

# STUDIES IN THE GLOSSOPTERIS FLORA OF INDIA — 2. EQUISETALES FROM THE RANIGANJ COALFIELD

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## ABSTRACT

The rhizome and vascular system of an equisetaceous stem is described. Some specimens of *Phyllothea indica* are described showing the range in size and form in the species. A fuller description of *Phyllothea Griesbachi* is given.

## INTRODUCTION

IN the Glossopteris flora of the southern hemisphere Equisetales is represented by two genera, *Schizoneura* and *Phyllothea*, as against *Calamites* and allied genera in the northern hemisphere. Our knowledge regarding the southern genera is, however, far from complete. In India *Phyllothea* and *Schizoneura* occur mostly as impressions on soft, argillaceous shales. In the Raniganj coalfield no compressions were found so far on carbonaceous shales.

Of the two genera, *Schizoneura* was more restricted and almost confined to India during the Permo-carboniferous period. It is regarded as essentially of Indian origin (ARBER, 1905). Nothing more than its leafy branches and a doubtfully referred cone (ETHERIDGE, 1903) is known.

On the other hand, *Phyllothea* is more abundant and better known, especially from Australia. Arber thought that *Phyllothea* originated first in Australia and later on spread to different countries (1905, p. xxiii).

Arber recognized seven species of *Phyllothea*. *Phyllothea Sahnii*, a new species, has recently been added by Saksena (1952, p. 409). So far only four species are reported from India. *Phyllothea indica* Bunbury, discovered from the Raniganj stage, is imperfectly known. It is very similar to *Phyllothea australis* and, according to Seward (1898, p. 288), it is practically impossible to distinguish the Indian species from the Australian species. Since the time Bunbury described several imperfect specimens from the Nagpur district under this name, nothing materially has been added to our knowledge of this species.

*Phyllothea Griesbachi*, described by Zeiller (1902), is based upon a single specimen from the Barakar stage of the South Rewa Gondwana basin. This species offers some comparison with *Phyllothea Etheridgei* from Australia.

*Phyllothea robusta* Feistmantel is an imperfectly known species. Only a few specimens were obtained from Dudrajpur (Dudrajpur?) in the Rajmahal Hills, Bihar, and since then recorded by Walkom from Australia also. This species resembles closely *Phyllothea Stschurowskii* (SCHMALHAUSEN, 1879, p. 16).

Saksena (1952, p. 409) described *Phyllothea Sahnii* from the South Rewa Gondwana basin. He also described cuticular structure of *P. Etheridgei* and compared it with *P. Sahnii*. Later he attempted a reconstruction of *P. Sahnii* and *P. Etheridgei* (SAKSENA, 1954, p. 51). *Phyllothea Sahnii* appears to be very similar to *P. Griesbachi* which has been reported from the same area.

It must be said that in the absence of fructifications, it becomes difficult to delimit the species of *Phyllothea*, especially when there is no great variation in the external morphology of the vegetative shoots. The species are distinguished mainly on the form of the leaf sheaths and the free leaf segments. In the impressions of *Phyllothea*, which are mostly obtained as fragmentary fossils, it becomes very difficult to observe these distinguishing features.

The plants described in this paper belong to the Raniganj stage and were collected from the East Raniganj coalfield by a party led by the late Dr. P. N. Srivastava, under whose able guidance and inspiration such valuable collection could be made.

## DESCRIPTION

### 1. Stems

A large number of leafless stem impressions are found on shales bearing leaf impressions of *Phyllothea* and *Schizoneura*. Many of these

