants was made by the author alone and also in the company of the late Professor B. P. Srivastava and Dr. H. S. Rao. The collection included petrifactions as well as impressions. The petrifactions were worked out by Srivastava (1945) and the impressions by me. The author published an abstract on these fossil impressions (GUPTA, 1936), but unfortunately detailed descriptions remained in the manuscript form which could not be published so far. There are, however, some specimens in the collection which are worthy of being recorded and these form the subject-matter of the present communication. In fact, the materials for my papers on *Williamsonia Sahnii* (GUPTA, 1943) and *Hausmannia indica* (in press) too belong to this very collection. At that time many of the places from where the collections were made were also new; though since then these fossiliferous localities have been visited by many subsequent workers. These places had then yielded many well-known plant fossils, characteristic of the Rajmahal flora (*see* TABLE 1). All or most of these are preserved at the Birbal Sahni Institute of Palaeobotany, Lucknow.

Since the classical work of Oldham and Morris (1863) and Feistmantel (1877-1881) the only notable contributions to the study of fossil plants from the Jurassic of Rajmahal Hills are papers by the late Professor B. Sahni and his school of palaeobotanical workers.

The locality *K* near Nipania has yielded by far the best material of silicified flora and whose investigation has contributed substantially to our knowledge of the petrified flora of the Jurassic times in general and that of the Rajmahal Hills in particular. The recognition of a new group of fossil gymnosperms, namely Pentoxileae, by the late Professor Sahni (1948) was the last but not the least important publication from the pen of that doyen among the botanists of India. The latest reference to our knowledge of the Indian Jurassic flora is a review by Dr. R. V. Sitholey (1954) submitted at the last International Botanical Congress, Paris. A few of the more important plant impressions out of those old collections are now described here.

LOCALITIES

1. *G.* Bartala, about a mile south-east of Mirzachowki, the exposure was different from the one described by Sahni and Rao (1933).
2. *I.* Nipania, at the head of a ravine, half a mile east of Nipania.
3. *K.* Nipania, in an inlet valley on a footpath leading from Nipania to Badapahar towards Domarchir (*see* PL. 1, FIG. 1).
4. *N.* Paharpurchhota, about one-third of a mile west of the main village.
5. *Q.* Banchapa, same as described by Sahni and Rao.
6. *R.* and *S.* Saharpur and Rampur, five or six miles east of Amrapara, with numerous exposures.
7. *W.* Khairbani, same as described by Sahni and Rao and lies to the west of Banchapa.

DESCRIPTION

1. *Rhizomopteris Sahnii* sp. nov.

Pl. 1, Figs. 2-5; Text-figs. 3a, b
Specimens W. 5, 6, 7, 8

Diagnosis — Impressions of creeping rhizomes, about 15 mm. broad, with no sign of

TABLE I — THE SPECIES THEN RECORDED FOR THE FIRST TIME FROM THE LOCALITIES NAMED

Species	Localities							Remarks
	1 G	2 I	3 K	4 N	5 Q	6 R & S	7 W	
Equisetales								
1. *Equisetites* (cf. *E. rajmahalense*) O & M.	×	×	...	...	...	...	...	
Filicales								
2. *Gleichenites gleichenoides* O & M.	...	...	...	...	...	...	×	
3. *Sphenopteris Hislopi* O & M.	...	...	...	...	×	...	×	
4. *Cladophlebis indica* O & M.	...	...	...	...	×	...	×	
5. *Coniopteris hymenophylloides* Brong.	...	...	×	...	...	...	...	
6. *Hausmannia indica* Gupta	...	...	×	...	...	...	...	Paper in press
Cycadales								
7. *Nilssonia fissa* Fst.	×	×	×	...	...	...	...	
8. *Taeniopteris spatulata* McCl.	...	×	×	...	...	...	...	Now known as *Nipaniophyllum*
9. *T. McCllelandi* O & M.	...	×	×	...	...	×	...	
10. *Ptilophyllum acutifolium* O & M.	...	×	...	×	×	...	...	
11. *P. tenerrimum* Fst.	...	×	...	×	...	...	...	
12. *Nilssonia princeps* O & M.	...	...	×	...	×	...	...	
13. *Dictyozamites falcata* Morr.	...	...	...	×	...	...	...	
14. *Williamsonia Sahnii* Gupta	...	...	...	...	...	...	×	
Coniferales								
15. *Araucarites cutchense* Fst.	...	×	...	×	...	...	...	
16. *Conites* sp.	...	×	...	...	...	...	...	Really belongs to Pentoxyleae
17. *Brachyphyllum* sp.	...	...	×	...	...	...	...	
Incertae Sedis								
18. Silicified woods	×	×	×	×	×	×	×	

