ON SOME PLANT FOSSILS FROM THE PARIWAR FORMATION, JAISALMER BASIN, RAJASTHAN

HARI K. MAHESHWARI
Birbal Sahni Institute of Palaeobotany, Lucknow-226007
&
N. P. SINGH
Oil and Natural Gas Commission, Jodhpur

ABSTRACT

The paper reports on plant megafossils found in the lower part of the Pariwar (Parihar) Formation exposed in the Jaisalmer Basin, Rajasthan. The plant fossils belong to the groups Filicales, Cycadales, Bennettitales and Coniferales. The identifiable species are: ?*Gleichenites* sp., *Phlebopteris* sp., Frond type 1, *Taeniopteris vittata, T. densinervis, T. spatulata, Pterophyllum* sp., *Otozamites imbricatus, Ptilophyllum acutifolium, Elatocladus conferta,* ?*Elatocladus* sp. and *Pagiophyllum* sp. In general composition the fossil assemblage is more akin to that known from the Kutch Basin of Gujarat, and is probably Upper Jurassic in age.

INTRODUCTION

THE vast Rajasthan shelf includes a number of sedimentary basins of which the Jaisalmer Basin is the largest. In the north-north-west and south of Jaisalmer, is exposed a thick sequence of marine and continental sedimentaries of post-Triassic age on a truncated, peneplained basement. The Mesozoic strata comprising Lathi, Jaisalmer, Baisakhi, Pariwar (formerly Parihar) and Habur (formerly Abur) formations have till recently not yielded any plant fossils though a mioflora of probable Lower Jurassic age (Srivastava, 1966) is known from the Lathi Formation.

During the 1972-73 field season, a field party of the Oil and Natural Gas Commission, of which the second author was a member, discovered plant megafossils in the lower part of the Pariwar Formation, east of the Habur Village. The thick arenaceous sequence of Pariwar Formation was earlier described as the 'Parihar beds' by Oldham (1886) and 'Parihar Formation' by Swaminathan, Krishnamurthy, Verma and Chandiok (1956).

The Pariwar Formation is named after the Pariwar Village (27° 14'30": 70°44'30") and consists of a poorly exposed but stratigraphically thick sequence of sandstone beds. The formation in the north-east part around Pariwar Village consists mainly of pebbly, current-bedded sandstones but to the south-east it is difficult to establish the stratigraphy due to paucity of the outcrops. The lower fossiliferous member consists mostly of variegated (yellow, yellowish-white, brown and ochreous brown) siltstone, sandstone and shale/clay beds of considerable thickness. Das-Gupta (1974) assigned a Lower Cretaceous (Neocomian) age to the formation on the basis of subsurface stratigraphical correlation in this area. However, the present study of plant megafossils collected from the type area suggests an Upper Jurassic affinity of the Pariwar Formation flora.

The fossils are preserved as impressions in ochre-yellow, argillaceous shale and in buff-coloured siltstone. Some of the impressions are partly coloured red, probably due to leaching of iron. Preservation is usually poor but sometimes wetting the specimens with xylol or liquid paraffin brings out certain structures clearly.

DESCRIPTION

Genus — *Gleichenites* Göppert 1836

Type Species — *Gleichenites porsildii* Seward 1926.

? *Gleichenites* sp.
Pl. 1, fig. 2

Description — Small fragmentary specimen, leaf as a whole not known, pinnules

small, about 2 mm long, margin entire, apex rounded, veins not preserved.

Remarks — Due to its extremely bad preservation the specimen is doubtfully referred to *Gleichenites*.

Genus — *Phlebopteris* Brongniart 1836

Type Species — *Phlebopteris polypodioides* Brongniart 1836.

Phlebopteris sp.

Pl. 1, figs. 6-7

Description — This is one of the more common plants in this assemblage but unfortunately preservation is extremely poor. All the specimens are incomplete and none shows the apical or basal parts of the frond. Specimens pinnate, largest specimen measuring 10 cm in length, rachis stout, up to 1·5 mm broad. Pinnae alternate or subopposite, almost at right angles to the rachis, straight or slightly falcate, adjacent pinnae confluent at base. Pinnae longer in the middle part of the leaf (up to 2·5 cm) and becoming smaller towards apical and basal parts; typically 2-5 mm broad at the widest. Pinna apex characteristically mucronate. Midrib prominent, persisting up to apex. Veins arising at an angle of approximately 75°-80° to the midrib, almost parallel, a few cross connections observed in some specimens (Pl. 1, fig. 6).

