THE FEMALE FRUCTIFICATION OF *SPHENOPTERIS HOENINGHAUSI* AND THE (SUPPOSED) RELATION OF THIS SPECIES WITH *CROSSOTHECA*

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INTRODUCTION

IN the section "Palaeobotany" of the Fifth International Botanical Congress I read a paper on the female fructification of *Sphenopteris* (*Lyginopteris*) *hoeninghausi* and the relation between this species and *Crossotheca*. The principal result of an examination of a rich material from the Carboniferous of the Netherlands was that the female fructification found in impressions is identical with the cupules with enclosed seeds, *Lagenostoma lomaxi*, which are considered by Oliver and Scott to belong to the stems named *Lyginodendron oldhamium*, both met with in the coalballs of Britain and Western Europe. In the impressions the actual attachment of cupules and seeds to the stems and petioles could be proved. There remains no doubt about the identity between *Sphenopteris hoeninghausi* and *Lyginopteris* (*Lyginodendron*) *oldhamia* and their seeds.

It is striking how well the reconstruction of Oliver and Scott matches the cupule now found in the impressions.

Misled by a superficial resemblance of the vegetative parts, Kidston described a *Crossotheca* from Coseley and Dudley as being the male fructification of *Sphenopteris hoeninghausi*. From the rich Dutch material it can be proved that this *Crossotheca* does not belong to *S. hoeninghausi*. The vegetative parts to which it has been found attached have a very wide range of variation and have been described by Kidston as *C. schatzlarensis* and *C. communis*. It is interesting that a similar variation has been found in *S. hoeninghausi*, but the fundamental form of the pinnules in both species is different. In both cases the extreme forms are connected by all kinds of transition, so that it is advisable to unite the different forms of *Crossotheca*, and to name them *C. Kidstoni*.

The male fructification of *S. hoeninghausi* is still unknown, though it may be possible that the *Telangium* described from the coalballs is related to it. An actual attachment is unknown.

It was a great pleasure to the author that Dr. Scott was present at the meeting in Cambridge. In the discussion he said "that the evidence of the connection between the seeds and the vegetative parts satisfied Oliver and himself, but after all, it is believed that apples grow on apple trees, not because of any elaborate comparison of structure, but because the fruit is seen growing on the tree. This is exactly the proof which Dr. Jongmans gave to the section yesterday. He has shown cupulate seeds, just as the speaker (Dr. Scott) and Prof. Oliver had figured them, borne *in situ* on the fronds of *Sphenopteris hoeninghausi*, the foliage of *Lyginopteris oldhamia*. In this case, then, the evidence is complete. We know all about the seed of one fern-like Carboniferous plant."

Drawings of *Calymmatotheca stangeri*, made by Miss Woodward after Stur's original specimen, and given to the author by Professor Oliver, so closely agree with the cupules of *S. hoeninghausi*, that there is no doubt about the generic identity of both species. A specifical identity may even be possible.

At present the name *Crossotheca hoeninghausi* must be dropped. The best name for this plant is *Sphenopteris* (*Calymmatotheca*) *hoeninghausi* Bgt.

HISTORICAL REVIEW OF THE KNOWLEDGE OF THE FRUCTIFICATION OF *S. HOENINGHAUSI* BGT.

As a result of the splendid work by Oliver and afterwards by Oliver and Scott it was proved that the stems and the seeds, with structure preserved, named *Lyginodendron oldhamium* and *Lagenostoma lomaxi* belong to the same plant. Although the actual attachment has not been found, the glandular characters shown by stems, branches, cupules were so narrowly identical that it has been

almost generally accepted that they belong together. As Scott and Oliver said in 1904 and Scott repeated in 1930 in the Cambridge meeting: The seed has not yet been found *in situ* on the *Lyginodendron* (*Lyginopteris*) plant, but short of this, the evidence for the one belonging to the other could scarcely be stronger than it is.

The specimens on which this research was based were collected in the coalballs in a seam, which is stratigraphically identical with the Finefrau-horizont of the continental coal basins (Westphalian A, lower part) and similar specimens occur in the coalballs of the Seam Catharina, which is the boundary between the Westphalian A and B. By the same characters for which the relation between the different parts of the plant in the structure-showing coalballs has been accepted, it could be proved that the plant, known as *Sphenopteris hoeninghausi*, is identical with the species from the coalballs. In the impressions no trace of a fructification could be found. In the coalballs and in the impressions no male fructification was found which could belong to the species, which in other ways was so well known.

Especially in his beautiful work on British carboniferous plants, but already in his papers of 1905 and 1906 Kidston described a *Crossotheca* which he supposed to belong to *Sphenopteris hoeninghausi*. The material for these researches was collected in Dudley, Coseley, localities belonging to the middle part of the Westphalian B. If Kidston's statement was true and as Kidston fully agreed with the conclusions of Oliver and Scott about the seeds of *S. hoeninghausi*, *Sphenopteris hoeninghausi* would have been the first Pteridosperm known in sterile condition and with male and female fructifications.

Several palaeobotanists especially Gothan (1913, 1928) and Hemingway could not agree with Kidston's conclusions as to the connection of *Crossotheca* and *Sphenopteris hoeninghausi*. The determination of Kidston's specimens from the Westphalian B was another object for criticism. This was based on the fact that until now no specimen which really belongs to *S. hoeninghausi* had been found in beds higher than the Westphalian A. Kidston's specimens did not entirely agree with the Westphalian A specimens of *Sphenopteris hoeninghausi*, the foliage occurring on the Coseley specimens being different from that of *Sphenopteris*. The chief argument is that the stems and branches of Kidston's *Crossotheca* never show the typical appendages which are so evident in *S. hoeninghausi*. Although *Lyginodendron oldhamium* and *Lagenostoma lomaxi* are very common in the coalballs of Britain and the Continent, no trace of a *Crossotheca* was associated with them. It was even doubted that *Lyginodendron oldhamium* was identical with *S. hoeninghausi* as this species was known only from the middle and lower parts of the Westphalian A. Therefore, it could not be easily accepted that this plant should reappear in large quantities in the coalballs of the Catharina horizon. This argument, however, does not stand, as numerous specimens of typical *S. hoeninghausi* have been found in the higher and highest parts of the Westphalian A, so that this agrees with the presence of numerous *Lyginodendron* specimens in the Catharina coalballs. It remains a remarkable fact that a species so common in the higher part of the Westphalian A and in the coalballs in the marine horizon, which is the boundary between the Westphalian B and A, is not known at all in the beds over that marine horizon in the lower part of the Westphalian B. Unfortunately fossil plants are very rare in the lower part of the Westphalian B. Moreover, it seems that the invasion by the sea, represented by the Catharina horizon, had an important influence on the flora. Besides *S. hoeninghausi*, several other species, survivals of the flora of the lower part of the Westphalian A — for instance *Mariopteris acuta*, *Neuropteris schlehani*, *Sigillaria elegans*, which, although mostly rarely, are still present in the higher beds of the Westphalian A — disappear entirely in the plant-beds over the Catharina horizon. By these facts it can be explained that *Sphenopteris hoeninghausi* or *Lyginodendron oldhamium* was still, at least locally, a common plant on the moors which were submerged by the Catharina sea, but has disappeared from the flora in the same way as have various other plants.

As the result of previous researches it can be accepted that *Lyginodendron oldhamium* and *Sphenopteris hoeninghausi* belong to the same plant, and that it is extremely probable that *Lagenostoma lomaxi* is its seed, although the actual attachment could not be proved, and that the

male fructification of this plant is still unknown.

Crookall (July 1930), contrary to this opinion, summarizes as results of his reinvestigation of Kidston's *Crossotheca* that Kidston's reference of *Crossotheca* to *L. oldhamium* is not vitiated by (a) misidentification of the sterile leaves, (b) the horizon of the specimens, (c) the associated plant remains, (d) the markings on the rachis, (e) the character of the sterile fronds, but only by the fact, that true *Crossotheca* is entirely absent from the coalballs, which precludes its being the microsporangia of *L. oldhamium*. He, therefore, separates Kidston's *C. hoeninghausi* as *C. Kidstoni*. However, the great similarity of the sterile leaves borne by *C. Kidstoni* to those borne by *L. oldhamium* (*Sphenopteris hoeninghausi*) indicates that it did belong to another, closely related, species of *Lyginopteris*.

Hemingway, however, who collected most of the specimens examined by Kidston, and who suggested in litt. the name *C. Kidstoni*, is, as Crookall states in a footnote, of opinion that the barren leaves of *C. Kidstoni* merge into those of *C. schatzlarensis*. Crookall (1930) could not accept this view, as no plants have been identified from Dudley as *C. schatzlarensis*. However, Crookall has not seen the specimens to which Hemingway refers and Kidston, on his Pl. 89, figures a number of specimens of *C. schatzlarensis*, which agree with the Crossothecas named *C. hoeninghausi*. The only difference is that some of them show Crossothecas of somewhat smaller size. On the same plate he figures *C. communis* with similar fructifications.

Crookall's conclusions were somewhat surprising and were based on a misidentification of the vegetative parts. The vegetative parts show not a single trace of the characteristical glandular appendages of *S. hoeninghausi* and, therefore, must be separated. If this argument fails, the other arguments (b), (c), (d) must equally be dropped.

As will be shown in the following pages, Dr. Crookall afterwards changed his opinion and stated that he agrees with my acceptance that *C. Kidstoni* merges into *C. schatzlarensis* and into *C. communis*. However, he is of the opinion that it also merges into *S. hoeninghausi*, as there is a great similarity between *C. Kidstoni* and *S. hoeninghausi*. Certainly both species show a similar variation. *S. hoeninghausi* has a forma *laxa* and *cuneata* and *typica* with all transitions. *C. Kidstoni* has forma *schatzlarensis*, *cuneata* and *communis*. However, *S. hoeninghausi* is never so lineal and the general form of the pinnules is different.

It will be shown from the Dutch specimens that Hemingway was completely right and that a revision of Kidston's specimens is necessary.

DESCRIPTION OF THE DUTCH SPECIMENS

Sphenopteris hoeninghausi is common in the plant-beds of the Westphalian A in the Dutch Carboniferous as it is also in other coalfields in Western Europe. It is not restricted to the lower and middle parts of that subdivision but is present even in beds very near to the marine Catharina horizon, where it has been found associated with *Neuropteris schlehani* as survivor of the older flora and with the flora which is ordinarily met with in these horizons. Most of the material with fructifications has been collected in the Oranje Nassau Coll. IV in a small seam under Seam B, which is not more than about twenty metres below the marine bed. The plant horizon has been examined at numerous places. It is curious that the flora is rather different in the places where it has been collected. In some places *S. hoeninghausi* is so common that it is the chief component of the flora ; in some of these places it is associated with *Neuropteris schlehani*, which is missing in other places. A number of localities in the same plant-bed did not show a single specimen of both. Of course, it is not possible to explain this fact, but the observation is remarkable in connection with the question how far negative arguments can be used for stratigraphical purposes.

As is seen in Figs. 5-15, *S. hoeninghausi* in the Dutch coalfield is a very variable plant in the same way as it is in other coalfields. The extreme forms are those named forma *laxa*, which are shown in Fig. 8 especially and in Figs. 10, 10a. Forms which are somewhat similar, in having very delicate pinnules, are Figs. 9 and 11. Much flattened pinnules are present in Figs. 12, 13, also in Figs. 6, 7. In Figs. 14, 15 the pinnules are rather small and crowded, the pinnae are distant and the entire plant is extremely glandulous, even in the smaller ramifications. Another extreme form is

shown in Fig. 5. Here the pinnules are much larger, the segments are rounded, the distance between the pinnae is small, the glandulous character is obvious. Such forms resemble very much the plant, which is generally called *S. stangeri*.

It is clear that all these specimens show the glandular appendages on the stems and the axes, even on the most delicate axes. Although the variation in the size and aspect of the pinnules is large, they never reach the narrow linear form of the segments, which is found in the plants of the *C. schatzlarensis* type (cf. FIGS. 38, 39, 44, etc.).

Among the material collected in the roof of the first veinlet under Seam B of the colliery Oranje Nassau IV near Heerlen, a large number of the cupules, with or without seeds, were present. They are born at the ends of a profusely ramified system of almost naked axes. Traces of sterile pinnules are seen only at some places (FIG. 16). The axes bear the glandular appendages and the sterile pinnules show the characters of *S. hoeninghausi*. The cupules are closed, as long as the seeds are attached (FIGS. 23, 24, 30). After the seeds have fallen out of the cupules, these are spread and the valves of the cupule are very clear and separated. They are free till their base. It seems that at least sometimes they were divided in two (FIG. 21 f.i.). Their number is probably six. They always show the glandular appendages, which are also very distinct on the leafless axes.

Some specimens have been found with large systems of such leafless axes (FIGS. 31, 32). It is clear that these fertile systems were rather big and occupied the upper parts of a leaf. The forking of the axis is very clear in several places. Still bigger systems have been figured in Figs. 33, 34. It is evident that Scott's reconstruction of the complete plant is correct even in the details.

Not a single trace of a male fructification was found in the rich material of this locality.

Other specimens of cupules with and without seeds have been collected in the roof of Seam XVIII of the colliery Hendrik. This locality belongs to the Westphalian A, an example is given in Fig. 22.

NOMENCLATURE OF *SPHENOPTERIS HOENINGHAUSI*

The nomenclature of this species is rather complicated. The impressions belonging to it are named *Sphenopteris* by Brongniart. This name has been adopted in most of the floras of the Carboniferous. Stur (*Culmflora*, II, p. 266) places it in his genus *Calymmatotheca* (*Calymmotheca* Stur) and compares it with his *C. stangeri*, of which he describes the cupules which he considers as an indusium. These cupules have six valves with spiny appendages, and are entirely comparable with those met with in *S. hoeninghausi*. As, however, the cupules of *S. hoeninghausi* had not been found in actual connection, this generic name has not generally been used.

