

# STUDIES IN THE GLOSSOPTERIS FLORA OF INDIA—41. GONDWANOPHYTON GEN. NOV. WITH A REVISION OF ALLIED PLANT FOSSILS FROM THE LOWER GONDWANA OF INDIA

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## ABSTRACT

*Gondwanophyton* a new plant fossil from the Barakar Formation of the Raniganj coalfield is recorded. The fossil is characterized by fan-shaped leaf with a wide rounded entire apex and sessile truncate base with parallel running dichotomous veins without any interconnections. Leaves are at times found attached to a narrow axis. Cuticle is differentiated into stomatiferous and non-stomatiferous surfaces. Stomatiferous surface has distinct bands of stomatal and non-stomatal zones. In the stomatal zone, the stomata are arranged in a single discontinuous row. In addition to this the systematics of allied fronds (*Psymphyllum* and *Rhipidopsis*) previously recorded from the Lower Gondwanas of India are discussed.

## INTRODUCTION

FAN-SHAPED fronds with  $\pm$  parallel, dichotomous veins are known from the Lower Gondwanas of India and equivalent formations of other countries in the Southern Hemisphere. The previous records are as follows:

*Psymphyllum kidstonii* Seward  
*Psymphyllum hollandii* Seward  
*Psymphyllum haydenii* Seward  
*Psymphyllum sahnii* Ganju  
*Rhipidopsis densinervis* Feistmantel  
*Rhipidopsis ginkgoides* Feistmantel

In a recent collection a number of fan-shaped leaves were collected from the Churulia pit of the Raniganj Coalfield. The fronds are entire with  $\pm$  parallel running dichotomous veins without any anastomoses. In some examples a number of them are found attached to an axis. Cuticular aspects of the leaves are also known. A comparison with the known records shows that these leaves are morphologically distinct and represent a new type for which the name *Gondwanophyton* is proposed. The systematic position of the previous records of fan-shaped leaf genera are discussed and suggestion are made for their proper taxonomic placements.

## MATERIAL AND METHODS

The material described in this paper has been collected from the carbonaceous shale beds lying above the Churulia seam at the Churulia pit in the East Raniganj Coalfield (West Bengal). The beds belong to the Barakar Formation. In all the specimens carbonized crust is preserved. Preparations of cuticles were made after taking out pulls from the surface of leaf with the help of Cellulose acetate prepared in acetone. This pull was macerated in  $\text{HNO}_3$  and subsequently treated with 5% KOH. After this the pieces of cuticles were stained in safranin and mounted in Canada balsam.

## DESCRIPTION

### *Gondwanophyton* gen. nov.

*Generic Diagnosis* — Fan-shaped entire leaves, apex broadly rounded, lateral margins converging to form narrow truncate base, base non-petiolate, attachment alternate to the axis. Veins erect, dichotomizing, running  $\pm$  parallel to each other without any interconnections.

*Genotype* — *Gondwanophyton indicum* sp. nov.

*Gondwanophyton indicum* sp. nov.

Pls. 1, 2; Figs. 1-7; Text-figs. 1-3

*Specific Diagnosis* — Fan-shaped leaves, apex broadly rounded and entire; base, truncate and non-petiolate; closely spaced, erect, spreading  $\pm$  parallel veins arise from the base, they run forward and dichotomize frequently at irregular intervals, Course of veins straight, density 20-26 veins per centimeter. Leaves attached obliquely to the narrow axis by their truncate base; arrangement alternate.

Cuticle differentiated into stomatiferous and non-stomatiferous surfaces. Non-stomatiferous surface has hair bases; cells

elongate-rectangular in shape. Stomatiferous surface non-papillate; shows alternate zones of stomatiferous and non-stomatiferous bands. Stomata haplocheilic, not sunken, usually single stomata across the width of stomatiferous surface, linear or slightly oblique orientation, pit surface rectangular, stomatal opening a vertical slit; subsidiary cells 4-6 in number.

*Syntypes* — Specimen No. 35025/1216, 35026/1216 and 35027/1216. Slide No. 4457 and 4458. of the Birbal Sahni Institute of Palaeobotany, Lucknow.

*Locality* — Churuliapit, Raniganj Coal-field.

*Horizon* — Barakar Formation (Churulia Seam).

