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TAPHOFLORA OF KARROO IN THE ZAMBEZI BASIN (TETE REGION, MOZAMBIQUE)

por

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ABSTRACT

A small collection of plant impressions in ferruginous shales of the Productive Series of the Karroo System, in the Zambezi Basin, Mozambique, contains elements of a typical **Glossopteris** Flora including: **Glossopteris communis** Feistm., **G. browniana** Brongn., **G. indica** Schimper, **G.** cf. **occidentalis** White, **G. stricta** Bunbury, **G. angustifolia** Brongn., **G.** cf. **G. longicaulis** Feistm., G. cf. **G. ampla** Dana, **Gangamopteris obovata** (Carr.) White, **Umbellaphyllites** cf. **U. ivini** Rigby, **Paracalamites australis** Rigby, scale-leaves and seeds. Some species as **Glossopteris occidentalis** White and **Umbellaphyllites ivini** Rigby are for the first time recorded in African Gondwanaland. This taphoflora suggests an Artinskian age for the Productive Series.

INTRODUCTION

General Geological Aspects

In Mozambique, the Eogondwana beds outcrops are disposed along the Zambezi Basin, laying on Precambrian rocks and they are covered by other rocks ranging from Jurassic to Cenozoic in age.

These beds are included into the Lower Karroo Sistem that is subdivided in Mozambique in 3 series: Tilitic, Productive and Superior or Matinde and they are considered as equivalent to the Dwyka–Ecca series of the South Africa, after Rocha–Campos (1972).

The fossil plants identified in the present paper were collected from red shales and siltstones of the upper part of the Productive *Series* outcropping on the bed of a secondary road linking the Tete-Estima road to the Sanangoe River valley, about 97 km NW of Tete.

The Productive *Series* after Rocha-Campos (1972) is characterized by alternation of sandstone, mudstone and shales, these associated with coal layers. Its *general environment of deposition... is then depicted as a paludal–lacustrine basin where the finer clastics and the plant fragments were being accumulated with periodical invasion by rivers represented by the channel sandstone and by mudflows.*

Taking into consideration the paleocurrents data and the nature of the sediments, Rocha-Campos (op. cit.)concludes that *most of the material, including the plant fragments, was derived from older crystalline terrain situated not very far from the present basin margin, possibly to the east.*

The local section starts with large, superposed sandstones, intercalated within dark shales and including thin coal lenses, outcropping on the river bank. The sandstones are coarse, feldspathic, cross-bedded and bear abundant

carbonized plant remains and clay pebbles near the channel bases.

The upper part of the exposure shows other small channels, passing higher up, about 5–6 meters above the river bed along the secondary road, to a sequence of fossiliferous red shales and siltstones. Oliveira (in Rocha–Campos, 1972).

We are very thankfull to Prof. Dr. A. C. Rocha–Campos, who collected the samples and kindly provided them for our studies.

HISTORY – The taphoflora in the Tete region has been known for a very long time, but it has not been throughly studied. Its history may be summarised as in the Table 1.

The first paleontological observations go back to the last century, reported by Zeiller and Lapierre (1883). The fossil plants were studied by Zeiller. He concluded that the mozambiquean species did not differ from the ones coming from carboniferous basins of Europe.

In 1914, Gothan studying some fossils of a *brown-ferruginous shales* from Mozambique, identified the presence of three species of **Glossopteris.** In opposition to Zeiller (1883), Gothan found no fossils with northatlantic or euroamerican taphoflora characteristics, and doubted the procedence of the zeillerian samples (in Teixeira, 1947).

Anthoine & Dubois (1922) arrived practically at the same conclusion as Gothan (1914) adding to their list: **Schizoneura africana, Sphenopteris lobifolia, Vertebraria,** etc. in the Karroo of Zambezia.

Teixeira (1947), in accordance with Gothan (1914) and Anthoine & Dubois (1922) about the presence of glossopterideae, noticed like Zeiller (1883) the presence of **Sphenophyllum.** He noticed yet the presence of **Asterotheca** and **Sigillaria.** Those are tipically nordic genera. He also found **Schizoneura,** as did Anthoine & Dubois (1922).

Real (1966) reported **Glossopteris brancai, G. browniana** and **G. indica** also from a similar lithology outcropping above dark shales on the banks of two tributaries of the Sanangoe, near the road to Tete.

Oliveira (in Rocha-Campos, 1972) published a preliminary list of the present material under study and revised the Teixeira (1947) list.

It seems not to be the same outcrop in all the cases as formerly Oliveira (in Rocha–Campos, 1972) believed. It may also not be same stratigraphical horizon or it may be due to incomplete collections of the same horizon.

The uncertain geographical and stratigraphical locations given by the authors, do not grant good correlations.

The authors have studied about 100 specimens in 50 samples, which occur as very well preserved impressions, permitting a good morphographic character identification.

SISTEMATICS – Our descriptions comprise the following list:

Sphenopsida.
– Order Sphenophyllales – Family Sphenophyllaceae
Umbellaphyllites cf. **U. ivini** (Walkom) Rigby..... 5%
– Order Calamitales – Family Calamitaceae
Paracalamites australis Rigby..... 10%
Pteridospermopsida

VEGETAL GROUPS	ZEILLER (1883)	GOTHAN (1914)	ANTHOINE & DUBOIS (1922)	TEIXEIRA (1947)	REAL (1966)	OLIVEIRA (in ROCHA-CAMPOS,1972)	PRESENT LIST
LYCOPSIDA				Sigilaria sp.			
SPHENOPSIDA	Annularia stellata Schloth. Calamodendron cruciatum Stemb. Sphenophyllum oblongifolium Germ & Kaulf. Sphenophyllum majus Brongn.		Schizoneura africana Feistm.	Schizoneura sp. Sphenophyllum oblongifolium Germ. & Kaulf. S. speciosum (Royle) Zeiller S. thoni Maur		Paracalamites sp. A Paracalamites sp. B Umbellaphyllites cf. U.ivini (Walkom) Rigby	Paracalamites australis Rigby Umbellaphyllites cf. U. ivini (Walkom) Rigby
FILICOPSIDA	Pecopteris arborescens Schloth. Pecopteris cyathea Schloth. Pecopteris unita Brongn. Pecopteris polymorpha Brongn.		Sphenopteris lobifolia Morris	Asterotheca sp.			
PTERIDOSPERMOPSIDA	Alethopteris grandini Brongn. Calypteridium ovatum Brongn.	Glossopteris indica Schimp. G. browniana Brongn. G. brancai Gothan	Glossopteris indica Schimp. G. browniana Brongn. G. brancai Gothan Vertebraria sp.	Glossopteris indica Schimp. G. browniana Brongn. G. brancai Gothan Gangamopteris cf. cyclopteroides Feistm.	Glossopteris indica Schimp. G. browniana Brongn. G. brancai Gothan	Glossopteris indica Schimp. G. browniana Brongn. G. communis Feistm. G.cf.G.longicaulis Feistm. G.cf.G.occidentalis White G. retifera Feistm. G. stricta Bunbury G. angustifolia Brongn. G.cf.G.ampla Dana G.sp. Gangamopteris obovata (Carr.)White Squamae or Scale-leaves Semina	Glossopteris indica Schimp. G. browniana Brongn. G. communis Feistm. G.cf.G.longicaulis Feistm. G.cf.G.occidentalis White G. stricta Bunbury G. angustifolia Brongn. G.cf.G.ampla Dana Gangamopteris obovata (Carr) White Squamae or Scale-leaves Semina
CORDAITOPSIDA	Cordaites sp.						