Remarks — Harris (1961, p. 101, 112) has remarked that the genera *Phlebopteris*, *Matonidium* and *Matonia* appear to intergrade. *Matonidium* can be distinguished from *Phlebopteris* only by its indusium formed from the expanded end of the placenta. In sterile condition the distinction between these two genera is difficult to make. We have provisionally referred our specimens to *Phlebopteris* on the basis of their general similarity with the figured specimens of *Phlebopteris* from India (*see* Bose & Sah, 1968, pl. 5, fig. 31; Sukh-Dev, 1970, pl. 1, figs. 6, 7, 9) and due to occurrence of occasional anastomoses. Our specimens, however, differ from those of *Phlebopteris polypodioides* Brongniart (*in* Sukh-Dev, 1970, p. 201) and *Phlebopteris* sp. (Bose & Sah, 1968, p. 22) in having less oblique pinnae. *Phlebopteris* sp. of Roy (1968, p. 110, pl. 1, figs. 6-7, pl. 2, fig. 9) is known only from a fragmentary specimen. Our specimens are further different from all the other phlebopterids in having a mucronate apex.

FROND TYPE-1

Pl. 1, fig. 8; Text-fig. 1

1975 *Cladophlebis* sp. (?): Das Gupta *et. al.*, p. 236, fig. 3.

Description — This is another very common type in the present assemblage. Frond bipinnate, main rachis winged, about 1·75 mm wide, pinna rachis less than 0·5 mm wide at base and gradually tapering towards apex. Pinnae opposite, arising at an interval of about 9-10 mm and at an angle of 35°-45°. Most complete pinna 5·5 mm long, lanceolate. Typical pinnules 5·5 to 6·5 mm long, slightly smaller in the upper pinnae, apex narrow obtuse, pinnules arising at an angle of 30°-35° to the pinna rachis, almost straight, pointing forwards, pinnule margin smooth, adjacent pinnules confluent at base. First pinnule arises on the basiscopic side and sometimes is almost on the rachis (Text-fig. 1). Each pinnule served with a distinct midrib which continues up to apex, further secondary veins not seen.

Remarks — Due to nonpreservation of secondary veins, assignment of these specimens to a genus is not possible. In habit these fronds resemble *Pachypteris*, *Onychiopsis*, *Scleropteris* and *Cladophlebis*. *Pachypteris* as instituted by Brongniart (1828), is characterized by the absence of veins or by the presence of only a single primary vein in the pinnules. Later studies have shown that *Pachypteris* is in its venation, as well as in other characters, very much like *Thinnfeldia*. *Pachypteris*, can further be ruled out altogether as the fronds of that genus are thick and coriaceous. *Scleropteris* is an ill-defined genus, but the midrib in that genus is usually indistinct or lacking. *Onychiopsis* has a typical venation. Because of the welldefined midrib the specimens could belong to *Cladophlebis* but the preservation being imperfect a definite determination is not possible.

TEXT-FIGS. 1-5

Genus — *Taeniopteris* Brongniart 1832

Type Species — *Taeniopteris vittata* Brongniart 1832.

Remarks — Nathorst (1909) described the cuticle of a specimen which he believed to be an example of *Nilssonia tenuinervis*. As it had sinuous cell walls he created a new genus *Nilssoniopteris* for it. Thomas (1913, p. 241) found, on re-examination, that this particular specimen resembled more *Taeniopteris vittata*. The genus *Nilssoniopteris* was therefore later abandoned (Thomas & Bancroft, 1913; Seward, 1917). Harris (1932) and Florin (1933a, 1933b) recognized the need for separate genera for taeniopterid leaves with different types of cuticle. While Harris (1932) created a new genus *Taeniozamites* for taeniopterid leaves with bennettitalean cuticle, Florin (1933a, 1933b) retained *Nilssoniopteris* for such leaves. We think that it is prudent to retain *Nilssoniopteris* for forms with bennettitalean cuticle as cuticle of the type specimen of the type species of the genus *Taeniopteris* (i.e. *T. vittata*) is probably not known. Further under prevalent botanical practices, the species *vittata* (with same holotype) must not be taken as type for two similar though unrelated genera, i.e. *Taeniopteris* and *Nilssoniopteris*. It is suggested that *vittata* should be retained as type species of the genus *Taeniopteris* and that a new type species should be designated for the genus *Nilssoniopteris*.

