

A MIDDLE TRIASSIC FLORA FROM THE CACHEUTA FORMATION, MINAS DE PETROLEO, ARGENTINA

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ABSTRACT. The fossil flora of the Triassic beds of Minas de Petroleo, a locality about 32 km. south-west of Mendoza in western Argentina (long. 69° 6' 25" W.; lat. 33° 3' 35" S.) is described. The strata belong to the Potrerillos Beds of the Cacheuta Formation of the Upper Gondwana of Argentina. The flora consists of about 34 species (3 new), belonging to about 20 genera (one new). Previously the flora of the Potrerillos Beds was known to consist of about 28 species. These beds were earlier referred to as the 'Rhaetic beds' and lately as of 'Lower to Middle Keuper' age, but the flora is now shown to be not younger than Middle Triassic in age.

THE fossils were collected from Minas de Petroleo in 1916-17 by the late Dr. G. R. Wieland, who never completed his study of the flora. The specimens, deposited in the Paleobotanical Collections of the Peabody Museum of Natural History at Yale University now bear official numbers referred to in the following pages. In addition to a couple of cards with collection data, there are also a few photographic negatives of some fossils, including those on which Wieland had published earlier (Wieland 1929), and two more on which he apparently had intended to report. Although the specimens in the unpublished photographs could not be located, they are being included in this paper.

STRATIGRAPHY

The Gondwanas of Argentina are divided into the Upper and Lower Gondwana. The Lower Gondwana or the 'Terreno de Paganzo' ranges from the earliest Carboniferous (perhaps with an Upper Devonian base) to the end of the Permian (Frenguelli 1950). Overlying the Patquia Formation of the Lower Gondwana are the so-called 'Rhaetic Beds' of the Upper Gondwana of Argentina (Krishnan 1954). These beds occur in the provinces of Mendoza, San Juan, La Rioja, and Patagonia, and are classified into various formations. The Cacheuta Formation of Mendoza represents one of the lowest formations in the Upper Gondwana of Argentina. Because of the existence of the so-called '*Thinnfeldia* flora' in these beds, they were earlier referred to as the 'Rhaetic beds' and later considered as 'Middle to Upper Keuper' (Groeber and Stipanovic 1952), and Middle Triassic to 'Infra-Liassic' (Frenguelli 1948). This subject is discussed further in a later part of this paper.

The Cacheuta Formation is further divided into four beds or 'Estratos':

4. Estratos de Rio Blanco
3. Estratos de Cacheuta { Upper
Lower
2. Estratos de Potrerillos
1. Estratos de la Cabras { 'Grupo del Cerro las Cabras' { Upper
Middle
Lower
'Fangalomerado' rojo

The rocks at Minas de Petroleo belong to the Potrerillos Beds (cf. Frenguelli 1944*b*, p. 557; 1948).

Minas de Petroleo is a well-known locality about 32 km. south-west of Mendoza in western Argentina (long. 69° 6' 25" W., lat. 33° 3' 35" S.). The outcrop is at the edge of an open region where the foothills rise rapidly. Wieland (1925) recognized seven zones in the 160-m. thick section rising from the Cacheuta volcanic base. Most of the plant fossils were found in laminated arenaceous to carbonaceous shales or fine clays in the second and third zones, starting from 10 m. above the volcanic base through a thickness of 70 m. Some ferns and Sphenopsida were found in a 10-m. thick zone (No. V) of shales and lesser conglomerates starting from 90 m. above the base.

Previous work. One paper by Wieland (1929) represents the only work on the plant fossils of the Triassic of Minas de Petroleo. He described some 'fruits' which he named *Fraxinopsis minor* and *F. major*, and a fragment of a leaf, which is now known as *Yabeiella wielandi* Oishi. However, much work has been done on other beds of the Cacheuta Formation. The main contributors to our knowledge of the flora of this formation were Geinitz (1876), Szajnocha (1889), Kurtz (1921), Wieland (1929), Oishi (1931), and Frenguelli (1941*a, c*; 1942; 1943*a, b*; 1944*a, b, c, d*; 1946; 1947; 1948; 1950). As a result of their work about 20 species are known from Estratos de la Cabras, about 27 from Estratos de Potrerillos, and about 17 from Estratos de Cacheuta (Frenguelli 1948).

Materials and methods. Most of the fossils are only impressions; some are compressions having a thin film of carbon, but no cuticle. Only one specimen (1120) yielded some fragments of cuticles; these were removed with a scalpel and transferred to a watch glass, and treated for a few minutes with 'Clorox', a commercial bleaching solution containing 5.25% sodium hypochlorite by weight in an inert ingredient. In a few minutes the material was cleared; then it was thoroughly washed. A few fragments were stained with 2% aqueous safranin, and washed to remove the excess stain. The stained as well as the unstained fragments of cuticles were mounted directly in glycerine jelly.

SYSTEMATIC DESCRIPTIONS

Division BRYOPHYTA?, Class HEPATICAE?, Order?, Family?

Genus THALLITES Walton 1925

Thallites sp.

Plate 86, figs. 1-3

Material. Two specimens (1104*a, b*) measuring 1-1.5 cm. in length, and *c.* 1 mm. in width above or below the dichotomy. In both the thalli branch twice dichotomously. A mid rib is recognizable in the middle of the thallus; no other structural details are discernible. Outline of thallus indistinct, uneven.

Remarks. Because there is no indication of natural affinities the specimens are referred to the form genus *Thallites* Walton (1925), defined to accommodate thalloid forms of uncertain affinities.

Division TRACHEOPHYTA
Subdivision SPHENOPSIDA
Order EQUISETALES
Family EQUISETACEAE
Genus NEOCALAMITES Halle 1908

Neocalamites carreri (Zeill.) Halle

Plate 86, figs. 4-6

Material. Four specimens (1095-7, 1106). 1095 (Pl. 86, fig. 4) is a stem fragment *c.* 12 cm. in length, and *c.* 3.5 cm. in width. It has two nodes separated by a 7-cm. long internode, one of the nodes being more distinct than the other. The surface shows 12-16 ridges per cm., alternating with furrows. It is not clear whether or not the ridges and furrows are continuous across the nodes.

At one of the nodes of the stem in 1096 (Pl. 86, fig. 5) there is a whorl of long linear leaves which are free to the base. The exact length of the leaves is not known, but they appear to be shorter than the internode, and measure *c.* 2 mm. in width. The internode in this specimen is *c.* 4 cm. long and has no visible surface markings.

1097 (Pl. 86, fig. 6) shows a detached nodal diaphragm *c.* 3 cm. in diameter. At its periphery is a whorl of leaves of which only the teeth-like basal parts are visible; faint further extensions indicate that the leaves were rather long as in 1096 (Pl. 86, fig. 5). An apparently similar diaphragm was described by Du Toit (1927) from the Molteno beds of the Karoo System of South Africa.

Genus *EQUISETITES* Sternberg 1933*Equisetites fertilis* Frenguelli

Plate 86, figs. 7-10

Synonymy. See Frenguelli 1944*c.*, pp. 501-9, pl. 1-4.

Material. Four specimens (1104, 1107-9). 1107 (Pl. 86, fig. 7) is part of a stem, with small, basally united leaves covering a node. It measures *c.* 1 cm. in width at the level of the sheath. Leaves are free above with pointed acuminate apices. On either side are some long, leaf-like branches, like those seen in some of the living species of *Equisetum*, but no nodes are visible in them.

1108 (Pl. 86, fig. 8) shows a node with six pocket-like depressions, each of which has a tooth-like projection representing the base of a lost leaf. It is estimated that there were about twelve leaves at the node. No surface features are visible.

1109 (Pl. 86, fig. 9) shows a minute shoot apex and the last two visible nodes of the stem. It measures *c.* 0.8 cm. in length, *c.* 1.5 mm. in width at the node, and *c.* 1 mm. at the internode. It is difficult to ascertain the number of leaves enveloping the apex of the stem.

1104 (Pl. 86, fig. 10) is a detached nodal diaphragm *c.* 7 mm. in diameter. The margin is fimbriated as in the specimen illustrated by Frenguelli (1944*c.*, pl. 5). No other details are discernible.

Subdivision PTEROPSIDA

Class PTEROPHYTA

Order FILICALES

Family OSMUNDACEAE

Genus *CLADOPHLEBIS* Brongniart 1849

EXPLANATION OF PLATE 86

- Figs. 1-3. *Thalites* sp. 1, 1104 *a, b*, $\times 1$; 2, 3, the same, $\times 2.5$.
 Figs. 4-6. *Neocalamites carreri* (Zeill.) Halle. 4, 1095, indicating a node, and longitudinal ridges and furrows on the stem, $\times 1$; 5, 1096, stem with a whorl of leaves at a node, $\times 1$; 6, 1097, a nodal diaphragm, $\times 1$.
 Figs. 7-10. *Equisetites fertilis* Frenguelli. 7, 1107, a node with a whorl of leaves, $\times 1$; 8, 1108, a node showing bases of leaves, $\times 1$; 9, 1109, stem apex covered with young leaves, $\times 5$; 10, 1104, a nodal diaphragm, $\times 10$.
 Fig. 11. *Cladophlebis kurtzi* Frenguelli. 1106, a pinna, $\times 1$.

Cladophlebis kurtzi Frenguelli

Plate 86, fig. 11; Plate 87, figs. 1, 2

- 1921 *Asplenium whitbyense* Heer; Kurtz, pl. 16, figs. 202 a, b.
 1927 *Cladophlebis nebensis* (Brongniart) Nath.; Du Toit, p. 321, fig. 2.
 1947 *Cladophlebis kurtzi* Frenguelli, pp. 52-53, pl. 4, figs. 4-6; pl. 6, fig. 2 (?1).

Material. Three specimens (1059, 1060, 1116), consisting of a large number of frond fragments lying close to, and overlapping each other. The pinna rachis is conspicuous, with pinnules attached closely by broad bases. Pinnules are small, c. 1 cm. long and 5-6 mm. broad at the base, oblong with an entire margin and obtusely rounded apex. Sometimes pinnules are slightly curved distally. Each pinnule has a distinct mid rib, and fairly steep and close lateral veins. Each lateral vein forks once close to the mid rib, and again at half the distance between the mid rib and the margin of the pinnule. Near the margin, all the branches of the lateral veins are almost equidistant from each other.

Remarks. This species was earlier identified as *Asplenium C. whitbyense* (Kurtz 1921), and later as *C. nebensis* (Du Toit 1927), but it differs from both in essential details. In *C. nebensis* (Brongn.) Nath. the lateral veins are forked only once (Brongniart 1828, pl. 98, fig. 3), whereas in *C. kurtzi* the lateral veins normally fork twice.

Cladophlebis mesozoica Kurtz

Plate 87, figs. 3-6

- 1947 *Cladophlebis mesozoica* Kurtz; Frenguelli, pp. 59-60, pl. 6, fig. 5; pl. 7B.
 1947 *Cladophlebis concinna* (Presl) Du Toit; Jones and de Jersey, p. 12, text-fig. 4 (pl. 1, fig. 4).

Material. Three specimens (1059, 1060, 1118). 1059 (Pl. 87, fig. 3) is a part of a bipinnate frond with a rachis c. 3 mm. thick, and bears two rows of opposite pinnae, each generally more than 7.5 cm. long. 1060 (Pl. 87, figs. 4, 5) shows a slender pinna rachis bearing distantly and alternately arranged pinnules. Each pinnule is attached by its broad base, measures c. 1.5 cm. in length, 8-9 mm. in width at the base, and has a more or less entire margin, and short acute apex. Further, each pinnule has a distinct mid rib with twice-forking, alternate lateral veins, the ultimate branches of the latter tending to become parallel toward the margin.