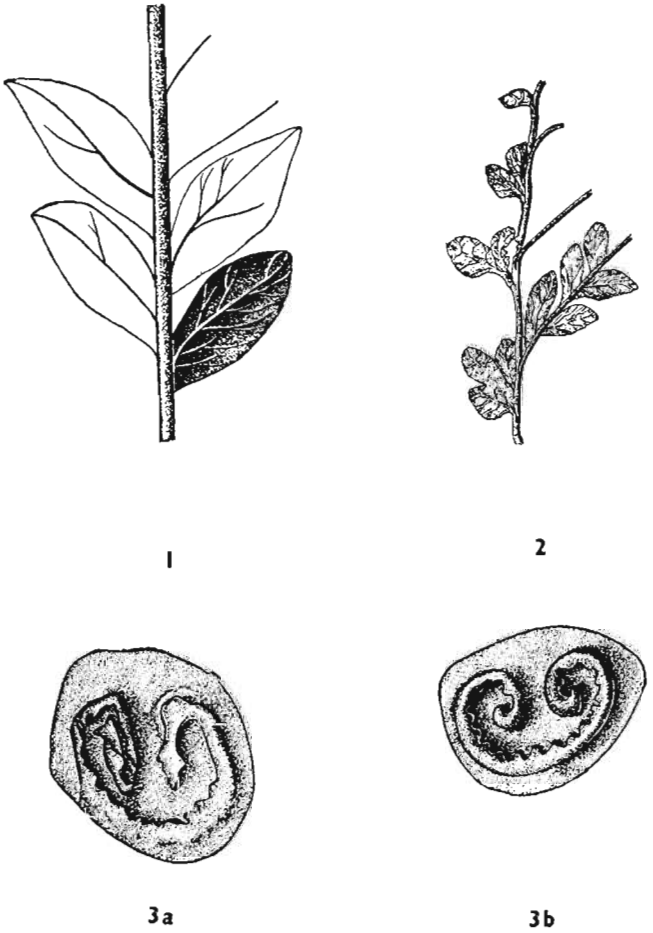
forking; covered with numerous petiolar bases, measuring about 3-5 mm. across and almost circular in shape. Leaf traces roughly U-shaped with incurved margins, inner margin of the trace plicated, containing about 20 projections marking the position of the protoxylem; rhizomes covered with numerous irregularly disposed roots, the latter arranging themselves somewhat concentrically round the bases of the petioles. They may belong to Dipteridaceae or Matoniaceae.

The specimens described under this name, though somewhat fragmentary, are easily referable to the artificial genus *Rhizomopteris* Schimp. The genus includes twenty species or more belonging to different origin and from different countries.

The surface features of this creeping rhizome which became somewhat flattened before fossilization are clearly seen. There are four blocks (W. 5, 6, 7, 8) reproduced in natural size (Pl. 1, Fig. 2). They have the impressions of not less than five petiolar stumps and numerous roots that clothed the rhizomes. The rhizome is about 15 mm. broad with no evident sign of forking as found in *R. Balli* Fst. from the Atgarh Sandstones (Feistmantel, 1877) or *R. Schenki* Nath. (1876) and *R. cruciata* Nath. (1906) from the Rhaetic of Sweden. The latter species also possess a different petiolar structure and show no definite arrangement of roots as in the present specimens.

The rhizome, which is about 15 mm. broad as mentioned above, is covered all over with numerous round scars (Pl. 1, Figs. 3-5). These scars, evidently left by adventitious roots, are arranged in an irregular manner except round the base of the petioles where a somewhat concentric arrangement is seen (Pl. 1, Fig. 3). The bases of the petioles were, so to speak, well protected by the roots. The central dot marking the position of the root stele is not clearly seen.