*Age* — Lower Permian

*Description* — The collection contain 40 specimens. Few of them are completely preserved and in cases are attached to an axis. The figured specimen in Pl. 1, Fig. 1 is a wide fan-shaped leaf, measuring 9.5 cm. long and 10.5 cm. broad at the widest regions. Lateral margins show convergence towards the base, which is narrow and truncate. In the basal portion of the leaf few longitudinal folds are preserved due to overlapping. From this it is evident that the leaves originally had an inner concavity near the point of their attachment. Eight erect divergent veins emerge from the basal portion of the leaf. Each of them dichotomize at the very basal region and show subsequent dichotomy as they run forward towards apical region. The veins are arranged  $\pm$  parallel. The angle of divergence at the point of dichotomy between two veins is from  $2^{\circ}$ - $3^{\circ}$ . The density of veins varies from 20-24 veins per cm. Usually the density of veins is less towards the lower portion of the leaf in comparison to the apical region. The apical portion of the leaf is not preserved. The specimen does not show any attachment to axis. However, one axis is preserved near the leaf which is 6.5 cm. long and 4 mm. broad. A faint median ridge is present in the axis.

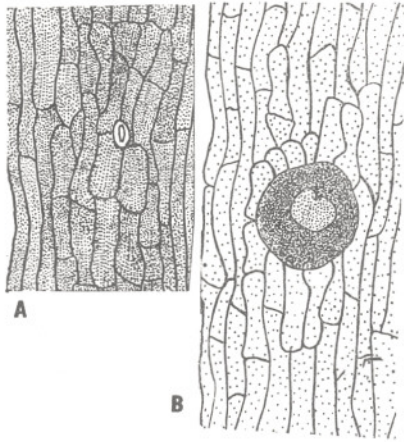
Another specimen figured here (Pl. 2, Fig. 6; Text-Fig. 1A) shows an axis measuring 2.5 cm. long and 3 mm. broad. To this axis a leaf is attached. The leaf is incomplete and has two major irregular longitudinal splits. The leaf shows attachment to the axis by its wide truncate base. A portion of leaf was cleared out from the rock matrix above the stem by careful

manipulation with the help of fine needles to see the mode of attachment. It revealed that the leaf was attached by its wide truncate base somewhat obliquely to the stem.

The specimen figured (Pl. 2, Fig. 7; Text Fig. 1B) shows an axis alongwith two leaves preserved in a transverse plane. The axis is 12 mm. long and 2 mm. broad and has fine striations. The two leaves are attached to the axis alternately at two different points. They are oppositely arranged. The leaf (A) which is preserved above is complete, whereas the leaf (B) preserved below is comparatively bigger and incomplete at the apical portion. The complete leaf measures 2 cm. long and 3 cm. broad at the widest part. The widest region of the leaf is near the apex. The leaf is V-shaped with a rounded apex. Apical margin is entire. Attachment to axis is



TEXT-FIG. 1. A.— Solitary leaf with longitudinal splits attached to a narrow axis, ca.  $\times 1$ .  
B.— Two leaves attached to axis preserved superimposed to each other showing alternate attachment of leaf, ca.  $\times 1$ .



TEXT-FIG. 2. A.—Cells of stomatiferous surface with stomata.  $\times 500$   
 B.—Cells of non-stomatiferous surface with hair base.  $\times 500$ .

by its truncate base. The lower leaf (B) is incomplete at the apical end. However, both the lateral margins are well preserved.

#### Epidermal Structure

All the leaves in the collection yielded identical cuticles. The cuticle is extremely thin. Two surfaces are easily distinguishable from each other. The gross difference are that on one surface (? lower) hair bases are absent and shows distinct longitudinal bands of stomatiferous zone and non-stomatiferous zones arranged alternately, whereas on the other surface (? upper) the hair bases are present and the epidermal surface is devoid of stomata.

The (?) lower surface of the cuticle shows distinct alternation of stomatiferous and non-stomatiferous bands (Pl. 1, Fig. 2). Non-stomatiferous bands are 8-10 cells wide. The cells of the non-stomatiferous bands are 4-6 sided, usually three to five times longer than broad, more or less arranged in rows and vary in shape from rectangular to trapezoid or rhomboidal. They measure 60-80  $\mu$  long 6-10  $\mu$  broad. The stomatiferous band is very narrow.