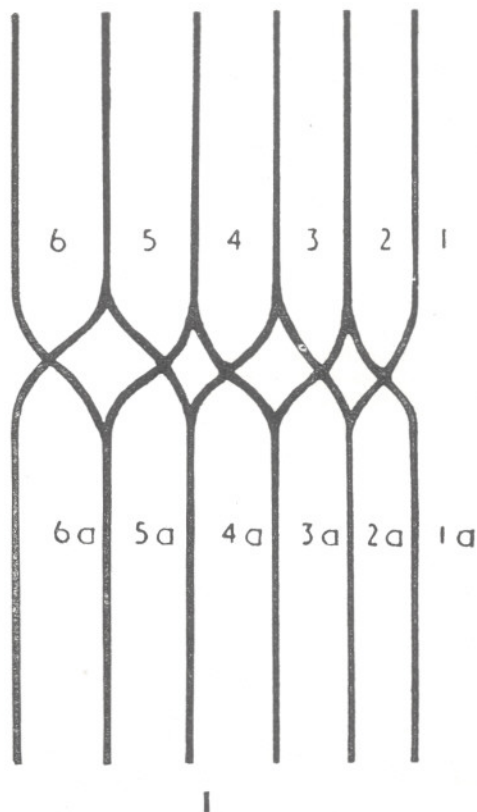
are obviously pith casts with longitudinal ribs and grooves continuous at the nodes. Such casts have been assigned by various authors in the past to either *Phyllothea* or *Schizoneura*. However, it is extremely difficult, as has been already pointed out by Seward (1898), to find any distinguishing features in these casts, on the basis of which they could be assigned to either of the two genera. Some of the pith casts in our material are 3-4 cm. broad with prominent, broad ribs and somewhat narrow grooves. Such pith casts are assigned usually to the Siberian species, *Phyllothea deliquescence*. However, I am not sure about this assignment. No leaf sheath of *P. deliquescence* has so far been found in India.

Equisetalean stems are branched. Fig. 1 shows a branched stem, 30 cm. long and 1 cm. broad, with nodes at a distance of 2.5 to 3.5 cm. Nodes are slightly swollen and the longitudinally running lines (ribs) are continuous. The stem shows two branches, one at the fourth and the other at the eighth node from below. The branches are small, 0.5 cm. in breadth, and curved.

**Vascular System** — In one rather unusual stem impression, shown in Figs. 2 and 3, it appears that the vascular bundles have left their marks which indicate their course through the stem.

The stem is about 13 cm. long and 1.2 cm. broad in the internodal region. The node is slightly raised and shows a chain of small scars extending beyond the impression of the stem on its either side. The bundles run straight in the internodal region, occasionally fusing with one another (is it due to displacement of vascular bundles by pressure during fossilization?). Just below the next node each bundle forks into two. Each fork does not fuse with the alternate bundle, as is the case in *Equisetum* and some species of *Calamites*, but in this case vascular system at the node appears to be more complex (Pl. 1, Fig. 3).

Text-fig. 1 shows a simplified arrangement of bundles at the node. Bundle 2a in the internode below is formed from the fusion of one fork each from bundles 1 and 3 in the above internode. The bundle in the next node which seems to be running in the same line and appears to be a continuation of the corresponding bundle in the above internode, is formed from the fusion of two branches, each branch given out from the alternating bundles in the above internode.



TEXT-FIG. 1 — Simplified diagram of vascular system of the equisetaceous stem.

This arrangement of bundles shows variation in the same node. One internodal bundle may be formed from three (instead of two) branches given out by three bundles. Sometimes the fork may pass over a few bundles before joining with some other bundle. Mostly the arrangement of bundles at the nodes as described above holds good.

It is not known from where the leaf traces arose, or to what genus this stem belongs. *Phyllothea* is found in association with this stem and probably it may belong to this genus.

## 2. Rhizome (*Phyllothea*?)

Pl. 1, Fig. 4, shows an impression of a rhizome of some equisetaceous plant possessing nodes and internodes. It is often found branched and the branches run in various directions. It does not show characteristic ridges and grooves as in the stems of *Phyllo-*



*theca* or *Schizoneura*, but instead short longitudinal lines are seen, which perhaps represent the impressions of the stelar part of the rhizome. The rhizome gives rise to the typically equisetaceous stems at the nodes (Pl. 2, Fig. 6).

The biggest specimen measures 14 cm. in length, 1.5 to 2 cm. in breadth with nine nodes at a distance of about 1.5 cm. From the nodes are given out long, sometimes branching (Pl. 2, Fig. 6), cylindrical organs which, I think, are the adventitious roots. The adventitious roots are about 1.3 mm. wide, sometimes showing a black line in the middle which perhaps represent their stele. One root was traced for 9 cm. The roots branch repeatedly, almost by dichotomy until they become thin and hair-like.

Usually the rhizomes are found lying obliquely in the shales; but some specimens are transversely fractured, showing three separate regions which can only be interpreted as the cortex, stele and the pith. Such impressions show the structure of the rhizome as would be seen in a transverse section.

The rhizome appears to possess a pith, perhaps hollow, with a ring of stele round the pith. In one impression the stelar ring shows radiating lines at regular intervals, possibly representing the impressions left behind by medullary rays. If it is so, then the stele must have consisted of secondary xylem wood with medullary rays as in the stem of *Calamites*. Cortex appears to be wide.