The leaf trace supplying the fronds was roughly U-shaped with the free margins curved inwards. The structure of the petiolar trace is very much like a matoniaceous leaf trace with numerous projections towards the inside (Pl. 1, Figs. 3, 4; Text-figs. 3a & 3b). These projections, nearly twenty in number, probably mark the positions of the protoxylems. Somewhat similar scars described as eye-shaped on a stem known as *Rhizomopteris chakshu* were recorded by Ganju (1946). A comparison in general, however, can be made with *R. Etheridgei* Sew. from the Jurassic of Victoria (Seward, 1904) and *R. Gunni* Sew. from the Jurassic of Southerland (Seward, 1911), but the detailed structure of the petiole is quite different in the two cases.



TEXT-FIGS. 1-3 — 1, *Cladophlebis Srivastavai* sp. nov., a few pinnules showing the venation on the pinnae. 2, *Cladophlebis Srivastavai* sp. nov., showing different abnormal types of pinnae on the main rachis (cf. FIG. 7, PL. 2 at P). 3a and b, *Rhizomopteris Sahnii* sp. nov. Two of the petioles drawn to show matoniaceous type of leaf trace. Diagrammatic.

The locality from where these specimens are described abounds in ferns like *Gleichenites*, *Marattiopsis*, *Sphenopteris*, etc. An undoubted specimen of *Hausmannia* has been described by the present author from the same locality. But no definite opinion can be expressed as to the affinities of *Rhizomopteris Sahnii* sp. nov. without further data, although its petiolar structure is similar to *Dipteris* or *Matonia*.

2. *Rhizomopteris rajmahalense* sp. nov.

Pl. 2, Figs. 9, 10

Specimen I. 43

Diagnosis — Impressions of underground or aerial fern rhizomes, longitudinally grooved, with numerous leaf scars. Each leaf scar 5-20 mm. long and roughly C-shaped with curved and overlapping margins; leaf scars crowded on one side; possible root traces preserved at some places. Affinities unknown.

The specimen here described, though somewhat puzzling, is undoubtedly filicinean in its nature and can very well be described under *Rhizomopteris* Schimp. It is about 11 cm. long and 5 cm. broad in the broadest region. There are longitudinal grooves which are interspersed with numerous leaf traces, arranged in an irregular manner. The latter are roughly C-shaped with overlapping margins. The horizontally lying rhizome, or the stem, seen in Pl. 2,

Fig. 9, is either dividing on one side or the latter represents only its broader end. However, it is certainly narrower on the opposite side bearing crowded and smaller leaf traces.

The details of the structures of the leaf trace are not clearly made out, there being no trace of the number of the vascular bundles supplying these leaf traces. But there are some round dots with a central elevation (PL. 2, FIG. 10) possibly marking the position of the roots. It is not possible to study the specimen in sections or in any other way; but it is certain that we are dealing here with an undoubted specimen of some fern stem or rhizome. Comparable structures have not so far been figured from the Indian Jurassic strata. Neither it is possible to compare the present specimen with any of the known species of *Rhizomopteris*.

3. ? *Rhizomopteris* sp.

Pl. 1, Fig. 6

The specimen here figured is too poorly preserved to be described in detail, but there are some indications that it represents an impression of some fern rhizome or stem. It is found on the same block (W. 8) on the other side of which is preserved *R. Sahnii* sp. nov. described above. There is a small bit of a rhizome which is curved and covered over with numerous small dots. These dots are undoubtedly left due to the falling away of the roots. Nothing definite, however, can be said about the specimen.

4. *Cladophlebis Srivastavai* sp. nov.

Pl. 2, Figs. 7, 8; Text-figs. 1, 2

Specimens G. 1, 2, 12, 16

Diagnosis — Fronds bipinnate, pinnae long and narrow, 10 cm. long and 5-7 mm. broad, on a slender rachis at an acute angle. Pinnules short, bluntly pointed, densely crowded in the lower half on the pinnae rachises; venation typically of the *Cladophlebis* type. Habit somewhat recalling that of *Todites Williamsoni*.