The cells in this zone vary from nearly isodiametric to linear elongated. The cells are 20-30  $\mu$  long and 8-10  $\mu$  broad. Usually one stoma (Pl. 1, Fig. 3; Text-Fig. 2A) is present across the stomatal band. Stomata 8-10  $\mu$  and longitudinally or slightly obliquely orientated. The guard cells are

extremely thin and show little or no cutinization, with the result that the entire surface of the pit appears almost transparent. The pit surface is usually polygonal or occasionally rectangular in shape. It usually shows a narrow slit-like aperture between the guard cells. The slit may or may not extend up to the full length of the pit surface. The subsidiary cells are 5-7 in number. They are similar to the ordinary cells of stomatiferous zone. The two poles are not as a rule occupied by two polar cells. There may be a single polar cell also. In rare instances adjacent stomata may share common subsidiary cells.

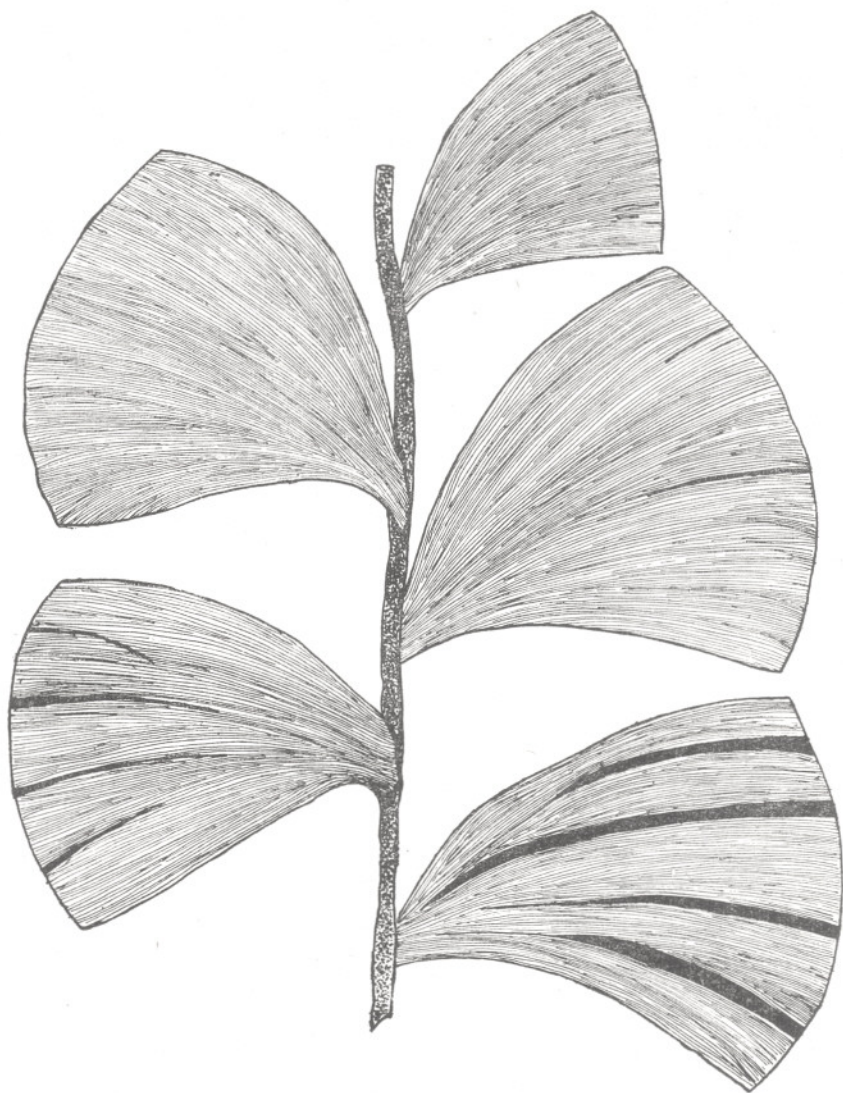
The non-stomatiferous surface of the cuticle is slightly thicker than the stomatiferous surfaces (Pl. 2, Fig. 4). It is characterized by linear elongated, 4 sided cells arranged in a definite rows. Cells are 60-120  $\mu$  long and 4-10  $\mu$  broad. They are usually rectangular, trapezoid to occasionally, rhomboidal. Remnants of hair bases are well marked. They are irregularly distributed. The remain of hair base is like a oval scar (Pl. 2, Fig. 5; Text-Fig. 2B), which is highly cutinized, measuring 20  $\mu$ .