The stems in the Lancashire coalballs have been named *Dadoxylon oldhamium* by Binney (1866, *Proc. Lit. and Phil. Soc. Manchester*, **V**, p. 113). Williamson (1869, *Monthly microsc. Journal*, **2**, p. 66) uses the name *Dictyoxylon*. Afterwards (1873, *Phil. Trans. Roy. Soc.* London, **143**, p. 404) he introduced the name *Lyginodendron oldhamium*. Much later, 1899, Potonié changed this name to *Lyginopteris*, as there is no evidence that *Lyginodendron* Gourlie belongs to the same group as the Oldham plant. It is even impossible to decide, to which group *Lyginodendron* belongs and affinity with *Lepidodendron* cannot be excluded. However, it cannot be considered as a *nomen nudum*. Therefore, it is not permissible to use it for a well-defined plant like the Oldham plant. Potonié was quite right in rejecting the name *Lyginodendron*. The discovery of the cupules with enclosed seeds shows that there is no doubt whatever that they belong to the same genus as those described by Stur for his *Calymmatotheca stangeri*. This is proved by a comparison with the drawing of the cupules of *S. stangeri* Stur (JONGMANS, 1930, PLATE, FIG. 3. Further the two species, *hoeninghausi* and *stangeri*, also possess foliage which suggests, if not specific identity, at least a very close relationship. It is, therefore, clear that *S. hoeninghausi* must be placed into the genus *Calymmatotheca* and must be named *Calymmatotheca hoeninghausi* (Bgt.) Stur (emend. Jongmans) as Stur's name is much older than *Lyginopteris* of Potonié. *Lyginopteris hoeninghausi* (Bgt.) Pot., *L. oldhamia* (Binney) Sew., and, as will be shown in the second part of this paper, *Crossotheca hoeninghausi* (Bgt.) Kidston *partim* must be considered as synonyms of this name.

CROSSOTHECA KIDSTONI **CROOKALL**

Crossotheca of this type has been found at several places in the Dutch coalfield, which for the greater part belong to the Westphalian B. The principal localities, where this plant has been collected, are:

1. Coll. Emma, roof of Seam B.
2. Coll. Maurits, roof of Seam III.
3. Coll. Maurits, veinlet under Seam I D.
4. Coll. Maurits, Seam B.

These localities belong to the lower part of the Westphalian B, between the Catharina horizon and the Domina horizon. The Domina horizon divides the Westphalian B in two parts, the lower part called the Hendrik group, the upper, between the Domina horizon and the Aegir (Petit Buisson) marine horizon, the Maurits group.

Localities 1-3 are in the upper half of the "Hendrik" group, locality 4 about at the top of this group.

Another locality is:

5. Coll. Emma, second NW Cross-cut W at 1775 and 1780 m.

This locality belongs to the "Maurits" group.

Specimens, which will be compared with this type, have been collected:

6. Coll. Hendrik, roof of Seam XVIII.
7. Coll. Wilhelmina, roof of Seam V.
8. Coll. Willem Sophia, roof of Seam Klein Mühlenbach.

These localities belong to the Westphalian A. The Westphalian A is divided by the Wasserbank horizon (somewhat over the Steinknipp seam) in two parts of almost equal size. The upper part in the Dutch coalfield bears the local name of the Wilhelmina group, the lower, of the Baarlo group. The localities 6-8 belong to the Wilhelmina group. It is possible that these specimens, of which the Crossothecas are somewhat smaller, belong to a special form (*fa. minor*) or to a separate species.

Figs. 35-66 show different types of sterile leaves which are considered as belonging to one species. Some of them, 35-39 which can be compared with *C. schatzlarensis*, as has been figured by Kidston, show very delicate pinnules, the outer segments of which are very narrow and almost linear. In some cases they are more or less cuneate at their tops. Figs. 40-45 have deeply divided pinnules like the first group, but the segments are broader and more crowded. The whole plant makes a coarser impression, but the general aspect is still more or less that of *C. schatzlarensis*. Still coarser are Figs. 46-48. Here the linear form of the pinnules disappears altogether, and such specimens approach to Figs. 53-66 where no trace of linear segments can be found and which completely agree with those which Kidston named *Crossotheca communis* Lesq. It is not certain that Kidston's *C. communis* is the same plant as the American described by Lesquereux.

It is clear that it is not possible to divide such a group of specimens into different species, all transitions being present. At the localities 1-5 the material contains both extreme forms as well as transitions between them.

It is not possible to decide whether these different forms of the pinnules represent different forms or varieties. As in all cases the different forms are associated in the material it is equally possible that the different forms of the pinnules are connected with the position of the pinnae in the entire leaves.

Some British specimens from Dudley, the locality at which some of Kidston's specimens have been collected (iron nodules), are shown in Figs. 49 and 50. They perfectly agree with our specimens 40-45, especially with Fig. 44.

Another British specimen from the same locality is shown in Fig. 64. It is very different from Kidston's forma *schatzlarensis* and agrees more or less with Kidston's forma *communis*.

At the localities 1-4 these sterile specimens were accompanied by fertile ones showing the *Crossotheca* fructification. It is not necessary to enter here into a description of the details of this fructification. It is perfectly clear that it belongs to the same type which has been figured by Kidston as *Crossotheca hoeninghausi*. And as it has been possible to find many specimens which show the fructification attached to the sterile parts it is also clear that there can be no question of their belonging to *S. hoeninghausi*, but that they belong to *C. Kidstoni*, under which name the forms figured by Kidston as *C. schatzlarensis*, *communis* and *hoeninghausi* must be united.

One of the most interesting specimens is that of Fig. 74, showing the *Crossotheca* in the lower part of the pinnae and the sterile, *schatzlarensis*-like pinnules in the upper part. In most of the other figured speci-

mens the pinnae are almost entirely fertile, but in those cases several pinnae show still more or less pinnules of sterile type in their upper parts.

The size of the Crossothecas varies very much as can be seen by comparing Fig. 72 with Figs. 71 and 73.

It has been a great pleasure to me that the discussion after the demonstration of these results at the congress in Cambridge showed that most of those who were present agreed with my results. Dr. Crookall, who published his paper on *Crossotheca Kidstoni* shortly before the congress, accepted not only the fact that Kidston's Crossothecas do not belong to *Sphenopteris hoeninghausi*, but also that *C. Kidstoni* merged, on the one hand, into *C. schatzlarensis* and, on the other, into *C. communis* (as they have been figured by Kidston). Dr. Crookall pointed to the great similarity between *C. Kidstoni* and *S. hoeninghausi*. However, it is not possible to agree with Dr. Crookall in this respect. The similarity is not so very great, although both plants are very variable. The glandular appendages all over the different parts of *S. hoeninghausi* are entirely absent in *C. Kidstoni*. Even the most delicate forms of *S. hoeninghausi* never show the almost linear, often somewhat cuneate segments of the pinnules, which are seen in the *schatzlarensis* form of *C. Kidstoni*. *C. Kidstoni* (at least those specimens described in this paper and in the papers by Kidston and Crookall) occurs in the Westphalian B, and until now no true specimen of *Sphenopteris hoeninghausi* has been collected in the Westphalian B. By this fact the difference between the associated floras must be accepted. So it is clear that most of the objections against the connection between *S. hoeninghausi* and a *Crossotheca* still stand.

It may be that Dr. Crookall is right when he accepts that *C. Kidstoni* also belongs to the genus *Lyginopteris*, but as far as we know at present, this cannot be proved.

In this connection attention must be called to the specimen of Fig. 78. This specimen has been collected in locality 5. It has been found together with true Crossothecas and with sterile fragments of both types.

It shows a profusely ramified portion of a leaf. There are traces of delicate, more or less linear pinnules on some of the thin branches. However, most of the ultimate ramifications bear small, almost triangular, cupule-like organs. The broad top of these triangles shows three or four small teeth. It could not be proved whether there are seeds enclosed in these cupules. It is clear that this specimen belongs to *C. Kidstoni* and it is not impossible that it represents the female fructification of this species. If this is true, Crookall's opinion that *C. Kidstoni* should be related with *Lyginopteris* would be supported rather much, although a generic relation cannot be accepted as there remain too many differences between *C. Kidstoni* and the species now known as belonging to *Lyginopteris*.

The result of the examination of the Dutch specimens of *C. Kidstoni* and *S. hoeninghausi* offers an opportunity for a revision of the figures in Kidston's and Crookall's papers on this subject.

Kidston's fossil plants, Pls. 85, 86, 87, 89.

Pl. 85, Figs. 1, 2. *Sphenopteris hoeninghausi.*
Pl. 86, Figs. 1, 2, 3. *Crossotheca Kidstoni.*
Pl. 86, Fig. 4. *Sphenopteris hoeninghausi.*
Pl. 86, Figs. 5, 6. *Crossotheca Kidstoni.*
Pl. 86, Fig. 7. *Crossotheca Kidstoni.*
Pl. 86, Fig. 8. *Sphenopteris hoeninghausi* (a rather poor specimen).
Pl. 86, Fig. 9. *Sphenopteris hoeninghausi.*
Pl. 86, Fig. 10. Indeterminable.
Pl. 86, Figs. 11, 12, 13. *Crossotheca Kidstoni.*
Pl. 87, Fig. 4. *Sphenopteris hoeninghausi.*
Pl. 87, Figs. 5, 10. Spores of *Crossotheca.*
Pl. 89, Figs. 1-8. *Crossotheca* "schatzlarensis" Kidst.
Pl. 89, Figs. 9-10. *Crossotheca* "communis" Kidst.

The specimens which belong to *Sphenopteris hoeninghausi* have been collected in Westphalian A.

The figures on Pl. 88 also belong to *C. Kidstoni* and show somewhat extreme forms of that species.

The specimens of *Crossotheca* on this plate are somewhat smaller than is usually the case in *C. Kidstoni*. However, such a difference of size also occurs among the Dutch specimens.

How far *Crossotheca hughesiana* Kidston, Pl. 88, belongs also to *C. Kidstoni* can only be decided after an examination of Kidston's material. The difference in size of the Crossothecas cannot make a specific difference on itself. I strongly suppose that this species is based on specimens of *C. Kidstoni* with large Crossothecas and

that it can be compared for instance with our Figs. 73 and 74 (*compare also* FIG. 67, a specimen from Kidston's type locality, Coseley near Dudley).

Kidston's figures in the *Proceedings of the Royal Society*, **76**, 1905, Pl. 6, Figs. 1-5; and in *Phil. Trans. Roy. Soc.*, Vol. **198**, 1906, Pls. 25, 26, Figs. 1-32 also belong to *C. Kidstoni*.

Crookall's figures, 1930, can be revised in the following way:

Pl. 33, Figs. 1, 2. Copies after older figures by Brongniart and Andrä.

Pl. 33, Figs. 3-7; Pl. 34, Figs. 10-12, 14-18. *Crossotheca Kidstoni*, sterile pinnules; some of these have already been figured by Kidston. Locality: Ten-foot Ironstone Measures, Coseley near Dudley. Westph. B.

Pl. 34, Figs. 13, 20. *Sphenopteris hoeninghausi*. Locality: Three-quarter Coal, Chopwell Co., Durham. Westph. A.

Pl. 34, Figs. 8, 9, 19. *Sphenopteris hoeninghausi*. Locality: Roof of Fireclay coal, Doulton's Marl Quarry, Netherton, S. Staffordshire. Westph. A.

Until now only the Dutch specimens of *C. Kidstoni* from the Westphalian B and the British specimens as far as they have been described by Kidston, equally from the Westphalian B, have been discussed.

It must, however, be mentioned that specimens with sterile pinnae showing the characters of *C. Kidstoni* and the same variation in the form of the pinnules, have been collected in the Westphalian A of the Dutch coalfield at the localities 6, 7, 8. It is curious that these collections also contain fertile specimens, which are profusely branched, and bear numerous very small Crossothecas, which are more or less similar to those figured by Kidston as *C. schatzlarensis* on his Pl. 89, Figs. 3, 4, but their size is still much smaller and it seems that the numbers of microsporangia is smaller.

The best specimen is that shown in Fig. 79. At several places of the enlargement 79a the small Crossothecas are visible. Some of the pinnules show traces of their original form; this is especially clear in the enlargement 79b. This form is that of the "schatzlarensis" type. A specimen of this form is seen in Fig. 80, while Fig. 81 is one of the "communis" specimens. They all have been collected from the same locality, Seam XVIII of Coll. Hendrik, Westphalian A.

It is not well possible to separate these specimens specifically from the ordinary type, but it will be safe to distinguish them as a forma *minor*.

Although they have been found in horizons where *S. hoeninghausi* also occurs, there is no question of a relation with this species, as they never show the slightest trace of the glandular spines which are so numerous on the axes of *S. hoeninghausi*, and as the fundamental form of the pinnules is that of *C. Kidstoni*.

If this conclusion is right, it is clear that the distribution in time of *C. Kidstoni* is much larger than that of *S. hoeninghausi*. The latter is restricted to the Westphalian A, and is found in the upper and lower parts of that subdivision. *C. Kidstoni* is known from the upper part of the Westphalian A (Wilhelmina group) and from the Westphalian B, where it has been collected in the Hendrik and Maurits groups. Probably it is still present in the lower Westphalian C.

CONCLUSIONS

The female fructifications of *Sphenopteris hoeninghausi* Bgt., identical with *Lyginopteris oldhamia*, have been found in organic connection as cupules with seeds enclosed on profusely branched systems without pinnules of the sterile types. Cupules and axes show the glandular spines which are characteristic of this plant. Fructifications, seeds and their position agree completely with the reconstruction by Oliver and Scott.