The fronds are bipinnate, each pinna being as much as 10 cm. long bearing pinnules nearly 5 mm. in length. The pinnae are arranged in an alternate manner on the main rachis (PL. 2, FIG. 7) which is not very stout; it is only a millimetre in thickness. The pinnules are comparatively small (5 mm.) than is usually the case with *Cladophlebis* species. They are bluntly pointed towards the free end and attached to the pinna rachis by a broad base (TEXT-FIG. 1; PL. 2, FIG. 7) at a wide angle. The margin is probably not quite smooth, although no definite dentations are visible. Some of the pinnules are of different character and are directly attached on the main rachis (PL. 2, FIG. 7) at P. That these are pinnules of different type and not the bases of the ordinary pinnules is clear from the bifurcating veins found on the margin of the pinnules, and in this respect a comparison is possible with *C. Brauni* and *C. Albertsii* from Greenland (SEWARD, 1925). The venations in the pinnules are typically of the *Cladophlebis* type. There is a main vein from which arise a number of bifurcating veinlets (TEXT-FIG. 1) arranged in an alternate manner.

The habit and structure of the species described under this name, though altogether different from any one so far known from the Rajmahal Hills, betray clearly its *Cladophlebis* nature in all its essentials. *Cladophlebis* has a very wide distribution in the Jurassic strata, commonly known from England, South Africa, Australia, Grahamland, etc. The species of this genus show a wide range in the form of the pinnules; but in some cases, e.g. *C. indica* and *C. undens*, the sporangia are also known. The present material has certain characters which, in their vegetative condition, are distinct enough from the well-known Indian species, *C. indica*. The habit is very much like that of *Todites Williamsoni* and the specimens figured by Seward (1900) from the Jurassic of Yorkshire and by Seward and Ford (1903) are worth comparing with the present one at least in their habit. The other species of *Cladophlebis*, bearing some resemblances with this type, are *C. nebbensis* Brongn., *C. browniana*, *C.* (*Klukia*) *exilis*, *C. Roesserti* Harr., *C. lobifolia*, *C.* (*Todites*) *Williamsoni* var. *tenuicaulis*.

5. *Williamsonia* sp. (cf. *W. indica* Sew.)

Pl. 3, Fig. 11

Specimen F. 145

The specimen was found at Onthea, a well-known locality and a place familiar to geologists since the time of Feistmantel, in a soft cream-coloured rock. Although the specimen is poorly preserved, the impression

of the overlapping bracts is clearly seen. They are narrow and linear as found in *Williamsonia* species which are figured by Feistmantel (1877) and Seward and Sahni (1920) and which are now known as *W. indica* Sew. (1917). The present flower is associated with numerous leaves of *Ptilophyllum tenerrimum, Nilssonia princeps* and *N. fissa*. Similar forms of *Williamsonia* are recorded by Wieland (1916) from Mexico as *W. Quetzaltoatl* and *W. texcatzoncatl*. Wieland's Mexican species like *W. xicotencatl* and *W. Cuauhtemoc* may also be compared with the Indian specimen.

6. *Cycadeospermum indicum* sp. nov.

Pl. 3, Figs. 13, 14

Specimen F. 144; G. 24

Diagnosis — Impressions of isolated seeds. Size about 15 × 30 mm. resembling modern *Cycas* in shape, being oval and smooth. Micropylar end rough and attenuated.

The specimens here described from two different localities are referable to the artificial genus *Cycadeospermum* Nathorst. Although the details of the structure are not available on the cast or the mould, their shape and size could be compared with similar seeds described elsewhere.

The seeds are ovate or round and smooth, measuring about 15 × 30 mm. The micropylar end, when preserved, is rough and attenuated. Oldham and Morris (1863) have figured some cycadaceous seeds from various localities in the Rajmahal Hills; but they are decidedly smaller (5-10 mm.) in diameter. The latter are also of different shape, usually roundish. More comparable seeds have been described by Wieland (1916) from the Liassic of Mexico under the name *Cycadeospermum oaxacense*. The general outline of both the seeds figured here could very well be compared with some of the modern seeds of Cycadales, e.g. *Cycas*. Some seeds probably cycadaceous have also been described under the name *Carpolithus* Linn. An unusually well-preserved specimen was described as a species of *Carpolithus* from the Wealden of Sussex which measured about 18 × 11 mm. (SEWARD, 1895). This is certainly comparable in size with the present specimen, but its shape and surface features are quite different.