#### Reconstruction

With the help of the data available an attempt has been made in Text-Fig. 3 to reconstruct the habit of the frond. In piecing together the detached fragments there always exists an element of error. This must be faced if a reconstruction is to be visualized. The reconstruction is based upon leaves found attached to an axis or in close association with stems. The evidence available gives the impression that the leaves were alternately arranged and were attached somewhat obliquely to the axis by their sessile truncate base. The old leaves towards the apical portion show irregular longitudinal splits.

#### Comparison

The present Gondwana form shows a close agreement with the members of order Palaeophyllales Høeg (in Boureau, 1967) in the morphology of leaves. *Ginkgophyllum* Saporta (1884) have pinnate leaves with large cuneate dissected leaflets, whereas in the present form, the leaf is essentially entire and the incision in some leaves is only a secondary feature accentuated by preservation.



TEXT-FIG. 3. A.—Reconstruction of *Gondwanophyton indicum*

*Ginkgophytopsis* Høeg (in Boureau, 1967) is characterized by broad cuneate or flabellate leaves, borne spirally on herbaceous or woody axes, usually with sheathing leaf bases and with a dense venation of delicate bifurcating veins with reticulate meshes (*Ginkgophytopsis flabellata* L. H.) Høeg, in Boureau, 1967). However, the Gondwana specimens differ in having fan-shaped leaf with sessile base. Veins do not show any interconnections. Beside this, the epidermal features of Gondwana specimens are known.

*Enigmophyton* Høeg (1962) superficially resembles the Gondwana forms, but the leaves show characteristic insertion at the point of dichotomy of stems. Another form, *Germanophyton* Høeg (1942) resembles the Gondwana forms, but the axis in the former is composed of tubes of *Prototaxite* type. A comparison with *Platyphyllum* (Dawson) Høeg (1942) is not possible, because it has been instituted for detached leaves showing a dissected apical margin comparable to Ginkgoalean remains.

Forms comparable with *Gondwanophyton* have been recorded from Lower Gondwanas of India and other countries of Southern hemisphere under *Rhipidopsis* and *Ginkgophyton* (*Psygmoephyllum*). *Rhipidopsis densinervis* Feistmantel (1881), a single specimen recorded from the Raniganj formation of India is characterized by leaf, divided into six broadly cuneate segments with a lobed or incised apex. The other species *Rhipidopsis gondwanensis* Seward (1919), earlier known as *R. ginkgoides* Feistm. (1886) from the Barakars is characterized by palmisect leaves having 6-10 segments. Lateral segments are obovate, while the median segments are cuneiform and truncated distally. From both the records of *Rhipidopsis*, the present form differs by the absence of stalk and regular apical incision.

The forms described under *Ginkgophytopsis* (*Ginkgophyton*) *kidstonii* Høeg (1967), *Ginkgophyton hollandii* Høeg & Bose (1960), *Ginkgophyton haydenii* Høeg & Bose (1960) and *Psygmoephyllum sahnii* Ganju (1943) differ from the present form by long drawn petiolate base and incision of the leaves at the apical margin resulting into lobing of the forms.

The present Gondwana form is comparable to *Noeggerathiopsis* Feistmantel (1879) and *Euryphyllum* Feistmantel (1879) in its venation feature. However, both the genera have lanceolate to spatulate leaves. Beside, these leaves are much linear in shape and do not possess a prominent wide apex as in *Gondwanophyton*. The cuticle of *Gondwanophyton* shows a general agreement to *Noeggerathiopsis*. However, the stomatal band in *Gondwanophyton* is extremely narrow and the stomata are arranged in a single discontinuous row.

*Megistophyllum* Archangallessky (1958) recorded from Argentina compares somewhat in venation features but it differs in having an overall circular leaves, veins radiating all round from the central point.

*Trizygia* Royle compares somewhat in venation, but differs in having 3 pairs of leaf attached to one point on an articulate axis. Furthermore, the epidermal structure is also different.

