

Significant Additions to the Upper Triassic Flora of Williams Point, Livingston Island, South Shetland Islands (Antarctica)

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ABSTRACT

This paper presents some significant additions of fossil plants to the Upper Triassic flora of Livingston island, South Shetland Islands, Antarctica. The megafossil assemblage described here includes 13 taxa belonging to Pteridophytes and Gymnosperms s. l.: Neocalamites, Marattiopsis, Dictyophyllum, Scoresbya, Cladophlebis, Dicroidium, Xylopteris, Sagenopteris, Caytonia, Taeniopteris, Sphenobaiera, Pagiophyllum and Elatocladus. A late Upper Triassic age has been assigned to this palaeoflora.

Additif a l'Inventaire de la Flore du Trias Supérieur de la Pointe Williams, Ile Livingston, Archipel des Shetland du Sud (Antarctique).

RESUME

La présente étude fournit un additif a l'inventaire de la flore du Trias supérieur de l'île Livingston de l'archipel des Shetland du Sud (Antarctique). L'ensemble floristique décrit comprend 13 taxa appartenant aux groupes des Ptéridophytes et des Gymnospermes s.l., à savoir les genres: Neocalamites, Marattiopsis, Dictyophyllum, Scoresbya, Cladophlebis, Dicroidium, Xylopteris, Sagenopteris, Caytonia, Taeniopteris, Sphenobaiera, Pagiophyllum et Elatocladus. Un âge "fin du Trias supérieur" a été attribué à cette paléoflore.

Nuevos registros de paleoflora del Triásico Superior de punta Williams, isla Livingston, islas Shetland del Sur (Antártica)

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RESUMEN

Se presentan nuevos registros de plantas fósiles del Terciario Superior de isla Livingston, islas Shetland del Sur, Antártica. La colección de megafósiles que se describen incluyen 13 taxa pertenecientes a Pteridofitas y Gimnospermas s.l.: Neocalamites, Marattiopsis, Dictyophyllum, Scoresbya, Cladophlebis, Dicroidium, Xylopteris, Segenopteris, Caytonia, Taeniopteris, Sphaenobaiera, Pagiophyllum y Elatocladus. A esta paleoflora se le ha atribuido una edad perteneciente a fines del Triásico Superior.

INTRODUCTION

A well diversified fossil assemblage has been found by one of us (Y. Lemoigne) during January to February 1986, under an International Scientific Expedition organised by the Instituto Antártico Chileno (INACH) from the north-western side of Williams Point at Livingston Island (62°36' S.; 60°30' W.), South Shetland Islands. The plant fossils described here are from locality A shown in text-figure 1. The specimens were recovered from a 30 cm thick vertically orientated Sandstone ex-

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Text-fig. 1. Map showing location of Livingston Island (L.I.) in the South Shetland Islands and fossiliferous sites at Williams Point (W), Livingston Island.

Carte montrant la localisation de l'île Livingston (L.I.) dans l'archipel des Shetland du Sud et les sites fossilifères à la Pointe Williams (W) de l'île Livingston.

K.G.I.	: King George Island Ile Roi Georges	N.I.	: Nelson Island Ile Nelson	R.I.	: Robert Island Ile Robert
G.I.	: Greenwich Island Ile Greenwich	S.I.	: Snow Island Ile Snow	D.I.	: Deception Island Ile Déception.

A : locality with Upper Triassic plants studied in the present paper.
gisement à plantes fossiles étudiées dans la présente note.

B, C, D : other localities with fossil plants
autres gisements à plantes fossiles.

posed at the northern edge of a flat dome. The dome is about 100 m in diameter and 10 m in height, consisting of creamish-grey coloured sandstone plaquettes and overlies basaltic rocks. The exact sequence of rocks is impossible to determine due to steep cliffs. Hobbs (1968) studied the geology of the South Shetland Islands and interpreted this as weathered boulders in conglomerate, of Miocene age. But Orlando (1968) has studied the fossil plants collected by Hobbs, and on the basis of the following assemblage i.e.: *Asterotheca crassa* n.sp., *Thinnfeldia* sp., *Coniopteris distans* n.sp., *Dicthyophyllum/Thaumatopteris*, *Xylopteris* cf. *elongata* Carr. and rachis of *Osmundaceae*, a Lower Middle Triassic age has been assigned to it. In 1975 new specimens have been collected by Thomson and Smellie, for the British Antarctic Survey, from three fossil sites at Williams Point and they have been studied by Lacey and Lucas (1981). They proposed a Ladinian-Carnian (Upper Middle-Lower Upper Triassic) age on the basis of the following fossil assemblage: *Thalites* sp., *Equisetites* sp., *Neocalamites* sp., *Asterotheca crassa* Orlando, *Dicroidium* cf. *lancifolium* (Morris) Gothan, *Dicroidium* cf. *spinifolia* (Frenguelli) Archangelsky, *Pterophyllum dentatum* n.sp., *Doratophyllum tenisonwoodsii* (Etheridge) Harris, *Pagiophyllum* sp., *Ginkgoites* sp. and *Hexagonocaulon minutum* gen. et sp. nov.

The present collection contains more than two dozen fragmentary plant remains of various groups of Pteridophytes and Gymnosperms *s.l.* All the specimens, except one stem cast, are preserved as impressions on greenish grey, fine grained sandstone and creamish tuffaceous sandstone. This collection is kept in the Department of Palaeobotany at the University Claude Bernard-Lyon 1.

SYSTEMATIC DESCRIPTIONS

Division: PTERIDOPHYTA

Order: Equisetales

Genus *Neocalamites* Halle

Neocalamites sp.

(Pl.1, fig. 1; text-fig. 2)

Description - Solitary piece of stem preserved as cast, about 5 cm long and 4,9 cm broad, consisting probably of two nodes, 3 cm apart. Nodal region at places showing rounded scars of leaf bases. Internodal region with longitudinal ridges and grooves which seems to be continuous from one internodal region to the other. Single oval diaphragm is present in the internodal region. Diaphragm measuring about 1,1 x 0,6 cm, peripheral region showing faint rounded scars. Leaves not preserved.

Remarks - On the basis of continuous longitudinal ridges in the internodal regions, the present specimen has been assigned to the genus *Neocalamites*. Due to the absence of leaves specific identification is not possible.

Order: Filicales

Family: Marattiaceae

Genus: *Marattiopsis* Schimper

Marattiopsis sp.

(Pl.1, figs 2-4; text-fig. 4 B, C)

Description - Two fragmentary specimens of incomplete leaves (probably pinnate), with a portion of rachis in one, are preserved as impressions. Rachis about 2 mm broad. Pinnae incomplete at

the base and apex. Largest available well preserved fragment of pinna is 2,2 cm long and 0,8 cm broad with crenulate margin. Midvein 0,5 mm broad, medianly raised; lateral veins mostly inconspicuous due to the presence of *venuli recurrentis*, veins arising at an angle of 70°-80°, run towards margin with slight curve, mostly forked once just after emergence. In the specimen shown in Pl.1, fig. 4, the upper pinna shows distinct oval protuberances at the margin, which seems to be a synangia; synangia typically 1 mm x 1,5 mm in size, no further details could be observed.