7. *Coniferocaulon rajmahalense* sp. nov.

Pl. 3, Figs. 15, 16

Specimen I. 36

1913. Bancroft, " Coniferocaulon sp.", Pl. 9, Fig. 2; Appendix Text-fig. 1. 1931. Sahni, " Coniferocaulon sp.", Pl. 12, Fig. 53

Diagnosis — Coniferous stem impressions from the Rajmahal series; the surface is irregularly grooved in a transverse direction, with occasional elliptical protuberances. Possible branch scars preserved, being oval in shape with a central elevation. Internal structure not known, possibly coniferous.

The present specimen is probably better than any one so far described from India (BANCROFT, 1913). It also contains a few branch scars. These scars (8 × 5 mm.) are oval in shape with a central elevation. The branches seem to have grown horizontally from the main stem in a manner somewhat comparable to the modern Araucarias and some other conifers. The surface features are otherwise similar to those figured by Bancroft and Sahni, though in their specimens no undoubted leaf or branch scars can be distinguished. The material of such specimens being so common in the Rajmahal Hills deserves a specific name in order to distinguish it from other similar stems like *Benstaedtia* species or the Lower Cretaceous species like *Coniferocaulon colymbeaeforme*.

8. *Cycadolepis indica* sp. nov.

Pl. 3, Fig. 12

Specimen Q. 4, 5

Diagnosis — Thick leathery leaves, scales or stipules up to 8 cm. long and 7 cm. broad, broader at the free end, margin deeply lobed in the young condition. Well-defined midrib absent, veins somewhat parallel in the basal region, diverging towards the margin while forking two or three times.

The definition of this generic name as extended by Seward (1903) includes bud-scales of cycadean fronds, scale-like leaf structures of cycadean plants of variable sizes, petiolar bases, carpellary and antheriferous scales without the traces of ovules or pollen sacs and, lastly, the protective scales of the vegetative leaves or fertile shoots. Stipular organs could, however, be conveniently added to this artificial genus. The three specimens, five including those mentioned by Sahni and Rao (1933) without further proof of any relationship, can be rightly referred to this genus, specially in

view of their resemblances with the specimens described by Seward (1903) from South Africa.

The biggest and probably the oldest leaf is about 8 cm. long and 7 cm. broad in the broadest region. The margin is folded, but the curling is not so pronounced as in the younger leaves (not figured here) where the folds are deep and numerous. The venation is quite distinct towards the margin. The veins that are running somewhat parallel in the lower half of the leaf begin to diverge and bifurcate twice or thrice before reaching the margin. No anastomoses are discernible. The impression of the younger leaves suggests that they may be of the nature of protective bud-scales.

Although numerous species of *Cycadolepis* are described from many places the majority of them such as *C. villosa* Saporta and *C. hirta* Saporta (1875); *C. maxicana* Wieland (1916) and *Cycadolepis* sp. described by Halle from Grahamland (1913) bear no comparison with the Indian form. Feistmantel's (1876) figure of *C. pilosa* from Bhoojooree (Kach) is absolutely not comparable in its size and structure; so also the *Cycadolepis* sp. from the Upper Gondwanas of the Madras coast (FEISTMANTEL, 1879, PL. XIV, FIGS. 10-12; PL. XV, FIG. 10) differ in having a broad base and small size from the present specimen. In 1933 Sahni and Rao described some specimens of *Cycadolepis* from the Rajmahal Hills, but did not figure them. They think that *Cyclopteris Oldhami* Fst. (FEISTMANTEL, 1877, PL. XXXIII, FIGS. 5, 6) from Bindrabun is not a fern, but should be referred to *Cycadolepis*. I agree with them, but the present specimens are quite different from all these. Most of the specimens referred to above are small in size and broader at their base and some of them possess hairy margins, whereas the present specimens are narrower at the base, thicker in texture, bigger in size and there seems to be no trace of hairs.