The systematic position of the genus *Gondwanophyton* remains open because it does not show any close affinity with any of the previous known groups except for some superficial resemblance to *Noeggerathiopsis*. In view of this, it is proposed

here to provisionally place *Gondwanophyton* under 'Palaeophyllales' Høeg (in Boureau, 1967), which has been instituted to accommodate similar forms whose affinities are yet not certain.

#### TAXONOMIC REAPPRAISAL OF PSYGMOPHYLLUM AND RHIPIDOPSIS FROM THE LOWER GONDWANA RECORDS

As mentioned in the introduction that the fan shaped leaves with,  $\pm$  parallel running veins from the Lower Gondwanas have either been classed under *Psygmoephyllum* or *Rhipidopsis*. A critical study of the past records shows that a revision is now needed especially for their placement.

#### Records of *Psygmoephyllum*

Høeg and Bose (1960) remarked that these Lower Gondwan leaves have evidently nothing to do with *Psygmoephyllum* Schimper (1870-72), if that genus is delimited as suggested by Saporta (1878), Zalesky (1918) and Høeg (1942). They further remarked that when more information about these Gondwana plants will be known then they would constitute a natural genus of their own. However, they recommended to place these forms provisionally under the form genus *Ginkgophyton* Zalesky. Høeg (1967) in Boureau pointed out that the genus *Ginkgophyton* is invalid because its name has earlier been used by Matthew (1909, cf. Stopes, 1914: 101; Halle, 1927; 215) for different plant. Therefore, he instituted a new generic name *Ginkgophytopsis* for those forms earlier placed under *Ginkgophyton*. To this new genus Høeg (l.c. p. 380) assigned the species *P. kidstoni* Seward (1903) with a ? mark within brackets after the generic name *Ginkgophytopsis*. Høeg (1942, p. 109) has already pointed out that there always remains an uncertainty about the placement when one is dealing with an intermediate form grading between the lobed *Ginkgophyllum* and the non-lobed *Ginkgophytopsis*. The Lower Gondwana forms always show dichotomy of leaf at least up to the middle portion of the leaf, therefore, their placement to *Ginkgophytopsis* is not justifiable because it has been instituted for entire forms. *Ginkgophyllum* Saporta has been instituted to accommodate leaves showing regular dissection into finer segments. The Lower Gondwana forms also show similar characters, therefore, it

is proposed to transfer the records of *Psymgophyllum* to *Ginkgophyllum* till more details are known about these plants.

*Ginkgophyllum kidstonii* (Seward) n. comb.

*Synonymy:*

1903 — *Psymgophyllum kidstonii* Seward, Pl. 12, Fig. 1.

1942 — *Ginkgophyton* (?) *kidstonii* Høeg

1967 — *Ginkgophytopsis* (?) *kidstonii* Høeg

1969 — *Psymgophyllum kidstonii* Plumstead, Pl. X, Fig. 2.

*Lectotype* — Pl. 12, Fig. 1, South African Museum, Capetown.

*Locality* — Vereeniging, South Africa.

*Horizon* — Ecca Series.

*Ginkgophyllum hollandii* (Seward) n. comb.

*Synonymy:*

1907 — *Psymgophyllum hollandii* Seward, Pl. 13, Figs. 3-6

1960 — *Ginkgophyton hollandii* Høeg & Bose

*Lectotype* — Pl. 13, Fig. 5. Geological Survey of India, Calcutta.

*Locality* — Gangamopteris bed in the neighbourhood of Khunmu, Kashmir.

*Horizon* — Lower Gondwana (Permian).

*Ginkgophyllum haydenii* (Seward) n. comb.

*Synonymy:*

1905 — *Psymgophyllum* sp. Seward & Woodwards

1912 — *Psymgophyllum haydenii* Seward, Pl. 3, Figs. 8-11

1943 — *Psymgophyllum haydenii* Sitholey, Pl. 10, 11; Figs. 1-8

1960 — *Ginkgophyton haydenii* Høeg & Bose

*Lectotype* — 52/293, Geological Survey of India, Calcutta.

*Locality* — Dandlutar, near Shopyan in the Pir Panjal range, Kashmir (India).

*Horizon* — Lower Gondwana.

*Ginkgophyllum sahnii* (Ganju) n. comb.