Remarks. There is a superficial resemblance between this species and *C. kurtzi*, but a closer study indicates that *C. mesozoica* differs in having distantly and alternately arranged pinnules with acute apices, as opposed to the closely and oppositely arranged pinnules with obtuse apices in *C. kurtzi*.

Similar specimens illustrated by Jones and de Jersey (1947) were erroneously compared with *Cladophlebis concinna* (Presl) Du Toit (1927, p. 318, pl. 17, fig. 1). The latter species differs from *C. mesozoica* in having almost overlapping leaflets with rounded apices, and typically once-forked lateral veins.

Cladophlebis johnstoni Walkom

Plate 87, figs. 7, 8

- 1925a *Cladophlebis johnstoni* Walkom, p. 76, figs. 2, 2a.

- 1947 *Cladophlebis mendozaensis* Geinitz; Frenguelli, pp. 60–63, pl. 8B; pl. 9, figs. 2, 3 (others?); pl. 10, figs. 1–3, 8 (others?); pl. 11; pl. 12, figs. (1–3?).

Material. Two specimens (1057, 1111). 1111 (Pl. 87, figs. 7, 8) shows the terminal part of a frond with pinnae varying in length from less than 0.5 cm. at the apex, to 2.3 cm. at the base, and with entire to broadly crenate margins. Lateral veins fork one to three times. Each lobe of a pinna has an independent set of veins, indicating the equivalence of a lobe to a pinnule.

Remarks. Frenguelli (1947) had referred many specimens of this species to *C. mendozaensis*, a species based primarily on a very fragmentary specimen described and poorly illustrated by Geinitz (1876, pl. 2, fig. 4). The latter differs from *C. johnstoni* in most of the structural details of the pinnule, such as shape, margin, and venation.

Cladophlebis australis (Morris) Seward

Plate 88, figs. 1–4; Plate 89, fig. 11

Synonymy. See Frenguelli 1947, pp. 56, 57, pl. 2, figs. 8–10.

Material. Four specimens (1053, 1055, 1056, ?1117), showing a typical bipinnate frond with a stout rachis measuring up to 6 mm. in width. Pinnae are alternate, forming angles of about 50° with the rachis. Pinnules are alternate to sub-opposite, lanceolate, and attached to the pinna rachis by the whole base. Each pinnule has a broad base, entire or slightly undulate margin, shortly acute or sometimes more or less truncate apex, up to 2.5 cm. in length, and 0.6 cm. in width at the base. The mid rib of each pinnule tends to fade out towards the apex. Lateral veins arise at acute angles from the mid rib and typically fork twice, the ultimate branches tending to become parallel near the margin. In 1053 (Pl. 89, fig. 1) the shape and attachment of the pinnules appear a little different from those of the other specimens; however, venation appears to be essentially of the same type; it is only tentatively referred to this species.

EXPLANATION OF PLATE 87

- Figs. 1, 2. *Cladophlebis kurtzi* Frenguelli. 1, 1115, fragments with closely set pinnules, $\times 1$; 2, part of 1116 showing veins, $\times 2.5$.
 Figs. 3–6. *Cladophlebis mesozoica* Kurtz. 3, 1059, indicating part of a bipinnate frond, $\times 1$; 4, 1060, showing shape and attachment of pinnules, $\times 1$; 5, part of above showing venation, $\times 2.5$; 6, 1118, a small pinna, $\times 1$.
 Figs. 7, 8. *Cladophlebis johnstoni* Walkom. 7, 1111, part of a frond, $\times 1$; 8, part of above showing veins, $\times 2.5$.

EXPLANATION OF PLATE 88

- Figs. 1–4. *Cladophlebis australis* (Morris) Seward. 1, 1055, part of a bipinnate frond, $\times 1$; 2, part of above showing veins, $\times 2.5$; 3, 1117 indicating shape of pinnules, $\times 1$; 4, 1056, apical part of a pinna, $\times 1$.
 Figs. 5, 6. *Cladophlebis* sp. 5, 1112, $\times 1$; 6, 1113, $\times 1$.

EXPLANATION OF PLATE 89

- Fig. 1. *Cladophlebis* sp. 1053, $\times 1$.
 Figs. 2, 3. *Cladophlebis wielandi* sp. nov. 2, 1054, parts of two pinnae, $\times 1$; 3, part of above showing venation, $\times 2.5$.
 Figs. 4, 5. *Sagenopteris longicaulis* Du Toit. 4, 1137a, a more or less complete leaflet, $\times 1$; 5, parts of leaflets with details, $\times 2.5$.
 Fig. 6. *Dicroidium odontopteroides* (Morris) Gothan. 1051, distal part of a forked frond, $\times 0.5$.

Cladophlebis wielandi sp. nov.

Plate 89, figs. 2, 3

1947 *Cladophlebis concinna* (Presl) Du Toit; Jones and de Jersey, p. 12, text-fig. 5, pl. 1, fig. 4?
Holotype. 1054 (Pl. 89, figs. 2, 3).

Material. Holotype only, showing two pinnae of a frond, probably still connected with the rachis (but not exposed by preparation because of other overlying significant specimens). Preservation good, with excellent details of pinnule venation.

Diagnosis. Leaf bipinnate, pinnules alternate to sub-opposite, fairly closely spaced, attached to the pinna rachis at angles of about 70°, *c.* 1.5 cm. in length, oblong-lanceolate with serrate margin, and acute apex; mid vein of each pinnule forked at the apex; lateral veins few, typically forked only once, rarely with a second dichotomy in one of the branches of the lateral veins.

Remarks. This species is closely associated with *Cladophlebis mesozoica* Kurtz, but it differs from the latter in having closely spaced pinnules with serrate margins, and a once-forking system of lateral veins, as opposed to the widely spaced alternate pinnules with almost entire margins and typically twice-forked lateral veins in *C. mesozoica* Kurtz.

The new species, however, shows some resemblance to *C. denticulata* (Brongn.) Fontaine, and *C. seawardi* Johansson. It is similar to *C. denticulata* in having pinnules with serrate margins and once-forking lateral veins, but differs in having shorter pinnules, a less acute apex, and fewer veins.

There is a greater resemblance between this species and *C. seawardi* (Johansson 1922, pl. 1, fig. 42), but it differs from the latter in lacking the regular second dichotomy of the lateral veins.

Cladophlebis sp. indet.

Specimen 1112 (Pl. 88, fig. 5) shows either the subterminal portion of a frond or part of a pinna of a large bipinnate frond. The rachis is *c.* 1 mm. in width, and has opposite to sub-opposite pinnules arranged in two rows. Pinnules are somewhat curved distally, up to 2 cm. in length and 7 mm. in width at the base. Each pinnule is lanceolate with a crenate margin and acute apex. Veins are poorly preserved.

This specimen appears similar to one of Frenguelli's specimens (Frenguelli 1947, pl. 9, fig. 5) referred to *Cladophlebis mendozaensis*, but it is hard to justify its identification with that species. It may be an ill-preserved specimen of *C. johnstoni*.

Specimen 1113 (Pl. 88, fig. 6) is similar to 1112, but the pinnules appear to be more slender in form and attached at wider angles. It may be related to one of the species described above, but superficially it resembles *C. integra* (Oishi and Tanah) Frenguelli (Frenguelli 1947, p. 35, fig. 21), and *C. indica* (Oldh. and Morris) Feistmantel (Oldham and Morris 1862, pl. 27, fig. 2).

Class CAYTONIALES

Genus SAGENOPTERIS Presl 1838

Sagenopteris longicaulis Du Toit 1927

Plate 89, figs. 4, 5

Material. Overlapping fragments of one or more specimens collectively numbered as 1137 *a-d*. Because of crowding, precise outline of individual leaflets is not clear. Each leaflet is *c.* 6 cm. in length, and has

a distinct mid rib and many lateral veins, the latter forming angles of about 65° with the mid rib. Lateral veins are a little less than 1 mm. apart and start branching and anastomosing freely only a short distance from the mid rib.

Class CYCADOPHYTA
Order PTERIDOSPERMALES
Family?

Genus THINNFELDIA Ettingshausen 1852

Thinnfeldia dutoiti sp. nov.

Plate 90, fig. 4

1927 *Thinnfeldia rhomboidalis* Ettings.; Du Toit, p. 340, text-fig. 6c.

Holotype. 1046 (Pl. 90, fig. 4).

Material. Holotype only, measuring c. 8 cm. in length.

Diagnosis. Leaves pinnate (as far as known); rachis slender; pinnules widely spaced, alternate to sub-opposite, attached by their whole bases, rhombic with more or less acute apices; four or more veins entering each pinnule, each vein forking once or twice.

Remarks. *Thinnfeldia dutoiti* differs from *T. rhomboidalis* Ettings. in having less slender leaflets, lacking a thickened margin and distinct mid rib. Townrow (1957) has also indicated that these species are different from each other.

Townrow (1957) is openly suspicious about the existence of *Thinnfeldia* in the Mesozoic floras of the Southern Hemisphere. All the specimens hitherto known from Gondwanaland, and earlier referred to this genus, probably belong to *Dicroidium* Gothan. But in the absence of any indication of dichotomy of the fronds, this species is referred to *Thinnfeldia*.

Thinnfeldia praecordillarae Frenguelli (1944c)

Plate 90, figs. 7, 8

Material. Two specimens (1044, 1052). 1052 is c. 8 cm. in length. It has a distinct rachis bearing two rows of pinnules; the pinnules are alternate, small, up to 5 mm. in length, and elliptical in shape. Each pinnule has a small mid rib, which gives off a number of small simple (all?) radiating veins. 1044 (Pl. 90, fig. 8) has more or less semicircular pinnules.

EXPLANATION OF PLATE 90

Figs. 1–3. *Dicroidium odontopteroides* (Morris) Gothan. 1, 1048, showing veins in some pinnules, $\times 1$; 2, 1047, showing lanceolate pinnules with characteristic venation, $\times 1$; 3, 1088, basal part of a forked frond, $\times 1$.

Fig. 4. *Thinnfeldia dutoiti* sp. nov. 1046, $\times 1$.

Figs. 5, 6. *Dicroidium feistmanteli* (Johnston) Gothan. 5, 1045, with veins in parts of some pinnules $\times 1$. 6a, 1050; 6b, 1119; 6c, 1049; three fragments of fronds, $\times 1$.

Figs. 7, 8. *Thinnfeldia praecordillarae* Frenguelli. 7, 1052, showing smaller and oblong pinnules, $\times 1$; 8, 1044, with larger and semicircular pinnules with distinct mid ribs, $\times 1$.

Figs. 9, 10, 14–16. *Incertae sedis*. 9, 1128, $\times 1$; 10, 1129, $\times 1$; 14, 1130, $\times 1$; 15, 1136, $\times 3$; 16, 1101, $\times 1$.

Figs. 11–13. *Fanerotheca extans* Frenguelli. 11, 1099, $\times 4$; 12, 13, printed from Wieland's photographic negatives, magnification unknown.

Remarks. Some specimens figured by Walkom (1928, pl. 26, figs. 1, 2) from the Esk district of Queensland were described by him as fertile specimens of *Todites williamsoni*. However, neither in the description nor in the illustrations is there any convincing evidence of this. If that is the case, they do not appear to be different from the present material of this species.

Family CORYSTOSPERMACEAE
Genus DICROIDIUM Gothan 1912

Dicroidium odontopteroides (Morris) Gothan

Plate 89, fig. 6; Plate 90, figs. 1-3

Synonymy. See Townrow 1957, pp. 33-39.