These rhizomes have been found to produce equisetaceous stems at the nodes. Pl. 2, Fig. 6, shows a rhizome which has given out a young stem, 3 cm. long and with a conical apex which must have enclosed the growing point. The young stem possesses nodes and internodes with typical longitudinal lines of a ribbed stem. The lower internodes are expanded but the conical tip region shows a number of nodes which have not yet lengthened. Such specimens clearly show that the specimens under discussion are the rhizomes of some equisetaceous plant, most probably of *Phyllothea*.

Feistmantel (1880, PLS. VIIIA, IXA, FIGS. 4, 5, 6) recorded such impressions from Karharbari and Raniganj stages but he considered them as leaf-bearing stems. He compared them with *Schizoneura gondwanensis*. Obviously Feistmantel regarded the long cylindrical organs coming out from the nodes as leaves and not roots. From

the above evidence, however, it will be seen that this interpretation is not correct. The impression shows branching which is like that of a rhizome, and produces roots and aerial stems at the nodes.

To what genus these rhizomes belong, it is difficult to say at present. Feistmantel was inclined to put them under *Schizoneura gondwanensis* (as leaf-bearing stems) on the evidence of association. However, I have found them equally well represented on the shales bearing *Phyllothea* leaf impressions. I am inclined to believe that the rhizomes belong to *Phyllothea*. In any case, it is obvious that at least one equisetaceous southern genus possessed rhizomes which produced roots and aerial stems showing similar habit as in the living *Equisetum*.

### 3. *Phyllothea indica* Bunbury

Except for description and some figures of incomplete specimens given by Bunbury and Feistmantel, nothing more is known about this species. Some of the specimens are, therefore, described below to give an idea about the range in size and form and habit of the species.

Pl. 2, Fig. 7, shows two detached, small, star-shaped leaf sheaths which appear to be young leaf sheaths of *Phyllothea indica*. A few similar leaf sheaths are present on the same piece of shale. The leaf sheath, about 3 mm. in diameter, is in the form of a very shallow cup, 1.5 to 2 mm. in diameter, slightly becoming narrow downwards where it clasped the stem which must have been less than 2 mm. in breadth. The rim of the cup is flattened horizontally from where 9-12 free leaf segments radiate out. Individual leaf segments are linear, straight, tapering very gradually towards the apex. They are about 1.5 cm. in length and 1 mm. in breadth at the base with a midrib in the middle in each leaf segment.

The characters of the leaf sheaths are similar to those of *Phyllothea indica*, except for the size which is not very important. These may have been borne on a young stem or on the finer branches of the stems. The leaf sheaths bear a striking resemblance to the star-shaped leaf sheaths of *Phyllothea australis*, figured by Arber (1905, PL. II, FIGS. 7, 8). These specimens further strengthen the similarity between *Phyllothea indica* and *Phyllothea australis*, already pointed out by Seward and other workers.

The cuticle will be able to decide this point, but until the availability of suitable material for such study the two species might best be kept separate.

Fig. 8 shows very well-preserved impressions of two leaf sheaths of *Phyllothea indica* in lateral view. The stem bearing the leaf-sheaths is not fully preserved. It is 0.7 cm. in breadth and the two nodes are at a distance of 1 cm. The internodes are longitudinally striated.

The leaf sheath forms a shallow cup, about 3 mm. in length, and expanding upwards. Free leaf segments are long, narrow, about 3 cm. in length, and with prominent midribs which are clearly seen descending down into the sheath and then into the stem. The free leaf segments first go up straight and then are reflexed. Maximum number of free segments counted is 19. The total number might be about 24.

Fig. 9 shows a slender plant, about 22 cm. in length and 0.7 cm. (at the node) to 0.5 cm. in breadth. It shows about 20 to 22 nodes at a distance of less than 1 cm. The leaves are not fully preserved. Near by two similar plants are lying on the shale which might have been the branches of the same plant. The free leaf segments are long and reflexed.

The plant does not appear to be strong enough to support its own weight, and might have taken support on the vegetation growing near by.

Figs. 16 and 17 show leafsheaths which appear to be thick and leathery. The stem possesses small longitudinal grooves placed distantly. Free leaf segments are long, linear with prominent midribs. The number of free segments do not appear to be more than 24. This plant may also belong to *Phyllothea indica*.