Remarks and comparison - None of the two specimens available in the assemblage show the complete nature of the frond. But the typical crenulate lateral margin of pinnae with distinct synangial protuberances at vein ends and the lateral veins with *venuli recurrentis* are grounds enough to assign these specimens in the genus *Marattiopsis*. The present specimens are somewhat comparable with *Marattiopsis crenulatus* described by Lundblad (1950) from Rhaetian of Sweden in having pinnae with crenulate lateral margins and in the shape of the synangia. They differ however in possessing comparatively smaller sized synangia. The specimen shown in Pl.1, fig. 4, can also be compared with *Marattiopsis anglica* figured by Harris (1961, fig. 23 C & F). But due to the absence of further details of synangia and spores in the latter detailed comparison is limited to gross features only.

Family: **Dipteridaceae**

Genus: *Dictyophyllum* Lindley and Hutton

Dictyophyllum sp.

(Pl. 1, fig. 5; text-fig. 4A)

Description - Fragmentary specimen showing part of pinna, about 2,5 cm in length and 1,8 cm in width. Pinna with lobed margin; midvein 1 mm broad, distinct. Primary lateral veins are emerging at an angle of 40°-60°, secondary veins arising mostly at wide angles and forming polygonal meshes by forking and anastomosing with others; tertiary veinlets are hardly perceptible in places.

Remarks and comparison - As the specimen described above is, too, fragmentary and sterile, it is therefore preferable to provisionally assign it to the genus *Dictyophyllum*.

The present fragment is somewhat similar to *Dictyophyllum tenuifolium* Stipanovic and Menendez figured by Bonetti and Herbst (1964, Pl.1. fig. 1) from the Upper Triassic of Argentina in gross features. Orlando (1968) has also figured same type of frond fragment from this locality under **Dipteridaceae**.

Family: **Dipteridaceae**

Genus: *Scoresbya* Harris

Scoresbya dichotoma (Shirley) Herbst

(Pl.1, figs.9-11; Pl. 2, fig. 1; text-fig. 4E, F)

Description - Leaves incomplete, dichotomously divided fragments are found as faint impressions on greyish sandstone. Size variable from 2 cm to 6 cm in length and 0,6 cm to 2,6 cm in width. Margin lobed-dentate, dentation 1,5-4 mm apart with acute-subacute tip. Midvein always forked, forming an angle of 45°-50°, 1,5 mm broad, gradually tapering towards distal end, medianly grooved. Lateral veins mostly inconspicuous, in places seem to fork at angles of 45°-50°, about 1 mm apart at base, dichotomously forked and forming elongated meshes by anastomosing with others. Lamina shows pseudo-marginal vein in places.

Remarks and comparison - Unfortunately, though the taxon is quite common in the assemblage no specimen shows a complete leaf. However, due to the presence of characteristic features like: dichotomously divided lamina with net veins and dentate margin, these specimens can safely be assigned to the genus *Scoresbya* Harris (1932). The two well preserved specimens in the present collection shown in Pl.1, figs. 9 & 11, also exactly match *Scoresbya dentata* Harris (1932, Pl.3, fig. 1 & Pl.2, fig. 7; Krausel and Schaarschmidt, 1968, Pl.26, fig. 4) from the Liassic of Greenland and Germany respectively. But, as the present specimen figured in Pl.2, fig. 1, also shows the pseudo-marginal

vein, we therefore refer our specimens to the species *Scoreshya dichotoma* (Shirley) described by Herbst (1974) from Upper Triassic of Queensland.

Family: ? Osmundaceae

Genus: *Cladophlebis* Brongniart

Cladophlebis sp.

(Pl.1, figs 6-8; text-fig. 4 D)

Description - Three fragments of pinnate fronds are found, probably of bipinnate nature. Largest pinna fragment is 4,9 cm long and 1,5 broad. Primary rachis not preserved. Pinnae probably linear-lanceolate in shape, incomplete. Ultimate rachis 8 mm broad, pinnules arising alternately at an angle of 50°-60° and becomes subopposite towards the distal end of pinna, falcate in shape, typically measuring 5-9 mm x 1,2-2 mm, gradually becoming smaller and narrower towards distal end, attached by broad base, lateral margin entire, slightly wavy and decurrent at both the basisopic ends, apex acute-subacute, midrib slightly asymmetrical in nature, first lateral vein catadromic and perhaps once forked, rest of the lateral veins mostly unforked.

Comparison - Three sterile pinnate fronds bearing pinnules with typical *Cladophlebis* type venation described here are preserved as impression on creamish tuff. In general appearance the present species comes closer to *Cladophlebis antarctica* Nathorst described by Halle (1913). But, the above species differs by its finer details like entire margin and lateral veins mostly once forked.

Division: PRESPERMATOPHYTA

Order: Corystospermales

Family: Corystospermaceae

Genus: *Dicroidium* Gothan

Dicroidium sp.

(Pl.2, figs 2 & 3; text-fig. 5 A)

Description - Solitary fragment of probably pinnate frond preserved as impression on creamish tuff, about 8 mm long and 2 mm broad. Rachis 0,2 mm broad, distinctly forked. Pinnae alternate, attached at an angle of 50°-60°, triangular to deltoid in shape, typically 2-2,5 mm x 1,8-2 mm in size, attached to the rachis by broad base, basisopic margin straight to decurrent, acrosopic margin slightly concave in the middle region; apex subacute to obtusely rounded. Venation obscure except in one pinna where forked veins seem to be arising from base without midrib.

Comparison - A small fragmentary frond showing typically forked rachis with triangular to deltoid pinnae has been assigned to *Dicroidium* sp. here. In shape and venation the present specimen somewhat is similar to *Dicroidium odontopteroides* figured by Townrow (1967, figs. 1 C & 2 A) from the Middle-Upper Triassic beds of Mt. Bumstead. But the *Dicroidium* sp. described here differs in having comparatively smaller size of pinnae. It also resembles *Dicroidium* sp. figured by Archangelsky (1968a, text-fig. 1 C) from the Triassic of Argentina in size and shape of pinnae. *Dicroidium odontopteroides orbicularis* Anderson & Anderson 1983, from Molteno Formation of Karoo Basin shows some similarity in general morphology. But, due to lack of cuticle in the present one detailed comparison is not possible. In gross features, the present one somewhat agrees with *Dicroidium zuberi* (Szajnocha) Archangelsky described by Pal (1984, text-fig. 17a) but the former differs from the latter by the pinnate nature of its leaf.