TABLE 1 - HISTORICAL RESUME OF MOZAMBIQUEAN TAPHOFLORAS STUDIES.

– Order Glossopteridales

G. communis Feistm	26%
G. browniana Brongniart	24%
G. indica Schimper	10%
G. cf. **G. occidentalis** White	6%
G. stricta Bunbury	5%
G. angustifolia Brongniart	3%
G. cf. **G. longicaulis** Feistm	2%
G. cf. **G. ampla** Dana	1%
Gangamopteris obovata (Carruthers) White	4%
Squamae or *Scale-leaves*	2%
Semina	not counted

Sistematic Descriptions

genus **Umbellaphyllites** Rasskazova,1961

Umbellaphyllites cf. **U. ivini** (Walkom) Rigby, 1966.

Pl. 1, fig. 6

DESCRIPTION – The specimens are incomplete verticilate leafwhorls. There are about 14–15 leaves in a half whorl, which makes us believe that a number of 28–30 leaves forms a complete whorl. In some specimens the verticillate leaves are attached to thin articulate stems, weakly longitudinally ribbed of the **Paracalamites** type, which are 3–5 mm in breadth and 15–18 mm in internode length. The leaves are uninervous, more lanceolate or oblanceolate than linear in shape, narrowing into a sheath. They are linked one to the other by 4/5 of their length towards the apex, forming a large planar (umbrella-like) leafy whorl. Unfortunately, none of the specimens occurs complete, all showing only a half or one third of the total number of leaves of a whorl, but their arrangement suggests a circular shape. Each leaf is narrower than 0,5 mm at the base and it is 5 mm at the broadest part near the apex. The apex may be mucronate or rounded. The most-complete leaf is 36 mm long. The ratio stem diameter to length of leaf is thus between 1:8 and 1:12, and the diameter of the whorl is about 75 mm. The leaf blade is wrinkled, with distinct transverse wrinkles running from the midrib to the margin at right angles. The wrinkles are arched curving towards the apex (see pl. **1**, fig. **6**); the distance between the wrinkles is about 0,2 mm.

DISCUSSION AND COMPARISON – By Rasskazova's diagnosis (in Rigby, 1966: 117) the authors did not have any doubt identifying their specimens as belonging to the genus **Umbellaphyllites.** But they seem to be different from the species **U.annularoides** Rasskazova because of the length and breadth of the internode. They also differ from **U.minima** Rigby by the number of leaves in a whorlshape, in the direction of leaf blade wrinkling and the ratio stem diameter to length of leaf. These specimens are similar to the description of **Umbellaphyllites ivini** (Walkom) Rigby by the number of leaves in a whorl shape, the direction of leaf blade wrinkling and the ratio stem diameter to length of the leaf. However we could not clearly observe if the apex is mucronate or not and if the proportion sheath length to stem diameter at the node is 1/2. The diameter of these whorls may be greater and the internode length smaller than Rigby's species. It is impossible to compare cuticular characters because there are only impressions. The authors prefer therefore, to identify them as **Umbellaphyllites** cf. **U.ivini** Rigby till better specimens are available.

genus **Paracalamites** Zalessky, 1927

Paracalamites australis Rigby, 1966

Pl. 1, fig. 5

DESCRIPTION – There are 10 specimens of articulate, leafless stems with opposite ribbing, occasionally alternating at each node, each fragment exhibiting 2 to 3 internodes. Size of the internodes varies between 0,5-2,0 cm in width and 1,4-2,9 cm in length. This length is always greater than the stem impression width. Number of ribs varies from 4 to 20 on the surface of specimens, which gives a ratio of 5

to 10 ribs per cm. In any specimens rib vascular bundles can be seen dichotomising and recombining with vessels of adjacent ribs at nodes of internal casts. In these specimens (as pl. 1, fig. 5) the scars of infranode channels of approximatly circular form are around 1,0mm in diameter. There are no tubercles.

DISCUSSION AND COMPARISON – Our specimens have weakly or better marked nodes of external casts than the specimens of **Paracalamites australis** Rigby, from Australia (Rigby, 1966) or from Antarctica (Rigby. 1969). The concentration of ribs is also variable, sometimes more sometimes less concentrated than **Paracalamites australis** Rigby. But these specimes are in accordance with the emended diagnosis of this species. We concur with Rigby that it is not good to erect many new species of the form-genus **Paracalamites** which presents very few diagnostic characters and as stated by Rigby (1969-F3): *The fact that no discernible difference exists between the stems of many of the Gondwana sphenopsid genera that are based on characters of leaves is acknowledged by the use of the specifc name* **P. australis** *for these various stems. If any species distinguished by features of leaves should prove to have a distinctive type of stem, then a separate species of* **Paracalamites** *might be proposed.* We believe that **Schizoneura** sp. described by Teixeira (1947, pl. XV. figs. 4, 4a and 5) may refer to the same species of **Paracalamites.**

genus **Glossopteris** Brongniart, 1822

Glossopteris cf. **Glossopteris ampla** Dana, 1849

Pl. 1, fig. 4

DESCRIPTION – There is only one fragment in our collection that could be identified as belonging to this species. It seems to be obovate or spatulate and presents neither apex neither base. It is 7,0 cm broad and the length of the fragment is about 5,5 cm. The midrib is quite distinct and is 1,8 mm in breadth tapering towards the apex, in all the preserved portion.

The secondary venation dichotomises and anastomoses throughout the lamina, forming a reticulation of long narrow meshes (ratio: breadth/length = 1/8 to 1/10) next to the midrib and becoming a reticulation of subparallel aspect towards the border with narrower and longer meshes (ratio: breadth/length = 1/12 to 1/15). The secondary veins emerge from the midrib at an acute angle (about 35º) and quickly curve as far as 65º – 70º. The number of veins per cm is 18 in the middle distance between midrib and margin and 21 at the margin.

DISCUSSION AND COMPARISON – Our specimen is very similar to the description given by Archangelsky (1958:56, Pl. 35, fig. 35) as **G. ampla** Dana, but their secondary veins have a divergent angle more like to the ones described by Plumstead (1962: 44, Pl. 6, fig. 1 and 4), in her antarctic specimens.