The male fructification is unknown.

Crossotheca is not, as Kidston accepted, the male fructification of *S. hoeninghausi* but belongs to a plant bearing sterile pinnae of the types *schatzlarensis* and *communis*, as these have been described in Kidston's papers. In agreement with Hemingway and Crookall this plant is named *Crossotheca Kidstoni*.

Although both species, *S. hoeninghausi* and *Crossotheca Kidstoni*, are very variable as to the form of the sterile pinnules, there is no possibility of accepting that they belong to the same plant. The chief differences are the appendages on the axes in *S. hoeninghausi*, and their absence in *C. Kidstoni*, the fundamentally different form of the pinnules, the difference in the outer surface of the axes, and the occurrence of *S. hoeninghausi* in the Westphalian A only.

Together with *C. Kidstoni* fertile profusely branched systems have been found, bearing small triangular cupule-like organs. It is

possible that these organs are the female fructifications. Seeds have not been observed.

A minor form of *C. Kidstoni* is known from the upper half of the Westphalian A in the Netherlands.

A revision of the occurrence of *S. hoeninghausi* published by Kidston, 1923, is necessary. This can be done only combined with a re-examination of the complete material, mentioned by him in his lists.

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EXPLANATION OF PLATES

(All photographs made by Mr. van Voskuylen, Geol. Bureau, Heerlen)

1-34 *Sphenopteris hoeninghausi* Bgt.

PLATE 1

1-4. Stems showing ornamentation and spiny appendages (1, 2: Coll. Hendrik, roof Seam XIV, Cat. 858; 3, 4: Coll. Domaniale Mijn, roof Seam Finefrau, Cat. 4026).

PLATE 2

5. Foliage, pinnae not very distant, pinnules large, segments crowded. Resembles *S. stangeri* (Cat. 4026).

6, 7. Foliage; pinnules flattened (Domaniale Mijn, roof Seam Finefrau, Cat. 4025).

PLATE 3

8. Foliage with distant pinnae and small, slender pinnules (Coll. Victoria, Lünen, Fettkohle, Cat. 885).

9. Foliage with small, more delicate pinnules (Coll. Maurits, roof Seam IX, Cat. 4024).

10, 10a. Foliage with small pinnules (Boring LVI, 385 m, Cat. 853).

PLATE 4

11, 11a. As Fig. 10 (Coll. Oranje Nassau III, Cat. 848).

12, 13. Flattened forms, transition to the forma *laxa* of Figs. 9-11 (Cat. 4025).

PLATE 5

14. Specimen with small spiny axes, extremely glandulous; pinnules small, crowded; pinnae distant (Cat. 858).

15. A similar specimen (Coll. Domaniale Mijn, roof of Seam L, Cat. 845).

PLATE 6

16. Female fructifications on small axes, which show the appendages very clearly, and bear foliage in the basal part only (Coll. Oranje Nassau VI, roof of small seam over Seam B, Cat. 850).

17-21 (and enlargements). Female fructification. Cupules, some of them (17, 18) closed, others widely opened. Note the distinct spiny appendages on the cupules and small axes (Cat. 850).

22. Open cupule (enlarged) (Coll. Hendrik, Seam XVIII, Cat. 5967).

23, 24 (and enlargements). Seeds enclosed in the cupules (Cat. 850).

PLATE 7

25-29 (and enlargements). Cupules, more or less opened, with distinct spiny appendages (Cat. 850).

30, 30a. Seed enclosed in the cupule (Cat. 850).

PLATE 8

31, 31a. Branched systems of leafless, very spiny, small axes bearing cupules (Cat. 850).

32, 32a. Branched systems of leafless, very spiny, small axes bearing cupules (Cat. 850).

PLATE 9

33, 34. Large specimens of profusely ramified systems bearing cupules (Cat. 850).

35–81 *Crossotheca Kidstoni* (Hemingway) emend. Jongmans

PLATE 10

35-41. Specimens with finely divided foliage, pinnules delicate with narrow, almost linear segments (35: Coll. Maurits, below small Seam I D, Westphalian B, Cat. 4013; 36-40: Coll. Emma, roof of Seam B, Cat. 4008; 41: Coll. Emma, between the Domina and Aegir horizons, upper part of Westphalian B, Cat. 4020).

PLATE 11

42-45. Specimens with deeply divided pinnules, segments somewhat broader, more crowded, and with more or less cuneate tips (42: Coll. Emma, roof of Seam B, Cat. 4009; 43: Coll. Maurits, roof of Seam B, Cat. 4018; 44, 44a: Coll. Maurits, roof of Seam I D, Cat. 4016; 45: Coll. Maurits, Seam I D, Cat. 4013). Westphalian B.

PLATE 12

46-48. Intermediate forms showing the transition between the pinnules with linear segments to such with more or less rounded and crowded segments (Coll. Emma, over Seam B, Cat. 4010 and 4009). Westphalian B.

PLATE 13

49, 49a, 50, 50a. Specimens from Coseley, near Dudley, showing pinnules with rather long and narrow segments. Westphalian B (Cat. 4136).

51, 52. Specimens with pinnules similar to Fig. 46-48, tips of the segments cuneate (Coll. Maurits, Seam I D, Cat. 4015).

PLATES 14-16

53-63, 65, 66. Specimens showing the broader pinnules with crowded rounded segments of the "communis" type (53, 56, 60, 65, 66: Coll. Emma, Seam B, Cat. 4011; 54, 58, 59, 61, 63 Coll. Emma, between the Domina and Aegir horizons, Cat. 4020; 55: Coll. Maurits, Seam I D, Cat. 4016; 57: Coll. Maurits, Seam I D, Cat. 4014; 62: Coll. Emma, Seam B, Cat. 4010). Westphalian B.

64, 64a. Specimen from Coseley, near Dudley, belonging to the "communis" type. Westphalian B (Cat. 4136).

PLATE 17

67, 67a. *Crossotheca Kidstoni*, Barnsley coal, Ward Green, Great Britain, Westphalian B, Cat. 722.

68, 68a. *Crossotheca* (Coll. Maurits, Seam B, Cat. 4019). Westphalian B.

69, 69a. *Crossotheca* and sterile pinnae (Coll. Emma, Seam B, Cat. 4012). Westphalian B.

70. *Crossotheca* (Coll. Wilhelmina, Seam V). Westphalian A, upper part (Wilhelmina group), Cat. 4021.

PLATE 18

71-73. Large specimens with pinnae, which are almost entirely fertile. Sterile parts of the foliage belong to the "communis" type (71: Coll. Maurits, Seam B, Cat. 4018; 72: Coll. Emma, Seam B, Cat. 4012; 73: Coll. Maurits, Seam III, Cat. 4022). Westphalian B.

PLATE 19

74, 74a. Pinnae fertile in the lower, sterile in the upper parts. Pinnules of the "schatzlarensis" type (Coll. Maurits, Seam B, Cat. 4019).

75. Fertile and sterile pinnae, the sterile pinnae in the upper part of the specimen belong more or less to the "communis" type (Coll. Maurits, Seam B, Cat. 4019).

76. Fertile specimen belonging to the "communis" type (Coll. Maurits, Seam B, Cat. 4019). Westphalian B.

PLATE 20

77, 77a. Fertile specimen (Coll. Maurits, Seam B, Cat. 4019). Westphalian B.

78 (and enlargements). Specimen with attached curious cupule-like organs. Form of the pinnules belongs to the "schatzlarensis" type. Possibly female fructification of *Crossotheca Kidstoni* (Coll. Emma, between the Domina and Aegir horizons). Westphalian B, upper half, Cat. 4020.

PLATE 21

79. Specimen showing a profusely branched fertile system with numerous small Crossothecas.

79a. Enlargement of part of Fig. 79, showing the form of the Crossothecas.

79b. Enlargement of one of the pinnae of Fig. 79. It clearly shows that the original form of the pinnules was that of the " schatzlarensis " type.

80. Specimen of the " schatzlarensis " type.

81. Specimen of the " communis " type.

The specimens of Figs. 79-81 all come from : Seam XVIII, Coll. Hendrik, upper half of the Westphalian A (Cat. 9164).

NOTE — All figured specimens are in the collections of the Geologisch Bureau, Heerlen.

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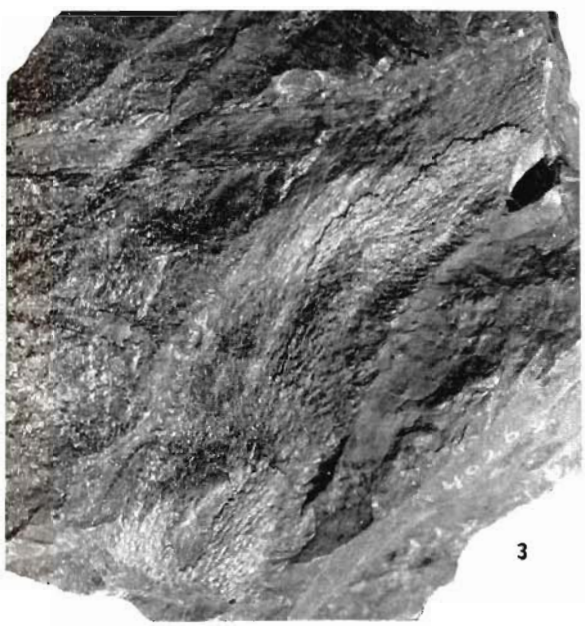

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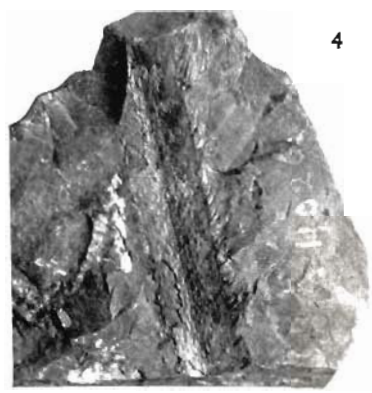

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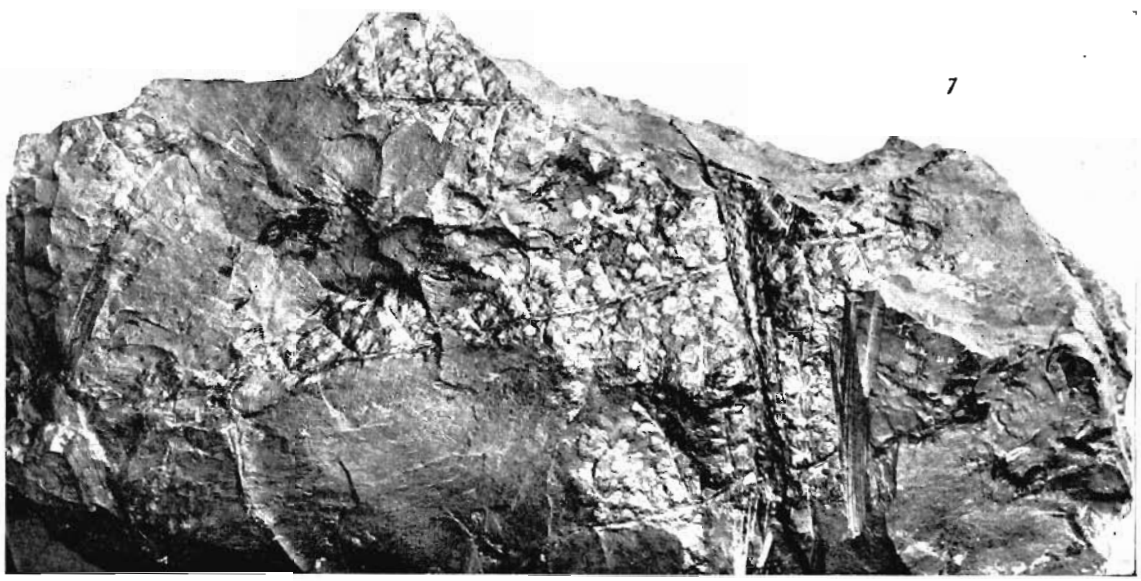

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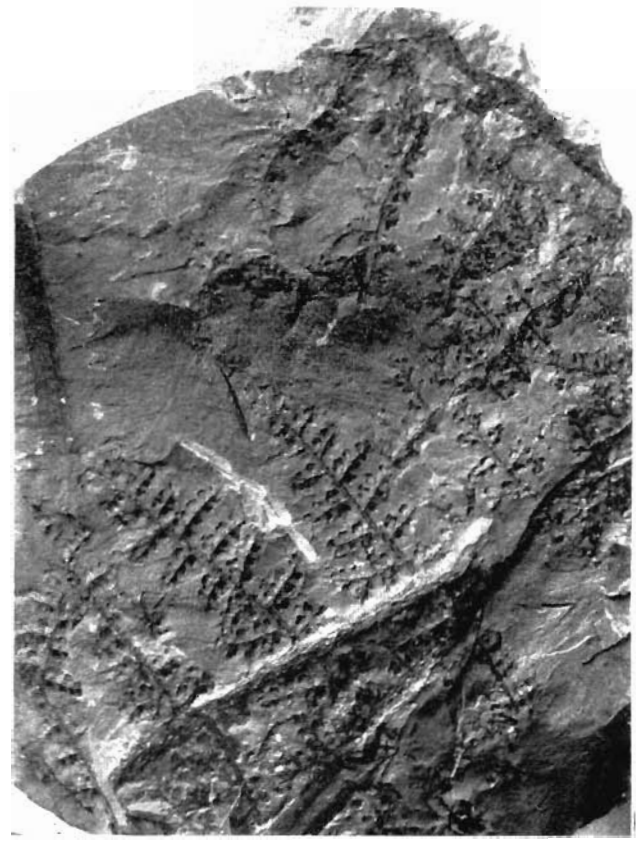