Lastly, it is also not possible to identify the present specimens with *C. jenkinsiana* Tate as figured by Seward (1903), because of the different size in the two cases and because of the different structure of their margin. The only useful comparison that can be made with the present specimens is with those figured from the Cape Colony, though there are a few minor differences. The Indian species has no well-defined midrib as found in the African leaf (FIG. 5 as given by SEWARD, 1903). Secondly, the Indian species has deeply folded margin and the veins divide a number of times before reaching at the margin of the leaf. These differences, coupled with the idea of their distribution in space, provide arguments in favour of creating a new species.

9. *Stem, Probably Cycadean*

Pl. 4, Figs. 17-19

Specimens J. 1-8

The specimens here described comes from Bhutahah, a locality described by Sahni and Rao, and seem to belong to the cycads though we cannot assign them to their proper systematic position. These are about an inch in breadth and covered over with wrinkles which look like rhomboid marks. However, this appearance is probably due to compression and not due to any structural features. But the more important feature of these impressions is the occurrence of small round or oval cavities (PL. 4, FIGS. 17, 18) at regular intervals (distances of an inch apart). These cavities, about 5 mm. in diameter, almost certainly mark the position of either buds or some sort of thick petioles. In the latter case they could be classed under *Rhizomopteris* Schimp. and then could very well be compared with similar though smaller structures which have been figured by Feistmantel (1876) from Kach.

10. *Stem Impressions*

Pl. 4, Fig. 20

Specimens Q. 1-3, all counterparts

Many such specimens and bigger than the one figured here were seen in the field on grey-coloured rocks, some of them measuring as much as a metre in length. They present an appearance as if the stems are ' worm eaten ', but probably it has something to do with the internal structure of the wood of these stems. On the left of Fig. 20 is seen a big smooth scar from where a leaf or a stipule-like organ seems to have fallen. The size and the surface marks indicate that the nature of these organs may have been similar to *Cycadolepis indica* sp. nov. described above. However, the impression of the entire stem looks problematical and its affinities cannot be deciphered at present.

ACKNOWLEDGEMENT

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EXPLANATION OF PLATES

PLATE 1

1. A general view of Nipania, showing the flat topped hills in the background and the fossiliferous locality *K* in the fore-ground.

2. *Rhizomopteris Sahnii* sp. nov. Three different blocks (W) showing the rhizomes with bases of the petiole. Natural size.

3. Same. One of the petiole bases enlarged to show its shape and the leaf trace; surrounding the petiole base are numerous regularly arranged root scars. × 5.

4. Same. Another petiole base enlarged. × 5.

5. Same. Root scars highly magnified. × 30.

6. *Rhizomopteris* sp. Preserved on the reverse side of the same block (W. 8) shown in Fig. 2. Natural size.

PLATE 2

7. *Cladophlebis Srivastavai* sp. nov., showing the general disposition of the pinnae on the rachis. At P are seen different types of pinnae (cf. *Dichopteris*). Natural size.

8. Same. A portion enlarged to show the venation on the pinnules, their broad base, rounded apex and probably a somewhat denticulate margin. × 3.

9. *Rhizomopteris rajmahalense* sp. nov., showing the general shape and size of the stem. Natural size.

10. Same. A portion enlarged to show the curved leaf traces and longitudinal grooves on the general surface. × 2.

PLATE 3

11. *Williamsonia* sp. (cf. *W. indica* Sew.), showing the impression of the enveloping bracts. Natural size.

12. *Cycadolepis indica* sp. nov., showing the general shape and size of the leaf. Part of another leaf at the right-hand corner. Natural size.

13 , 14. *Cycadeospermum indicum* sp. nov. Two seeds from two different localities. Natural size.

15. *Coniferocaulon rajmahalense* sp. nov., showing surface features and a few possible branch scars. Natural size.

16. Same. A portion slightly enlarged.

PLATE 4

17. Cycadean stem, showing more than six roundish scars, possibly marking the position of buds or thick petioles. Natural size.

18 , 19. Other cycadean stems. Slightly reduced.