The species was established by Dana (1849) for very large leaves from Australia but the holotype is believed to be lost by many authors (as Plumstead, 1962), but Rigby (1966: 130, Pl. 34, fig. 41) has given a photograph of it placed in the U.S. National Museum.

Unfortunately, the upper portion of the leaf has not been preserved and, therefore, the other characters as the broadly oblong or very obtuse and emarginated apex can not be observed.

We therefore prefer to identify it as **Glossopteris** cf. **G. ampla** Dana, although Du Toit (1939) has already identified this species in sediments from Tete region.

Glossopteris angustifolia Brongniart, 1828

Pl. 1, fig. 1

DESCRIPTION – In our collection we could

identify three specimens as **Glossopteris angustifolia** Brongn. They are fragments of narrow, elongated and linear leaves, without apex and base 1-2,8 cm in breadth and 1,7 – 4,0cm in length. The midrid is distinct, longitudinally striated, about 2,0 mm wide at the lower part and continues throughout all the preserved length of the lamina. The secondary veins emerge at an acute angle (about 35º) from the midrib, with a polygonal elongated net, near the principal nervure slightly open, assuming afterwards a subparallel, narrow and elongated polygonal form with rare anastomosis and dichotomies towards the margin. The concentration of veins is about 20-25 nervures per cm, half the distance between midrib and margin of the leaf.

DISCUSSION AND COMPARISON – These specimens have shown us that some secondary veins do not anastomose, remaining free, at a great extension towards the margin, as Zeiller (1896: 369-370) had already observed in specimens from Transvaal. They are very similar to south african specimen presented by Seward (1897, Pl. 21, fig. 4a) as **Glossopteris browniana** var. **angustifolia** since Seward considered **G. angustifolia** Brongniart as a variety of **G. browniana** Brongniart. On the other hand, Arber (1905) supposed that **G. angustifolia** migth be a variety of **G. indica** Schimper.

Although our study is only concerned with morphographic characters, our specimens show a striking resemblance to **G. angustifolia** Brongniart (in Feistmantel, 1881, Pl. 27A, fig. 6,8,11,12 and 13); to **G. angustifolia** Brongn. (in Zeiller, 1896, Pl. 18, fig. 1–3 and Text figs. 14 and 15) and also to **G. angustifolia** Brongn. (in Dolianiti, 1953, Pl. 5, fig.1). Comparing them with **G. angustifolia** Brongn. (in Plumstead, 1962, Pl. 8, fig. 4–6), they only present a somewhat greater concentration of veins and a slightly more acute divergent angle.

Du Toit (1939) was the first person to notice **G. angustifolia** Brongniart in the shales from the Karroo of Tete.

Glossopteris browniana Brongniart, 1828
Pl. 2, fig. 5 and Pl. 3, fig. 6

DESCRIPTION – We have 21 specimens of our collection in which the following characters are observed: lanceolate leaves, oblong, oblanceolate or spathulate in form. Some are complete, showing obtuse apex and gradually contracted towards the base. The specimens measure 3,3 – 8,5 cm in length and 2,1 – 5,2 cm in breadth at the widest part. Midrib is proeminent and broad, sometimes striated, 1,3 – 2,0mm wide in the median portion, once showing 3,5mm, continuing throughout the preserved length of the lamina. Secondary veins form an acute angle (35º – 50º) with the midrib and with a broad curve pass out to the margin. Sometimes they form an angle between 35º – 40º and pass out straigth to the margin, i.e., they do not curve. The dichotomies and anastomosis form polygonal, open elongate meshes, broader and shorter near the midrib (the ratio breadth/length here is 1:3 to 1:6, more or less 0,7mm: 3,0mm or 0,9mm: 4,5mm) and narrower and longer, oblong fusiform or rombic meshes towards the margin, where they present a subparallel aspect (the ratio breadth/length of the meshes here is 0,6mm: 5,0mm to 0,7mm: 8,0mm, i.e., 1:8 to 1:11).

At the median portion of the leaf, there are 6 – 10 veins per cm next to the midrib, 14–19 veins per cm in the middle part between midrib and margin and 18–22 veins per cm at the margin.

DISCUSSION AND COMPARISON – Gothan, 1912, was the first to notice **Glossopteris browniana** Brongniart in the Tete region, however, as the measures of his specimens were very large, he prefered to call them **G.** cf. **browniana.**

R. Anthoine & Dubois, 1922, noticed

again the presence of **G. browniana** Brongniart in the Karroo of Zambezia.

We observe in our collection the three principal kinds of venation of **Glossopteris browniana** Brongniart, to which Maheshwari & Prakash (1964) direct attention. The secondary venation forms: oblong or triangular opened polygonal meshes next to the midrib and elongate and narrower towards the margin. Besides this, the divergence angle and the concentration of veins do not cast out doubt that they are **G. browniana.** One specimen presents the leaf only near the base, similar to **Glossopteris retifera** Feistmantel as Archangelsky (1958) had already observed in some specimens from Bajo de la Leona. However, also in this case we can observe a ratio bigger than (1:1) between breadth and length of the meshes of secondary venation. The specimens which Oliveira (in Rocha -Campos, 1972) believed to be representatives of **G. retifera** Feistmantel in fact are **G. browniana** Brongniart.

We agree with Oliveira (in Rocha-Campos, 1972) when stating that the following specimens of Teixeira (1947) belong to the species **Glossopteris browniana** Brongniart: **Glossopteris** cf. **G. browniana** Brongniart (Pl. 3, fig.1, 1a, 3,5 and 9 and Pl. 4, fig.1, 1a, 3 and 3a); **Glossopteris indica** Schimper (Pl. 10, fig.1, 1a, and 2) and **Glossopteris** sp. (Pl. 11, fig. 3 and 3a).

Glossopteris communis Feistmantel, 1876
Pl. 2, fig. 2 and 4

DESCRIPTION – The majority of the 26 specimens are fragments. The breadth, at the widest part, is about 4,0 – 5,0cm, and the length is about 6,0 – 10,0cm. The leaves are variable in form: lanceolate, oblanceolate, oblong or ovate. The majority is lanceolate, and the apex is acute or obtuse. None of the fragments show the base. Midrib is stout, about 2mm wide in the lowest portion of the fragments, reaching the apex while tapering gradually. Secondary veins are numerous (21 – 29 nerv/cm) close to the margin coming out from the midrib at very acute angles (35º–45º) and curving slightly towards the margins. The secondary veins dichotomise and anastomose, forming narrow – elongate meshes near the midrib of almost the same size of those near the border (see Pl.2, fig. 2 and 4).