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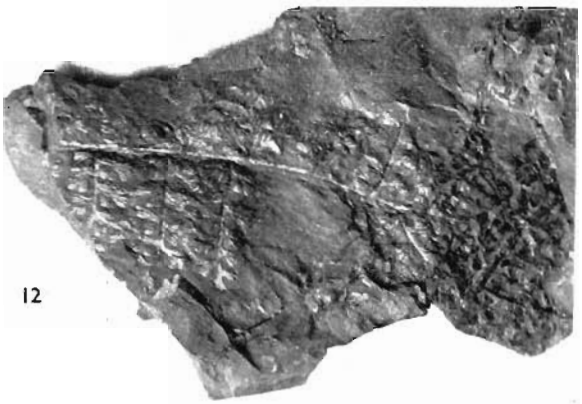

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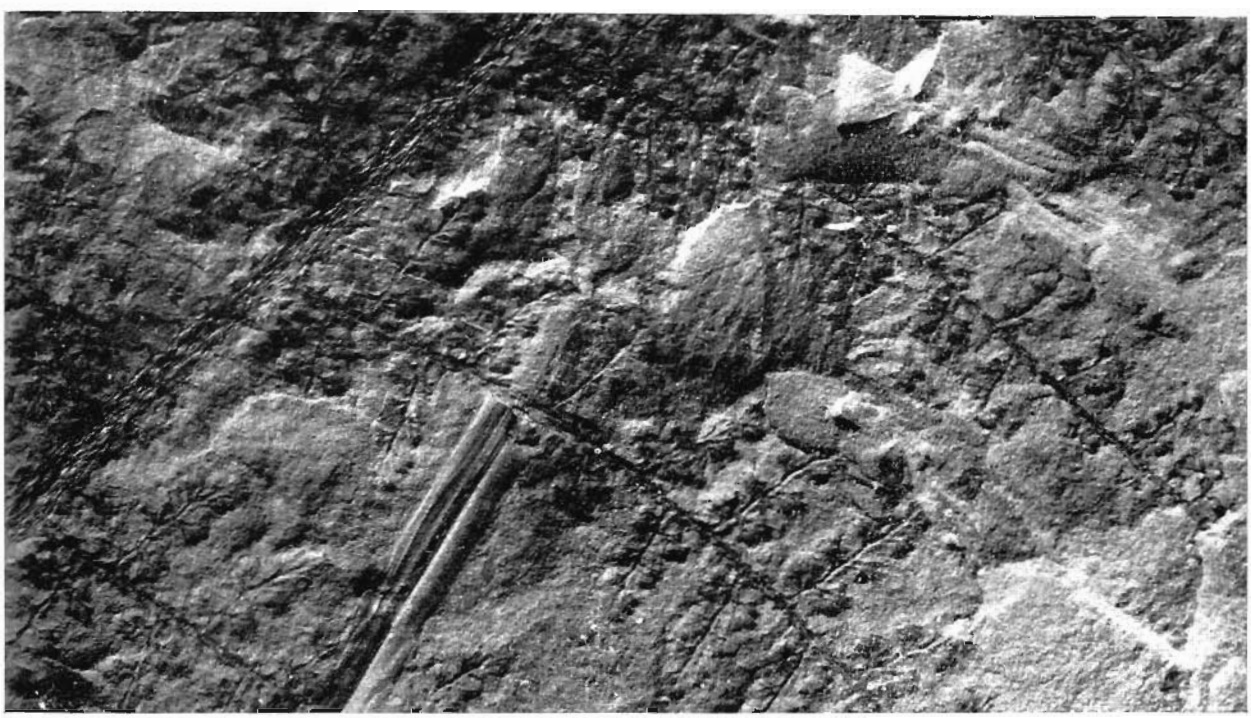

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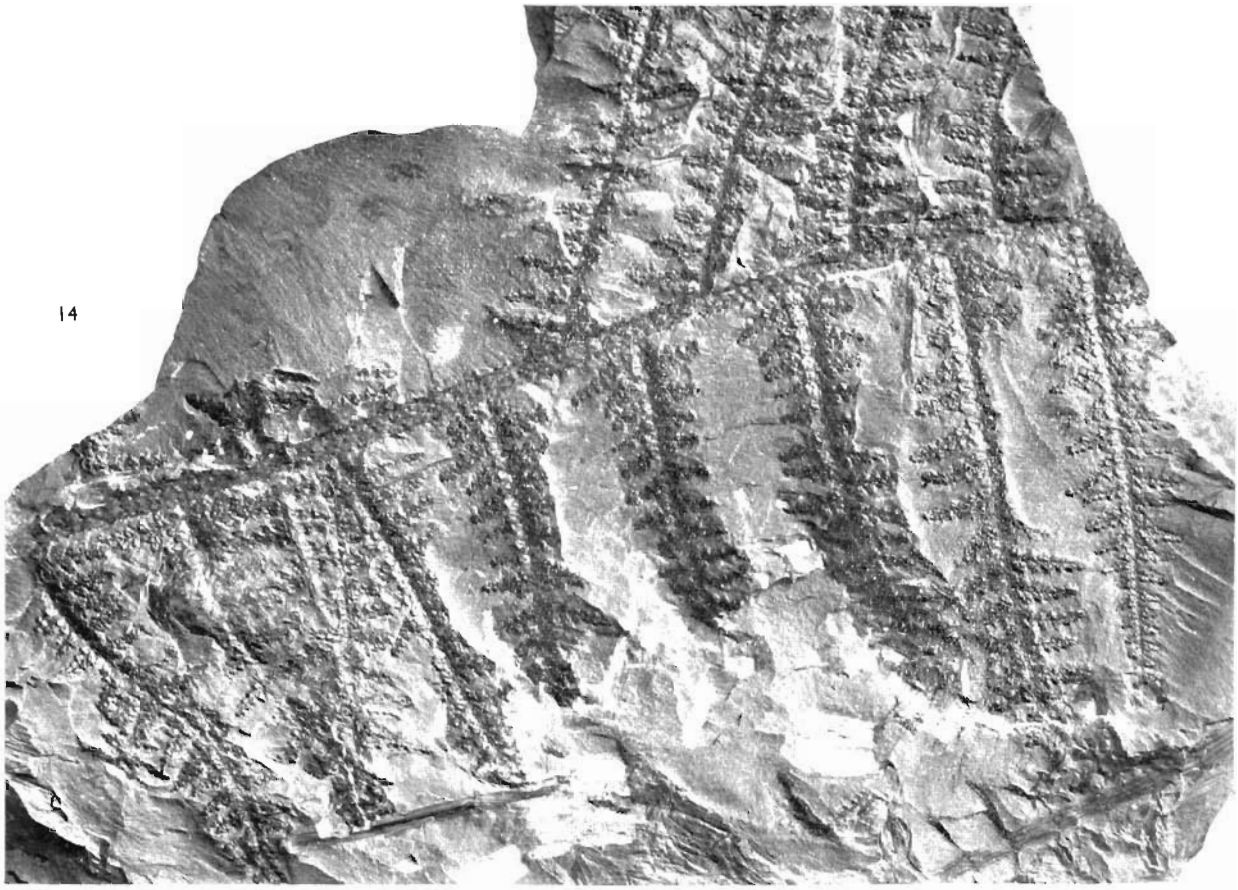

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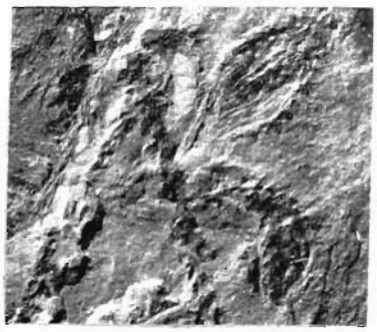

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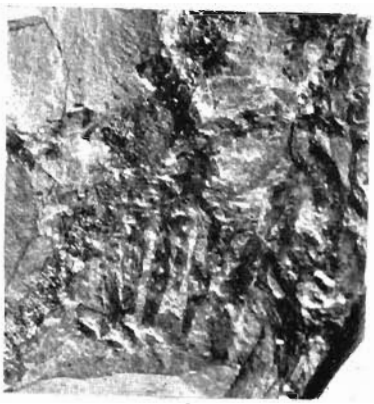

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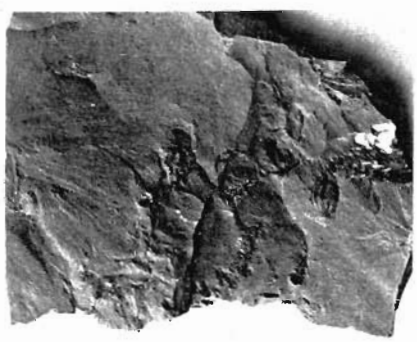

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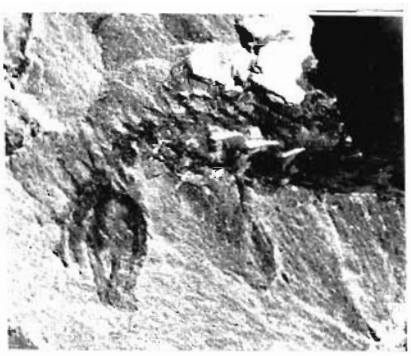

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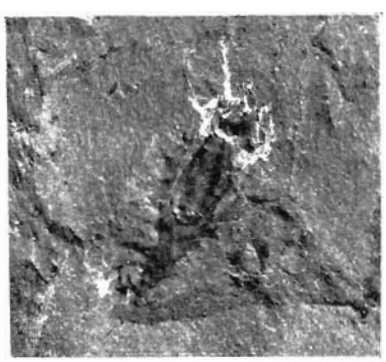

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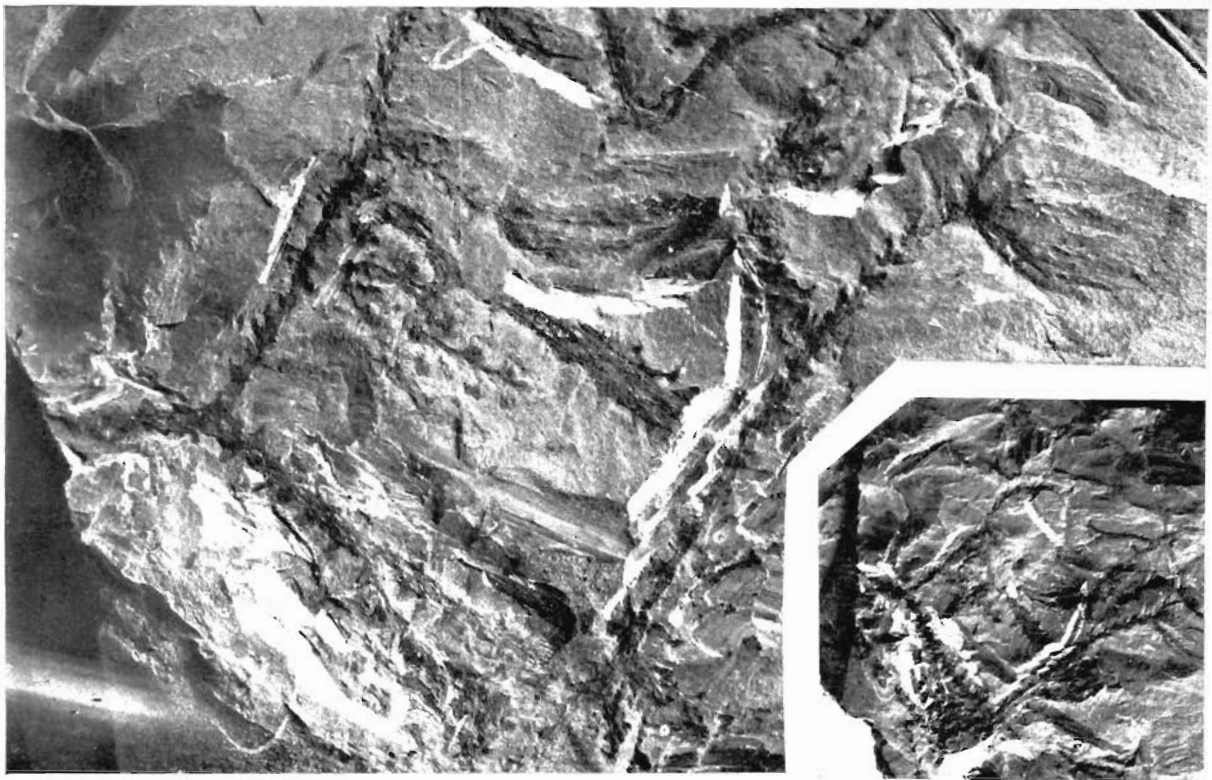