Taeniopteris vittata Brongniart 1832

Pl. 2, figs. 9, 12

Description — Simple leaves, linear-lanceolate in shape, complete leaves not preserved but probably up to 14 cm long and 2 cm broad at the widest. Leaves petiolate, petiole base swollen, lamina gradually increasing in width from the petiole, reaches maximum width in the middle region and then gradually tapers to form an acute apex, margin entire except in basal region where it is slightly wavy. Midrib strong, about 3·5 mm wide at base and gradually narrowing towards apex, fine longitudinally running striations seen. Secondary veins arising from midrib almost at right angles, slightly curved forwards almost reaching margins, simple or occasionally once-forked.

Remarks — This species has been reported from Kutch under the name *Oleandridium* (*Taeniopteris*) *vittatus* (Feistmantel, 1876, p.15, pl. 1, figs. 1-3; pl. 2, figs. 1-5).

Taeniopteris densinervis Feistmantel 1876

Pl. 1, fig. 5; Text-fig. 4

Description — Simple leaf, oval spathulate, base and apex not preserved, incomplete specimens 4·6-7·9 cm long and 1·6-3·1 cm broad at the widest. Midrib stout, 1·5 mm broad at base and gradually tapering towards apex, finely pitted. Veins arise from midrib at angles of 75°-80° and then curve sharply forwards meeting the margins at low angles, mostly simple, rarely once-forked. At one or two places there is slight appearance of an anastomosis but it could as well be a preservation artefact, concentration of veins 22-24 per cm.

Remarks — In general appearance and the angle of emergence of the veins, the figured specimen resembles those of *Taeniopteris densinervis* from Kutch (Feistmantel, 1876, pl. 2, fig. 6).

Taeniopteris spatulata McClelland 1850

Pl. 2, fig. 13; Text-fig. 5

Description — Leaf simple, narrow, strap-shaped, apex and base broken, incomplete specimen measures 3·6 cm in length and 0·6 cm in maximum width. Lamina margin entire. Midrib flat, 1·0 mm broad. Veins arise almost at right angles to the midrib,

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TEXT-FIGS. 1-5 — 1, outline drawing of a part of frond to show the basal pinnule, and the midveins of the pinnules × 2. 2, *Otozamites imbricatus* Feistmantel 1876, line drawing of the specimen to show pinnule base and venation × 2. 3, *Pterophyllum* sp., line drawing showing the nature of venation × 2. 4. *Taeniopteris densinervis* Feistmantel 1876, line drawing to show venation × 2. 5, *Taeniopteris spatulata* McClelland 1850, × 2.

are simple and meet the margin at wide angles.

Remarks — In its shape and venation pattern the specimen shows some resemblance to *Taeniopteris spatulata* McClelland (1850, pl. 16, fig. 1; *see also* Oldham & Morris, 1863, pl. 6, figs. 1-6).

Genus — *Pterophyllum* Brongniart 1828

Type Species — *Pterophyllum longifolium* Brongniart 1828.

Pterophyllum sp.

Pl. 1, figs. 3, 4; Text-fig. 3

Description — Leaf pinnate, as a whole linear, strap-shaped, 11 cm long and 1·6 cm wide, base and apex not preserved. Rachis thick, 4 mm wide in basal region, gradually narrowing towards apex, with two longitudinally running marginal ridges. Pinnae alternate, of unequal breadth, irregular rectangular to more or less triangular, sometimes falcate, attached by the whole base, basal segments smaller in size than those in the middle, segments attached laterally on the upper surface of the rachis, hence in fossil condition seem to slightly overlap the rachis, typical segments 5-7 mm long and 4-7 mm wide, apex occasionally notched. Veins usually simple, rarely forked, parallel to the edge of the lamina, ending at distal margin, and slightly curved forwards, about 8 veins per centimetre.