Genus: *Xylopteris* Frenguelli

Xylopteris cf. *elongata* (Carruthers) Frenguelli

(Pl.2, figs. 4 & 5; text-fig. 5 B)

Description - (fronds seem to be bipinnate) - Largest available fragment of leaf is about 7,8 cm long. Pinnae rachis probably 2 mm broad, with a distinct groove. Pinnae attached at an angle of 25°-45°, alternate, perhaps linear in shape, incomplete, 1,6 mm apart. Ultimate rachis 1,5 mm broad,

medianly grooved. Pinnules arising alternately at angles of 10°-15°, linear in shape, measuring 1-3,5 cm x 0,1-0,15 cm, with entire margin gradually tapering into an acutely rounded tip. Midvein distinct up to apex.

Comparison and remarks - Superficially the present species most resembles *Xylopteris elongata* (Carruthers) Frenguelli described by Townrow (1967) from Allan Nunataks and Mt. Bumstead. However, the former species can be distinguished from the latter by its bipinnate nature. *Xylopteris cf. elongata* described here is also comparable with *Dicroidium elongatum* forma *remotipinnulum* figured by Anderson & Anderson (1982, text-fig. 26) from the Molteno Formation, South Africa. This taxon shows a wide geographical range in the Middle-Upper Triassic beds of Argentina, Australia, South Africa, Antarctica and India. Archangelsky (1968b) and Anderson & Anderson (1983) have merged the genus *Xylopteris* Frenguelli into *Dicroidium* on the basis of cuticular similarity instead of vast external morphological differences. But we prefer to maintain the separation between the two genera on the basis of external variations as well as ultramicroscopic differences in cuticular details shown by Baldoni (1980).

Order: Caytoniales
Family: Caytoniaceae
Genus: *Sagenopteris* Presl
Sagenopteris sp.
(Pl.2, figs. 6-11; text-fig. 5 C-E)

Description - Three leaf segments probably of compound leaves are found in the assemblage as impressions. All are incomplete from the base and apex. Leaf segments perhaps lanceolate in shape, the best available leaf fragment is about 3 cm long and 1,6 cm broad. Margin entire, gradually tapering towards base. Midrib distinct, venation hardly perceptible at places, seems to be reticulate. Besides these, two small pieces of lamina with distinct reticulate venation have also been found, which are shown in Pl.2, figs. 9-11.

Remarks - All the specimens recovered here are, too, fragmentary in nature, therefore a detailed comparison is not possible here. Evidence of attribution of these detached leaf segments with reticulate venation to the genus *Sagenopteris* Presl are firstly, in one of the specimens shown in Pl.2, fig. 7, the slight asymmetrical nature of the lamina could be seen in the middle region and secondly more than a dozen *Caytonia* fruits are also found on the similar shale as impressions.

Genus: *Caytonia* Thomas
Caytonia sp.
(Pl.2, fig. 13; Pl.3, fig. 1; text-fig. 5 F)

Description - Large number of detached fruits have been found scattered as impressions on a creamish sandstone in linear rows. Pedicel of the fruits mostly not preserved but one fruit has a small pedicel. Pedicel 0,5 mm broad, with small black dots which may represent the trichome bases. Fruits probably rounded in shape but due to compression at places have become irregular, 2-3,5 mm in diameter. Sometimes 2-3 oval raised areas of about 2 mm long and 0,8 mm broad could also be seen which may be of seed impressions. Trichome bases are also discernible as black dots similar as on pedicel. Mouth of the fruits clearly visible in a few fruits, typically 1 mm in length and 0,2 mm in width. In association with these fruits, two pieces of detached rachises are also preserved. Of the two, one rachis shows a distinct oval scar of fruit pedicel.

Remarks - The fruits with distinct lipped mouth and impressions of ovules inside it could be placed under the *Caytonia* Thomas. The other side of the shale also have a few impressions of fruits in association with two pieces of rachises which again indicate that perhaps these fruits were borne laterally on the rachis. In size and shape these fruits resemble *Caytonia* species described by Harris (1964, figs. 9G, I; 10G and 11F) from Jurassic of Yorkshire. The surface of the fruits and rachis with

pedicel scar shown in Pl.2, fig. 12, are hardly distinguished from the figured specimen of *Caytonia* rachis by Harris (1964, fig. 10 A; the basal-most fruit surface). But due to the absence of cuticle in the present one, the specific identification remains incomplete.

Order: ?Cycadales

Genus: *Taeniopteris* Brongniart

Taeniopteris sp.

(Pl.3, fig. 13; Text-fig. 3)

Description - Two fragments of perhaps simple leaf have been preserved as impressions on grey sandstone. The largest one is about 5 cm in length and 3,4 cm in width, apex and base are not preserved. Margin entire, midrib about 4 mm broad, finely striated, lateral vein comes out at right angles to the midrib seems to be channelled, 5 veins per cm, mostly unforked.

Comparison - As the cuticle of these fragments is unknown, their affinities therefore remain uncertain whether they are cycadalean or benettitalean. We have thus assigned them to the comprehensive form genus *Taeniopteris*. On external features these fragments are quite comparable with *Taeniopteris* sp. E figured by Anderson & Anderson (1983, Pl.15, fig. 5) from the Molteno Formation of South Africa.

Order: Ginkgoales

Family: Ginkgoaceae

Genus: *Sphenobaiera* Florin

Sphenobaiera sp.

(Pl.3, figs 2-7; text-fig. 5 G-K)

Description - Leaves oblanceolate to obtusate in shape, without a distinct petiole; lamina undivided to one divided. Leaves generally measuring 2-2,5 cm x 0,5-1,3 cm, margin entire, apex obtuse-notched, rarely bilobed. Veins 0,5-0,8 mm apart, repeatedly forking and running subparallel upto distal margin. Occasionally the surface of lamina inbetween veins showing stomatal imprints.

Remarks and comparison - *Sphenobaiera* sp. is quite frequent in the present assemblage. Unfortunately, almost all the specimens are incomplete either at the base or in the middle region. However, we have specimens with simple obtuse apex to divided obtuse-notched apex on the same shale, the lamina with more than 4 veins and without a distinct petiole. Therefore, it is preferable here to assign them to the genus *Sphenobaiera* rather than *Baiera*. The specimens described here are closely similar to *Sphenobaiera argentina* (Kurtz) Frenguelli described by Jain & Delevoryas (1967, Pl.96, figs. 4 & 5) in the distally once divided nature of the lamina. In general outlook it comes nearest to *Sphenobaiera gyron* Harris *et al.* (1974, fig. 18 A-D) but due to lack of cuticle in the present one, detailed comparison is not possible. In gross features the specimens shown in Pl.3, figs. 6 & 7, are also somewhat comparable with *Sphenobaiera stenoloba* Stanislavsky (1976, Pl.78, figs. 11 & 15).

Division: SPERMATOPHYTA

Order: Coniferales

Family: Araucariaceae

Genus: *Pagiophyllum* Heer

Pagiophyllum sp. A

(Pl.3, figs. 8 & 9; text-fig. 6 C-D)

Description - Fragmentary leafy shoots found in association with a *Dicroidium* leaf on a creamish sandstone. Leaves spirally disposed, spreading at an angle of 45°-50°, falcate in shape, size varying from 2-3 mm x 0,8-1,5 mm, apex pointed, base decurrent, distinctly keeled. In a specimen shown in Pl.3, figs. 8 & 9 at two places oval depressions are visible which may be of fertile parts but their exact identification is impossible unless we have seeds or pollen in them.