#### 4. *Phyllothea Griesbachi* Zeiller

This species appears to be stouter and larger in size than *Phyllothea indica*. Usually a number of stems are found lying side by side on the shales. It may be accidental; or this plant is much branched and all the branches preserved on a single shale indicate secondary and further branches of a single plant. Zeiller (1902) found similar case in *Phyllothea Griesbachi* which was discovered from South Rewa Gondwana basin.

The piece of shale from which Fig. 5 has been photographed contains five stems which

perhaps represent branches of different order. The biggest stem is 1.5 cm. in breadth and shows eleven nodes placed at a distance of 1 to 1.3 cm. It possesses faint, very narrow, longitudinally running grooves placed rather distantly. Leaf sheaths are partially preserved.

The other stem, seen on the left in Fig. 5, appears to be younger, about 1 cm. in breadth with nodes placed at a distance of 1.5 cm. Leaf sheaths and the free leaf segments are again partially preserved. They appear to be firm, long, linear and 1 mm. wide.

The third stem on the right side in Fig. 5 is still younger and shows apical portion of the branch. It is 0.8 cm. in diameter tapering gradually above. Sixteen nodes could be counted, each less than 1 cm. apart, but the distance diminishes progressively upwards, until in the last 4 cm. of the stem the nodes and internodes could not be distinguished clearly. Leaf sheaths are not clearly seen. Free leaf segments are numerous, slender, linear and almost cover the stem completely. This may be due to the fact that the internodes in this region had not completely lengthened, with the result that the free segments of the leaf sheaths overlapped one another.

Figs. 12-15 show some of the detached leaf sheaths. Fig. 14 shows a complete leaf sheath containing 36 free segments. The leaf sheath is in the form of a horizontally spreading disc, 1.3 cm. in diameter, showing depression in the middle where it must have clasped the stem. The free segments are spread out horizontally and are held straight.

Figs. 12, 13 and 15 show clearly the flat or slightly hollow nature of the leaf sheaths and their long free segments which are 3 cm. or more in length. The free segments appear to be stouter and, therefore, capable of holding themselves straight and not reflexed as in *Phyllothea indica*. The number of free segments is between 28 and 36. It appears that the free leaf segments in *Phyllothea* species are in multiples of three. By the number of isolated leaf sheaths frequently met with, it appears that almost complete leaf sheaths fell off from the stems.

*Comparison* — This plant is almost identical with *Phyllothea Griesbachi*, described by Zeiller (1902) from Baraker stage in the South Rewa basin and of which only a single specimen is known. However, the specimens described here are obtained from the



younger horizon, the Raniganj stage in the Raniganj coalfield. Both the plants have numerous leaves, 2 to 3 cm. long, united at the base to form a sheath, expanding into an almost horizontal disc. The length of the sheath in the Raniganj specimens is less than 1 cm., but I do not think this feature alone will justify their exclusion from *P. Griesbachi* described from South Rewa Gondwana basin. On the other hand, it appears that *Phyllothea Sahnii* (SAKSENA, 1952) may be a very nearly allied, if not identical, species to *P. Griesbachi*. Cuticular evidence will, however, decide this point.

From *Phyllothea indica*, *P. Griesbachi* differs in possessing leaf sheath in the form of horizontal disc and numerous free leaf segments which are held straight and not reflexed.

*Emended Diagnosis* — Stems ribbed, fairly stout with nodes placed at short distances, 1.5 cm. and less; leaf sheaths attached to the stem for a few millimetres only, spreading horizontally like a disc; free segments from 28 to 36, held straight and not reflexed.

#### 5. Equisetaceous Cone ?

Fig. 20 shows an impression of what appears to be an incomplete cone, 1 cm. in length. It shows hexagonal impressions which can be interpreted as the impressions of peltate heads of the sporangiophores. They are about 1 mm. in diameter. This impression is found on a shale containing nothing but impressions of rhizomes, stems and incomplete leaf sheaths of *Schizoneura*.

This impression resembles very much to that described by Srivastava (1954) which he has ascribed to *Schizoneura*. If these cones really belong to one of the equisetaceous genus in the Glossopteris flora, the presence of a compact cone like that of a modern *Equisetum* as early as in the Palaeozoic period is interesting, especially when

none of the Palaeozoic *Calamites* possessed such compact cones. Although *Archaeocalamites*, the Devonian genus, possessed strobilus without intervening sterile bracts between the whorls of sporangiophores (and in this character came nearer to *Equisetum*) the sporangia were borne just as in *Calamostachys*.

However, there is also a strong possibility that this cone may have belonged to *Glossopteris*. It is described here with some hesitation, because this impression was found from a dump of shales showing almost nothing else but impressions of *Phyllothea* and *Schizoneura*.