DISCUSSION AND COMPARISON – Our specimens are almost identical with **G. communis** (Feistmantel, 1876:375; 1879:16–17, Pl. 17, fig. 1 and 2; 1881:98–99, Pl. 24A, fig. 1; Pl. 29A, fig. 5 and 9; Pl. 31A , fig.4; Pl.32A, figs. 2 and 2a; Pl. 35A, fig. 1,2 and 3; Pl. 36A, fig. 1; Pl.37A, figs. 3, 3a and 4; Pl. 38A, figs. 1 and 2; and 1882: 32–38, Pl. 12, fig. 1). Feistmantel (1876) first described this species as long broad leaves with long and narrow meshes. However, Zeiller (1896) and Arber (1905), did not support him and included such fronds under **G. indica** Schimper. In 1955, Sen proved its independent existence, based on description of the fructification, and Srivastava (1956) confirmed it with the description of cuticular material. Plumstead (1962) identifying **G. communis** Feistm. among Antartida specimens stated: *I believe that both on cuticular evidence (Srivastava, 1956:5–7) and on gross from the two* **G. communis** *and* **G. indica** *can be separated.*

Rigby (1966) discussing the morphographic differences between **G. indica** and **G. communis** (which are more important for us, because we have only leaf impressions) said: *The most apparent difference between* **G. indica** *and* **G. communis** *lies in the size and shape of the reticulations in the secondary venation adjacent to the midrib. In* **G. indica** *they are short and often triangular and broader than the meshes towards the margin. In* **G. communis** *they are long and rectangular, and uniform in width throughout the leaf. The veins in* **G. com-**

munis *tend to intersect the margin at a lesser angle. The leaf of* **G. communis** *is frequently much larger.*

We believe that many of the specimens originating from Tete, identified and figured by Teixeira (1947) as **G. indica** are, in fact, **G. communis** by the above described morphographic characteristics, according to Oliveira's synonomy (in Rocha-Campos, 1972). As **G. communis** were also determined the specimens (Pl. 2, fig. 1 and 2, Teixeira, 1947), then identified as **G. browniana.**

It is interesting to notice that one specimen (an assymmetrical,spathulate leaf of 1,5cm in breadth and 3,5cm in length with a proeminent midrib in the base, becoming gradually less evident towards the apex), seems to be by these aspects **G. communis var. stenoneura** Feistm., 1881, Pl. 38A, fig. 5 However, after Srivastava (1956) the cuticular study of this variety shows that it is similar to **G. communis** Feistm.

Glossopteris indica Schimper, 1869
Pl. 3, fig. 5

DESCRIPTION – They are fragments of leaf impressions, showing variable breadth (1,5 – 3,8cm). Their length is about 3,4 – 8,2cm. The majority of the leaves are lanceolate, only some fragments suggesting oblong or obovate form. The apex is generally, acute and we notice only one basal region tapering gradually. The midrib is frequently, very thin (0,6 – 1,5mm) attaining sometimes 2 or 2,5mm. It occasionally seems striated and narrowed towards the apex. The secondary venation branched from the midrib at a divergence angle of about 25º – 40º, becoming suddenly, oblique with an angle of 45º – 60º, reaching the margin more or less straight. The secondary venation, with dichotomies and anastomosis, establishes a reticulation which presents, near the midrib, triangular or poligonal short meshes, broader than those of the margin, where they are oblong narrow and long. The ratio width/length of the meshes nearby the midrib is (1:3) or (1:4) and near the margin the same ratio is (1:9) or (1:11). On the other hand, the secondary venation towards the margin becomes, approximately, straight and subparallel, as we can notice clearly in Pl. 3 fig. 5. The venation ranges between 8 – 14 nerv./cm near the midrib and 18-25 nerv./cm near the margin.

DISCUSSION AND COMPARISON – The distinctions between **G. communis** Feistm. and **G. indica** Schimper have already been discussed previously. We only wish to emphasize that some specimens, identified by Teixeira (1947) as **G. indica,** are according to our points of view identified correctly, such as Pl. 6, fig.4, 4a; Pl.7, fig. 1; Pl.8, fig.1,2 and Pl. 9, fig.1, while others, regarded by the same author as **G. brpwniana** Brongniart (Pl.2, fig.3) would better be designated as **G. indica,** as asserted by Oliveira (in Rocha Campos, 1972). Besides this, we noticed others specimens in our collection belonging, undoubtedly, to this species. Specimens as Pl. 3, fig. 5, showing subparallel and straight secondary venation, forming triangular and broad meshes adjacent to the midrib and narrow and elongated towards the margin; leaf-shape narrower and longer than **Glossopteris communis** Feistm., are characterized as **G. indica** Schimper.

Glossopteris cf. **G. longicaulis** Feistmantel, 1881
Pl. 1, fig. 3

DESCRIPTION – There are only two fragments of leaf impressions, 3,0 cm at the maximum breadth and 7,6 cm and 4,7 cm in length. The apex is not preserved in any of the specimens. The leaves may be oblong-oval in shape. The base presents a very long petiole. In one of the specimens (Pl. 1, fig. 3) the

petiole is 3,1 cm in length in spite of being fragmented. It seems to be striated as the midrib and it is a little writhed. The midrib has a width of 3 to 3,5 mm at the lowest part near the petiole. This specimen is the best preserved, and therefore it is possible to distinguish the reticulation of the secondary veins forming rather broad oblong meshes. The secondary veins emerge to form, with the midrib, an acute angle (more or less 30º) and pass out arched to the margin. The concentration of veins is about 14 nervures per cm halfway between midrib and margin.

DISCUSSION AND COMPARISON – Our specimens have many characteristics of **Glossopteris longicaulis** Feistm. as is described in: Feistmantel (1881:54, Pl.21, fig. 1 and 3); Srivastava (1956:23–25, Pl.10, fig. 62 and 63) ; Plumstead (1962, Pl.8, fig. 1 to 3); Maheshwari (1964:134–135, Pl. 2, fig. 13 and Text fig. 8) and Maithy (1964:257, Pl.4, fig. 29). But unfortunately, in neither of them the upper portion of the leaf is preserved, and therefore, the other character: the fact that the midrib becomes more indistinct and vanishes towards the upper part of the leaf, could not be verified. For this reason, we prefer to call them **Glossopteris** cf. **G. longicaulis** Feistm.

Glossopteris cf. **G. occidentalis** White, 1908

Pl. 2, fig. 3 and Pl. 3, fig. 3

DESCRIPTION – They are fragments, in general, without apex and base, 4–4,6 cm in breadth and 4,7 – 7 cm in length. The fragments suggest oblong form with lateral parallel borders, rapidly converging near the top to form an acuminated apex. The base is not preserved in any specimen. The midrib is very broad (2–3 mm) and is continuous till the apex. The secondary venation emerging at an acute angle (less than 25º), soon assumes a direction of 70º to 75º towards the margin. It shows dichotomies and anastomosis forming á reticulation with relatively large, polygonal or triangular elongated meshes near the midrib. Then, after the curve at 70º to 75º the secondary veins assume a parallel and closed feature, with rare and oblique anastomosis. The concentration of veins is very high; about 40–46 veins per cm near the margin.