Comparison - These specimens are very much comparable with *Pagiophyllum* sp. described by Lacey and Lucas (1981, fig. 4) from the same locality at Livingston Island, as the shoots described here are, too, fragmentary and without cuticular details or definite fertile parts. Therefore we prefer to put them provisionally under an arbitrarily defined genus *Pagiophyllum*.

Pagiophyllum sp. B
(Pl.3, fig. 10; text-fig. 6 E)

Description - Leafy twig preserved as impression. Leaves spirally disposed, elongated ovate in shape, typically measuring 3-3,5 mm x 1,2-1,5 mm. Leaf base perhaps rhomboidal, apex acute, lamina with distinct median keel upto apex.

Comparison - *Pagiophyllum* sp. B differs from *Pagiophyllum* sp. A in having elongated to ovate adpressed leaves, where in *Pagiophyllum* sp. A leaves are falcate and more spreading.

Family: ? Podocarpaceae
Genus: *Elatocladus* Halle
Elatocladus sp. A.
(Pl.3, fig. 11; text-fig. 6 B)

Description - A fragment of sterile shoot preserved as an impression. Leaves spirally attached on 0,2 mm broad axis, lanceolate in shape, size varies from 2,5-5 mm long and 0,5-1,5 mm broad. Base constricted and twisted. Margin entire and apex subacute.

Elatocladus sp. B
(Pl.3, fig. 12; text-fig. 6 A)

Description - Leafy twig of about 1,9 cm long. Axis 1 mm broad with spirally attached leaves. Leaves linear to lanceolate in shape, laterally spreading, measuring about 6-8 mm x 1-1,2 mm, base twisted and decurrent. Margin entire, apex probably subacute. Midrib distinct at places.

Remarks - Two badly preserved fragments of leafy twig referred here as *Elatocladus* sp. A and sp. B may belong to the same species but due to its extreme variation of leaf size we have tentatively assigned them separately to *Elatocladus* sp. A and *Elatocladus* sp. B.

PLATE I

PLANCHE I

Fig. 1 - *Neocalamites* sp.

Stem showing nodes, internodal region with longitudinal ridges, grooves and a diaphragm, x1.
Tige montrant des nœuds, des entrenœuds costulés et un diaphragme.

Figs. 2 - 4 - *Macattiopsis* sp.

2 - specimen showing pinnae with crenulate margin, x1.

specimen montrant des pinnules à marge crénelée.

3 - fertile pinna showing oval depressions of synangia at the vein endings near margin, x1.

pinnule fertile montrant, près de sa marge et à l'extrémité des nervures, des dépressions ovales dues à des synanges.

4 - enlarged pinna showing veins, venuli and synangial depressions at places, x4.

pinnule à un fort grossissement montrant nervures, nervules et par endroits des dépressions synangiales.

Fig. 5 - *Dietyophyllum* sp.

Fragment of a leaf showing lobed margin and reticulate venation, x1.

Fragment de feuille montrant une marge lobée et une nervation réticulée.

Figs. 6 - 8 - *Cladophlebis* sp.

6 - frond with falcate pinnules, x2.

fronde à pinnules falcées.

7 - further enlargement of the above specimen to show unforked lateral veins, x4.

specimen de la figure précédente au grossissement x4 montrant les nervures latérales non divisées.

8 - showing linear pinnae with alternate to subopposite pinnules, x1.

penne linéaire avec pinnules alternes à subopposées.

Figs. 9 - 11 - *Scorshya dichotoma* (Shirley) Herbst.

9 - the distal portion of a leaf with dentate margin, x1.

partie distale d'une feuille à marge dentée.

10 - above specimen further enlarged, x2.

figure 9 au grossissement.

11 - proximal part of a leaf with a forked midrib and dentate margin, x1.

partie proximale d'une feuille montrant une nervure médiane bifurquée et une marge dentée.