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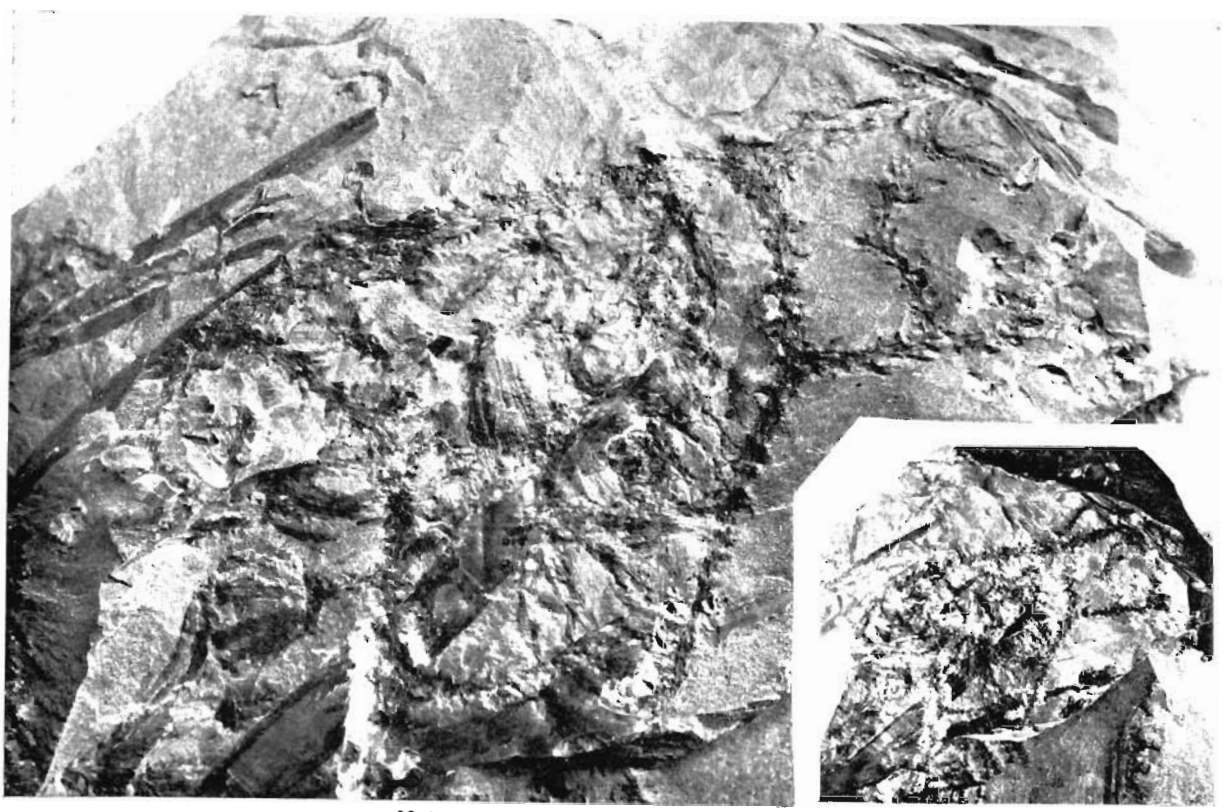

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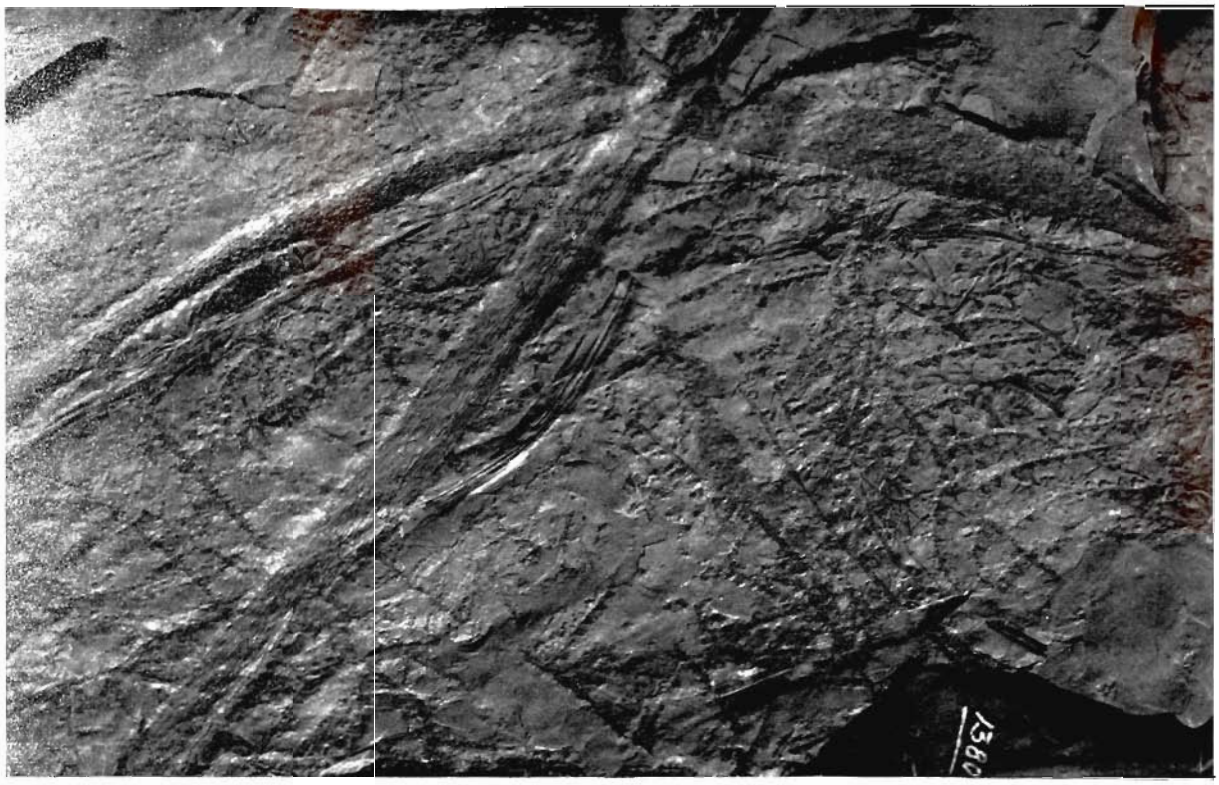

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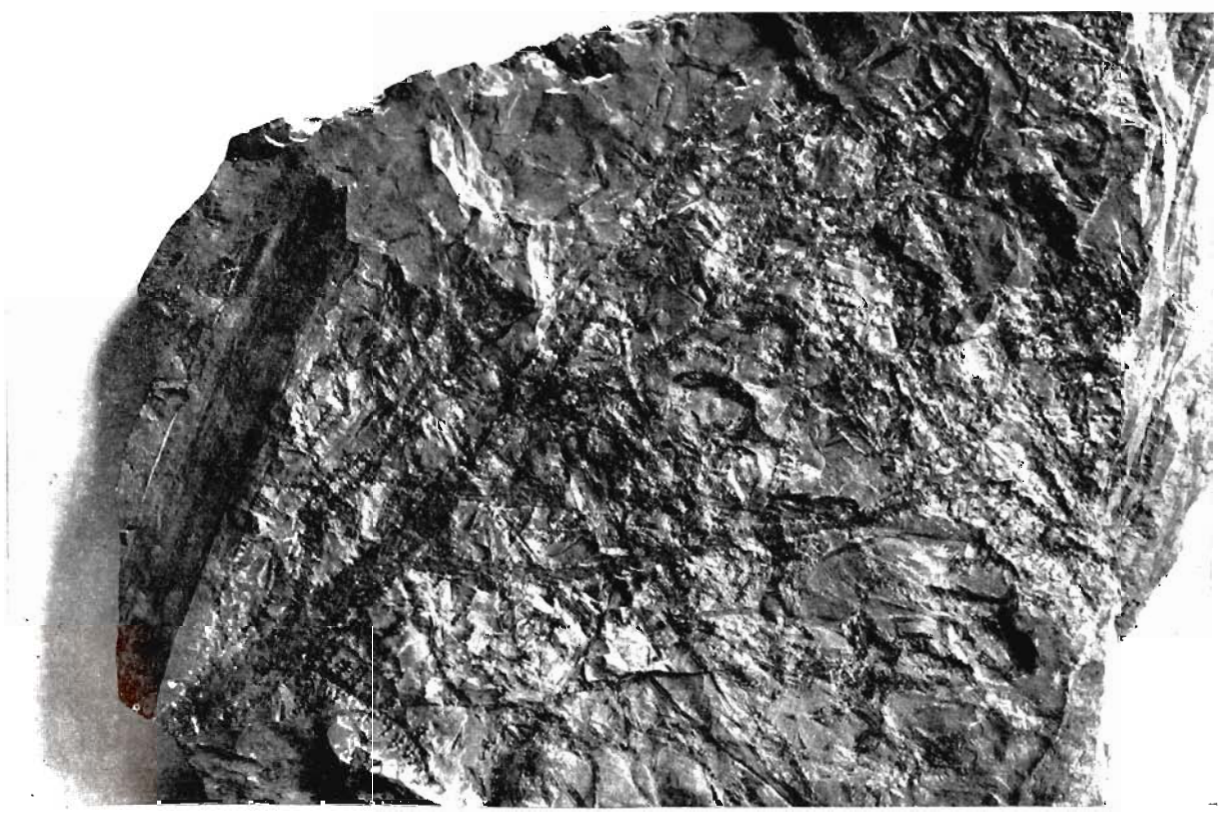

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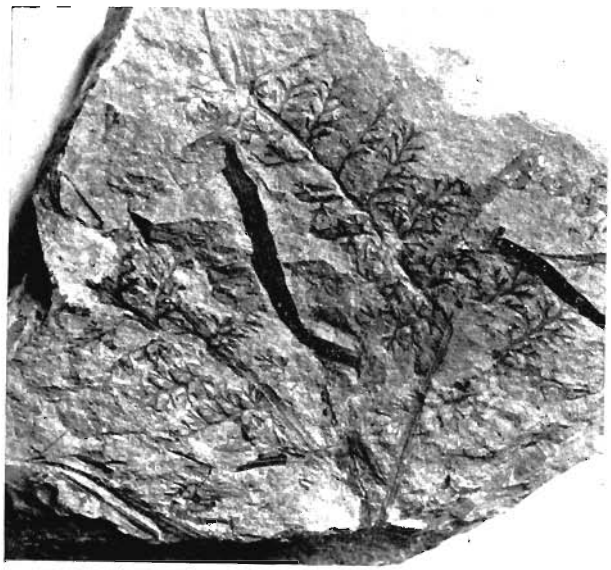

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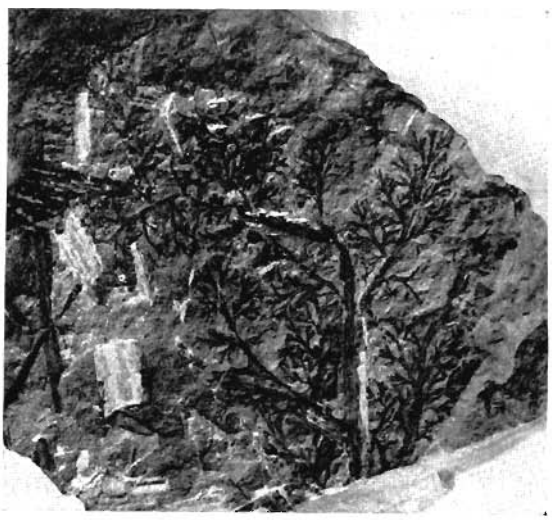

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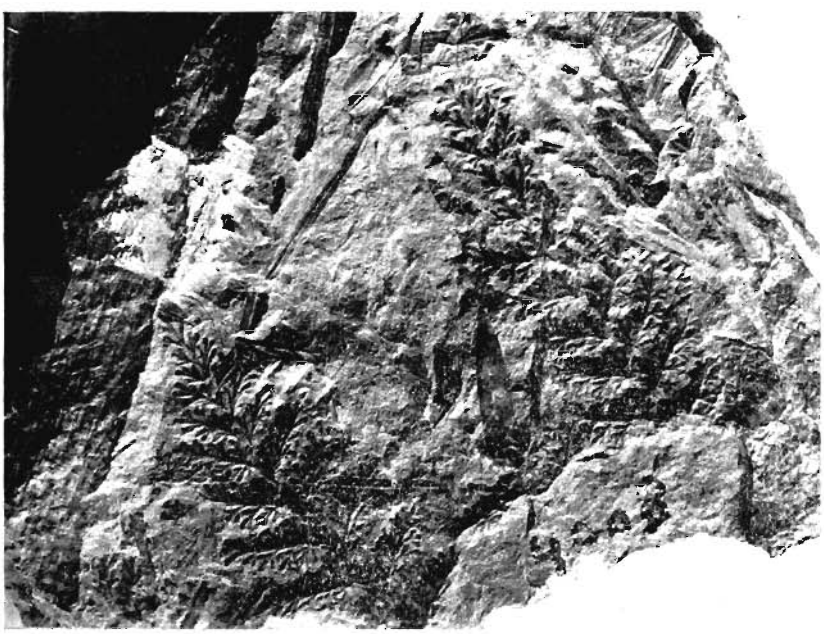

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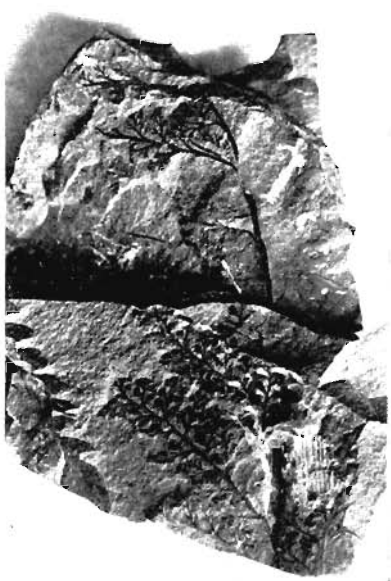