Material. Four poorly preserved specimens (1047-8, 1051, 1088). 1051 (Pl. 89, fig. 6) shows distal part of a forked frond, each half up to 13 cm. in length with an axis c. 2 mm. wide. Pinnules are sub-opposite, smaller in size near the base and apex, and larger between. The largest pinnule is c. 2.5 cm. in length, and 0.5 cm. in width at the base. Each pinnule is attached to the rachis by its whole broad base, and has an entire margin, and shortly acute apex. The veins are not visible. Venation, visible in 1048 (Pl. 90, fig. 1) and 1047 (Pl. 90, fig. 2) is typically without a mid rib. In 1047 the pinnules are lanceolate. In 1088 (Pl. 90, fig. 3) the pinnules appear as lobes of an undivided lamina.

Remarks. All the specimens described are either small fragments or are very badly preserved. However, together they justify their inclusion in this species. But for the merger of *Dicroidium lancifolium* in *D. odontopteroides* (Townrow 1957), some of the specimens could certainly be identified with *D. lancifolium*.

Dicroidium feistmanteli (Johnston) Gothan

Plate 90, figs. 5, 6

Synonymy. See Townrow 1957, p. 39.

Material. Four specimens (1045, 1049-50, 1119) showing fragments of fronds with closely arranged sub-opposite pinnules on a rachis. The pinnules are rather expanded, broader distally than at the base. There is no mid rib, and all the veins tend to converge toward the base, but they do not meet at the same point.

Remarks. The specimens could almost as well be referred to *Dicroidium (Zuberia) zuberi* (Szajnocha) Townrow (1957). Although it is difficult to distinguish between the leaves of these two species, Townrow (1957) declined to express any opinion about this species, presumably because of its reported association with peculiar fructifications that are never found associated with *D. feistmanteli*. Because no such fructifications occur in association with the leaves described above, it is reasonably safe to refer these specimens to *D. feistmanteli*.

Also, without cuticles it is difficult to distinguish between *Dicroidium* and *Hoegnia* (Townrow 1957), and none occurs.

Dicroidium coriacium (Johnston) Townrow

Plate 91, figs. 1, 2

Synonymy. See Townrow 1957, p. 45.

Material. Five poorly preserved specimens (1908–93), up to 10 cm. in length, and forking once at some distance (about one-third of the length of the leaf) above the base. The margin varies from entire to broadly crenate, even in the same leaf. Each marginal projection (Pl. 91, fig. 2) represents an unseparated pinnule with 2–3 veins arising jointly from the mid rib far below the projection of the margin. The distance between two marginal projections represents the length of a pinnule.

Remarks. This species was first described and illustrated by Johnston (1887; 1888, pl. 26), and subsequently by Walkom (1925a, pp. 79–81, figs. 6–8). Townrow (1957) was doubtful about the propriety of referring two specimens, represented by Walkom's figs. 6 and 7, to this species, apparently because of some differences in the outline of the leaves. However, it is apparent from the specimens described above that the margins may vary even in the same leaf, and there is no doubt that Walkom's three specimens belong to this species.

Geinitz (1876, p. 6, pl. 2, figs. 7, 8) described the species *Pachypteris stelzneriana*, which Frenguelli (1941a) later redescribed as *D. stelznerianum*. Geinitz's drawings suggest that it is distinct from *D. coriacium*, but subsequent illustrations and a restoration of this species by Frenguelli (1941a) make it impossible to distinguish it from *D. coriacium*. If Frenguelli correctly identified his specimens with Geinitz's then the two species are in reality one.

Genus PTERUCHUS Thomas 1933

Pteruchus rhaetica (Geinitz) comb. nov.

Plate 90, fig. 15

1876 *Sphenolepis rhaetica* Geinitz, p. 12, pl. 2, figs. 23, 24.

1903 *Stachyopitys* sp., Seward, pp. 66, 67, pl. 9, figs. 1, 2.

Material. A single specimen (1136) consisting of a large number of microsporangiate (?) appendages arranged in fertile heads of c. 5 mm. in diameter. Stalks are not visible in the specimen, but the presence of more than one fertile head is clearly indicated.

Remarks. The specimen described above is specifically identical with *Sphenolepis rhaetica* Geinitz, whatever it may be. Geinitz (1876) had considered these fossils as spherical or compressed cones bearing numerous spirally arranged obovate woody scales. Seward (1903) considered them as male flowers. Although no spores have been recovered from the specimen, it seems to be an organ similar to microsporangiate structures described by Thomas (1933) as a species of *Pteruchus* Thomas.

Pteruchus is a pollen-bearing genus reminiscent of *Crossotheca*, a Palaeozoic pteridosperm microsporangiate structure (Delevoryas 1962, p. 123). Apparently similar Mesozoic microsporangiate fructifications have been referred to *Antholithus* (Antevs 1914) and *Stachyopitys* (Shirley 1898; Seward 1903), but these genera either lack a precise definition or include more than one natural group of plants (Thomas 1933). *Pteruchus*, on the other hand, is a precisely defined genus of *Corystospermaceae*, a family of Southern

EXPLANATION OF PLATE 91

Figs. 1, 2. *Dicroidium coriacium* (Johnston) Townrow. 1, 1089, almost three complete fronds, $\times 1$; 2, 1090, distal part of a frond with crenate margin, $\times 1$.
Figs. 3–7. *Xylopteris rigida* (Dun) comb. nov. 3, 1070, showing greater part of a frond, $\times 1$; 4, 1078, frond with closely arranged pinnules, $\times 1$; 5, 1075, $\times 1$; 6, 1126, indicating half a frond with distantly arranged pinnules, $\times 1$; 7, 1077, a smaller frond, $\times 1$.

Hemisphere pteridospermous plants. Therefore, the specimen described above is referred to this genus.

Genus FERUGLIOA Frenguelli 1944b

Feruglia samaroides Frenguelli (1944b)

Plate 97, figs. 15–19

Material. Two specimens (1064, 1105). 1064 (Pl. 97, figs. 15–17) measures *c.* 5.5 mm. in length and in width. It matches Frenguelli's specimen closely except that at the distal end it is apparently less cordate in shape, and the bifid micropyle is not as evident as in Frenguelli's specimen. The central line is also not very clear. The wing-like extensions are clearly seen.

1105 (Pl. 97, figs. 18, 19) is *c.* 6 mm. in length, and 4 mm. in breadth. It has a long distal prolongation, but the bifid nature of the micropyle is not evident. Wings are masked by the dark colour of the specimen; the central line is quite distinct.

Genus XYLOPTERIS Frenguelli 1943a

Xylopteris rigida (Dun) comb. nov.

1889 *Sphenopteris elongata* Carruthers; Szajnocha, pp. 223, 224, pl. 2, fig. 2.

1903 *Stenopteris elongata* (Carruthers) Seward, p. 70, pl. 7, fig. 2; pl. 11, fig. 3.

1909 *Stenopteris rigida* Dun, p. 313, pl. 50, figs. 1, 2.

1917a *Stenopteris elongata* (Carruthers) Walkom, p. 40, pl. 1, fig. 1; pl. 6, fig. 2.

1933 *Stenopteris densifolia* Thomas, p. 247, fig. 51.

1943b *Xylopteris elongata* (Carruthers) Frenguelli, pp. 324, 325, figs. 30, 31.

1951 *Xylopteris elongata* (Carruthers) Frenguelli; Menendez, pp. 224–6, pl. 15, figs. 9, 11.

Material. Ten fairly well-preserved specimens (1063, 1070–3, 1075–9, 1102). The largest is *c.* 10 cm. in length and no stalk is present in any. Typically, the main axis of each frond is forked once; each half regularly bears alternate to sub-opposite, simple, linear pinnae. Each pinna is *c.* 1 mm. broad, has a lamina with an entire margin, and, like the rachis, a single vein which terminates within a small rounded obtuse apex. The pinnae are spaced *c.* 0.5–1 cm. apart.

Remarks. This species has often been confused with *X. elongata* (Carruthers) Frenguelli (Carruthers 1872; Frenguelli 1943b). The latter has forked fronds, which are irregularly pinnate and have simple, forked, or more divided pinnae, often all on the same frond. *X. rigida*, on the other hand, has only simple and regularly arranged pinnae.

Further, it is difficult to distinguish between this species and *Xylopteris argentina* (Kurtz) Frenguelli (1943b). The latter is a rather ill-defined species based on some fragmentary specimens illustrated by Kurtz (1921, pl. 16, figs. 200–2). All these fragments may belong to *X. elongata* (Carruthers) Frenguelli, *X. rigida* (Dun) comb. nov., or *Sphenobaiera tenuifolia* (Johnston) comb. nov. (described later).

Considering the range of variation in size and spacing of the pinnae in *X. rigida*, it also becomes difficult to separate this species from *X. densifolia* (Du Toit) Frenguelli (Du Toit 1927, p. 364, text-fig. 13; Thomas 1933, text-fig. 51; Frenguelli 1943b).

Genus FANEROTHECA Frenguelli 1944a

Fanerotheca extans Frenguelli (1944b)

Plate 90, figs. 11–13

Material. A single specimen (1099, Pl. 90, fig. 12) having the appearance of a small flower-like structure

with four or more appendages terminating a small stalk. The terminal part of this fructification is c. 1 cm. in diameter. Also included in this species are specimens illustrated in Pl. 90, figs. 12, 13, printed from the old negatives left by Wieland, and for which the original specimens are no longer available.

Order CYCADEOIDALES, Family?
Genus YABEIELLA Oishi 1931

Yabeiella wielandi Oishi

Plate 92, figs. 1-7

- 1921 Un-named specimens, Kurtz, pl. 21, figs. 187, 190, 191, and the un-numbered figure to the left of 187.
1929 Un-named specimen, Wieland, p. 447, leaf in fig. 5a.
1931 *Yabeiella wielandi* Oishi, pp. 263, 264.
1943a *Yabeiella brackebushiana* (Kurtz) Oishi; Frenguelli, pl. 2, fig. 4.
1947 *Yabeiella brackebushiana* (Kurtz) Oishi; Jones and de Jersey, pp. 50, 51, text-figs. 43, 45.

Material. Five specimens (1008?, 1026-8, 1030). Holotype (1026, Pl. 92, figs. 1-2) is c. 3.1 cm. in length, 0.8 cm. in width. The margin, as in all other specimens of this genus, is entire. It has parallel sides and an obtusely rounded apex. Lateral veins form angles of about 65° with the mid rib. Some of the lateral veins fork once at varying distances from the mid rib, while some unite with the adjoining ones. Near the margin of the leaf there are about 18 lateral veins per cm., and all of them join the marginal veins. In 1027 (Pl. 92, fig. 3) the apex of the leaf is more or less acute. 1028 (Pl. 92, figs. 4, 5) has a narrower form, c. 5.5 mm. in width. 1008 (Pl. 92, figs. 6, 7) is the largest specimen, c. 8.8 cm. in length, but having much fewer and steeper lateral veins (about 11-13 per cm. along the margin, and forming angles of about 45° with the mid rib); no cross connexions between the veins are visible; the general form of the leaf is like that of the other specimens, but this specimen is only tentatively assigned to the species.

Remarks. There is a considerable range of variation in form and venation of the leaf. Further, although a large number of specimens have been assigned to this species, nothing is known about the base of the leaf.

Jones and de Jersey (1947) are of the opinion that this species is indistinguishable from *Yabeiella brackebushiana*, and that the specimens referred to it show secondary veins identical with those of *Y. brackebushiana*; however, the leaves have rounded apices, and have parallel edges, in contrast to the acute apex and lanceolate form of the latter. Further, they think that Kurtz's specimens demonstrate a gradation in the acuteness of the apices and in the form of the leaves.