Triassic Flora of Livingston Island

PL. 1

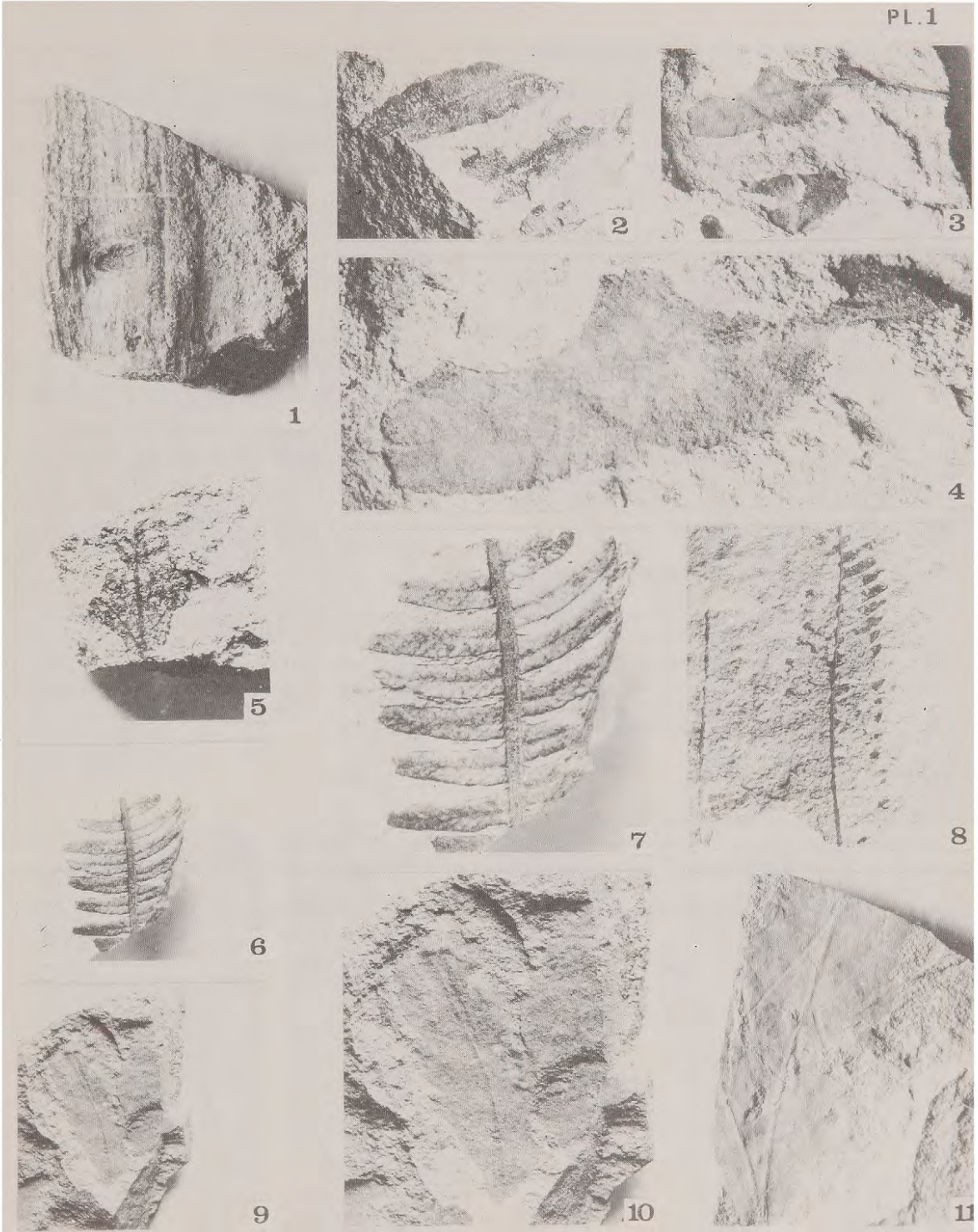


PLATE 2

PLANCHE 2

Fig. 1 - *Scorobya dichotoma* (Shirley) Herbst.

Proximal part of a leaf showing dichotomously divided midvein, net nervation and pseudo-marginal vein, x2.

Partie proximale de feuille montrant une nervure médiane bifurquée, une nervation nette et une nervure pseudomarginale.

Figs. 2 - 3 - *Dicrodium* sp.

2 - frond showing forked rachis with deltoid pinnae, x3.

fronde montrant un rachis bifurqué et des pennes deltoides.

3 - further enlargement of fig. 1, x6.

figure 1 au grossissement x6.

Figs. 4 - 5 - *Xylopteris* cf. *elongata* (Carruthers) Frenguelli.

4 - showing linear pinnules with a distinct midvein, x1.

segments foliaires linéaires montrant une nervure médiane nette.

5 - another specimen showing alternately attached pinnae and pinnules, x1.

autre spécimen montrant une ramification alternée.

Figs. 6 - 11 - *Sagenopteris* sp.

6 - Specimen showing fragment of a leaf, x1.

fragment de foliole.

7 - above specimen enlarged to show slight asymmetrical nature of lamina, x2.

figure 1 au grossissement double montrant le caractère asymétrique de la foliole.

8 - detached leaf segment showing gradually tapering lamina at base, x1.

fragment basal de foliole détachée montrant le rétrécissement graduel de la lamina vers le bas.

9, 10, 11 - leaf fragments showing reticulate venation, x2, x1 and x2.

fragments de folioles montrant une nervation réticulée.

Figs. 12 - 13 - *Caytonia* sp.

12 - specimen showing detached fruits in linear rows, x1.

utricules ovulifères détachés mais demeurés en ordre linéaire.

13 - other side of the above specimen showing a few fruits in association with two pieces of rachises, x1.

revers de l'échantillon précédent montrant quelques utricules associés avec deux fragments d'axes.



PLATE 3

PLANCHE 3

Fig. 1 - *Caytonia* sp.

Enlarged fruits showing small pedicel, lips and impression of seeds, x4.

Utricules grossis montrant un petit pedicelle, une ouverture en bec et, en impression, des ovules.

Figs. 2 - 7 - *Sphenobaiera* sp.

2 - **specimen showing dichotomously divided veins at base, x1.**

échantillon montrant dans sa base une nervation dichotomique.

3 - **specimen showing a leaf with dichotomously divided subparallel veins, x1.**

feuille montrant une nervation dichotomique subparallèle.

4 - **specimen in fig. 2 enlarged, x2.**

figure 2 au grossissement x2.

5 - **another specimen showing dichotomously divided lamina with obtuse-notched apices of the segments, x2.**

specimen montrant une lamina divisée dichotomiquement, les segments ayant un apex obtus.

6 - **three leaves showing shallow-to deep incision of lamina, x1.**

trois feuilles montrant une incision peu profonde à profonde de leur lamina.

7 - **fig. 6 enlarged, x3.**

figure 6 au grossissement x3.

Fig. 8 - *Pagiophyllum* sp. A.

Shoot showing an oval depression in the axil of a leaf, x4.

Axe feuillé montrant une depression axiale ovale de la feuille.

Fig. 9 - *Pagiophyllum* sp. A.

Shoot fragment showing spirally attached falcate leaves, x2.

Fragment d'axe feuillé montrant des feuilles falquées en ordre spirale.

Fig. 10 - *Pagiophyllum* sp. B.

Specimen showing elongated ovate leaves adpressed to the axis, x4.

Axe feuillé portant des feuilles allongées, ovales et appliquées contre l'axe.

Fig. 11 - *Elatocladus* sp. A.

Shoot fragment showing spirally attached linear leaves, x2.

Fragment d'axe feuillé portant des feuilles linéaires en ordre spirale.

Fig. 12 - *Elatocladus* sp. B.

Shoot fragment showing linear leaves with twisted decurrent bases, x1.

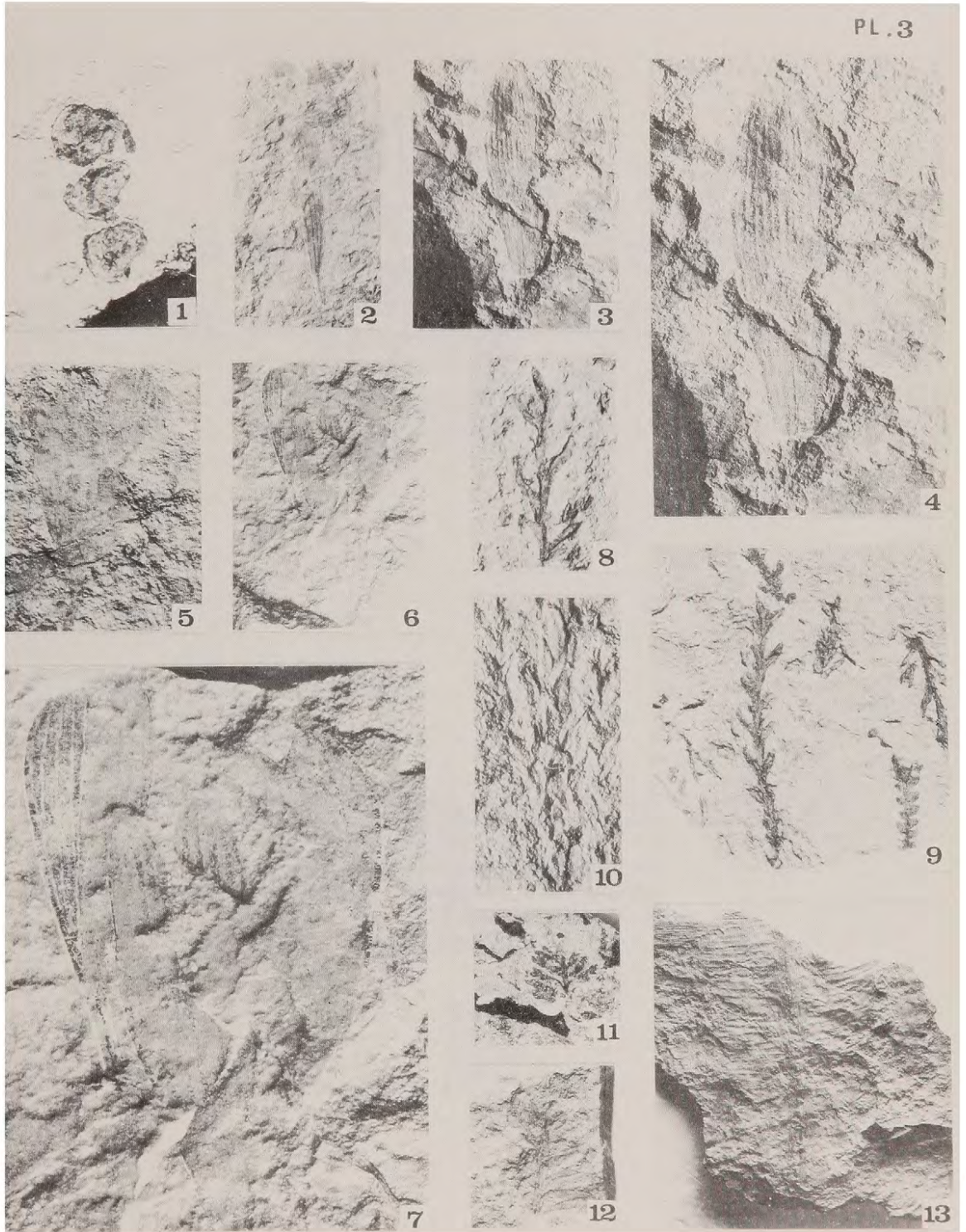
Axe feuillé portant des feuilles linéaires à base décurrente tordue.