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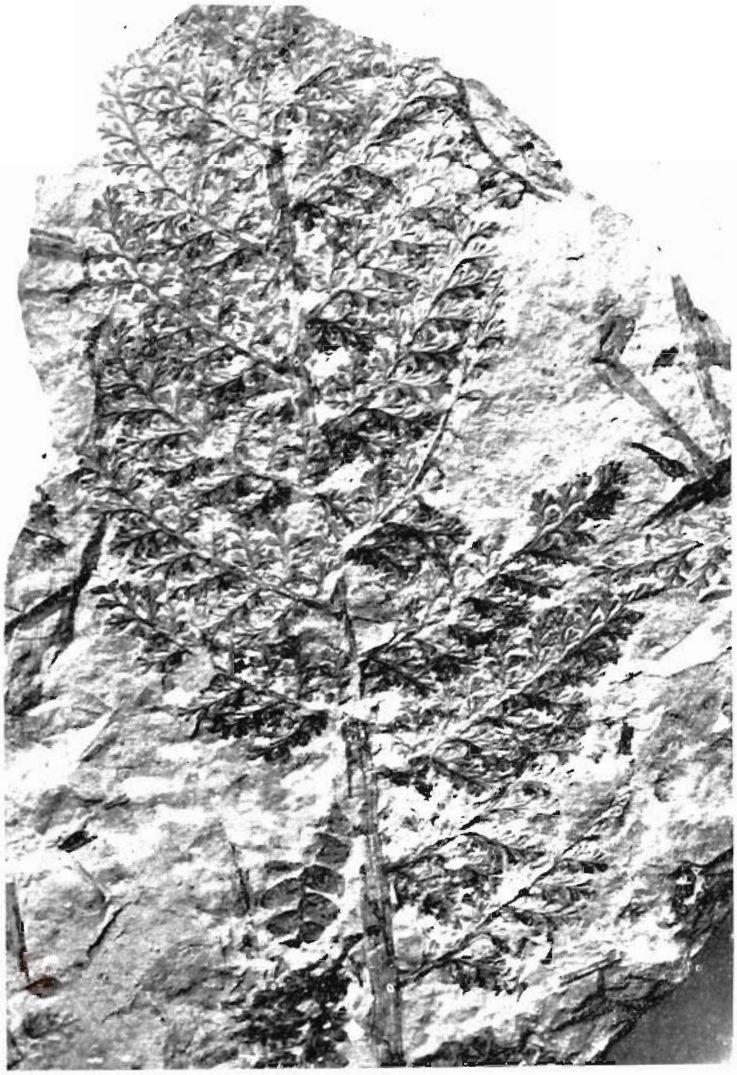

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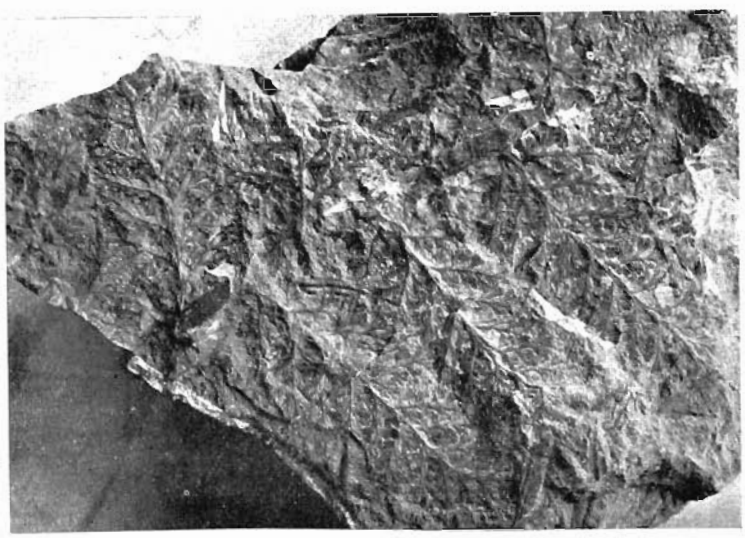

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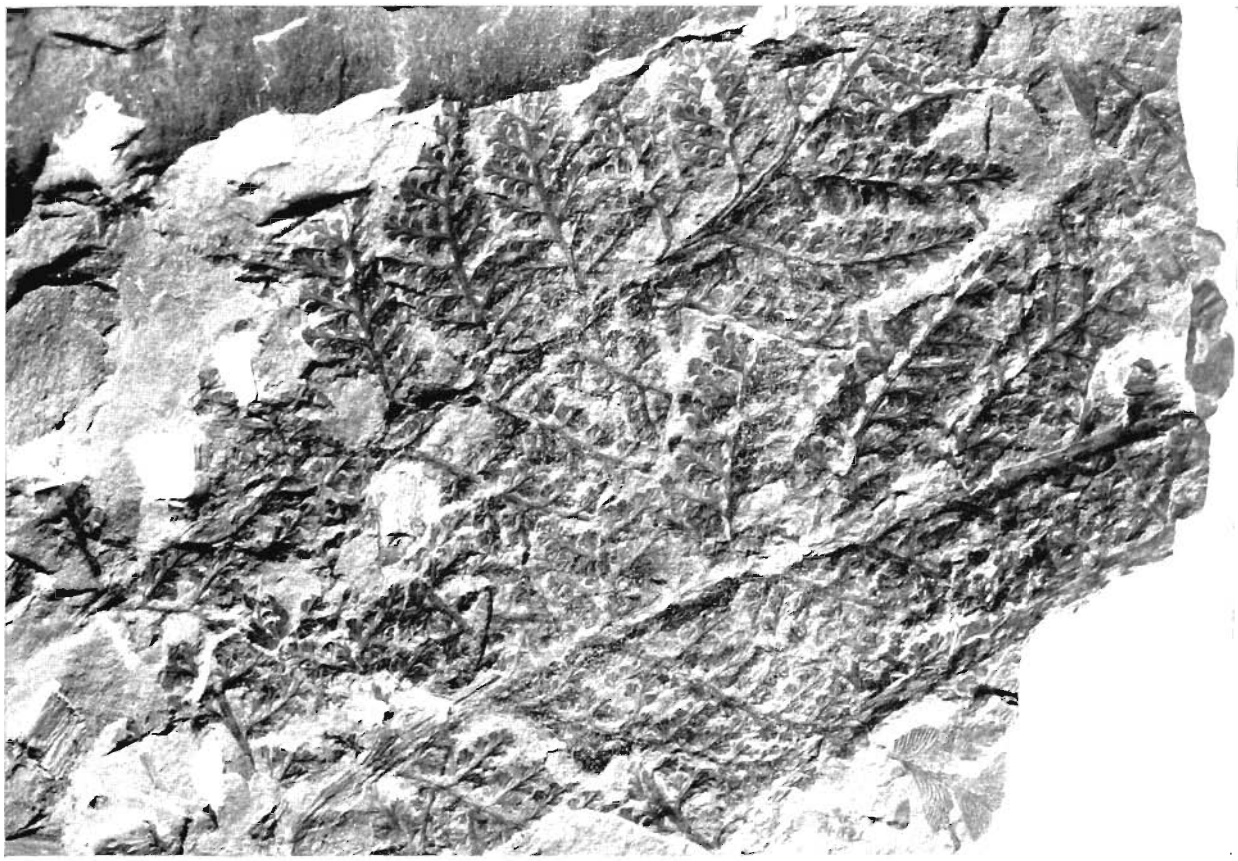

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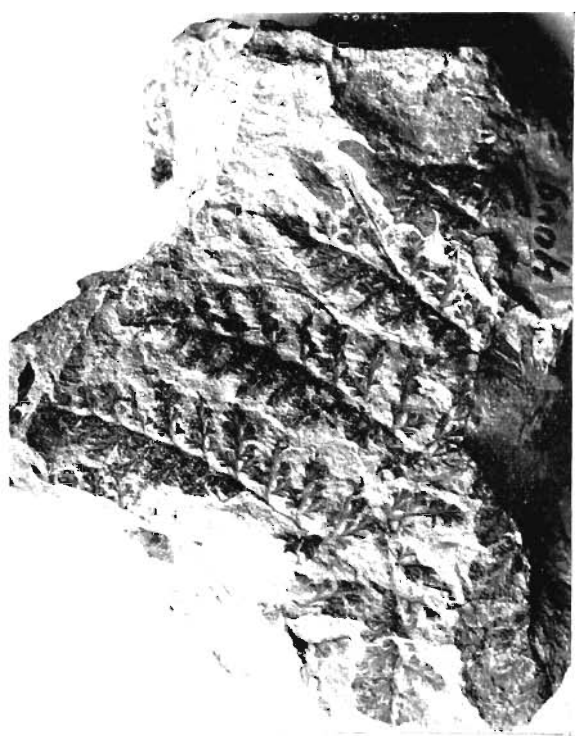

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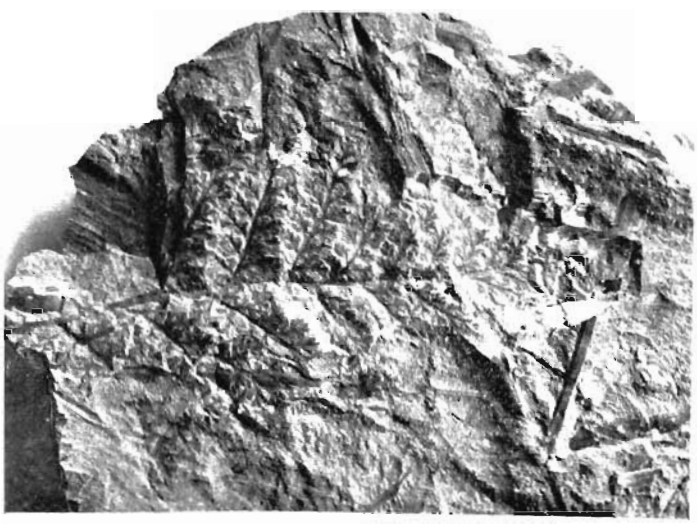

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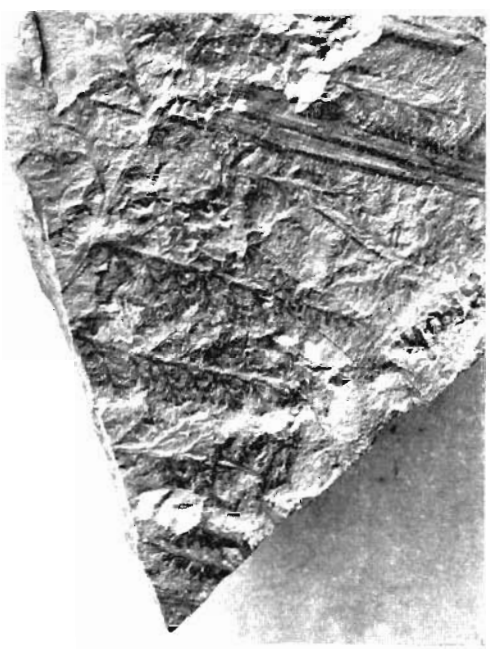

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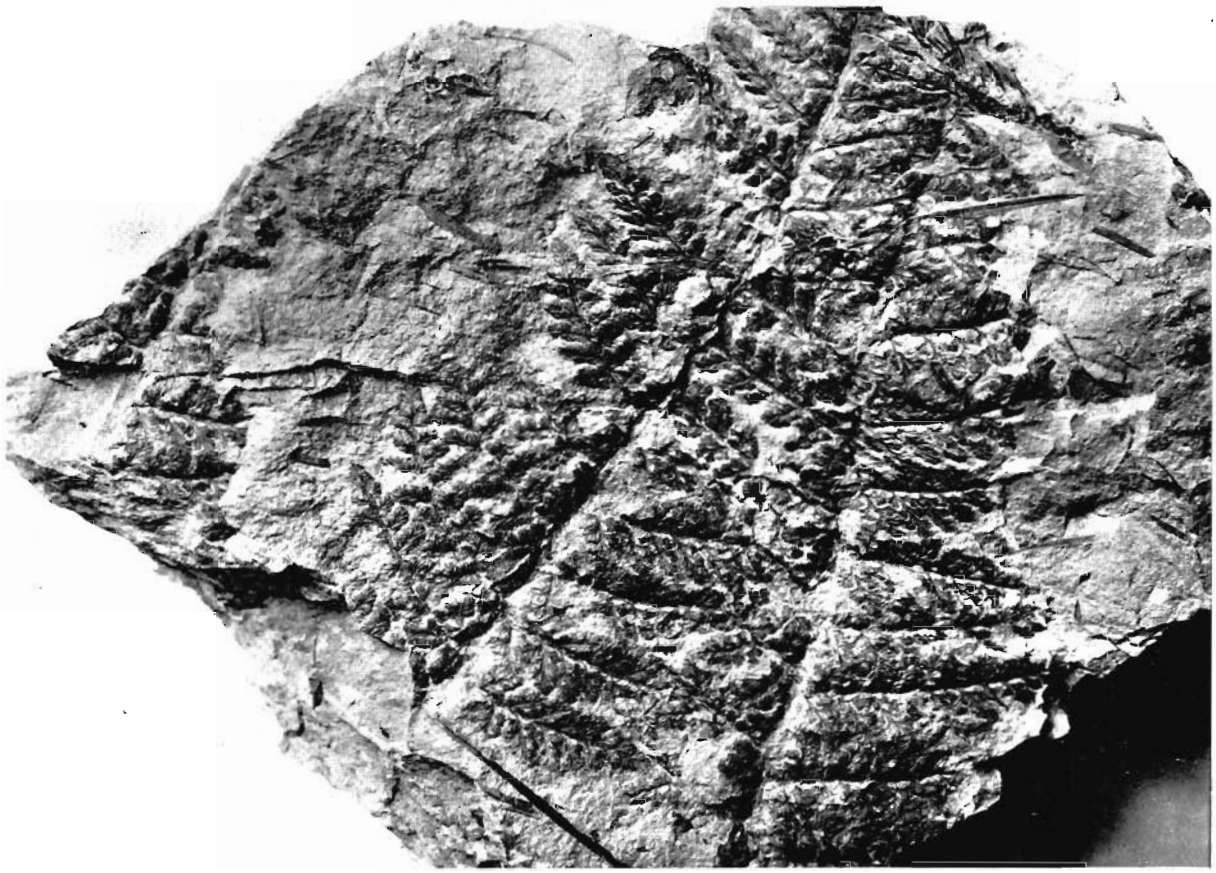