#### 6. Incertae Sedis

Numerous oval bodies as shown in Fig. 18 are found on some shales bearing the stem and leaf impressions of *Phyllothea* and *Schizoneura*.

These bodies are about 1 mm. in size and are either oval, round or slightly elongated in shape. These various shapes are no doubt due to compression at the time of fossilization. They always contain some coaly matter, mostly vitrain, which is brittle. When the coaly matter is removed, faint longitudinal striations are visible. The coaly matter was macerated but failed to reveal spores or any other organic matter. Sometimes these bodies appear to be attached at the end of a stalk. This could not, however, be confirmed.

It is difficult to say what these bodies are. No spores have been found and hence it cannot be said that they are sporangia. They are also found in association with underground stems. Can these be branch tubers similar to those in *Equisetites Burchardti* (SEWARD, 1898, p. 279, FIG. 65)? There is also a third possibility that these are the seeds of some other plants. At present nothing definite can be said.

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## EXPLANATION OF PLATES

## PLATE 1

1. A leafless stem showing branching at two places.  $\frac{1}{15}$  Nat. size.
2. An impression of vascular bundles of the stem showing their course through the internodes and nodes.  $\times$  Ca. Nat. size.
3. A node from the impression in Fig. 2 magnified to show the course of vascular bundles.  $\times$  3.
4. Rhizome with long roots at the nodes.  $\frac{1}{2}$  Nat. size.
5. A number of stems of *Phyllothea Griesbachi*, varying in size and bearing leaf sheaths.  $\times$  Ca. Nat. size.

## PLATE 2

6. Young stems showing a conical apex and crowded nodes are seen attached to a rhizome. On the left a bifurcating root of the same rhizome. Ca. Nat. size.
7. Two detached young leaf sheaths of *Phyllothea indica*. Small oval bodies are also seen lying on the shale.  $\times$  2.

8. Two leaf sheaths of *Phyllothea indica* attached to the stem.  $\times$  3.
9. A narrow stem bearing leaf sheaths and long, reflexed free segments. Ca. Nat. size.
10. A leaf sheath of *Phyllothea Griesbachi* attached to a stem.  $\times$  Nat. size.
11. An impression of an incomplete cone.  $\times$  6.5.

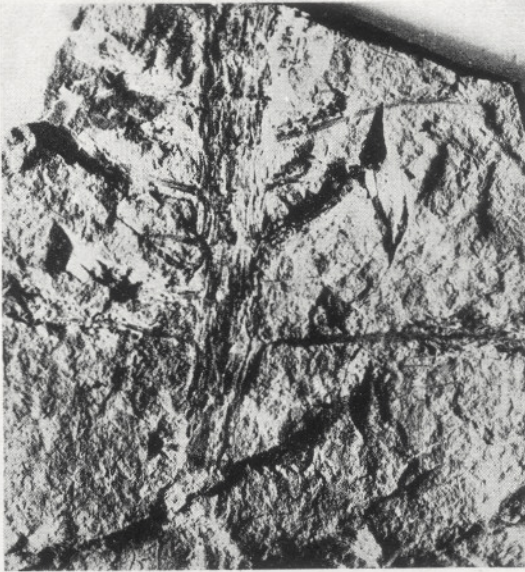
## PLATE 3

12. *Phyllothea Griesbachi*. Leaf sheath plate-like with free segments spreading out straight. Impression of the stem bearing this leaf sheath is seen in the middle.  $\times$  2.
13. Three leaf sheaths of *Phyllothea Griesbachi*.  $\times$   $1\frac{1}{4}$ .
14. A complete detached leaf sheath of *P. Griesbachi*. Note the straight free leaf segments.  $\times$  Ca. 3.
15. *Phyllothea Griesbachi*. Two leaf sheaths borne on a stem.  $\times$  Nat. size.
16. A number of leaf sheaths with reflexed free segments of *P. indica*.  $\times$  Nat. size.
17. *Phyllothea indica*. A thick leaf sheath.  $\times$  2.
18. Five small oval bodies.  $\times$  15.