*Synonymy:*

1943 — *Psymgophyllum sahnii* Ganju, Pl. 14, Fig. 1.

*Lectotype* — R/5, Department of Botany, University of Lucknow.

*Locality* — Risin spur.

*Horizon* — Lower Gondwana.

**Records of *Rhipidopsis***

Two species of *Rhipidopsis* viz. *R. densinervis* Feistmantel (1881) and *R. gondwanensis* (Feistm.) Seward (1919) are known from the Lower Gondwanas of India. The type specimen of the former form is now preserved at the Geological Survey of India, Calcutta, but the specimen of the latter species is misplaced or lost from the collection of the Geological Survey of India. It is, therefore, difficult to put any comment on the latter species.

*Rhipidopsis densinervis* Feist. is known from Kamthis of South Godavari district near Kuntcheru. Only a solitary specimen with its counterpart is known. The examination of the type specimen shows that the lamina is divided into six obtuse segments and that too irregularly lobed on the truncate margins. Veins arise from the divergent base and pass forward showing frequent dichotomy. Veins are closely spaced and  $\pm$  parallel to one another. Density of veins is 26-28 per centimeter.

In the specimen 5338, Feistmantel (1881, 56A, Fig. 2) has figured the presence of a small petiole. However, no such structure was seen in the present examination. Due to lack of petiole the placement of these specimen under *Rhipidopsis* is doubtful, because the genus was instituted by Schmalhausen (1879) for the specimen with large petiole. In view of this it is proposed here to place this form under *Platyphyllum* (Dawson) emend Høeg (1942). Under this genus Høeg (*l.c.*) has proposed to place all the (old) Palaeozoic detached fan-shaped leaves with parallel bifurcating veins.

***Platyphyllum* (Daws.) Høeg**

*Platyphyllum densinervis* (Feistmantel) n. comb.

*Synonymy:*

1881 — *Rhipidopsis densinervis* Feistmantel, Pl. 56A, Fig. 2.

*Diagnosis* — As given by Feistmantel (1881)

*Lectotype* — 5338, Geological Survey of India, Calcutta.

*Locality* — South Godavari district near Kuntcheru.

*Horizon* — Kamthi (Upper Permian).

