VANNUS GONDWANENSIS, A NEW *GANGAMOPTERIS* FRUCTIFICATION FROM THE TRANSVAAL, SOUTH AFRICA

EDNA P. PLUMSTEAD
University of Witwatersrand, Johannesburg, Transvaal, South Africa

ABSTRACT

A seventh distinctive type of Permo-Carboniferous fructification of the class Glossopteridae is described. The interpretation and affinities of *Vannus* — the Fan type, are discussed. The fructification is almost certainly generically, and possibly specifically identical with a fossil plant originally described by Zeiller from the Karharbari beds of India as *Schizoneura wardi*. One of the new specimens has been found in an axillary position of growth on a leaf identified as *Gangamopteris* cf. *clarkeana* Feistmantel, a species recorded formerly only from Australia and Tasmania. This fossil plant provides a further example of the unusual fructifications of this southern class of plants and, through its relationships, demonstrates once more the close affinity which existed between the floras of component parts of Gondwanaland, at that time.

In addition the fructification exhibits a certain resemblance to *Vojnovskya paradoxa* Neiburg, a lower Permian species from the Angara floral province. The significance of a possible relationship is discussed.

INTRODUCTION

LOCALITY — From the quarry on the farm Leeuwkuil in the Vereeniging district of the southern Transvaal, and from the same horizon as that which yielded the previously described fructifications of Glossopteridae (PLUMSTEAD, 1952, 1956a, b, 1958), a new type has been found. The fossils occur in the lower beds of the Coal Measures of the Karroo System, known as the Middle Ecca Beds, of which only patchy outliers now remain in the area.

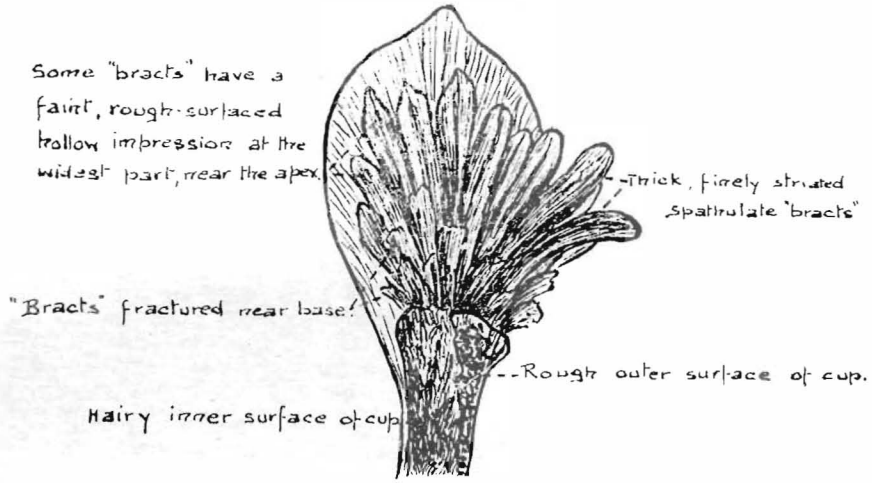
Nature and Preservation of Fossils — There are six specimens of the new fructification in the present collection and one of them is attached to a *Gangamopteris* leaf (PL. 1, FIGS. 1-3) so that the fossils must be included in the Glossopteridae but they differ considerably from all others known to belong to this class of plants. Four of the six specimens, including the composite leaf and fructification, have counterparts. These are not mere impressions of the original, but present different aspects of the same fossil because part of the thick plant organ was embedded in each half. They have therefore, been given different numbers, e.g. 1 and 2 instead of 1 and 1a. In addition there is one other example which probably may be included in the same genus (PL. 3, FIG. 10).

One of the detached fructifications has been replaced by ochre but all the rest may best be described as casts and moulds of compressions of the original plant. Both the matrix of the rock and the replacements are of the same very fine sediment on which minute details of structure are preserved. A little dark organic matter still adheres to both casts and moulds. Although the plant organs are considerably compressed there is still marked relief which in the photographs has been emphasized as much as possible by using very oblique lighting. The aspect presented by each fossil depends on the level at which the rock has been severed. Some, e.g. Plate 2, Figs. 4 and 7 have been parted through the middle of the fructification, others, e.g. Plate 3, Fig. 10, on the outer surface, of what was obviously, originally a radially symmetrical organ.

NAMING AND CLASSIFICATION OF THE FOSSILS

In their compressed state the fossils are essentially fan-shaped and in keeping with the descriptive names selected previously for fructifications of Glossopteridae (PLUMSTEAD, 1958), the name *Vannus* a fan, is proposed for this new genus. The specific name of *gondwanensis* has been selected to indicate that it appears to have a wide relationship within Gondwanaland.