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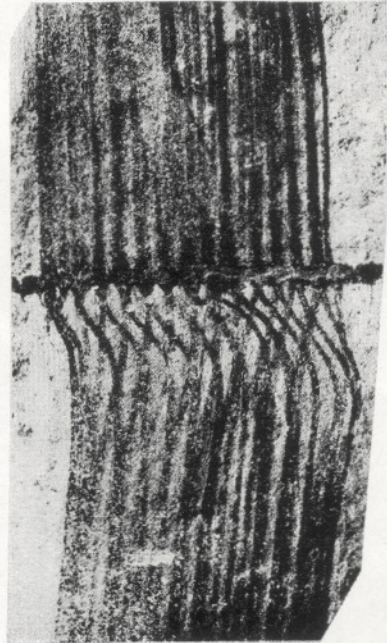
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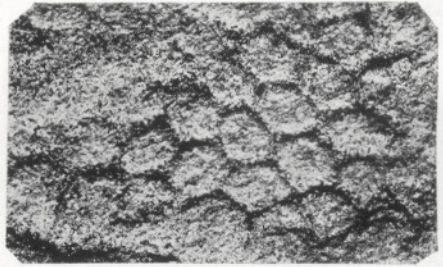
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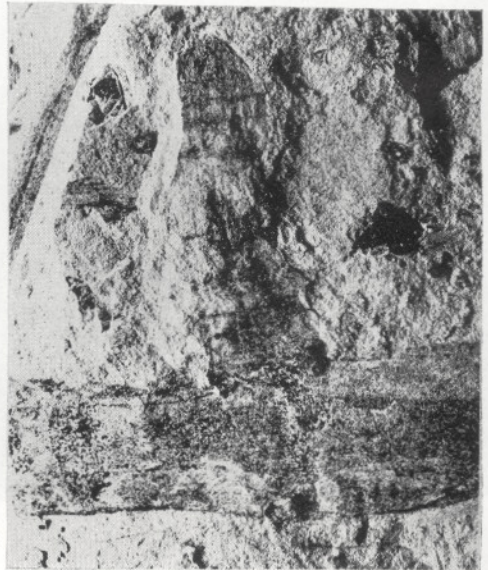
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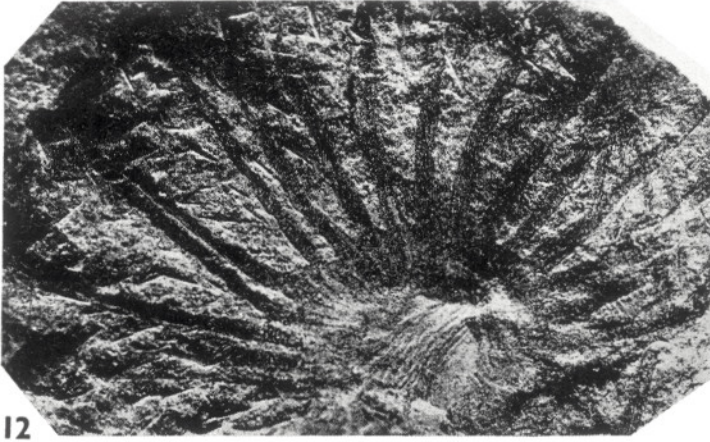


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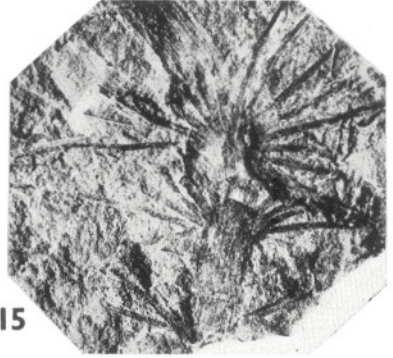
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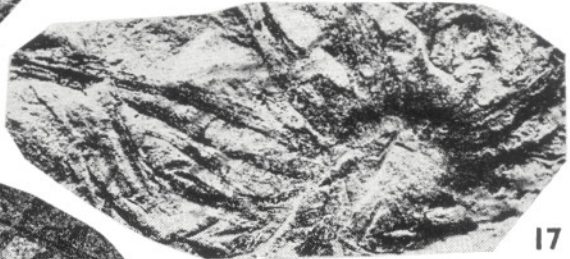
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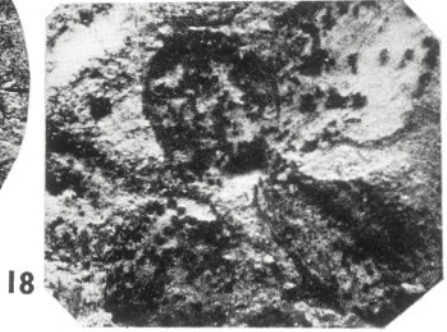
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