On the contrary, *Y. wielandi* is easily distinguishable from *Y. brackebushiana*, even if the apices are not quite rounded in the former. There is a consistent difference in the shape and in the lateral veins of the leaves of the two species, and there is no indication that the specimens are fragments of compound leaves. All the available specimens strongly indicate that they are fragments or whole specimens of simple leaves.

EXPLANATION OF PLATE 92

- Figs. 1-7. *Yabeiella wielandi* Oishi. 1, 1026, holotype, also with the holotype of *Fraxinopsis major* Wieland, × 1; 2, holotype, showing details, × 2.5; 3, 1027, a fragment with more or less acute apex, × 1; 4, 1028, a narrower form of leaf, × 1; 5, same, showing details, × 2.5; 6, 1008, leaf with fewer and steeper veins, × 1; 7, same, showing details, × 2.5.
Figs. 8-14. *Yabeiella spatulata* Oishi. 8, 1062, × 1; 9, same, showing details, × 2.5; 10, 1021, a small complete leaf, × 1; 11, 1022, × 1; 12, same, showing details, × 2.5; 13, part of 1019 showing veins, × 2.5; 14, 1032, basal part of a leaf, × 1.

Yabeiella spatulata Oishi

Plate 92, figs. 8–14

1931 *Yabeiella spatulata* Oishi, p. 264, pl. 26, figs. 2, 2a.1947 *Yabeiella brackebushiana* (Kurtz) Oishi; Jones and de Jersey, text-figs. 43, 46.

Material. Eight specimens (1018–23, 1031, 1062), up to 6.5 cm. in length, and 7 mm. in width at the apex. The leaf is shortly petiolate to sub-sessile at the base, and gradually wider toward the apex (being more so in smaller or younger specimens). When present, the apex appears to be emarginate. The mid rib is characteristically stout up to the apex, longitudinally striated, and minutely pitted. The lateral veins form angles of about 55–65° with the mid rib, fork once at some distance from the mid rib (a few unite with the adjoining ones), and number 11–14 per cm. along the margin of the leaf before they unite with the marginal vein.

Remarks. Oishi (1931) founded this species on a single specimen from the Triassic of Argentina, in which the leaf has a broad, rounded apex. In the specimens described above, only two show apices, which are emarginate. An emarginate apex may be a character of the species, or it may result from some injury while the leaf was young; therefore, this character alone is insufficient to assign these specimens to a new species. All other characters are identical with the previously known characters of this species.

Yabeiella brackebushiana (Kurtz) Oishi

Plate 93, figs. 1–5

1921 *Oleandridium brackebushianum* Kurtz, pl. 18, fig. 307; pl. 21, figs. 147–50, 302, 304–6 (also un-named figs. in same plate, 145, 310, 312).1927 *Taeniopteris* cf. *brackebushiana* (Kurtz) Du Toit, p. 354, text-fig. 2.1931 *Yabeiella brackebushiana* (Kurtz) Oishi, p. 263, pl. 26, figs. 3, 5, 6.

Material. Three specimens (1007, 1009, 1029), up to 12 cm. in length, and 1.6 cm. in width in the middle. The mid rib is thick at the base, becoming gradually narrow above. Lateral veins form angles of 60–70° with the mid rib (angles being smaller at the apex and the base). Only a few veins are seen to bifurcate once and unite with the adjacent veins at different distances away from the mid rib. There are about 20 veins per cm. along the margin.

Remarks. *Y. brackebushiana* is a species with rather variable characters. It includes leaves with acute to acuminate apices, veins ranging from 14–20 per cm. along the margin, and forming angles of 50–70° with the mid rib. The specimens described above are similar to Kurtz's figs. 145, 308, and 312.

Yabeiella crassa Jones and de Jersey

Plate 93, figs. 6–13

1947 *Yabeiella crassa* Jones and de Jersey, pp. 53, 54, text-fig. 48, fig. 5 (only).

Material. Four specimens (1011, 1013 a, b, 1016), up to 7 cm. in length, and up to 1.6 cm. in width. The leaf has sub-sessile base, and narrowly obtuse apex. Mid rib is generally thick and distinctly striated, c. 2 mm. toward the base. Lateral veins form angles of about 65° with the mid rib, being somewhat steeper toward the apex, and number about 14 per cm. along the margin. Forking and union of veins are rare.

Remarks. The specimens generally agree with those of Jones and de Jersey (1947), who

have also included in this species some fragments of much larger leaves which apparently belong to *Y. mareyesiaca*.

Yabeiella mareyesiaca (Geinitz) Oishi

Plate 94, figs. 1-6

- 1876 *Taeniopteris mareyesiaca* Geinitz, p. 9, pl. 2, figs. 1-3.
 1917a *Taeniopteris dunstoni* Walkom, p. 37, pl. 9, fig. 1.
 1921 *Oleandridium mareyesiicum* (Geinitz); Kurtz, pl. 21, figs. 189, 314a.
 1931 *Yabeiella mareyesiaca* (Geinitz); Oishi, pp. 262-3.
 1947 *Yabeiella crassa* Jones and de Jersey, p. 53, pl. 8, fig. 1.

Material. Four incomplete specimens (1010, 1012, 1014-15), up to 7.5 cm. in length, and 2 cm. in width below the apex. Lateral veins form angles of 70-75° with a narrow mid rib. Some of the lateral veins fork once, and a few others unite with adjacent veins. They number 18-20 per cm. along the margin of the leaf.

Remarks. The specimens generally agree with those illustrated by Geinitz (1876) and Kurtz (1921). It is unfortunate, however, that Geinitz described the lateral veins as forming angles of about 85° with the mid rib, while his illustrations show angles of only 70-75°.

Yabeiella sp. indet.

1024 (Pl. 94, figs. 8-10) shows the greater part of a probably immature leaf without its apex. It is c. 2.8 cm. in length, and c. 7 mm. in width slightly above the base. The mid rib is somewhat thick at the base and narrow above. Lateral veins form angles of about 60-70° with the mid rib, and number about 24 per cm. near the marginal vein. Some of the lateral veins fork, and a few unite with the adjacent ones. Although the leaf has rather well defined characters, the small size and frequency of lateral veins per unit length of the leaf suggest that it is probably an immature leaf. Thus, it is not possible to assign it to any of the species described above.

1025 (Pl. 94, figs. 11, 12) is complete, shortly petiolate, c. 3.7 cm. in length (including a petiole c. 1 cm. long) and c. 6 mm. in width below the apex. It has a relatively thick mid rib, which remains equally thick up to the apex. The lateral veins form angles of about 65-70° with the mid rib; some of them fork once, and a few unite with the adjacent ones. They number about 20 per cm. near the marginal veins. This also is an apparently immature leaf. The thick mid rib, somewhat spatulate shape, and

EXPLANATION OF PLATE 93

- Figs. 1-5. *Yabeiella brackebushiana* (Kurtz) Oishi. 1, 1007, an almost complete leaf, ×1; 2, part of above showing details of venation, ×2.5; 3, 1029, a fragment with short acute apex, ×1; 4, 1009, ×1; 5, 1009, showing venation in the apex, ×2.5.
 Figs. 6-13. *Yabeiella crassa* Jones and de Jersey. 6, 1011, sub-basal region of a leaf, ×1; 7, part of above showing venation, ×2.5; 8, 1016, basal part of a leaf, ×1; 9, same, showing details, ×2.5; 10, 1013a, ×1; 11, same, showing veins, ×2.5; 12, 1013b with apical part of a leaf, ×1; 13, same, enlarged to show veins, ×2.5.

EXPLANATION OF PLATE 94

- Figs. 1-7. *Yabeiella mareyesiaca* (Geinitz) Oishi. 1, 1014, leaf with sub-sessile base and missing apex, ×1; 2, part of 1014 showing details, ×2.5; 3, 1010, indicating apex, ×1; 4, details of venation in the apex, ×2.5; 5, 1015, showing middle part of a distorted leaf, ×1; 6, part of 1015 with details of venation, ×2.5; 7, 1012, a fragment with sub-sessile base, ×1.
 Figs. 8-12. *Yabeiella* sp. 8, 1017, ×2.5; 9, 1024, an immature leaf, ×1; 10, same, with details of venation, ×2.5; 11, 1052, another immature leaf, ×1; 12, same, showing veins, ×2.5.

frequency of lateral veins suggest that it may belong to *Y. spatulata*, but without intermediate forms identification is uncertain.

1017 (Pl. 94, fig. 8) shows the middle part of a leaf. It is *c.* 4 cm. in length, and *c.* 9 mm. in width, with almost parallel edges, a thick, longitudinally striated mid rib, and numerous (about 24 per cm). lateral veins arising from the mid rib at angles of about 65°. Some of the lateral veins fork once, and a few join the adjacent ones. This specimen shows some resemblance to *Y. wielandi*, particularly in having parallel edges, and in the narrow form of the leaf, but it obviously differs from that species in having a thick mid rib, and numerous veins (about 24 per cm. as against 14–18 in that species). It is not impossible that this specimen shows an extreme form of *Y. wielandi*, and may actually belong to it.

Class CONIFEROPHYTA
Order GINKGOALES
Family GINKGOACEAE
Genus BAIEROPHYLLITES gen. nov.

Type species. *B. florinii* sp. nov.

Generic diagnosis. Same as for the type species, see below.

Baierophyllites florinii gen. et sp. nov.

Plate 95, figs. 1–5; Plate 96, figs. 1–3

Diagnosis. Leaves narrow, linear, up to 13 cm. long and 0.5 cm. broad, without any distinction into petiole and lamina, forked only once at some distance above the base into more or less equal halves that terminate in round or somewhat depressed apices; veins indistinct.

Cuticle moderately thick, epidermal cells rectangular over the veins, shorter further away, with straight walls; stomata scattered sparsely in vein and intervein areas, each typically having two small terminal, and two large lateral subsidiary cells; lateral subsidiary cells over the veins scarcely or little different from the ordinary epidermal cells, but forming a more or less round group of cells in stomata away from the veins; no papillae on epidermal or subsidiary cells.

Description. Four specimens (1083–4, 1086, 1120). The holotype, 1120 (Pl. 95, figs. 1–5) shows a few overlapping leaf compressions. The form of the leaf is better seen in other specimens, but this specimen is significant in having cuticle preserved in places. Although the veins are not clearly visible in the specimens, they are more easily recognized in the cuticle. Because of the small size of cuticle pieces, however, the number of veins could not be determined.

The cuticle is moderately thick, the epidermal cells are rectangular, *c.* 120–50 μ long and 20–25 μ broad over the veins, and shorter and irregular away from the veins. They have straight walls and no papillae. The stomata are thinly scattered over the entire leaf surface. Along the veins the stomata are typically longitudinally oriented, i.e. the axes of the stomatal apertures are parallel with the long axis of the leaf. The stomatal aperture is narrow, *c.* 25 μ long, and flanked by a pair of guard cells which are nearly as long as, or a little longer than, the aperture. Guard cells (Pl. 95, figs. 4, 5) are *c.* 7 μ wide in the middle but are abruptly narrowed to a line on either end. Each stoma has a short terminal subsidiary cell at either pole. A large subsidiary cell is adjacent to each

guard cell. These lateral subsidiary cells are scarcely different from the adjoining epidermal cells, except for a slight difference in size.

The stomata have the same fundamental structure away from the mid rib except that they appear to be surrounded by a group of two to five, usually four, subsidiary cells. This is apparently due to divisions of the lateral subsidiary cells or polar epidermal cells, or both. The stomatal apparatus is also a little wider than it is over the veins.