Fig. 13 - *Taeniopteris* sp.

Leaf segment showing lateral veins almost at right angles to the midrib, x1.

Fragment de feuille montrant des nervures latérales naissant presque orthogonalement à partir de la nervure médiane.

Triassic Flora of Livingston Island

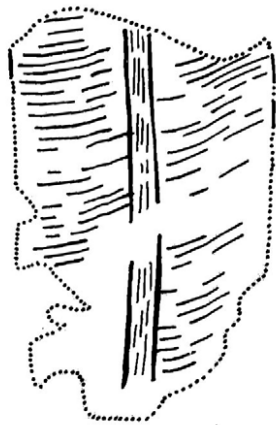
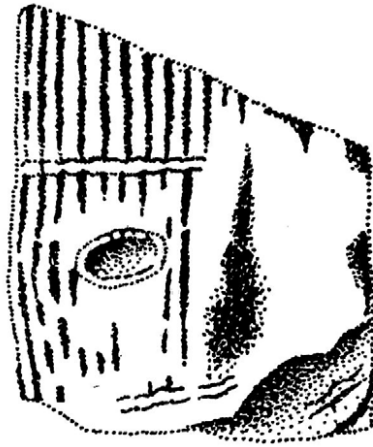


Text-fig. 2. *Neocalamites* sp.: fragment of stem showing two nodes and internodal region with a diaphragm, x1.

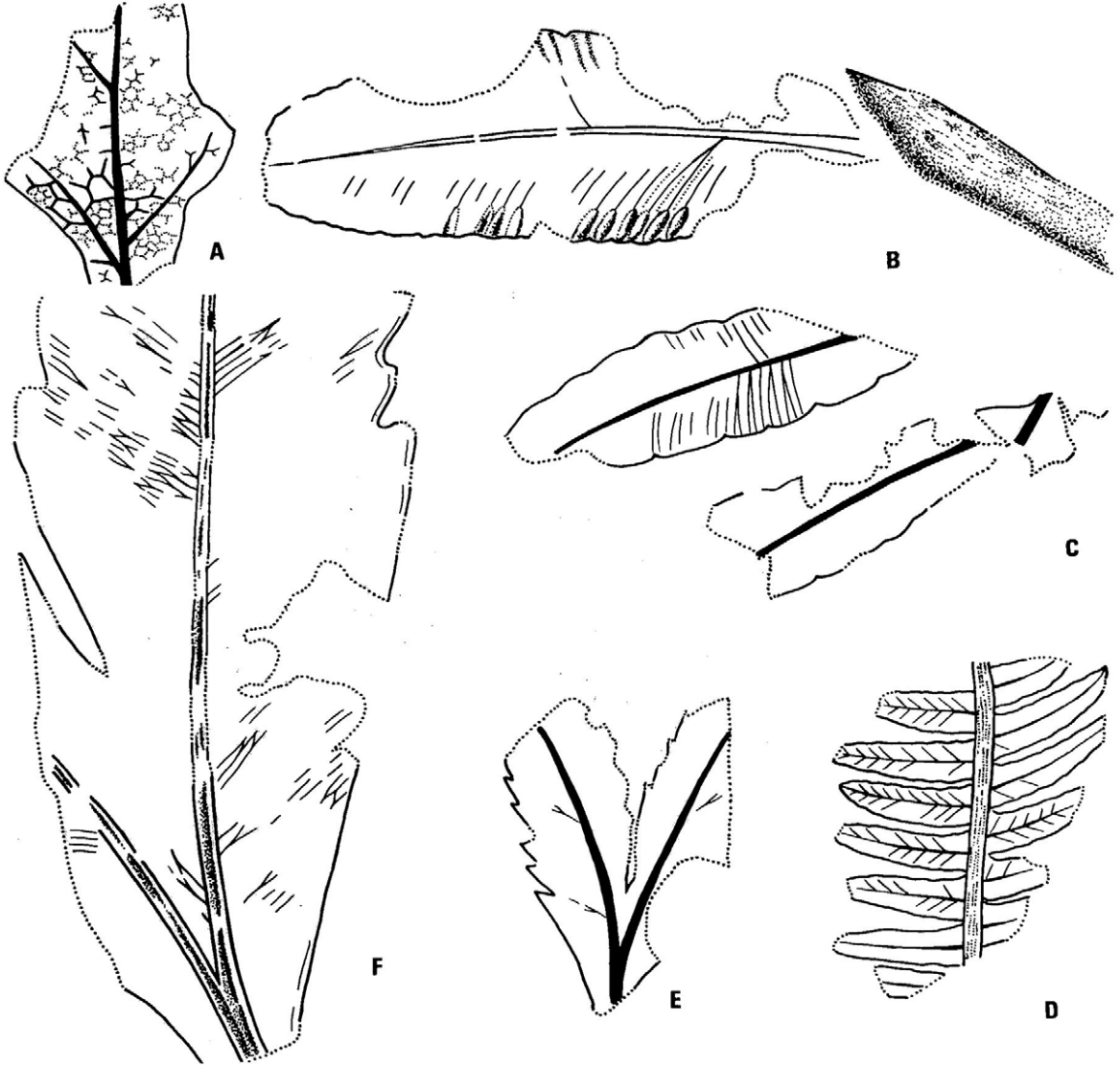
Neocalamites sp.: fragment de tige montrant deux noeuds avec diaphragme séparés par un entre-noeud, x1.