Remarks — The features found in this specimen occur individually or collectively in certain cycadalean or bennettitalean leaves, viz., *Ctenozamites* Nathorst 1886, *Anomozamites* Schimper 1870 and *Pterophyllum* Brongniart 1828. The present specimen, however, can not be referred to *Ctenozamites* as in that genus the main rachis may fork in the middle region of the leaf and the pinnae arise on the upper side of the pinna rachis. Further the veins in *Ctenozamites* are much forked. Differences between *Anomozamites* and *Pterophyllum* are not clearly marked and according to Harris (1969, p. 79) "The sole distinction from *Pterophyllum* is in the shape of the lamina segment which in *Pterophyllum* are typically much longer than broad. Thus when a specimen is not satisfactorily placed on this character, the difficulty is obvious." This distinction in the relative width of the pinnae of the two genera is not a satisfactory distinguishing criterion, in the absence of cuticular features, for in some species of *Anomozamites* the segments are not necessarily as long as broad [e.g. *Anomozamites nilssonii* (Phillips) Seward *in*, Harris, 1969, fig. 37A, D]. Further, so far, there is no report of the presence of true *Anomozamites* in India. *Anomozamites fissus* may be a *Taeniopteris* (Bose, 1974b, p. 190). *Anomozamites amarjolense* of Sharma *et al.* (1971, p. 32, pl. 1, fig. 5) is a *Pterophyllum* leaf. A negative evidence of the absence of *Anomozamites* in India is the nonoccurrence of *Wielandiella*, a fructification usually associated with *Anomozamites*. Therefore, depending upon the external morphology alone, we provisionally refer our specimen to *Pterophyllum*. In the absence of cuticular features a satisfactory specific assignment of the present leaf is not possible. The leaf, however, shows some resemblance with a leaf figured as *Pterophyllum* (*Anomozamites*) *inconstans* (Braun) Zeiller by Du Toit (1927, p. 379, pl. 24, fig. 1), and as *Anomozamites inconstans* Schimper by Saporta (1875, pl. 9, fig. 3).

Genus — *Otozamites* Braun in Münster 1843

Type Species — *Otozamites* (*Filicites*) *bechei* (Brongniart 1825) Harris 1961; recommended by Harris (1969, p. 10). Andrews (1970, p. 147), on the other hand, designates *Otozamites* (*Otopteris*) *obtusus* (Lindley & Hutton 1834) Brongniart 1849 as the type of *Otozamites*.

Otozamites imbricatus Feistmantel 1876

Pl. 2, figs. 10-11; Text-fig. 2

Description — Overall shape of the leaf lanceolate, with tapering base, apical part not known. Incomplete specimen 9·5 cm in length and 2·6 cm in width at the broadest. Leaf pinnate, pinnae alternate, linear-lanceolate, almost straight or slightly falcate, their long axis at an angle of about 60°. Pinna base asymmetrical, auriculate, auricle developing at acroscopic angle. Pinnae in middle region 1·5-1·7 cm long, veins conspicuously marked, diverging right

from the point of attachment, forking 1-2 times, about 11-13 veins in the middle of each pinna, mostly veins ending in lateral margins, a few reaching the acute apex.

Remarks — The specimen is morphologically identical with the ones reported by Feistmantel (1876, p. 48, pl. 8, fig. 1) and by Bose (1974 p. 100, pl. 46, figs. 1, 2) from Kutch. The cuticular structure of this species was described by Roy (1965, p. 215, pl. 1, figs. 3-5). *Otozamites imbricatus* was so far not known from any area other than Kutch.

Genus — *Ptilophyllum* Morris in Grant 1840

Type Species — *Ptilophyllum acutifolium* Morris in Grant 1840.

Ptilophyllum acutifolium Morris in Grant 1840

Pl. 1, fig. 1

Description — Leaves pinnate, apical and basal parts not preserved, rachis stout, about 2 mm broad. Pinnae alternate, obliquely attached by whole base, central axis of pinnae forming an angle of 75°-80° to the rachis, linear-lanceolate, almost straight or slightly falcate, apex broadly acute, base apparently decurrent.