Only in one widely open, and particularly well-preserved, stoma (Pl. 95, fig. 3) was it possible to see that a cuticular flap formed a sort of arch over the stomatal aperture, leaving only a small stomatal passage. In the figure the flap is seen as a lighter area on the inner sides of the guard cells enclosing a slit-like stomatal aperture.

1084 (Pl. 96, fig. 1) shows a poorly preserved leaf of full size. It also shows the place and extent of forking and a depressed apex in one of the halves.

Remarks. The specimens have been referred to a new genus of Ginkgoaceae. The form of the leaf and the cuticular structures amply support this assignment. The genus is probably closer to *Ginkgoites* than to *Sphenobaiera*. Some affinities with *Sphenobaiera* are indicated by the form, but the cuticular structure of species of *Sphenobaiera* (Harris 1935; Florin 1936 *a, b*; Kräusel 1943) indicates the fundamental difference between the two genera. The subsidiary cells around the guard cells in the cuticles of *Sphenobaiera* show a varying degree of development of papillae projecting over the guard cells, a character entirely absent in the new genus. This character, as well as the presence of small terminal subsidiary cells, indicates closer affinities with *Ginkgoites* (Harris 1935).

Genus SPHENOBAIERA Florin 1936a

Sphenobaiera argentina (Kurtz) Frenguelli

Plate 96, figs. 4, 5

1876 *Baiera taeniata* Geinitz, p. 8, pl. 2, fig. 10.

1894 *Baiera argentina* Kurtz, pl. 4, figs. 4-6.

1946 *Sphenobaiera argentina* (Kurtz) Frenguelli, pp. 109-19, pl. 2, fig. 4; pl. 3; pl. 4, figs. 1, 2; pl. 5; pl. 6, fig. 1.

EXPLANATION OF PLATE 95

Figs. 1-5. *Baierophyllites florinii* gen. et sp. nov. Holotype, 1120. 1, leaves, $\times 1$; 2, cuticle from area away from veins, $\times 100$; 3, stoma from cuticle away from vein, $\times 500$; 4, cuticle on the vein, $\times 100$; 5, stoma from cuticle on the vein, $\times 500$.

EXPLANATION OF PLATE 96

Figs. 1-3. *Baierophyllites florinii* gen. et sp. nov. 1, 1084, a complete leaf, $\times 1$; 2, 1086, another leaf with almost swollen ends, $\times 1$; 3, 1083, a smaller leaf showing depressed tips of each half of the leaf, $\times 1$.

Figs. 4, 5. *Sphenobaiera argentina* Frenguelli. 4, 1056, showing major part of a leaf, $\times 1$; 5, a part of a segment of the above showing veins, $\times 2.5$.

Figs. 6-9. *Sphenobaiera tenuifolia* (Johnston) comb. nov. 6, 1080, greater part of a leaf with double dichotomy, $\times 1$; 7, 1081, a leaf with triple dichotomy, $\times 1$; 8, 1082, a fragment with double dichotomy, $\times 1$; 9, 1074, stem with attached leaves, $\times 1$.

Fig. 10. *Baiera rollerii* Frenguelli. 1122, $\times 1$.

Fig. 11. *Baiera cuyana* Frenguelli. 1121, $\times 1$.

Figs. 12, 13. *Stachyopitys anthoides* Frenguelli. 12, 1110, $\times 1$; 13, same, enlarged, $\times 2.5$.

Material. A single specimen (1065), c. 8.5 cm. in length, is distally forked once. Each segment of the fork is c. 1 cm. in width, and shows about 10 parallel veins.

Remarks. This species resembles *Sphenobaiera longifolia* (Heer 1876, pl. 7, figs. 2, 3; pl. 8), but differs essentially in having only once-forked leaves.

Sphenobaiera tenuifolia (Johnston) comb. nov.

Plate 96, figs. 6-9

1887 *Baiera tenuifolia* Johnston, p. 176, pl. 3, figs. 2 a-e.

1890 *Trichopitys johnstonii* Feistmantel, p. 113.

1947 *Czekanowskia tenuifolia* (Johnston) Jones and de Jersey, pp. 59-61, text-fig. 55; pl. 5, fig. 4?; pl. 6, fig. 2.

Material. Five specimens (1080-2, 1074, 1103), up to 10 cm. in length, and each segment c. 1-1.5 mm. in width. The leaf is in the form of a two-dimensional axis which is two to three times dichotomously branched. A single longitudinally striated vein is seen throughout the leaf.

1074 (Pl. 96, fig. 9) is a stem fragment bearing bases of three leaves, one of the latter showing a distinct dichotomy, another one also indicating a dichotomy with a small base of a missing branch of the leaf. The axis is c. 3 mm. in width, suggesting that it represents a young part of the stem.

Remarks. This species was previously known only from the Triassic of Tasmania. It shows some resemblance to *Czekanowskia* and *Trichopitys* on the one hand, and *Sphenobaiera* on the other. Feistmantel (1890) referred this species to *Trichopitys* on the assumption that certain fructifications found in close association with these leaves were very like those found in the genus. But Walkom (1925a) failed to find any actual connexion between fructifications and leaves, and no such fructifications have been found in association with the specimens described above. It is therefore reasonable not to refer to these leaves as *Trichopitys*.

The leaves show some resemblance to *Czekanowskia* Heer in form, but there is no evidence to show that they were born in clusters or on dwarf shoots. Further, the cuticular structure of this species described by Jones and de Jersey (1947) is quite unlike that of *Czekanowskia*, particularly in having prominent epidermal papillae, hitherto unknown in *Czekanowskia*. If specimen 1074 (Pl. 96, fig. 9) represents the kind of plant that produced these leaves, as has been supposed here, the evidence is that these leaves were borne singly. There is thus no sound basis for referring this species to *Czekanowskia*.

On the other hand, the morphology and cuticular structures suggest affinities with *Sphenobaiera* Florin, particularly *S. furcata* (Heer) Florin (Kräusel 1943, text-figs. 9, 10). However, it differs specifically from the latter at least in lacking the terminal dichotomy of the segments of the leaves. It is therefore included in this genus as *Sphenobaiera tenuifolia* (Johnston) comb. nov.

Genus BAIERA Braun 1843

Baiera rollerii Frenguelli (1946)

Plate 96, fig. 10

Material. A single specimen (1122), a poorly preserved whitish impression on a light piece of rock. It is c. 2.3 cm. in length, and c. 0.3 cm. in width at the undivided widest part of the wedge-shaped leaf.

Distally it is divided into four segments, each of which is nearly as long as the undivided basal part of the leaf. No veins are visible.

Baiera cuyana Frenguelli (1942)

Plate 96, fig. 11

Material. A single specimen (1121), c. 3.5 cm. in length, and roughly wedge-shaped with a small stalk, and a distally divided lamina. The lamina is divided into six segments; a deep central incision divides the distal segments into two groups of three each. Preservation is poor, and no veins are visible.

Remarks. This species is distinguishable from *B. rollerii* Frenguelli in having a central long incision dividing the lamina into two primary lobes, each in turn being divided into three segments, as opposed to three equally deep incisions dividing the lamina into four equal segments in *B. rollerii*.

Genus PHOENICOPSIS Heer 1876

Phoenicopsis elongatus (Morris) Seward

Plate 97, figs. 1, 2

1927 *Phoenicopsis elongatus* (Morris) Seward; Du Toit, p. 368.

1947 *Phoenicopsis elongatus* (Morris) Seward; Jones and de Jersey, p. 62, text fig. 57.

1951 *Podozamites elongatus* (Morris) Feistmantel; Menendez, p. 206, pl. 12, fig. 5.

Material. Three specimens (1068, 1131–2), up to 11 cm. in length, and 0.7 cm. in width. The leaf gradually tapers at one end, where it measures c. 4.5 cm. in width. There are about 13–14 simple veins separated from each other by narrow 'interstitial veins'.

Remarks. This species has been shuffled between *Podozamites* and *Phoenicopsis*, mainly because it was based on isolated leaves that can hardly be distinguished from the dispersed leaves of *Podozamites*. Also, many specimens have been found from various localities showing their occurrence in fan-shaped dwarf shoots. On the other hand, no specimen has so far been recorded showing the attachment of these leaves along an elongated axis that would indicate their affinity with *Podozamites*. It seems reasonable to assign this species to *Phoenicopsis* Heer.

EXPLANATION OF PLATE 97

Figs. 1, 2. *Phoenicopsis elongatus* (Morris) Seward. 1, 1068, a leaflet, $\times 1$; 2, part of above showing veins, $\times 2.5$.

Figs. 3, 4. *Incertae sedis*. 3, 1134, $\times 2$; 4, 1135, $\times 1$.

Fig. 5. *Noeggerathiopsis* sp., 1098, $\times 1$.

Figs. 6–8. *Podozamites lanceolatus* var. *genuinus* Heer. 6, 1087, a small complete leaflet, $\times 1$; 7, 1066, greater part of a larger leaflet, $\times 1$; 8, 1076, a fragment showing veins, $\times 1$.

Figs. 9–11. *Fraxinopsis major* Wieland. 9, 1061, the largest specimen incomplete at the base, $\times 2.5$; 10, holotype, 1033, $\times 2.5$; 11, 1042, basal part indicating the complete division of the basal body into two equal halves, $\times 2.5$.

Figs. 12–14. *Fraxinopsis minor* Wieland. 12, 1034, lamina with one forking vein, $\times 2.5$; 13, 1032, a specimen with narrower lamina, $\times 2.5$; 14, 1039, a smaller specimen with narrow lamina, $\times 2.5$. Note the absence of forked veins in figs. 13, 14.

Figs. 15–19. *Feruglioia samaroides* Frenguelli. 15–17, 1064; 15, $\times 1$; 16, $\times 2.5$; 17, $\times 5$. 18, 19, 1105; 18, $\times 1$; 19, $\times 2.5$.

Genus STACHYOPITYS Schenk 1867

Stachyopitys anthoides Frenguelli (1944a)

Plate 96, figs. 12, 13

Material. A single specimen (1100), c. 7 mm. in length, and c. 5 mm. in width, appearing as a small axis bearing alternately arranged, minute bodies, looking like tiny flowers. Each body consists of 4-5 small oval appendages.

Order CORDAITALES

Family CORDAITACEAE

Genus NOEGGERATHIOPSIS Feistmantel 1879

Noeggerathiopsis sp.

Plate 97, fig. 5

Material. A single badly preserved specimen (1098). It is an elongate-spatulate leaf with a rounded apex that appears parted in the middle, perhaps due to faulty preservation, or to injury. It is c. 6.5 cm. in length, and c. 2.1 cm. in width below the apex, tapering gradually to a 6 mm. wide base. The veins are barely visible.

Remarks. The specimen shows considerable resemblance to *Noeggerathiopsis hislopi* (Bunbury) Feistmantel in shape, but the species of this genus are better distinguished from each other with the help of cuticular structures.

Because of the striking resemblance between the leaves of this genus and of *Cordaites* Unger, there has been a persistent suspicion that the two genera are, in reality, one. Pant and Verma (1964) have demonstrated similarity in the cuticular structure of these genera and have further emphasized the possibility of generic identity. However, they have preferred to retain *Noeggerathiopsis* as a distinct genus.

Order CONIFERALES, Family?

Genus PODOZAMITES (Brongn.) Braun 1843

Podozamites lanceolatus var. *genuinus* Heer (1876)

Plate 97, figs. 6-8

Material. Four poorly preserved specimens (1066-7, 1087, 1133), measuring 4.1-5.7 cm. in length, and 0.7-0.9 in width near the spatulate apex. There are 8-11 indistinct veins converging towards the narrow base of the leaf.

Order CONIFERALES, Family?