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## EXPLANATION OF PLATES

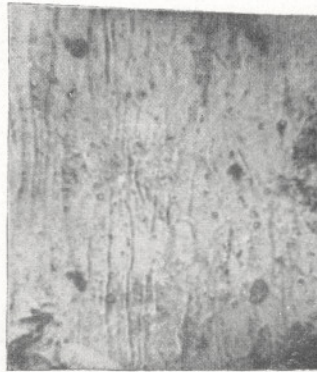
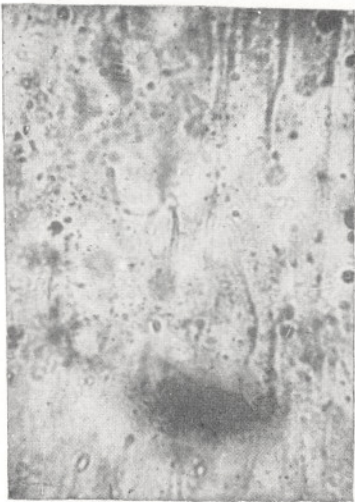
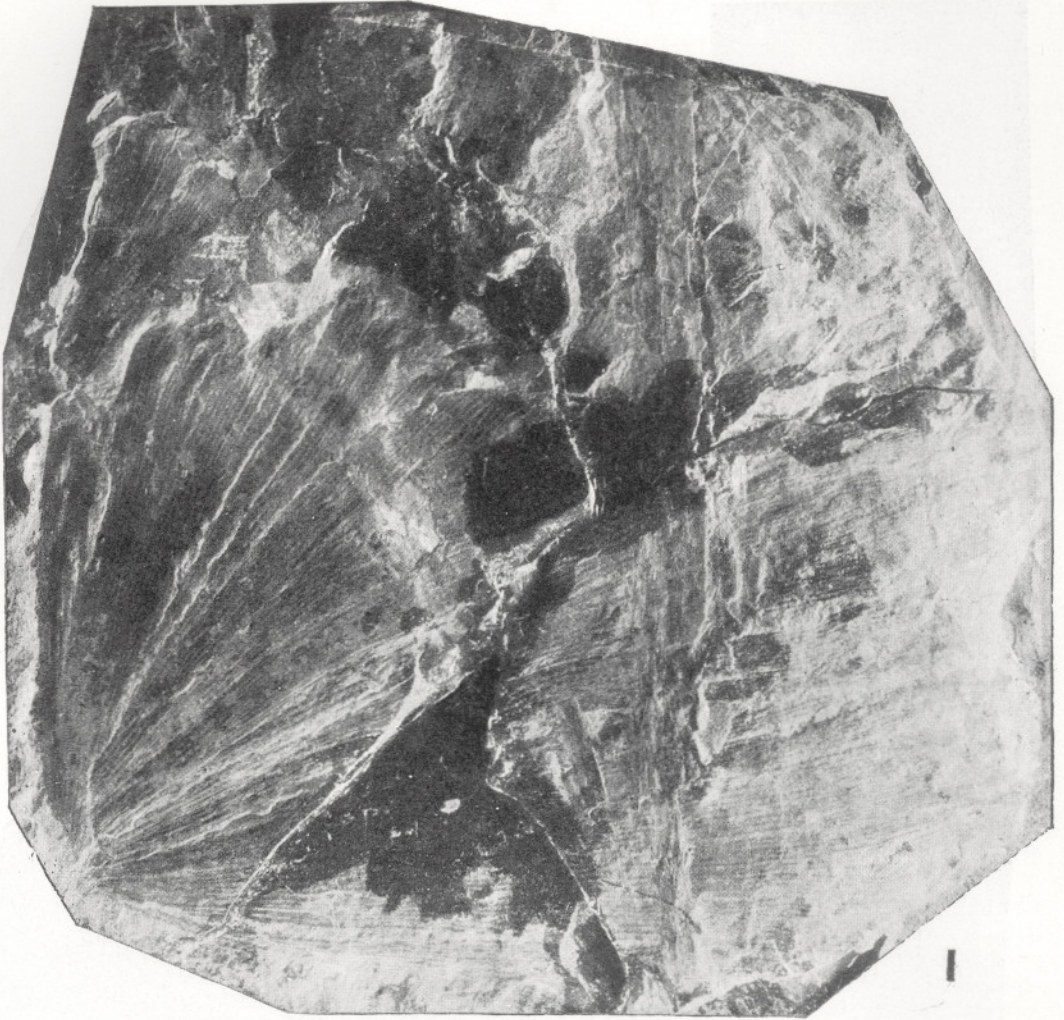
*Gondwanophyton indicum* gen. et. sp. nov.

## PLATE 1

1. A leaf showing, cuenate base with parallel running dichotomous veins. × 2. Specimen No. 35025.
2. Cuticle of stomatiferous surface showing alternate band of stomatiferous and non-stomatiferous region. × 500. Slide No. 4457.
3. A stomata enlarged. × 1000.
4. Non-stomatiferous surface showing the rectangular cells. × 500. Slide No. 4458.

## PLATE 2

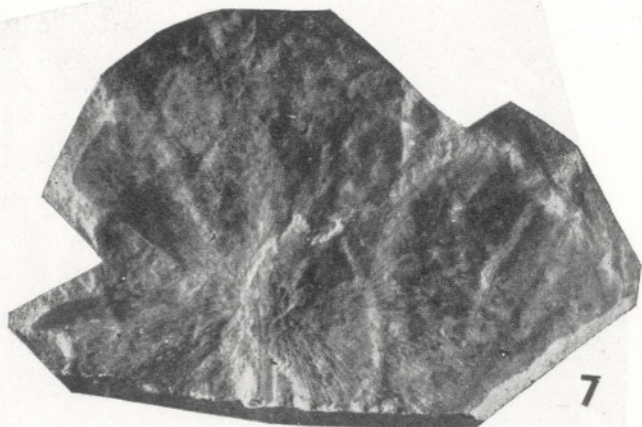
5. Non-stomatiferous surface showing a hair base. × 500. Slide No. 4458.
6. A leaf with irregular longitudinal splits attached to the axis. × 2. Specimen No. 35026.
7. Two leaves attached to axis dorsiventrally preserved. The leaf preserved above is V-shaped and complete. The leaf preserved below is incomplete. × 2. Specimen No. 35027.







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