20. Another stem impression. On the left is seen a broad surface, possibly the base of a big stipular organ. Natural size.

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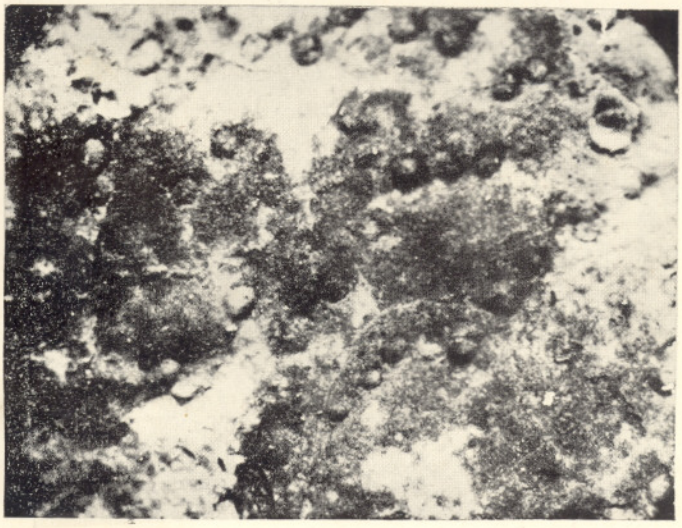

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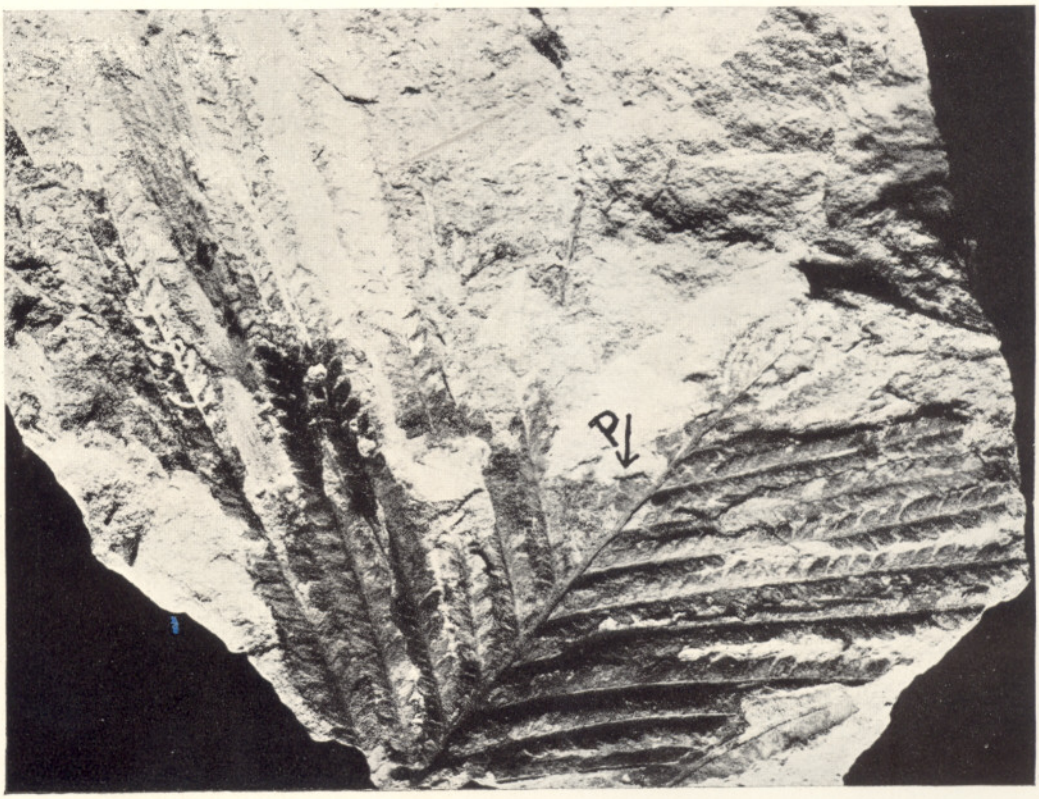