DISCUSSION AND COMPARISON – Because of the scarcity of dichotomies and anastomosis at the borders, we thought at first that these specimens could be identified as **Rhabdotaenia**, but because of the presence of a more complicate mesh next to the midrib we came to the conclusion that they belong to genus **Glossopteris.**

These specimens have general features, similar to **Glossopteris communis** Feistm. but they can be distinguished from this species by the divergent angle, by the density of venation and by number of anastomosis and dichotomies becoming rarer towards the borders and giving a longer reticulation.

They are also similar to **G. stricta** Bunb., and can be distinguished from this species by their wider form, the reticulation of narrower and longer meshes near the midrib, the bigger concentration of veins and an extremely rare anastomosing of the secondary venation towards the margin. They are similar to **Glossopteris occidentalis** White (1908:510–516, Pl. 7, fig. 4 and 4a) but they have a slightly shorter density of nervation than brazilian specimens. On account of what we said above, and because we were unable to see the cordiform base of the White's species, we shall refer to these specimens as **G.** cf. **G. occidentalis** White.

They are also similar to: **Glossopteris** sp. Kurtz (1921, Pl. 9, fig. 96 and 100), **Glossopteris** cf. **G. ampla** Dana, in Read (1941, vol. 12:76–78, Pl.4, fig. 3 and 5) and **Glossopteris stricta** Bunbury, in Dolianiti (1953, nº 60:1–4, Pl. 1 and 2) which we believe, are in the **Glos-**

sopteris occidentalis White (1908) synonomy.

Glossopteris stricta Bunbury, 1861
Pl. 1, fig. 2 and Pl. 3, fig. 1 and 4

DESCRIPTION – They are, generally, fragments of leaf impressions without apex and base, but they seem to be oblong-lanceolate in shape, long and rather narrow in proportion. They are 1,6 – 2,8 cm in breadth and 8,6 cm in length (the biggest fragment). One specimen suggests an acute apex. The midrib is very distinct and is 2 – 2,4 mm at the lowest part. It is striated, tapering towards the apex. The secondary veins emerge from the midrib at an acute angle of about 40º to 45º and after a gentle arch pass straight to the margins at an angle of about 60º to 85º. Near the midrib the secondary venation forms distinct, short, broad, polygonal, almost losangular nets, and after curving they become subparallel with narrow and transversely elongated nets at the margins (see Pl.3, fig. 1 and 4). Some specimens, as Pl. 1, fig. 2 have their secondary veins slightly curved upwards at the margin. The number of veins per cm at the margin is about 26–35.

DISCUSSION AND COMPARISON – These specimens are similar to **Glossopteris angustifolia** Brongn., because they are long and narrow leaves, but they can be distinguished from this species by the more open divergent angle, by the larger concentration of veins and by the less frequent dichotomies and anastomosis at the margin. They are distinct from G. **browniana** Brongn., because they are more elongated and narrowed leaves, the meshes are narrower, subparallel and subhorizontal towards the margin and the number of veins per cm is higher. From **G. occidentalis** White, they can be distinguished by the shape, concentration of veins and divergent angle of the secondary veins. They are practically undistinguishable from **Glossopteris stricta** Bunbury (Bunbury, 1861: 331, Pl. 9, fig. 5) as well as from **Glossopteris stricta** Bunbury (in Feistmantel, 1876: 74; Pl.3, in Archangelsky, 1958:62–64, Pl.46, fig. 46 and in Plumstead, 1962:45–46, Pl.10, fig. 1 and 2). They also present a close resemblance to **G.** cf. **browniana** Brongn. (in Teixeira 1947:12–13, Pl.4, fig. 2 and 2a– which Oliveira (in Rocha-Campos, 1972) has already put into **G. stricta** Bunbury's synonomy. **G. stricta** Bunbury *although never very common, has a wide distribution in Lower Gondwana beds* after Plumstead (1962). Therefore it is not adequate for stratigraphic correlation.

genus **Gangamopteris** Mc Coy, 1861
Gangamopteris obovata (Carruthers) White, 1905
Pl. 2, fig. 1 and Pl. 3, fig. 2

DESCRIPTION – There are some fragments obovate-spathulate in shape, which are 4–6 cm at the greatest breadth, with obtuse or oval – rounded apex and gradually tapering to the base. The median subparallel veins are stronger towards the base, anastomosing and dichotomising and becoming gradually smooth towards the apex. From these veins come out lateral veins which anastomose and dichotomize, forming more open and longer meshes towards the center and shorter and narrower meshes towards the margin. In the basal portion, the secondary veins emerge at an acute angle of 7º or 8º, curving afterwards touching the margin at 50º. In the median an apical por - tions, the secondary veins come out from the central part, forming with the median longitudinal axes an angle of 12º to 13º, curving slightly towards the margin. As to concentration of veins there are: 24 veins per cm near the base, 28 veins per cm at the median portion and 32 veins per cm close to the apex, measures being taken half way between the longitudinal axes and the margin.

DISCUSSION AND COMPARISON – As there

are only impressions, we cannot verify their cuticular characters. Comparing the above description of our specimens with the characterizations given by Feistmantel (1879) and by Pant & Singh (1968) to **Gangamopteris cyclopteroides** Feistm. emended Pant & Singh, we see that they agree perfectly. However, Seward (1903), Arber (1905), White (1905), White (1908), Dolianiti (1954), Archangelsky (1958), Plumstead (1962) and Rigby (1966) had already noticed the synonymy between **Gangamopteris cyclopteroides** Feistm. and **G. obovata** (Carruthers) White, claiming (since White, 1905) the priority of the last name. In 1964, Maithy distinguished **G. obovata** from **G. cyclopteroides** on account of the oval-spatulate shape with rounded apex of the leaves of the first species; besides the ill-preserved and more arching venation. The differences in form and venation are not sufficiently distinctive characters. References as to form: Feistmantel (1876) and Pant & Singh (1968) and White (1908); and to venation: Seward (1903) and White (1908).

On studying the specimens from Mozambique we could not find any differences between **G. cyclopteroides** Feistm. and **G. obovata** (Carruthers) White as far as the morphographic characters are concerned. In 1966. Rigby described a specimen of **G. obovata** (Carr.) White that presented a microstructure similar to the upper epiderm from **G.** cf. **cyclopteroides** Srivastava (1956) and to the upper epiderm from **G. cyclopteroides**, Hoeg & Bose (1960).

Therefore, taking into consideration the priority of the name, we conclude that our specimens, just as those identified by Teixeira (1947:15, Pl.5, fig. 4, 4a) from Mozambique, may be considered as **G. obovata** (Carr.) White (1905).

Squamae or Scale – leaves

DESCRIPTION – They are convex impressions of lanceolate form (except one which is concave, because it is a counterpart) giving the idea that it was somewhat resistent to the compression. The size is more or less 0,8 – 0,85 cm in breadth and 1,55 – 1,67 cm in the length. The apex is acute or acuminate in form and the base is cuneated. The nervures irradiate from the base to the borders and they dichotomise but there are no anastomosis. One specimen is a *squamae* that suggests linkage to a striated stem but not articulated.