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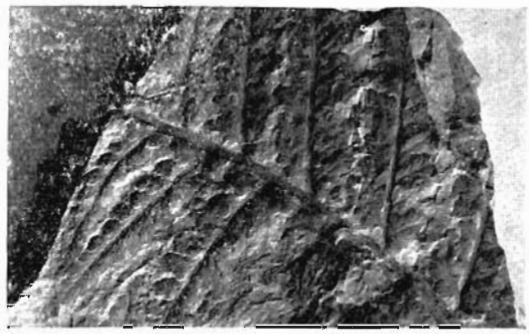

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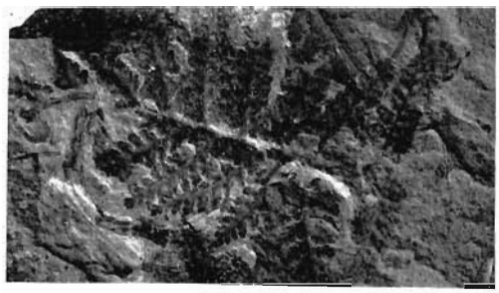

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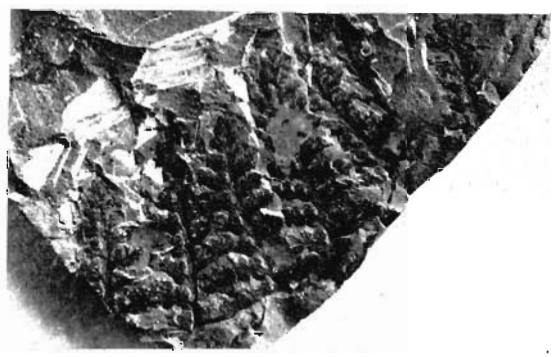

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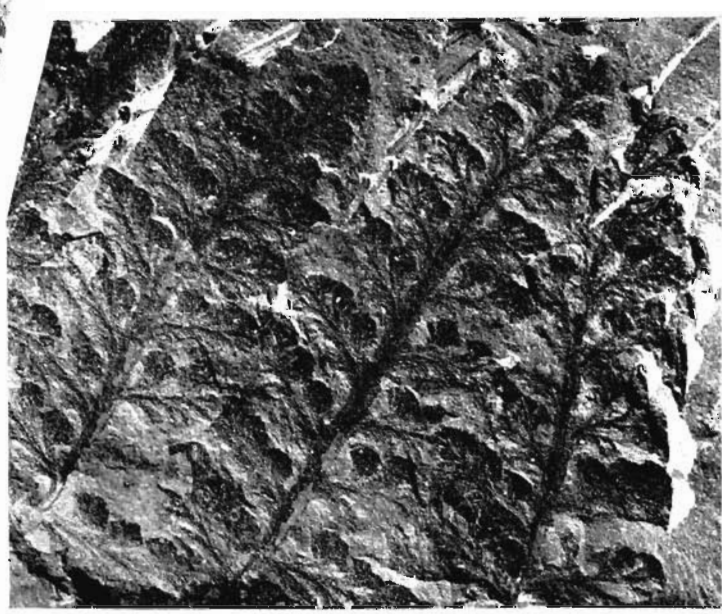

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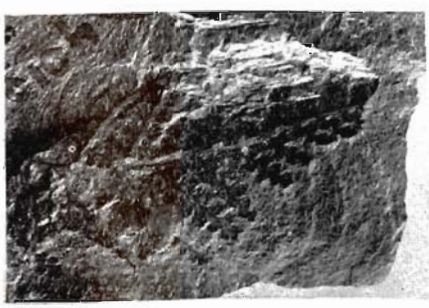

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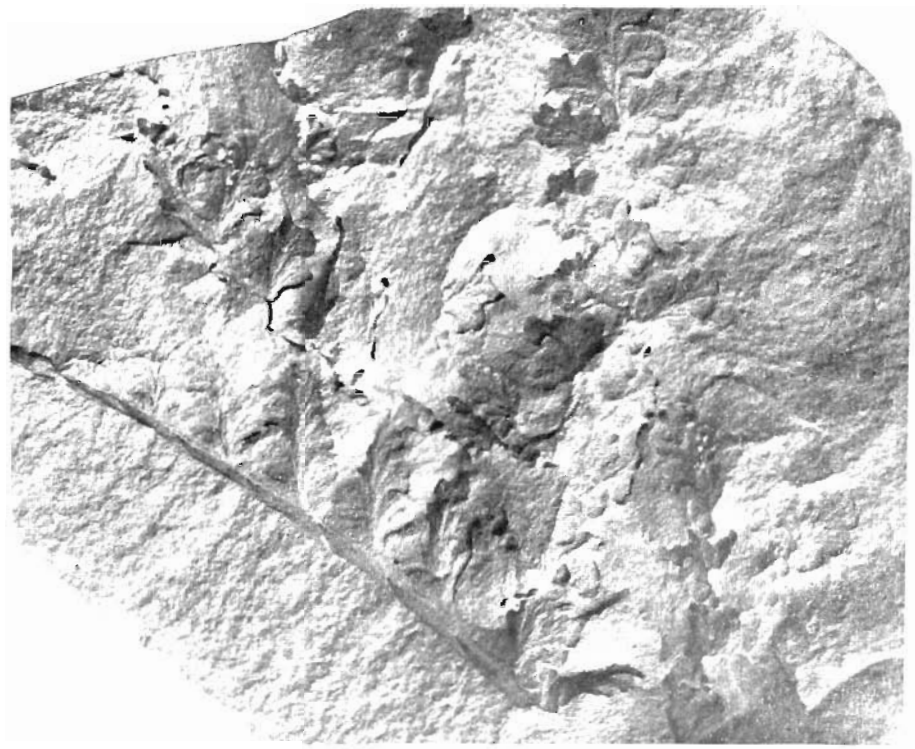

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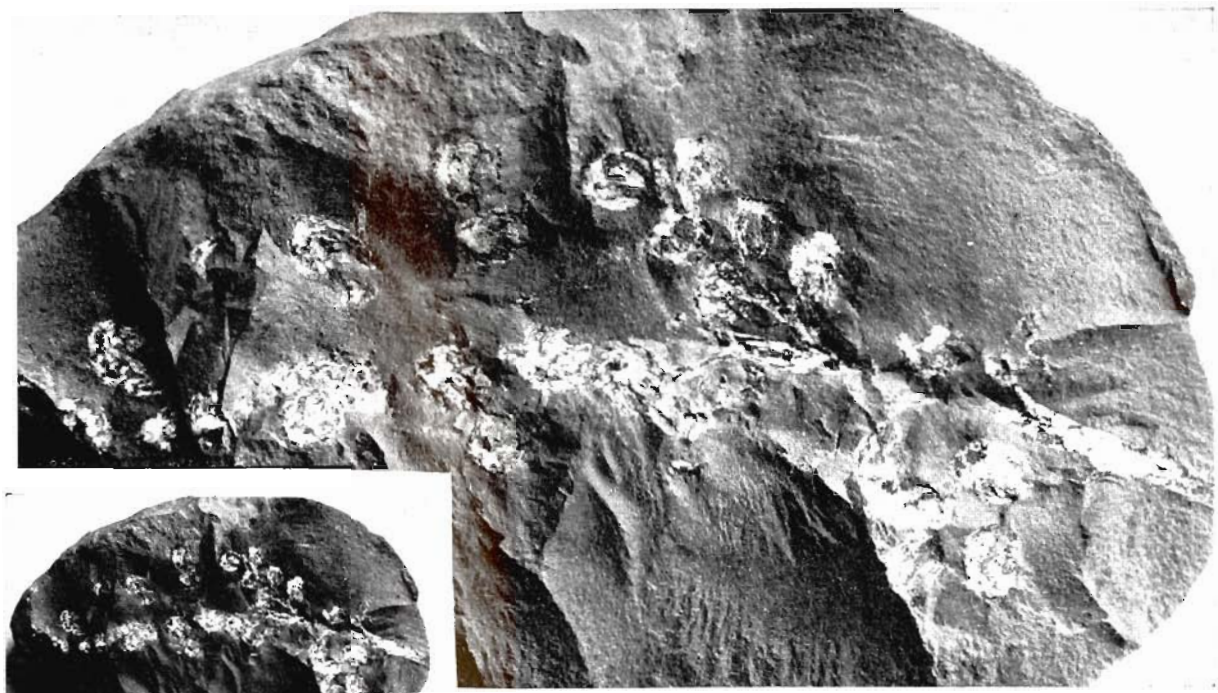

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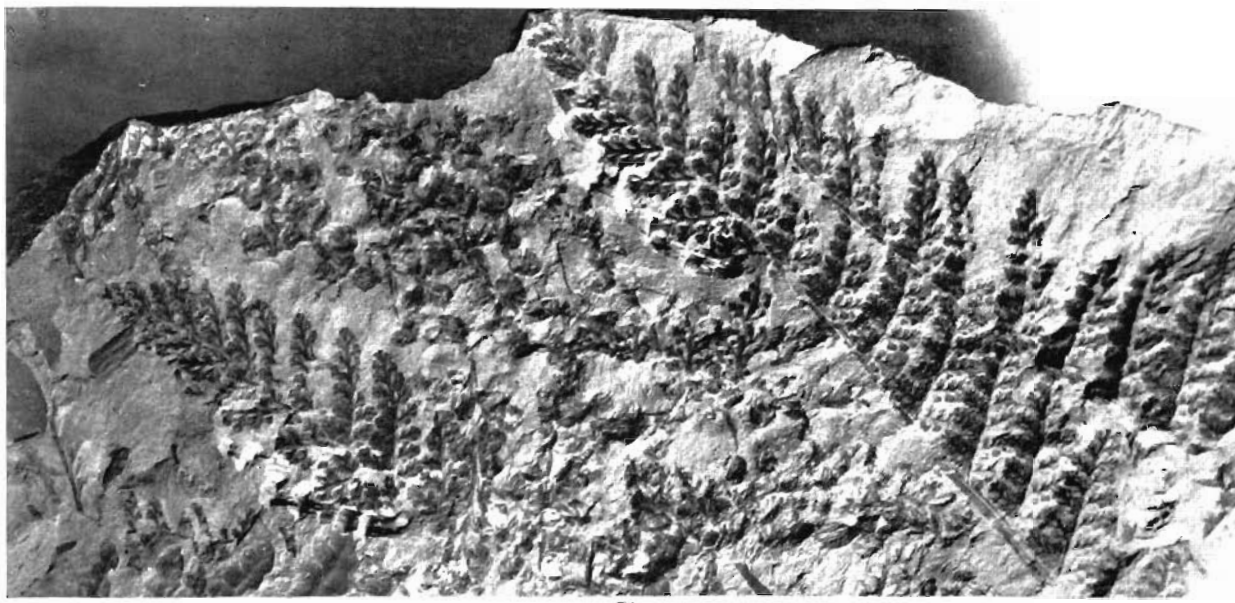

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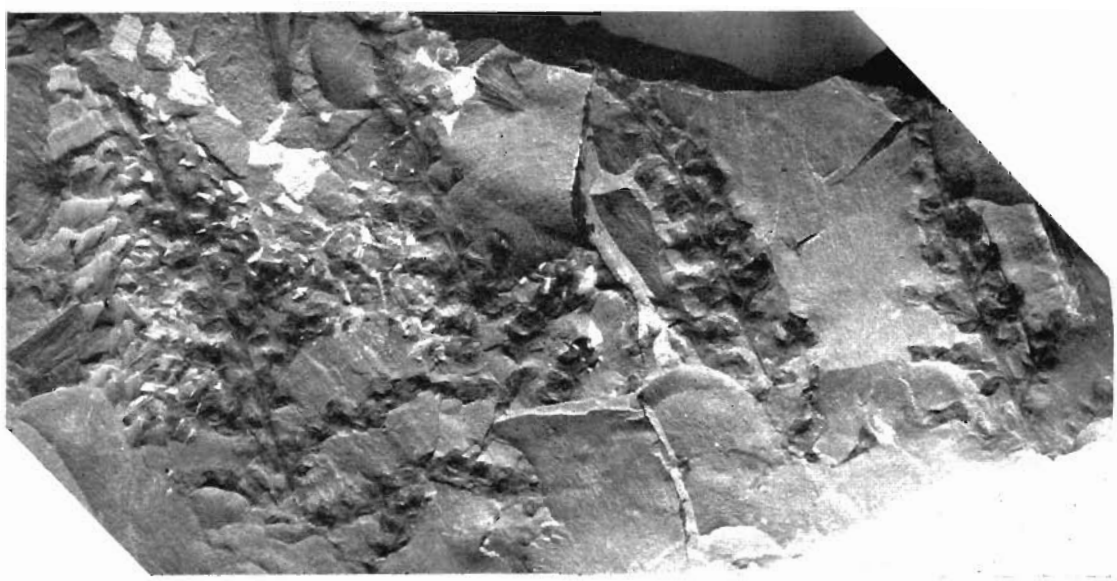