Genus FRAXINOPSIS Wieland 1929

Fraxinopsis major Wieland

Plate 97, figs. 9-11

1929 *Fraxinopsis major* Wieland, pp. 447-8, fig. 5a.1944c *Cycadocarpidium majus* Frenguelli, pp. 557-8, pl. 3.

Material. Five specimens (1033, 1042-3, 1051, 1069). The holotype (1033, Pl. 97, fig. 10) has apparently deteriorated considerably since it was studied by Wieland (1929). The veins have almost disappeared in the basal part of the lamina. It measures c. 3.5 cm. in length including its basal fertile

part, which has a body, or possibly two, separated from each other by a distinct longitudinal slit. The distal sterile part of the lamina has numerous veins that apparently fork more than once.

The largest specimen (1061, Pl. 97, fig. 9) is c. 3.5 cm. in length, excluding the basal fertile part of the sporophyll, which is largely missing.

Remarks. See remarks under *F. minor* below.

Fraxinopsis minor Wieland

Plate 97, figs. 12–14

1929 *Fraxinopsis minor* Wieland, pp. 447–8, fig. 5b.

1941b *Cycadocarpidium andium* Frenguelli, pp. 485–98, pl. 1–3.

1944c *Cycadocarpidium minus* Frenguelli, pp. 557–68, pl. 1–4.

Material. Fourteen specimens (1032, 1034–41, 1123–7), most of which are poorly preserved or fragmentary. They vary in size from 2–2.5 cm. in length including the basal fertile part, and 4–6.5 mm. in width. Typically there are seven simple veins in the distal sterile part of the lamina. In some of the wider specimens, one of the veins is seen to fork (Pl. 97, fig. 123). The basal fertile part is quite similar to that of the other species described above.

Remarks. Wieland (1929), reporting on these two species, described these fructifications as ‘fruits’, noting some resemblance between *Fraxinopsis* and *Cycadocarpidium* Nathorst, but considering them as distinct. Further, he favourably compared these fossils with fruits of the modern genus of angiosperms, *Fraxinus*, the source of the generic name *Fraxinopsis* Wieland.

Oishi (1931) described specimens of *F. minor* from the Cacheuta beds of the same formation, located a few miles away from Minas de Petroleo. He thought these fructifications did not belong to angiosperms, but were probably gymnosperms or ‘hemiconifers’ (of Wieland 1929). Seward (1931) also compared *Fraxinopsis* Wieland and *Cycadocarpidium* Nathorst, without giving any opinion about their relationship. Harris (1935) remarked on some resemblances among *Fraxinopsis* Wieland, *Cycadocarpidium* Nathorst, and *Dioonitocarpidium* Lilienstern, but allowed the possibility that they might be different genera.

Frenguelli (1941c), possibly unaware of *Fraxinopsis*, described some specimens as *Cycadocarpidium andium*. Subsequently Frenguelli (1944c) suggested differences between *C. andium* and *Fraxinopsis minor*, but considered *Fraxinopsis* and *Cycadocarpidium* generically identical, transferring species from the former to the latter.

Dioonitocarpidium (Lilienstern 1928) consists of an axis bearing two rows of sickle-shaped appendages, and, near the base of the axis, two small bodies, each about 1 cm. long. It is thus quite different from *Fraxinopsis*, in which there are no appendages at all. Similarly, *Cycadocarpidium* Nathorst is an alate organ having a distal sterile laminate part similar to that of *Fraxinopsis*, and a stalk-like basal part bearing a pair of appendages, each of the latter bearing a seed-like body. In *Fraxinopsis*, on the other hand, the basal fertile part is also more or less laminate in form, and has no appendages at all. Thus, structurally, *Fraxinopsis* is distinct from the other two genera.

Regarding the affinities of this genus, there is no evidence to support the view that it could belong to the angiosperms. It was the basal fertile part of the fructifications that Wieland (1929) considered to be seeds, showing the two cotyledons of their embryos. This, and the presence of some taeniopteroid leaves, which, he thought, were also of

angiosperms, led him to assign the fructifications to the angiosperms. Oishi (1931) noted that a clear space divides the basal body into two, and the two bodies only happen to lie very close to each other. This fact, and the apparent similarity between the sterile distal parts of these fructifications in this genus and *Cycadocarpidium*, suggest that there may be some affinity between the two genera.

Concerning the taxonomy of the genus, *Fraxinopsis minor* and *F. major* are distinct from each other, not only in size differences, but also in the profuse branching of the veins in the distal sterile part of the lamina in *F. major*, and the almost simple veins in the others. Also, it is interesting to note that the branching of veins in the lamina tends to coincide with the larger width of the specimens. It is quite possible, therefore, that the specimens assigned to *F. major* simply represent the largest specimens of one and the same species, *F. minor*. But this is purely speculation until other specimens are found to bridge the gap in the known characters of the two species.

On the other hand, it is impossible to distinguish between *F. minor* and the so-called *Cycadocarpidium andium*. The comparative data published by Frenguelli (1944c, p. 560) to demonstrate the distinction between them seem to emphasize the continuous range in size and other characters in the two species. Further, one specimen of *C. andium* is shown to have a forking vein in the distal lamina. This character, which obviously varies with the width of the lamina (Pl. 97, figs. 122-4), is not lacking in *F. minor* either. Therefore, *C. andium* Frenguelli would seem to be a later synonym of *F. minor*.

Incertae Sedis

Specimens 1128, 1129 (Pl. 90, figs. 9, 10). Both lie close together on the same rock fragment. 1128 shows a three-dimensional body terminating a small stalk. The terminal body shows three ovoid lobes, each c. 6 mm. in length, and up to 3 mm. in width. The other specimen shows a four-lobed structure, each with the same dimensions as in the first.

These specimens show superficial resemblance to *Sagenopteris nilssoniana* (Brongn.) Ward, in Frenguelli (1941c, pl. 3, figs. 4, 5), but no veins are visible in our specimens. The absence of veins and the three-dimensional appearance of the specimens suggest that these may be some sort of fructification, rather than the foliage of *Sagenopteris*. They also bear a striking resemblance to *Fanerotheca extans* Frenguelli (Pl. 90, figs. 42-44), but a precise comparison is impossible.

Specimen 1130 shows two seed-like bodies split open longitudinally into halves (Pl. 90, fig. 14). Each body is c. 5-7 mm. in length, and c. 3-4 mm. in width, showing a central part surrounded by a thick wall. No other details are visible. It is difficult to ascertain their natural affinities, but they have the appearance of seeds or fruits.

Specimen 1101 (Pl. 90, fig. 16) is a cluster of seed-like bodies attached to an axis by short stalks. Each body is a small ovoid structure, c. 2 mm. in long diameter, and a little shorter in the other. The axis is not entirely exposed, but attempts to expose it further would have ruined the specimen.

These bodies probably represent some kind of ovulate fructification. Apparently similar bodies are usually found associated with the leaves of ginkgophytes as well as certain pteridosperms, particularly the *Corytospermaceae* (Thomas 1933).

Specimens 1134, 1135. 1134 (Pl. 97, fig. 3) consists of a small laminate organ bearing three small bodies on its surface. The entire specimen measures c. 4 × 2 mm. The small bodies are of unequal size, c. 1 mm. in diameter, and each having a distinct border separated from a central mass by a distinct groove. 1135 (Pl. 97, fig. 4) is a more fragmentary specimen bearing four bodies on its surface.

It is difficult to ascertain the morphology and affinity of these specimens. They bear superficial resemblance to *Umkomasia cacheutensis* (Frenguelli 1942, p. 317, fig. 1).

CONCLUSIONS

Stratigraphy. The relationships of the four beds or 'Estratos' of the Cacheuta Formation with other Triassic beds of Argentina were reviewed and summarized by Groeber and Stipanovic (1952). They considered these beds to be of Norian to Rhaetic age (Table 1), perhaps allowing for the possibility that the Beds of Cerro de la Cabras may be a little older, i.e. of Upper Carnian, and that those of Rio Blanco may be a little younger than Rhaetic.

Krishnan (1954) also considered these beds to be mainly 'Upper Triassic', with the probability that the La Cabras may be partly 'Middle Triassic', and the Rio Blanco, Rhaetic. However, Frenguelli (1948) had reached the conclusion that these beds are 'Middle Triassic to Rhaetic', possibly even 'Lower Jurassic' in age. He had also compared the flora of the 'Estratos de los Rastros-Potreriillos' with the Middle Triassic floras of Africa and Australia, and concluded that these beds are not younger than 'Lower Keuper' in age. Menendez (1951) was of the same opinion and stated that there is sufficient evidence from fossil fishes and plants to support Frenguelli's estimate of the ages of these beds. Also it must be pointed out that the 'Lower Keuper' is now considered equivalent to the Upper Ladinian, i.e. Upper Middle Triassic (see Jones and de Jersey 1947). However, the following observations indicate that the flora of the Potrerillos Beds is not younger than Middle Triassic in age.

Table 2 shows the complete list of plants known from the Potrerillos Beds of the Cacheuta Formation, and their occurrence in other Southern Hemisphere floras. No comparison has been made with contemporary floras of the Northern Hemisphere, because there are hardly any species in common. Besides the papers referred to in the text above, the following papers were consulted in preparing this table: Arber (1917), Du Toit (1932), Feistmantel (1881), Hill (1930), Lele (1955, 1962), Nye and Blake (1938), Sahni (1922, 1926), Seward (1933), and Walkom (1918, 1919, 1924, 1925 *a, b*).

It will be seen that out of the 42 listed species, 15 are confined to this flora, and hence are of not much stratigraphic value. However, many of them are represented by closely allied species in the contemporary floras. Of the remaining 27, 21 (more than 77%) occur in the flora of the Ipswich 'Series' of Queensland (mostly in the beds of Kholo and Tivoli Stages), 13 (about 48%) in the Molteno beds of the Stormberg 'Series' of South Africa, 11 (more than 40%) in the Triassic beds of Tasmania, and 9 (more than 33%) in the Esk 'Series' of Queensland. Thus the flora of the Potrerillos Beds has strong affinities, and is contemporaneous with, the floras of the Ipswich and Esk 'Series' of Queensland, Triassic of Tasmania, and Molteno beds of South Africa.

As regards the ages of the above floras, they were also previously considered to be of Upper Triassic to Rhaetic ages, but more recently they have been shown to be of Middle Triassic age (Thomas 1933; Watson, *in* Thomas 1933; Townrow 1957; Bryan and Jones 1946, 1950; Jones and de Jersey 1947; Allen 1961). Jones and de Jersey (1947) have indicated that the flora of the Ipswich 'Series' is not younger than 'Lower Keuper' (Middle Triassic), though in their correlation scheme the 'Series' has been shown to range from Lower Triassic to the basal part of the Upper Triassic. In Table 2, it is significant that out of 27 species, there are 9 in common with the flora of the Esk 'Series'. The Esk 'Series' is considered to be equivalent to the Kholo Stage of the Ipswich 'Series'.