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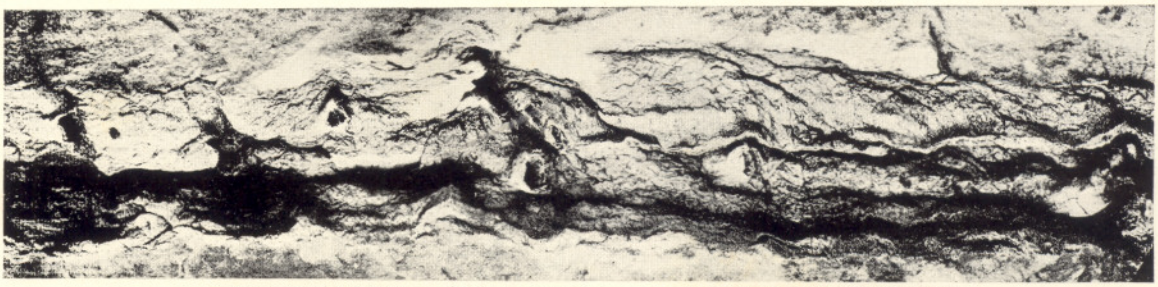

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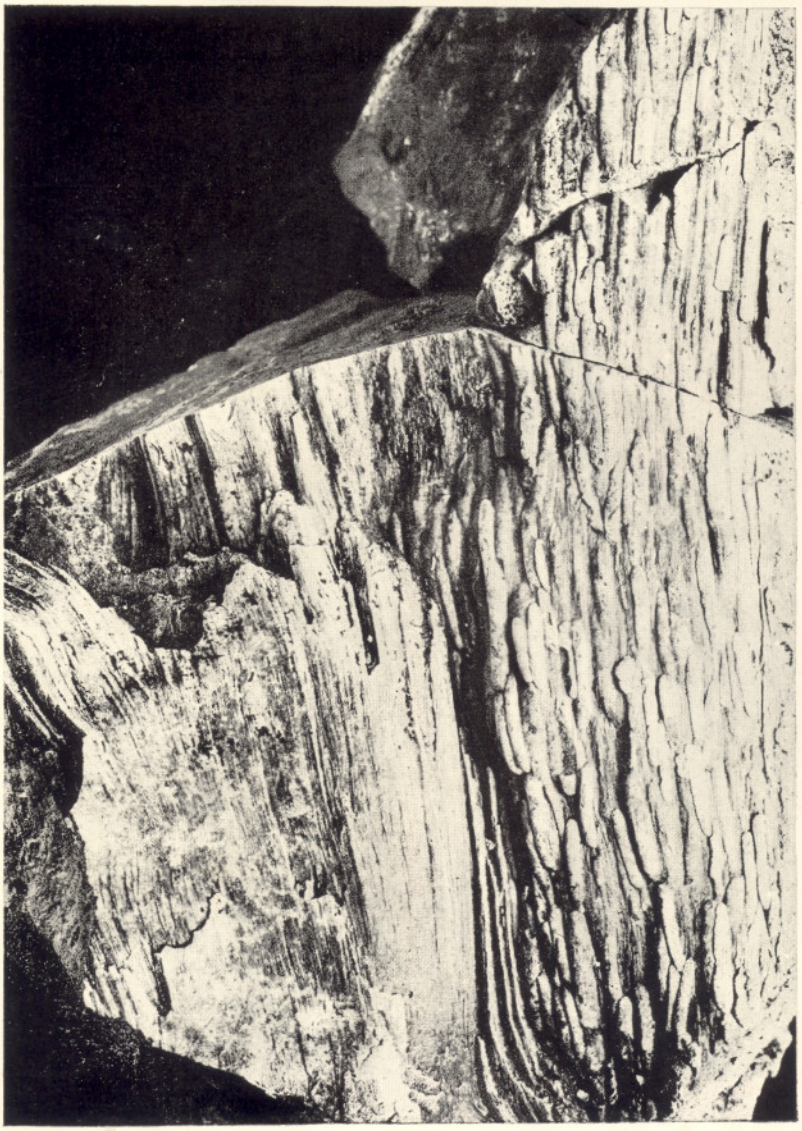

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