Text-fig. 3. *Taeniopteris* sp.: leaf fragment showing lateral veins arising almost at right angle to the midrib, x1.

Taeniopteris sp.: fragment de feuille montrant des nervures latérales naissant presque orthogonalement à partir de la nervure médiane, x1.



- Text-fig. 4. A :** *Dictyophyllum* sp., leaf fragment showing polygonal meshes, x2.
Dictyophyllum sp., fragment de feuille montrant un reticulum nervuraire à mailles polygonales, x2.
- B :** *Marattiopsis* sp., pinnae showing veins, venuli and synangial depressions at the vein endings, x4.
Marattiopsis sp., pinnules montrant leur nervation et des dépressions synangiales à l'extrémité des nervures, x4.
- C :** *Marattiopsis* sp., steril pinna showing venation, x2.
Marattiopsis sp., pinnule stérile montrant sa nervation, x2.
- D :** *Cladophlebis* sp., pinna fragment showing falcate pinnules with unforked lateral veins, x4.
Cladophlebis sp., fragment de penna montrant des pinnules falquées avec des nervures latérales non divisées, x4.
- E :** *Scoresbya dichotoma* (Shirley) Herbst, distal portion of a leaf showing forked midvein and dentate margin, x2.
Scoresbya dichotoma, partie distale d'une feuille montrant une nervure médiane bifurquée et une marge dentée, x2.
- F :** *Scoresbya dichotoma* (Shirley) Herbst, proximal part of a leaf showing reticulate venation and pseudomarginal vein, x2.
Scoresbya dichotoma (Shirley) Herbst, partie proximale d'une feuille montrant une nervation réticulée et une nervure pseudomarginale, x2.



Text-fig. 5. A : *Dicroidium* sp., showing forked rachis and venation of a pinna, x6.

Dicroidium sp., montrant un rachis bifurqué et la nervation d'une pinnule, x6.

B : *Xylopteris* cf. *elongata* (Carruthers) showing elongated linear pinnules with a distinct mid-vein, x2.

Xylopteris cf. *elongata* (Carruthers) Frenguelli, montrant des pinnules linéaires allongées ayant une nervure médiane distincte, x2.

C : et D : *Sagenopteris* sp., fragmentary pieces of leaves showing reticulate venation, x4, x4.

Sagenopteris sp., fragments de feuilles montrant une nervation réticulée, x4, x4.

E : *Sagenopteris* sp., leaf showing slight asymmetrical nature of the lamina and venation, x4.

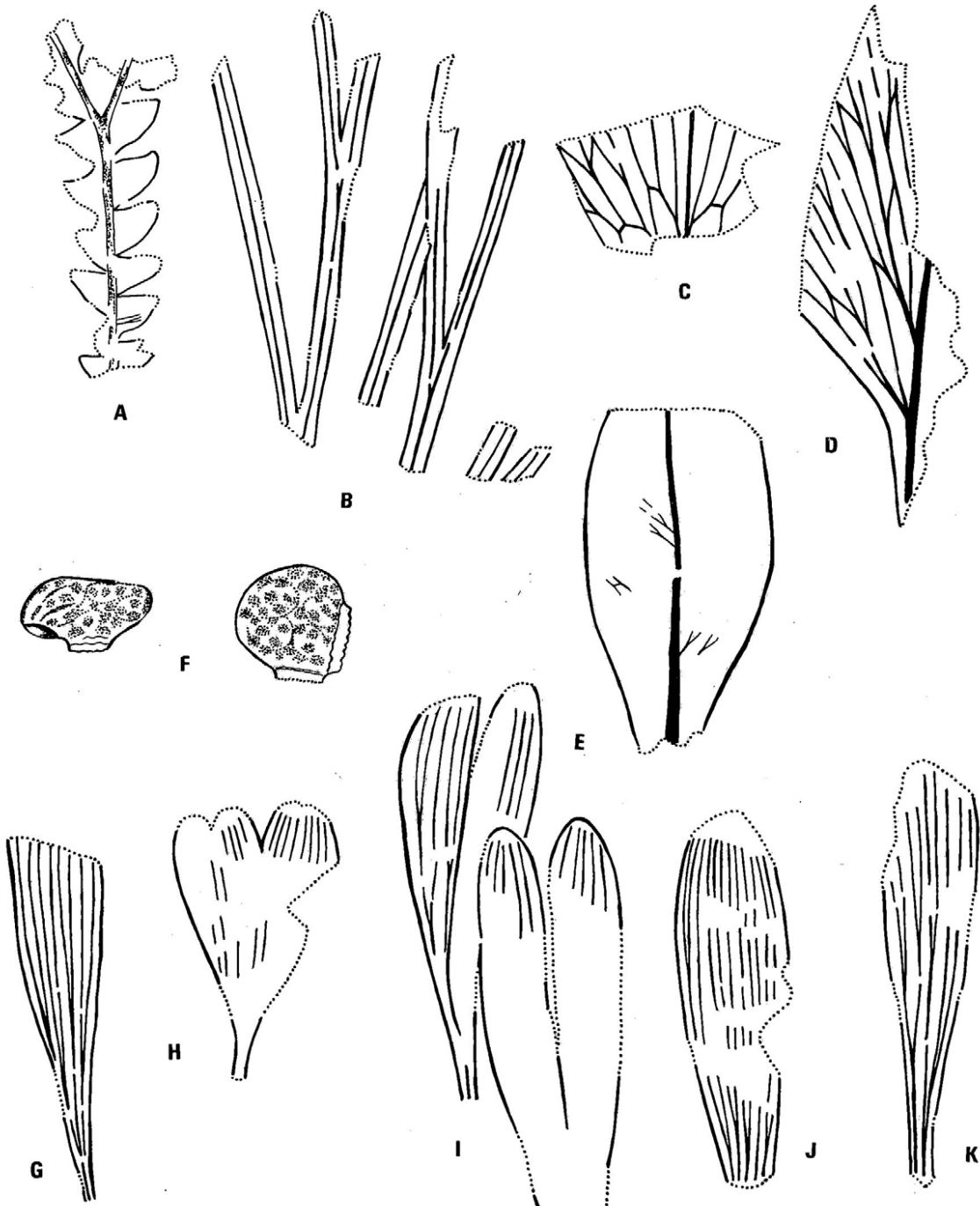
Sagenopteris sp., feuille asymétrique avec nervation, x4.

F : *Caytonia* sp., fruits showing lips, impression of ovules inside fruits and fruit wall with trichome basis, x6.