Remarks — The specimens compare well with the figured specimens of *Ptilophyllum acutifolium* (*see* Oldham & Morris, 1863, pl. 20, figs. 1-2; Feistmantel, 1877, pl. 2, fig. 2; Bose & Kasat, 1972, pl. 1, figs. 1-6, pl. 14, figs. 115-116).

Genus — *Elatocladus* Halle 1913

Type Species — *Elatocladus heterophylla* Halle 1913.

Elatocladus conferta (Oldham & Morris 1863) Halle 1913

Pl. 2, figs. 14-15

Description — Branched conifer shoots, branches showing a radial and/or a dorsiventral symmetry. Leaves linear, linear-lanceolate or oblong in shape, rarely falcate, usually obliquely inserted, spirally arranged, adpressed in radial shoots and spread out apparently in two rows in dorsiventral shoots. A faintly marked midrib occasionally seen in some leaves. Leaf apex obtuse, base twisted, contracted and ?decurrent.

Remarks — So far *Elatocladus conferta* was supposed to be a dorsiventral type and any specimen showing dimorphism was placed in *E. heterophylla*. Specimens in the present assemblage clearly show the occurrence of dimorphism in *E. conferta* also. In fact there is not much difference between *E. conferta* and *E. heterophylla*, except that in the latter species the leaves are narrowly linear and sharply acute (Halle, 1913, p. 84). It is possible that both species refer to the same plant. *E. australis* Frenguelli (1944, p. 543, pl. 1, figs. 1-3) is also probably conspecific.

? *Elatocladus* sp.

Pl. 2, figs. 16a, 17

Description — Fragmentary specimen with dorsiventral symmetry. Leaves lanceolate, almost straight, spirally arranged, distichous, with indications of a number of more or less parallel veins.

Remarks — The specimen shows a certain resemblance to a figure of *Elatocladus dicksoniana* (Heer) Seward (1926, p. 108, pl. 10, fig. 91).

Genus — *Pagiophyllum* Heer 1881

Type Species — *Pagiophyllum circinicum* (Saporata) Heer 1881.

Pagiophyllum sp.

Pl. 2, fig. 16b

Description — Branched conifer twigs, largest shoot fragment 7·5 cm long. Leaves spirally borne, crowded, in the basal part look like obliquely inserted spines, arising from a ?rhomboidal leaf base cushion at an angle of 40°-50° at base and spreading out in the top part. Leaves much longer than broad, more or less triangular to linear, sometimes falcate, keeled, apex acute, margin entire.

Remarks — The specimens show some resemblance to *Pagiophyllum divaricatum* (Bunbury) Sahni (1928) in having smaller,

spine-like leaves in the basal portion. However, in the upper half our specimens show longer and more spreading leaves as in *P. marwarensis* Bose & Sukh-Dev (1972), but this species is primarily based on cuticular features.

DISCUSSION

The megafloral assemblage from the Jaisalmer District, Rajasthan described in the previous pages comprises species belonging to the groups Filicales, Cycadales, Bennettitales, and Coniferales. Filicales are represented by Gleicheniaceae (*?Gleichenites* sp.), Matoniaceae (*Phlebopteris* sp.) and an unidentifiable fern. The Bennettitales are not very common and are represented by *Ptilophyllum* and *Otozamites*. The Cycadales are represented by *Taeniopteris*. Araucariaceae are represented by *Pagiophyllum* while *Elatocladus* probably represents the Podocarpaceae.

The total absence of the Nilssoniales and *Dictyozamites*, and rarity of *Pterophyllum* show that the beds studied are younger than Lower Jurassic in age. On the other hand, the total absence of *Weichselia reticulata* and *Onychiopsis paradoxus* shows that the beds are older than the Lower Cretaceous. In general composition the flora is more akin to that known from the Kutch region of Gujarat. Following plants are common between the two: *Taeniopteris vittata, T. densinervis, Otozamites imbricatus, Ptilophyllum acutifolium, Pagiophyllum* sp., and *Elatocladus conferta. Taeniopteris vittata* is characteristic of the Inferior Oolite of England and is also recorded from the Jurassic of Soviet Union, Arctic regions, Poland, Japan, China and Australia etc.