TABLE 1
Stratigraphic correlation of various Triassic strata of Argentina according to Groeber and Stipanovic 1952

Stage	Mendoza		San Juan		La Rioja		Patagonia
	South	North	Barreal	Hilario	South	North	
Rhaetian	Estratos de Llantenes	Estratos de Rio Blanco	Estratos del Rio de Los Patos Estratos de Cepeda	Estratos de Hilario	Estratos de Los Colorados or Gualo	'Cretacico superior andino'	Paso Flores and Malacara
		Estratos de Cacheuta	Estratos de la Cortaderita	Estratos del Alcazar	Estratos de Ischigua-lasto		
		Estratos de Potrerillos	Estratos de Barreal	Estratos del Agua de Los Pajaritos	Estratos de Los Rastros		?
Norian	Estratos de Chihuui	Estratos de La Cabras (s.l.)					↑
		Choiyoiitense					Chacay-Co
					Famatense		Choiyoiitense and
Carnian	Upper						
	Middle						
	Lower						Palaeozoic and/or Pre-Cambrian

Kholo and Tivoli are the two oldest stages of the Ipswich 'Series' (Bryan and Jones 1950). Therefore, even if the uppermost strata of the Ipswich 'Series' belong to the basal part of the Upper Triassic, the comparison is strong with the Middle Triassic strata of the

TABLE 2

Distribution of species of the flora of Potrerillos Beds of Argentina in other floras of the Southern Hemisphere.

No.	Species	Beaufort	Molteno	New Zealand	Ipswich	Waloan	Esk	Tasmania	Narrabeen	Hawkesbury	Wiamamatta	Parsora	Panchet
1.	<i>Phyllothea australis</i> Brongniart	*			*			*	*				
2.	<i>Neocalamites carreri</i> (Zeiller) Halle	*	*		*			*	*				
3.	<i>Equisetites fertilis</i> Frenguelli				*								
4.	<i>Sphenopteridium</i> sp. aff. <i>truncatum</i> Kurtz				*								
5.	<i>Callipteridium argentinum</i> Frenguelli				*								
6.	<i>Cladophlebis kurtzi</i> Frenguelli		*		*								
7.	<i>Cladophlebis mesozoica</i> Kurtz				*								
8.	<i>Cladophlebis johnstoni</i> Walkom				*	*	*						
9.	<i>Cladophlebis australis</i> (Morris) Seward		*		*	*	*		*	*	*		
10.	<i>Cladophlebis copiosa</i> Frenguelli				*								
11.	<i>Cladophlebis wielandi</i> sp. nov.				*								
12.	<i>Sagenopteris longicaulis</i> Du Toit		*										
13.	<i>Thinnfeldia dutoiti</i> sp. nov.		*										
14.	<i>Thinnfeldia praecordillariae</i> (Freng.)		*										
15.	<i>Dicrodium odontopteroides</i> (Morris) Gothan	*	*	*	*	*	*	*	*	*	*	*	*
16.	<i>Dicrodium feistmanteli</i> (Johnston) Gothan	*	*	*	*	*	*	*	*	*	*	*	*
17.	<i>Dicrodium coriaceum</i> (Johnston) Townrow	*	*	*	*	*	*	*	*	*	*	*	*
18.	<i>Xylopteris rigida</i> (Dun) comb. nov.	*	*	*	*	*	*	*	*	*	*	*	*
19.	<i>Pteruchus rhaetica</i> (Geinitz) comb. nov.	*	*	*	*	*	*	*	*	*	*	*	*
20.	<i>Fanerotheca extans</i> Frenguelli												
21.	<i>Feruglioia samaroides</i> Frenguelli												
22.	<i>Yabeiella wielandi</i> Oishi				*								
23.	<i>Yabeiella spatulata</i> Oishi				*								
24.	<i>Yabeiella brackebushiana</i> (Kurtz) Oishi		*		*								
25.	<i>Yabeiella crassa</i> Jones and de Jersey		*		*								
26.	<i>Yabeiella mareysiaca</i> (Geinitz) Oishi		*		*		*						
27.	<i>Baierophyllites florinii</i> gen. et sp. nov.												
28.	<i>Sphenobaiera argentiniae</i> Frenguelli												
29.	<i>Sphenobaiera tenuifolia</i> (Johnston) comb. nov.		*		*		*						
30.	<i>Czekanowskia</i> sp.				*		*						
31.	<i>Baiera cuyana</i> Frenguelli							*					
32.	<i>Baiera rollerii</i> Frenguelli							*					
33.	<i>Ginkgoites bidens</i> (Tenison-Wood) Florin				*		*	*					
34.	<i>Ginkgoites truncata</i> Frenguelli				*		*	*					
35.	<i>Ginkgoidium bifidum</i> Frenguelli				*		*	*					
36.	<i>Phoenicopsis elongatus</i> (Morris) Seward		*		*	*	*	*					
37.	<i>Desmiophyllum</i> sp.												
38.	<i>Stachyopteryx anthoides</i> Frenguelli												
39.	<i>Noeggerathiopsis</i> sp.											*	
40.	<i>Podzamites lancolatus</i> var. <i>genuinus</i> Heer												
41.	<i>Fraxinopsis major</i> Wieland				*								
42.	<i>Fraxinopsis minor</i> Wieland				*								
Totals		4	13	1	21	4	9	11	3	3	4	2	1

Note: In the table *(u) indicates the occurrence of the species based on an unpublished thesis reported in Jones and de Jersey (1947).

Ipswich 'Series'. The unavoidable conclusion is that the flora of the Potrerillos Beds of the Cacheuta Formation is not younger than Middle Triassic in age.