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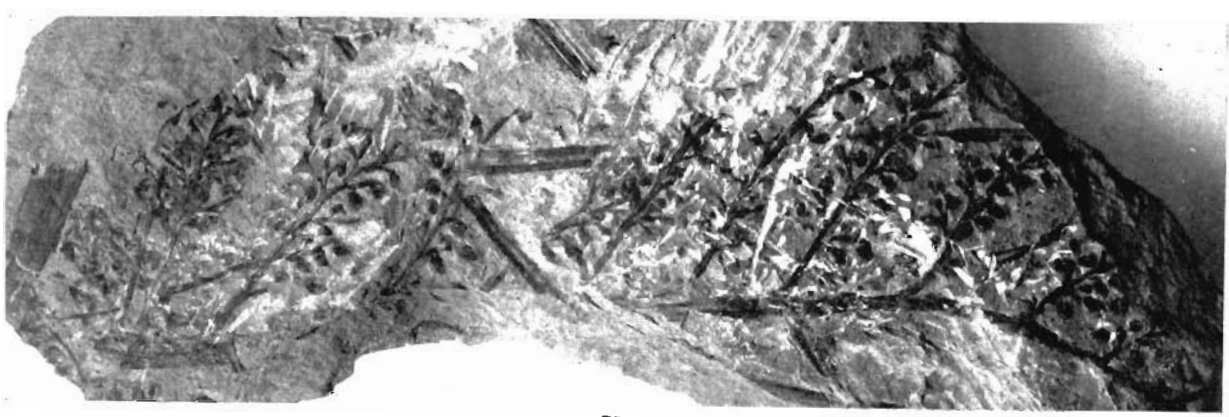

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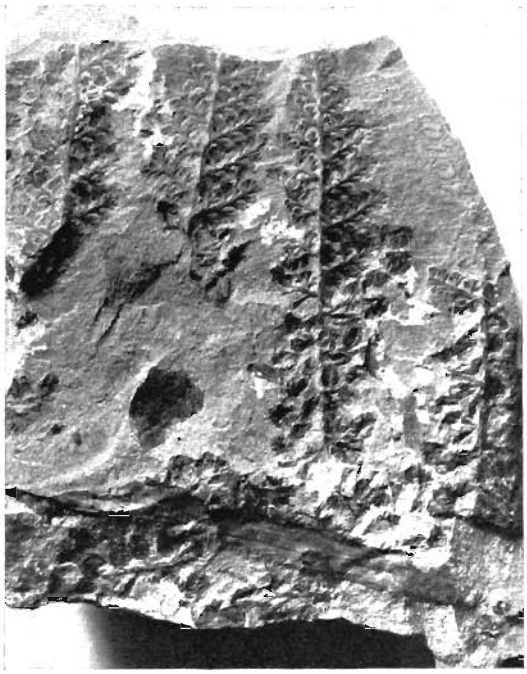

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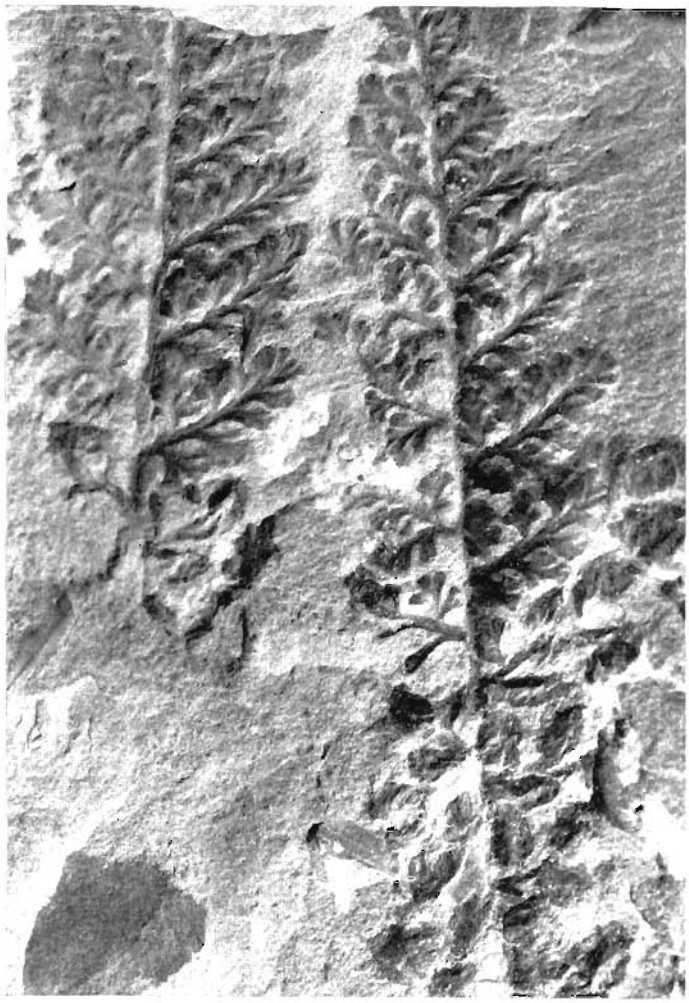

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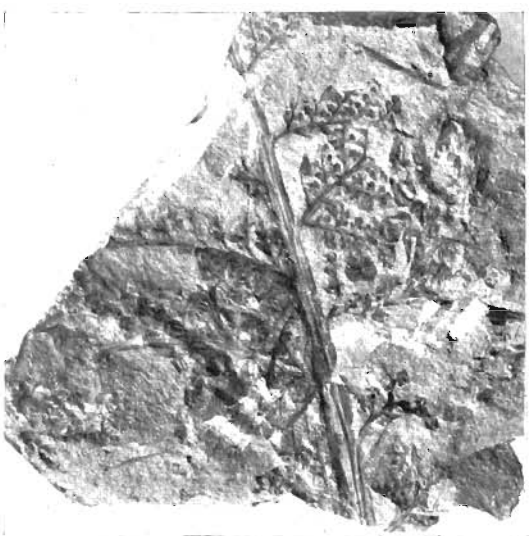

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76 A


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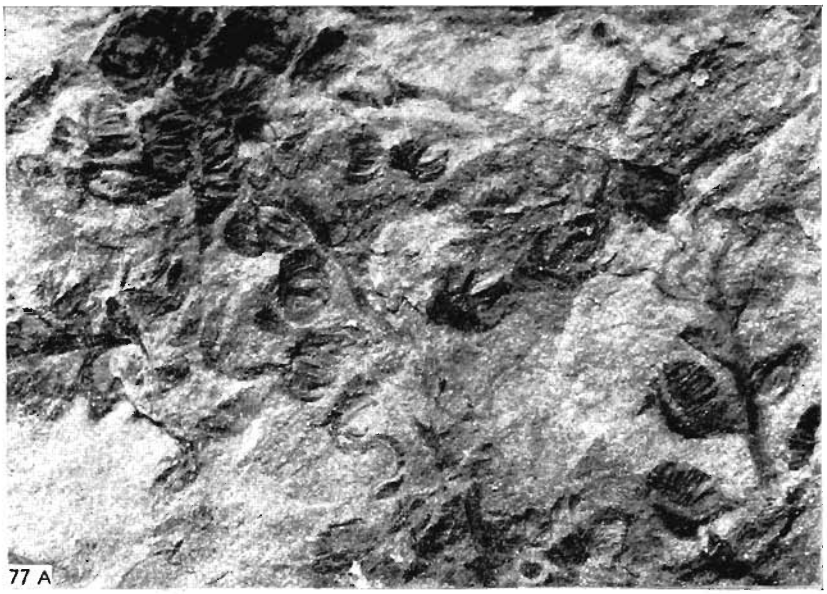
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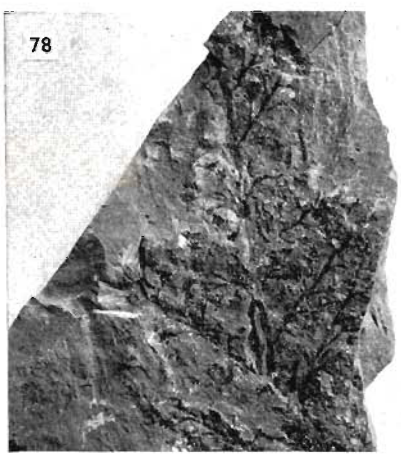
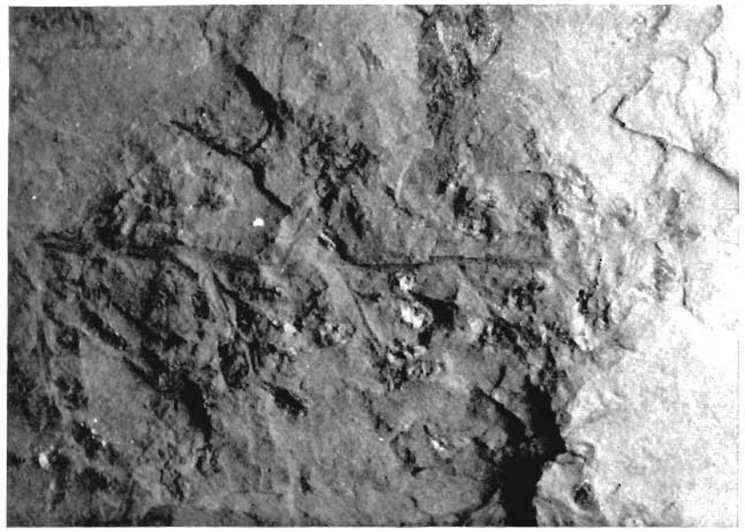

78


78 A

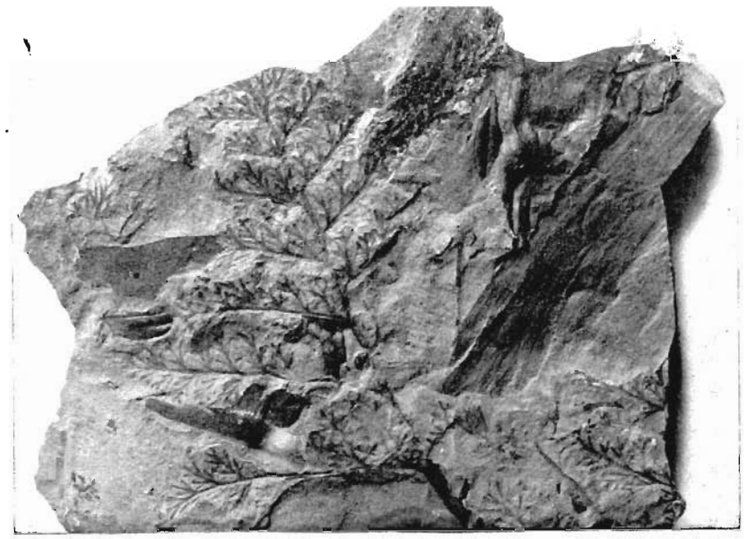

78 B


78 C


78 D



79 B



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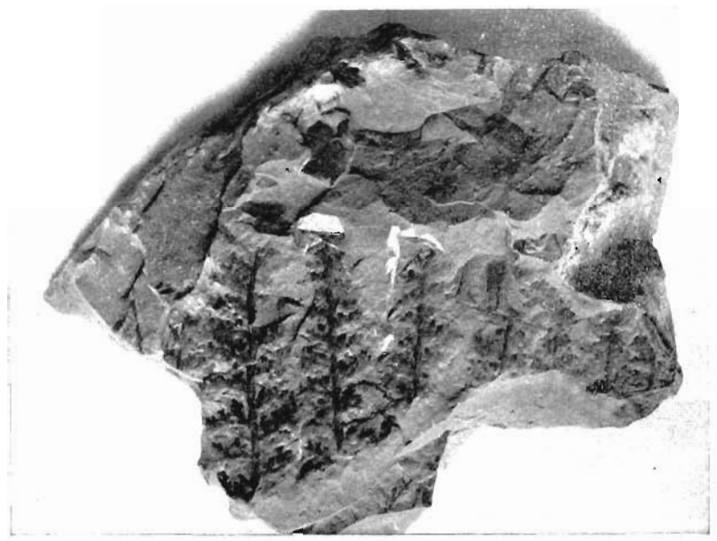

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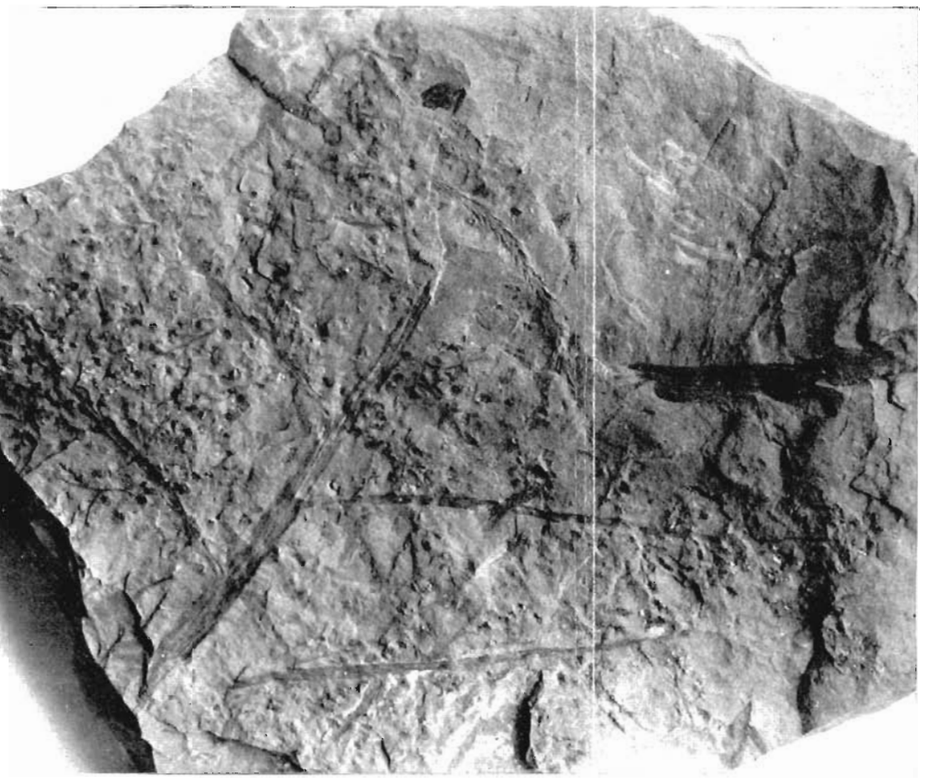

79

79 A