DISCUSSION AND COMPARISON – Feistmantel (1822) suggests connection between these *squamae* and **Noeggerathiopsis**. His specimens have different shape from ours, although the venation aspect may be the same. Our specimens are very similar to the scale-leaf of **Glossopteris**, presented by Walkom (1921, Pl.21, fig. 5, from Queensland).

Sahni (1926) suggested that these *squamae* or scale-leaves as common protective scales of vegetative buds of **Glossopteris.**

Plumstead (1962) describing about the sistematic linkings of the scale-leaves from India, Australia and South Africa stated: *They are always attributed to* **Glossopteris** *but there is actually no direct evidence than constant association to support even a generic claim. The marked differences in shape suggest that they belong to more than one species.*

Concerning its function she stated yet: *I have found, but have not described small scale leaves still covering closely packed clusters of* **Arberiella** *in Lower Beaufort rocks in the Orange Free State, and feel with Arber and Du Toit that there is enough evidence to consider that some at least of these scales are connected with reproduction.*

Rigby (1966) thinks that there are not

GEOGRAPHIC LOCALIZATION	ANTARCT.	AFRICA									AUSTRALIA						ASIA							SOUTH AMERICA								
		SOUTH AFRICA								RHODESIA	NEW S.WALES		QUEENS-LAND		TASMANIA		INDIA						ARGENTINA			BRAZIL				FALKLANDS
																	Pan-chet Div.	Damuda Division			Talchir Division					Passa Dois Group		Tubarão Group		
STRATIGRAPHIC LOCALIZATION	Permian	Molteno	Upper Beaufort	Middle Beaufort	Lower Beaufort	Upper Ecca	Middle Ecca	Lower Ecca	Dwyka	Upper Wankie Sandstone	Upper Coal Measures	Lower Coal Measures	Upper Bowen Series	Lower Bowen Series	Upper Coal Measures	Lower Coal Measures	Panchet Stage	Raniganj Stage	Barren Measures	Barakar Stage	Karharbari Stage	Talchir Stage	Serie Bonete	Bajo de Los Velez	Nueva Lubecka	Estrada Nova Formation	Irati Formation	Bonito Formation	Itarare Subgroup	Lafonian System
Glossopteris cf. G. ampla Dana	*				*	*	*	*		*	*	*	*	*				*	*	*	*							*		
Glossopteris angustifolia Brongn.	*			*	*		*			*	*						*	*	*	*	*							*	*	*
Glossopteris browniana Brongn.	*	*	*	*	*	*	*	*		*	*	*	*	*		*		*		*	*		*		*	*	*	*	*	*
Glossopteris communis Feistm.	*					*	*	*			*					*		*	*	*	*	*							*		*
Glossopteris indica Schimper	*				*	*	*	*		*	*	*	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Glossopteris cf. G. longicaulis Feistm	*						*											*			*										
Glossopteris cf. G. occidentalis White																												*			
Glossopteris stricta Bunbury	*				*		*			*								*		*			*					*	*		
Glossopteris Scale-leaves	*		*	*	*	*	*	*					*	*				*	*	*	*	*								*	*
Gangamopteris obovata (Carruthers) White	*					*	*	*	*	*		*		*		*		*	*	*	*		*	*		*	*	*	*	*	*
Umbellaphyllites cf. U. ivini Rigby												*																			
Paracalamites australis Rigby	*										*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	

TABLE 2 : OCCURRENCE OF ELEMENTS FROM TETE TAPHOFLORA IN OTHER PARTS OF GONDWANALAND.

definite evidences to consider many of them as having been true leaves, bracts or other organs. He interpreted the differences in shape from his specimens as having been derived from different species.

Our specimens differ from Plumstead's specimen (1962, Pl.14, fig. 10) because they are more symmetrical ,and from Rigby's specimens (1966, Pl.33, figs. 27 and 28) by the more lanceolate shape. They are not well preserved and they are detached from other organs (except one as above mentioned, that suggests to be linked to a striated stem, but not articulated).

Thus, unfortunately, we have nothing to add to the knowledge of these forms.

Semina

Some seeds, which we were not able to identify, we called *semina.*

According to our opinion they deserve a more careful study based on better specimens.

CONCLUSIONS

Our collection proceeding from the Tete region, is like Gothan's (1914), a typical association of the Lower Gondwana Flora where elements of the Euroamerican Flora as **Sphenophyllum**, **Pecopteris** and **Sphenopteris** are lacking. We do not dare to affirm that the upper part of the Productive *series* presents a *pure* Glossopteris Flora, as we have only a small collection from this horizon, though having strong reasons to believe so.

The studied collection does not suggest an endemic floristic association, showing common forms usually found in the Gondwana regions, even **Glossopteris** cf. **G. occidentalis** White up to the present only observed in Brazil and **Umbellaphyllites** cf. **U. ivini** Rigby from Australia and Antarctica.

It seems, according to personal comunication with Rocha Campos, that Teixeira (1947) does not refer exactly to the same horizon in his study.

It is interesting to note in this floristic association the absence of Cordaitales, Coniferales, i.e., of other Gimnospermae besides the Glossopteridales. Maybe this suggests a restricted environmental sedimentation such as autumn leaf banks (as Plumstead describes these leaf deposits). Remarkable is also the lack of fructifications of Glossopteridales, and of well preserved seeds.

Observing table 2 we verify that the majority of the studied species has a very large stratigraphic distribution which is chronologically of little use. Comparing this association however, with the ones in the nearest area, i.e. South Africa, we conclude that it corresponds roughly to that one of the middle Ecca, as according to Archangelsky (1958), Artinskian.

Comparing the Glossopteridales from Tete with the brazilians we notice in the Tete's species a large quantity with a secondary venation of slightly larger meshes. Would this suggest any climatic difference?

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EXPLANATION OF PLATES

All these specimens are from the same locality:

Upper part of Productive **Series**, *outcropping on a secondary road linking the Tete-Estima road to the Sanangoe River valley.*

They form part of the Collection of DPE – Inst. de Geociências – Universidade de São Paulo.

PLATE 1

Fig. 1 – **Glossopteris angustifolia** Brongniart. Specimen nº GP 3T118, showing a median portion of a leaf with clearly visibles meshes near the midrib 3,5x.

Fig. 2 – **Glossopteris stricta** Bunbury. Specimen nº GP/3T119, presenting a portion of leaf near the apex. 2,5x.

Fig. 3 – **Glossopteris cf. G. longicaulis** Feistmantel. Specimen nº GP/3T 120. Half of a leaf with a long petiole. 1,8 x.

Fig 4. – **Glossopteris** cf. **G. ampla.** Dana. Specimen nº GP/3T 121 only a fragment of a half leaf. 1,0x.

Fig. 5 – **Paracalamites australis** Rigby. Specimen nº GP/3T 122. Two stem fragments. The larger one showing clearly the infranode channels and the opposite ribbings at the node. 0,8x.