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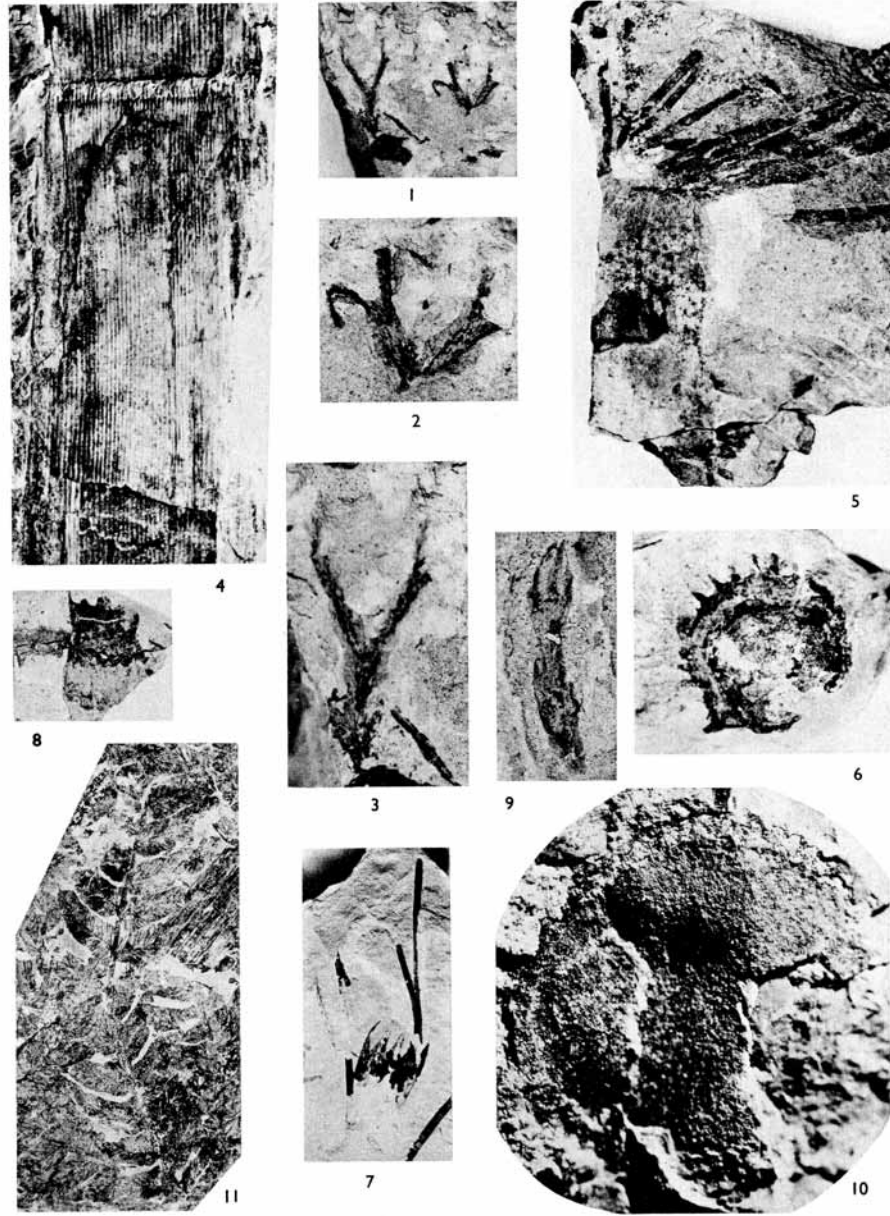
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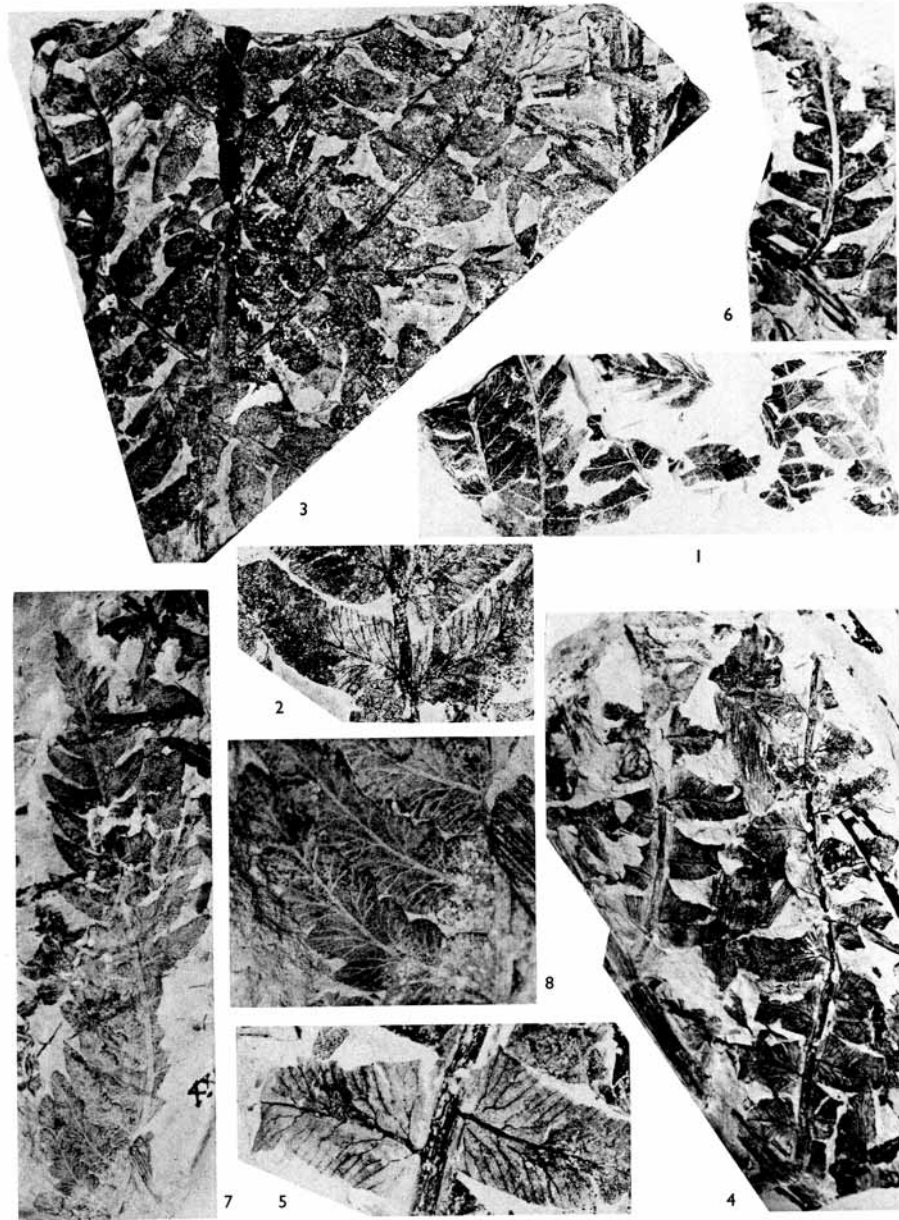
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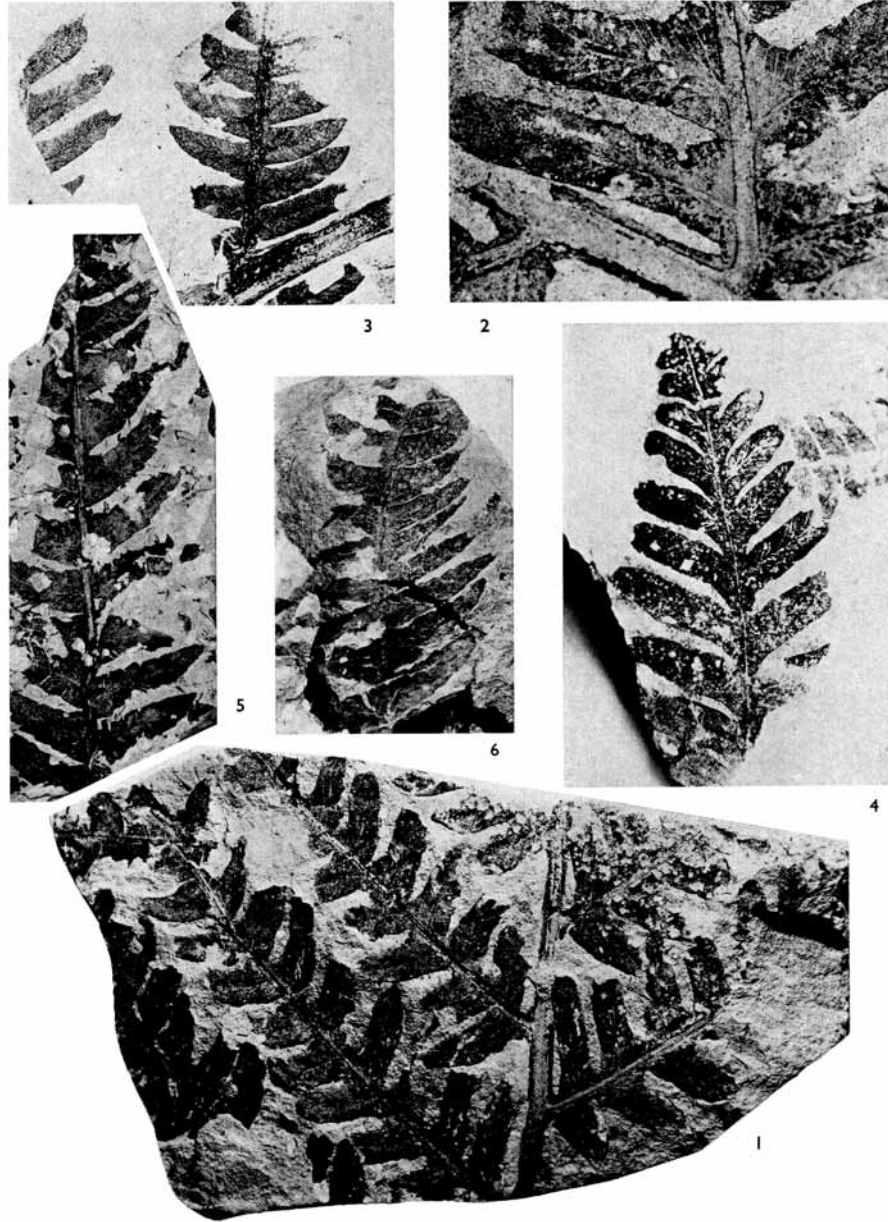
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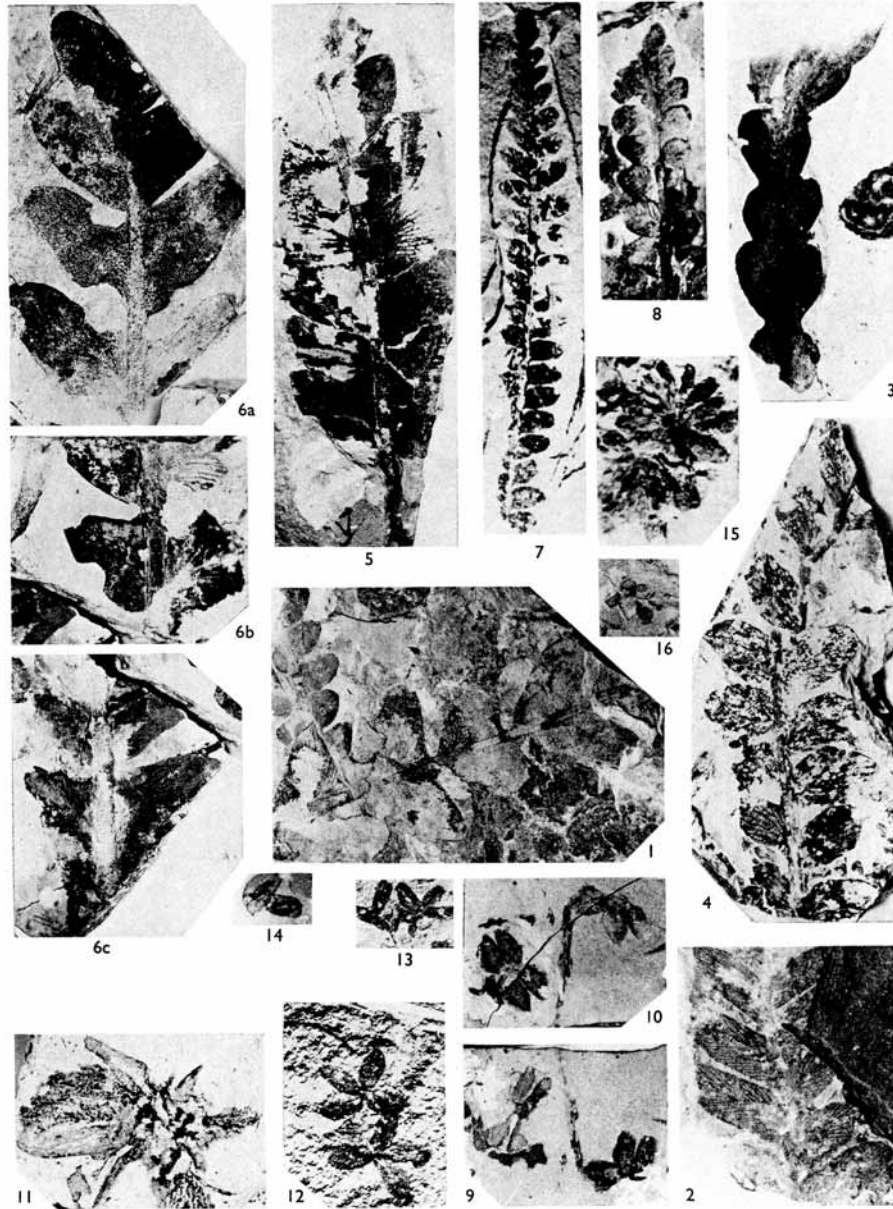


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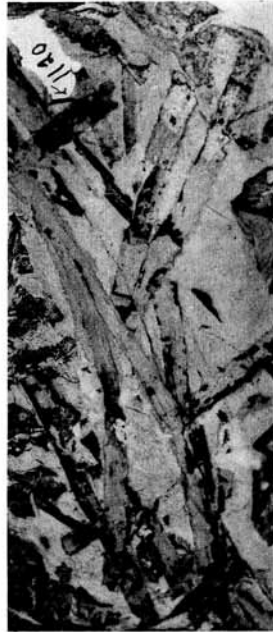
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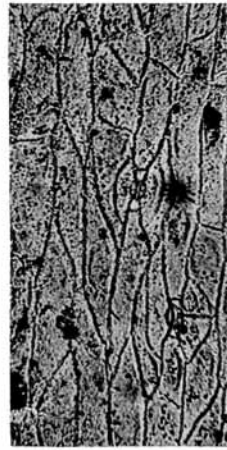
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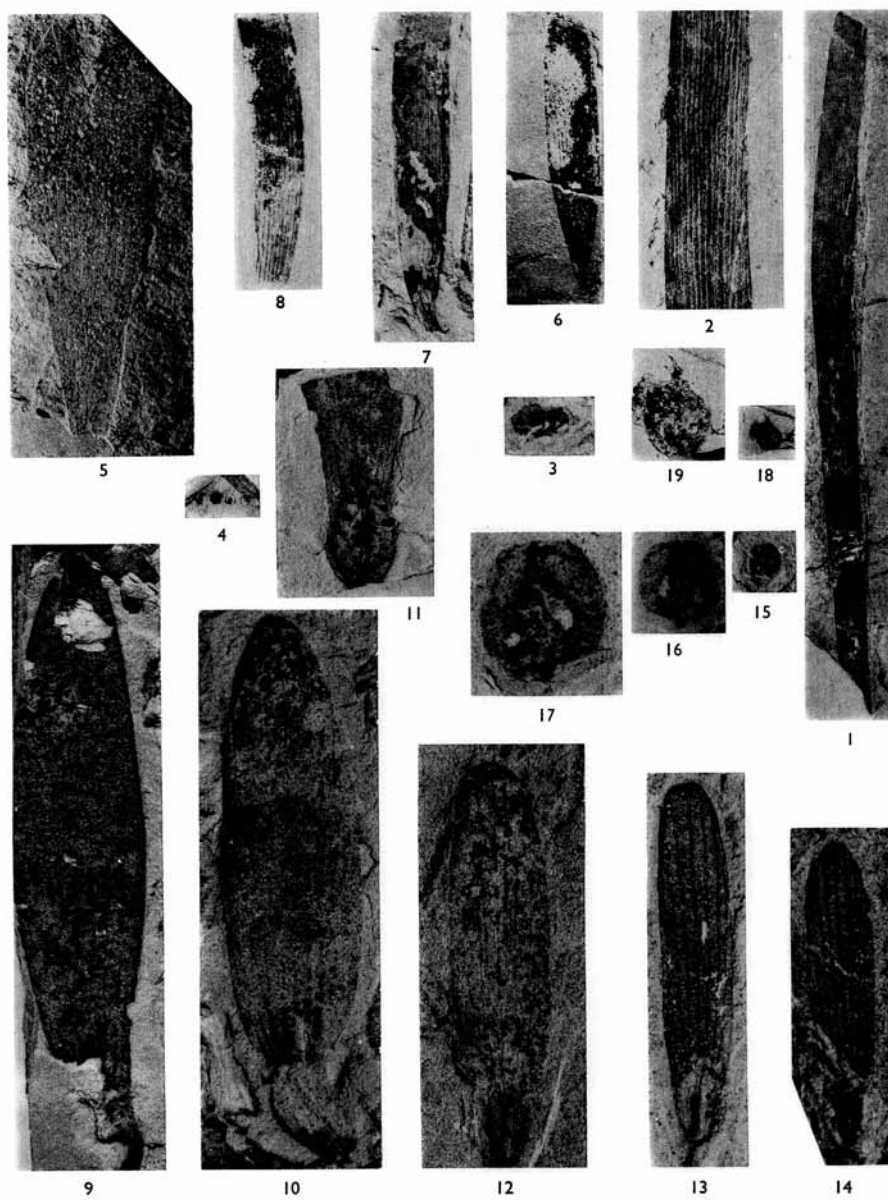
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