The present megaflora seems to fit in the *Pagiophyllum - Brachyphyllum* Assemblage sub-zone of the *Ptilophyllum* Assemblage zone. This sub-zone is assigned on Upper Jurassic age by Sah, Singh and Sastry (1971, table 3).

ACKNOWLEDGEMENTS

To Shri S.N. Talukdar, Director of Geology, Oil & Natural Gas Commission, Dehradun, thanks are due for permission to work out this material at Lucknow and to publish it. Dr. K. R. Surange, Director, Birbal Sahni Institute of Palaeobotany, Lucknow kindly granted laboratory and library facilities for this work at the Institute. Thanks are also due to Dr M. N. Bose, for critically going through the manuscript.

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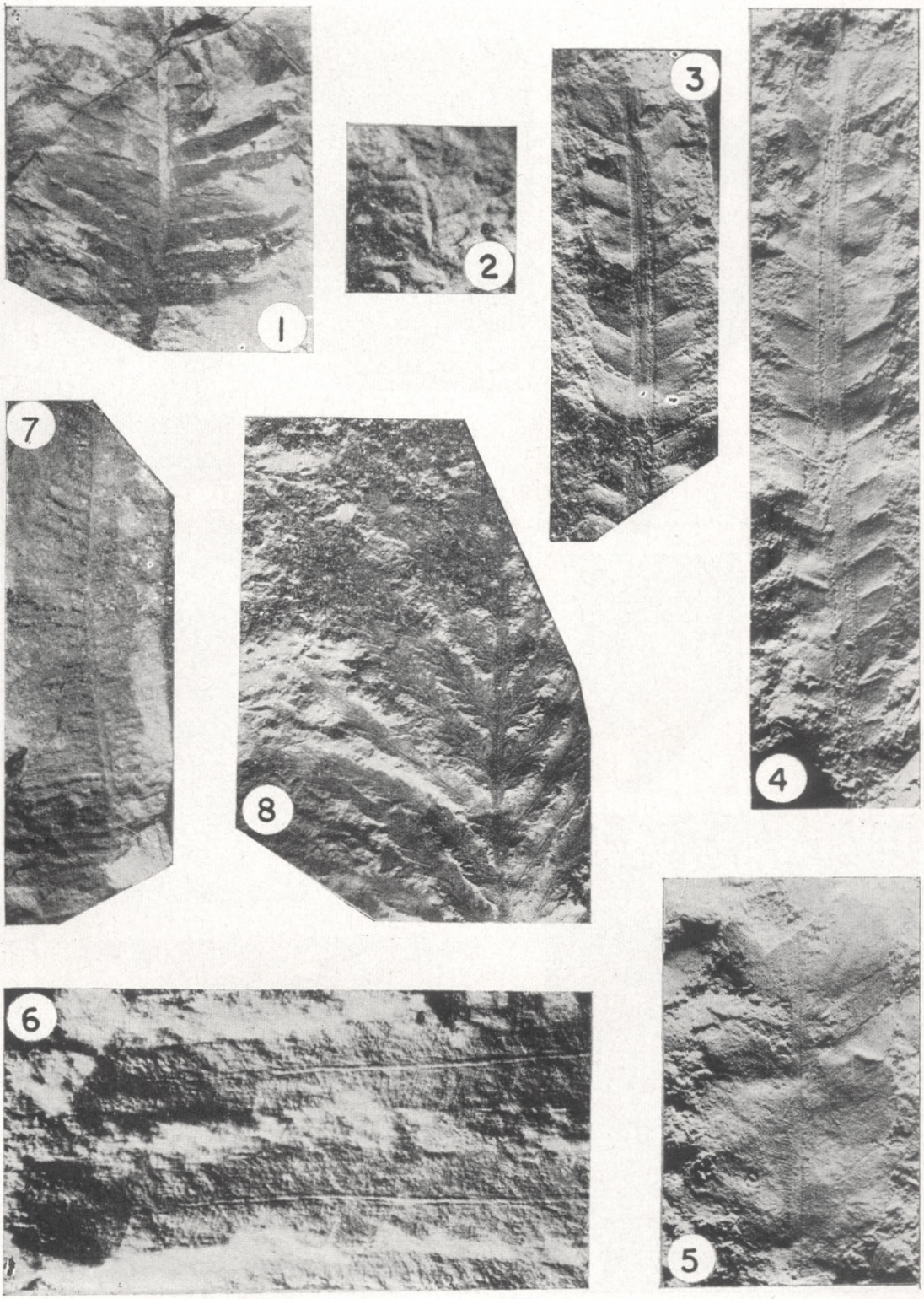
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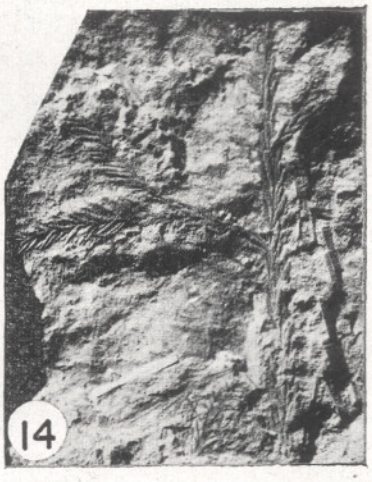
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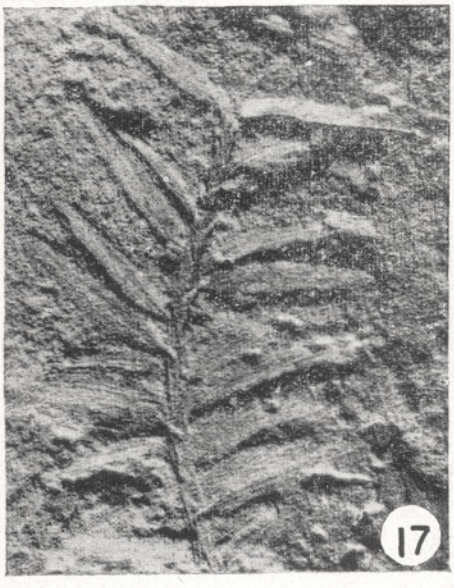
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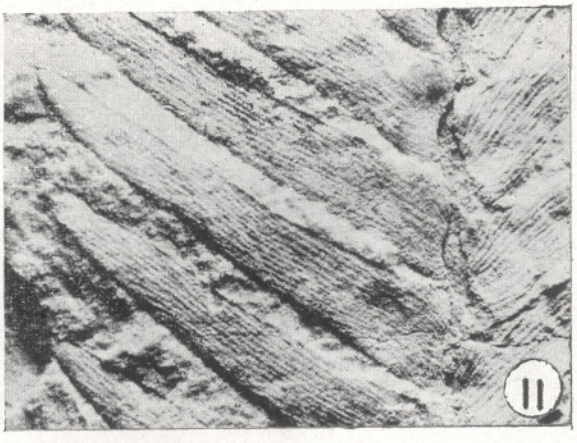
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EXPLANATION OF PLATES