Fig. 6 – **Umbellaphyllites** cf. **U. ivini** (Walkom) Rigby, Specimen nº GP/3T 123 showing more or less 1/4 of a verticile. The leaves are wrinkled and linked one to the other by 4/5 of their lengthd. 5,0x.

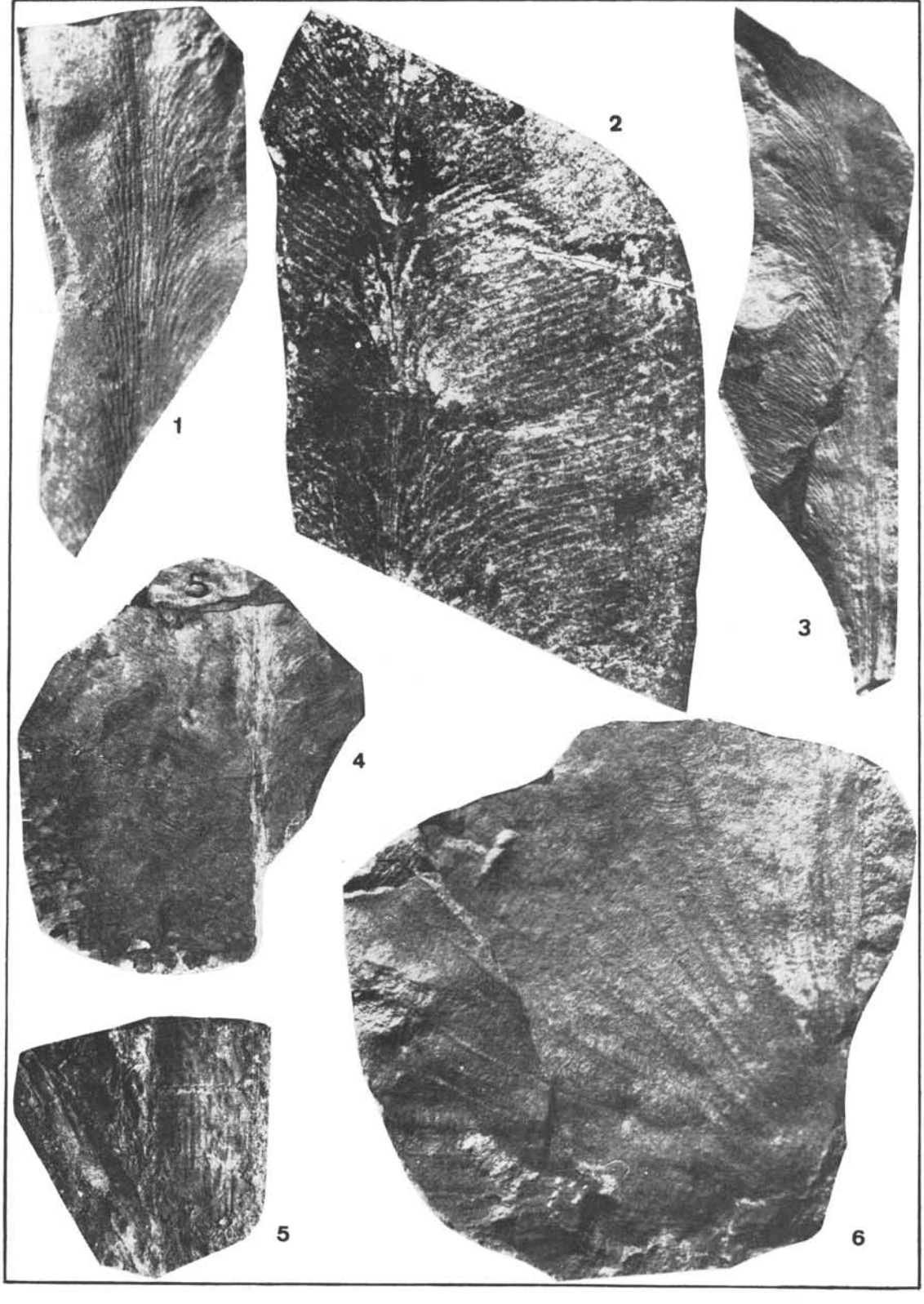
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PLATE 2

Fig. 1 – **Gangamopteris obovata** (Carruthers) White. Specimen nº GP/3T 124, showing almost the whole leaf. 1,6 x.

Fig. 2 – **Glossopteris communis** Feistmantel. Specimen nº GP/3T 125, fine and uniform network over the entire leaf. 1,0 x.

Fig. 3 – **Glossopteris** cf. **G. occidentalis** White. Specimen nº GP/3T 126, showing half a median part of a leaf with high venation density. 1,4 x.

Fig. 4 – **Glossopteris communis** Feistmantel, Specimen nº GP/3T 127, an almost complete leaf. 1,0 x.

Fig. 5 – **Glossopteris browniana** Brongniart. Specimen nº GP/3T 128, presenting a venation with broad and large meshes near the midrib, long and narrow near the margin, having an oblique aspect being almost straigth. 2,7 x.