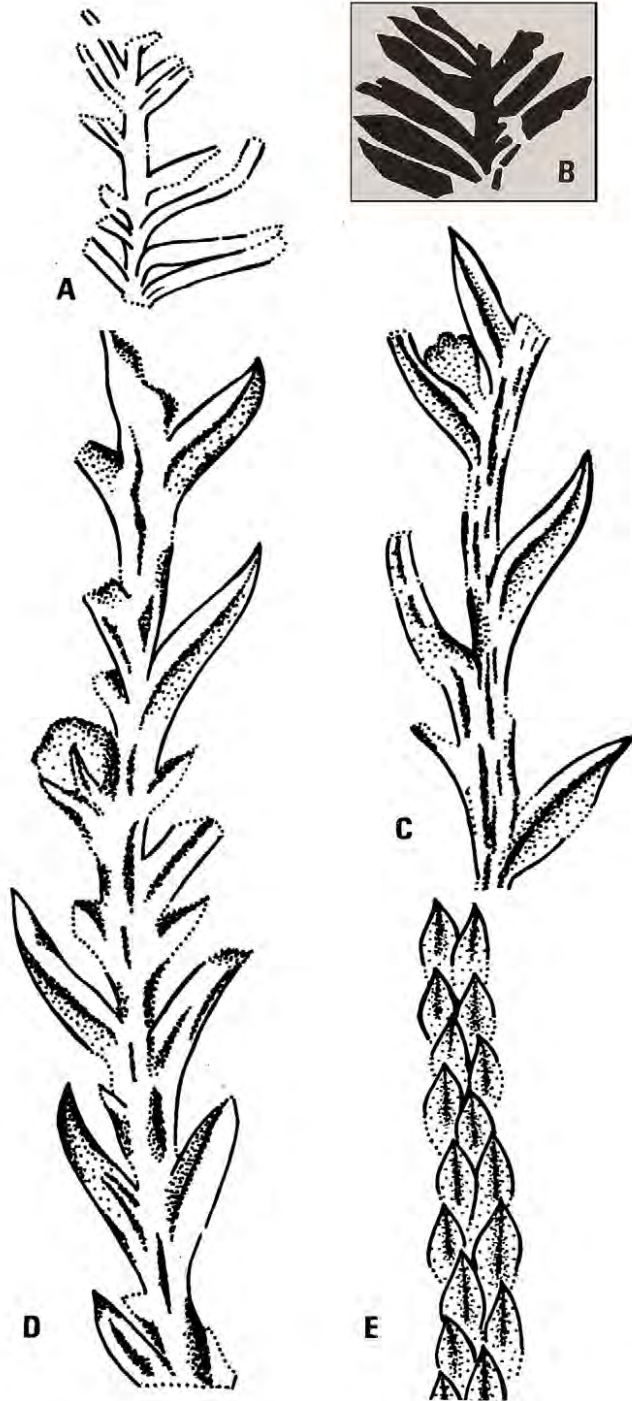
Caytonia sp., utricules montrant une ouverture en bec, des ovules en impression à l'intérieur de ceux-ci et sur la paroi des utricules des bases de poils, x6.

G, H, I, J, K, : *Sphaenobaiera* sp., leaves showing morphological variations x4, x2, x4, x2, x2.

Sphaenobaiera sp., série de feuilles montrant une variation de leur morphologie, x4, x2, x4, x2, x2.



- Text-fig. 6.** A: *Elatocladus* sp. B, shoot showing spirally disposed leaves with decurrent bases, x2.
Elatocladus sp. B, axe portant des feuilles décurrentes disposées selon un ordre hélicoidal, x2.
- B: *Elatocladus* sp. A, short fragment of leafy shoot, x4.
Elatocladus sp. A, court fragment d'axe feuillé, x4.
- C, D: *Pagiophyllum* sp. A, showing keeled spreading leaves, x4.
Pagiophyllum sp. A, axes à feuilles carénées et étalées, x4.
- E: *Pagiophyllum* sp. B, showing adpressed keeled leaves, x4.
Pagiophyllum sp. B, axes avec feuilles carénées appressées, x4.



GENERAL DISCUSSION AND CONCLUSION

Megafloristic investigation of the Upper Triassic bed exposed at Williams Point in Livingston Island was first undertaken by Orlando in 1968. He described an assemblage comprising *Asterotheca crassa* n.sp., *Thinnfeldia* sp., *Coniopteris distans* n.sp., *Dictyophyllum/Thaumatopteris*, *Xylopteris cf. elongata* and rachis of *Osmundaceae*. Later on Lacey and Lucas (1981) restudied this flora along with a new collection, and they included the rachis of *Osmundaceae* described by Orlando as *Asterotheca* and *Thinnfeldia* sp. under *Dicroidium cf. lancifolium*. Moreover, the latter authors made some additions of fossil plants viz.: *Pterophyllum dentatum*, *Doratophyllum tenison-woodsii* (Etheridge) Harris, *Pagiophyllum* sp. and *Ginkgoites* sp.

The present assemblage described in the foregoing pages is well diversified though poor in preservation. It adds further elements such as *Marattiopsis*, *Scoresbya*, *Sagenopteris*, *Caytonia*, *Sphenobaiera* and *Elatocladus*, to the already known Upper Triassic flora of Williams Point, Livingston Island. Besides this, the present study also confirms the typical association of various groups of plants i.e. *Pteridophyta*, *Prespermatophyta* and *Spermatophyta (Coniferales)* during Upper Triassic throughout the Gondwanaland. Lacey and Lucas (1981) have already compared this flora with the Upper-Late Middle Triassic flora of East Antarctica described by Townrow (1967); Upper Anisian-Lower Norian Molteno floras of Southern Africa (Du Toit, 1927; Anderson, 1974; Lacey, 1970 and 1976); Upper Ladinian to Upper Norian Ipswich flora of Queensland, Australia (Jones and De Jersey, 1947; Retallack, 1977) and the early Carnian to early Norian Marayes flora and the early Norian to Upper Norian Ischigualasto flora of Argentina (Archangelsky, 1968a; Stipanovic and Bonetti, 1969). Moreover, this assemblage also shows somewhat similarity with the flora of Cacheuta Formation of Argentina described by Jain and Delevoryas (1967) and the Tiki Formation of South Rewa Basin, India, described by Pal (1984).

The present fossil assemblage shows a dominance of Prespermatophytes like *Xylopteris*, *Sagenopteris*, *Caytonia*, *Sphenobaiera* and with rare occurrence of *Dicroidium* followed by Pteridophytes such as *Marattiopsis*, *Scoresbya*, *Dictyophyllum* and *Cladophlebis*. Occurrence of Conifers are relatively less, represented by only two genera i.e. *Pagiophyllum* and *Elatocladus*. On the basis of general composition of the assemblage and correlation with the other Upper Triassic floras it is concluded that the present assemblage is of undoubted Upper Triassic in age. It shows a relatively younger aspect than the others, as certain typical Liassic forms like *Marattiopsis*, *Scoresbya*, *Sagenopteris*, *Caytonia*, *Pagiophyllum* and *Elatocladus* were also appearing in the flora. Therefore, it is preferable to suggest Late Upper Triassic age for the Williams Point assemblage described here.

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