PLATE 1

1. *Ptilophyllum acutifolium* Morris 1840, × nat. Size.
2. *?Gleichenites* sp., × 4.
3. *Pterophyllum* sp., × nat. size.
4. *Pterophyllum* sp., counterpart of specimen in figure 3, × ca 1.2.
5. *Taeniopteris densinervis* Feistmantel 1876, × nat. size.
6. *Phlebopteris* sp., two pinnules enlarged to show the distinct midrib and faint secondary veins, × 4.
7. *Phlebopteris* sp., × nat. size.
8. Frond type 1, × nat. size.

PLATE 2

9. *Taeniopteris vittata* Brongniart 1832, note the distinct petiole, robust midrib and wavy lower margin of the lamina, × nat. size.
10. *Otozamites imbricatus* Feistmantel 1876 emend. Roy 1965, × nat. size.
11. *Otozamites imbricatus*, a portion of specimen in figure 3 enlarged to show pinnule base and venation, × 4.
12. *Taeniopteris vittata*, note the acute apex in left hand specimen, × nat. size.
13. *Taeniopteris spatulata* McClelland 1850, × nat. size.
14. *Elatocladus conferta* (Oldham & Morris 1863) Halle 1913, × nat. size.
15. *Elatocladus coniferta*, × nat. size.
16. a:? *Elatocladus* b: *Pagiophyllum* sp., sp., × nat. size.
17. ? *Elatocladus* sp., note several parallel veins in each leaf, × 4.