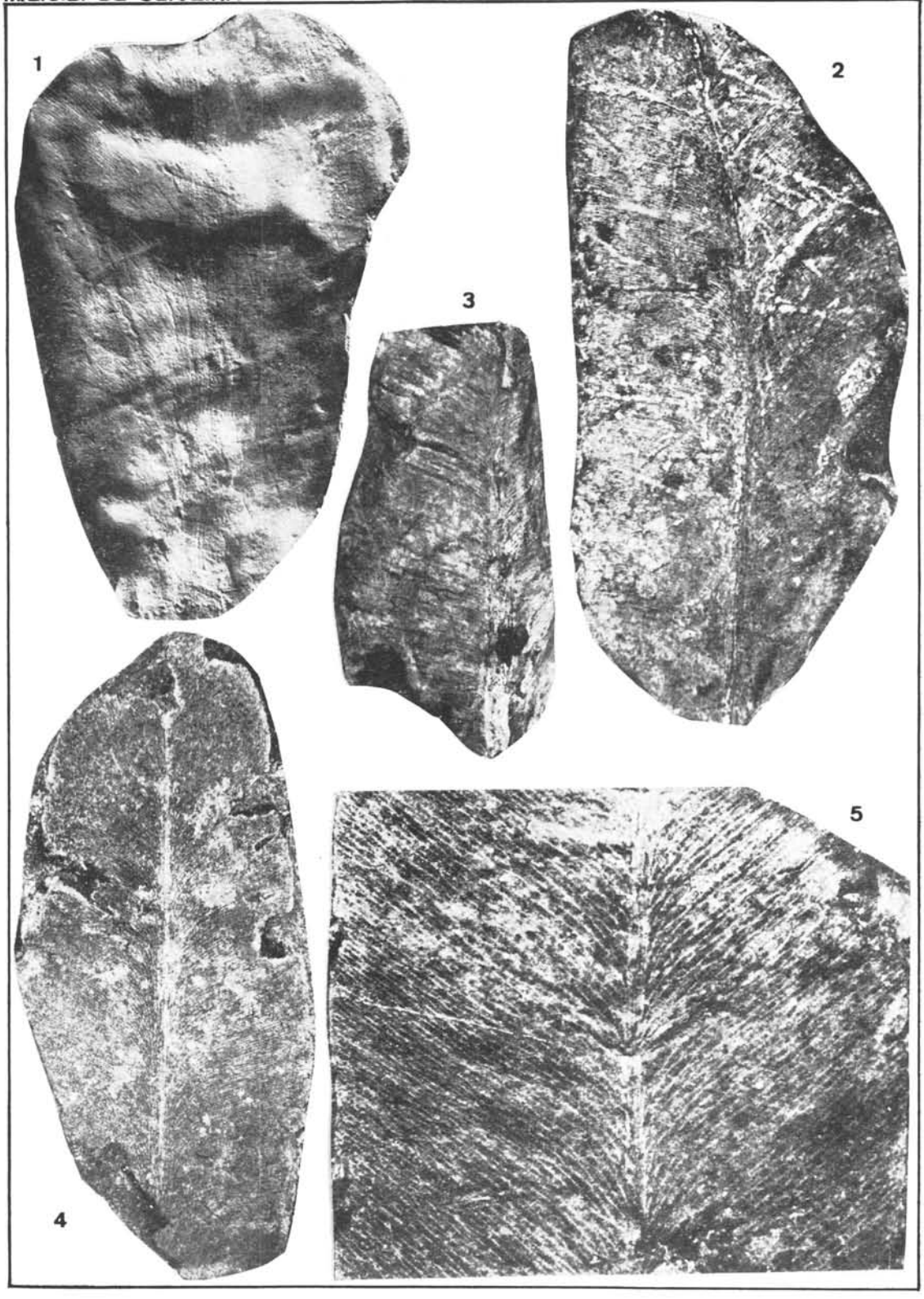
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PLATE 3

Fig. 1 – **Glossopteris stricta** Bunbury. Specimen nº GP/3T 129, a median portion of a leaf. 1,2 x.

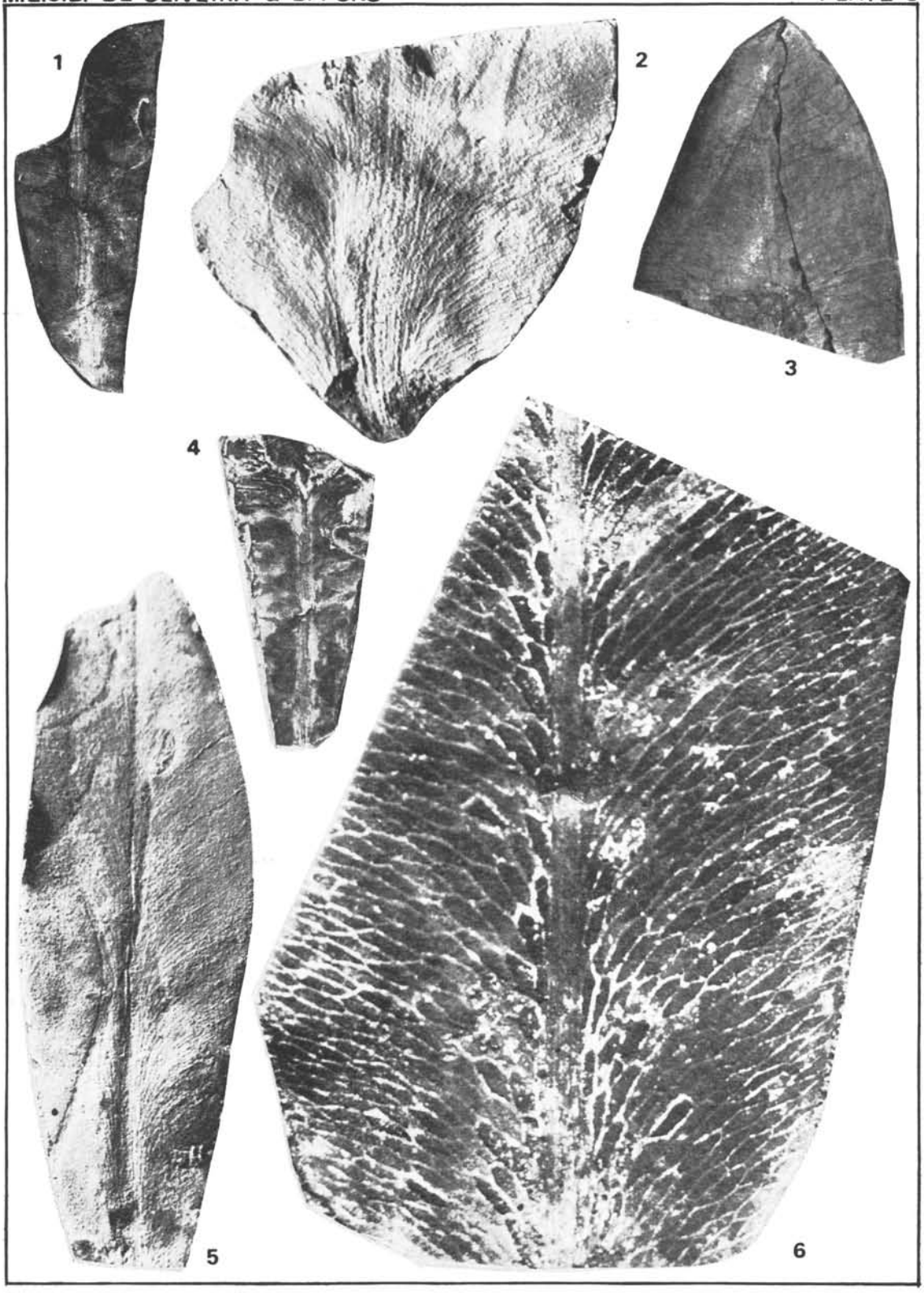
Fig. 2 – **Gangamopteris obovata** (Carruthers) White. Specimen nº GP/3T 130, a basal portion of a leaf, in which the median veins are thicker close to the base, gradually vanishing towards the distal region. 2,5 x.

Fig. 3 – **Glossopteris** cf. **G. occidentalis** White. Specimen nº GP/3T 131, an apical portion of a leaf. 1,2 x.

Fig. 4 – **Glossopteris stricta** Bunbury. Specimen nº GP/3T 132, counterpart of the specimen of fig. 1. 1,0 x.

Fig. 5 – **Glossopteris indica** Schimper. Specimen nº GP/3T 133 An almost entire leaf. 1,9 x.

Fig. 6 – **Glossopteris browniana** Brongniart. Specimen nº GP/3T 134. A basal portion of a leaf showing a well preserved venation. 3,6 x.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