This is the seventh type of the distinctive reproductive organs of the early Glossopteridae to be described. It is possible that some of them may prove to be true genera while others may be of higher status. The position is still far from clear and the new fructification has to a certain extent enhanced the problem, e.g. at the present time *Scutum*, the Shield Type, includes a number of species all of which are associated



TEXT-FIG. 1 — Diagrammatic view of *Vannus* showing axillary growth on *Gangamopteris* cf. *clarkeana* Feist.

with *Glossopteris* leaves which exhibit certain common characteristics. On the other hand only two species of the *Lanceolatus*, or Spear Type are known and they are attached to leaves of two completely different form genera, namely *Glossopteris retifera* and *Palaeovittaria kurzi* and now, the new Fan Type is the second to be associated with leaves of the form genus *Gangamopteris*, since two other species, *Gangamopteris buriadica* and *Gangamopteris obovata* were found with an *Ottokaria* type of fructification (PLUMSTEAD, 1956a). The evidence emphasizes once more that the long established leaf-genera of the Glossopteridae cannot be regarded as true genera and supports the conclusions reached by Srivastava (1956) and Srivastava & Surange (1956) which were based on the cuticular examination of a number of different leaf genera and species. Nevertheless it is proposed that until a system of classification based on true affinities emerges from the present maze of new and old forms, the early practice established by the author, of giving new and distinctive names to each new fructification, should be continued but that for the present, the old established names for previously described leaves, should be retained even where these are found in close association with new fructifications. In this way it is hoped that a premature and possibly erroneous classification will be avoided and that with accelerated interest and research in the Glossopteridae, a true pattern of relationship between its members may not be long delayed.

THE GENUS *VANNUS*

Definition

The genus is a fructification of the class Glossopteridae and is of axillary growth. It consists of a hollow cup-like lower portion, the function of which is at present unknown, and a separate upper portion consisting of a large number of erect blade-shaped projections which have fine longitudinal striations on the surface, and a rounded or pointed apex. Near the top of some of these organs there is a small rough-surfaced indentation. The provisional designation of "bracts" has been applied to these projections pending further knowledge of their function. Specimen V 3 is nominated as the type.

Description of the Fructification *Vannus gondwanensis* gen. *et* sp. nov.

Text-fig. 1, Plates 1-3

In Text-fig. 1 a diagrammatic sketch has been provided which embodies all the features evident in different specimens.

a) *Type Specimens* — The most complete fructification is specimen V 3 (PL. 2, FIGS. 4, 5) and its counterpart V 4 (PL. 2, FIG. 7). Specimen V 3 is therefore nominated as the holotype but since the only fructification

attached to a leaf is specimen V1 (PL. 1, FIGS. 1, 2) and its counterpart V2 (PL. 1, FIG. 3), a special place must be given to it. Specimen V1 is therefore nominated as the "attached holotype".

b) *The Fructification*—This consists essentially of two parts. The lower portion is a tapering cup while the upper consists of a fan-shaped collection of stiff bract-like organs.

The cup measures from 2 to 2·3 cm. in length and tapers upwards from 0·5 cm. at the base to a maximum width of 1·5 cm. In some specimens there is a small outward bulge of the upper part of the cup (PL. 2, FIG. 4 and PL. 3, FIGS. 8, 9). In the holotype (PL. 2, FIG. 4) two surfaces of the cup are visible, an outer one on the upper right-hand side, on which some harsh dark tissue can be seen and a lower, or inner surface covered, especially near the base, with fine hairs which lie in different directions. On the counterpart (PL. 2, FIG. 7), the lower part of the cup is not preserved but vein-like longitudinal markings can be seen in the upper part. These ridges are visible also in Plate 1, Figs. 1 and 2. On Plate 1 the harsh outer surface of the cup has adhered to the counterpart (PL. 1, FIG. 3). For this reason, the lower part of the fructification is regarded as a cup and not merely as a thick, fleshy pedicel supporting the upper half. It is to be noted however that where the inner surface is revealed, the bract-like organs do not extend down into the cup but appear to grow from the top. There is a marked boundary between the two.

The fan-shaped upper half consists of long, spathulate bladed organs which radiate stiffly upwards from the top of the cup. For these the non-commital term bract-like or "bracts" has been selected in preference to petal-like or leaf-like, for their function is not clear. In some specimens there is an outward bulge just above the junction with the cup, resembling the spread of the petals of a rose-bud just above the receptacle. The crowding and overlapping of the bracts makes it difficult to estimate their number. Usually between twelve and fifteen are visible in one plane, but since portions of others can be seen beneath and at least an equal number occur embedded on the counterpart, the total number of "bracts" must be nearer thirty. They vary in length, the longest seen being 4 cm., and are narrowly spathulate in shape with a maximum width of 6-7 mm., which is attained within 4 mm. of the apex, and a minimum width of 2 mm. at the base. That the bracts were thick in section may be seen from the relief shown in Pl. 2 Fig. 5, which was taken with different lighting from that of the same specimen on Pl. 2 Fig. 4. It is especially visible also in the ochreous specimen (PL. 3 FIGS. 8, 9). The organs are likely to have been bladed rather than cylindrical because in the broadest part of some of the "bracts" there appears to be a small oval depression (or an outward bulge according to the view presented) in which the surface is rough. This is incompatible or improbable on a cylindrical object. The apex of each "bract" is either smoothly rounded or tapered quite sharply. Both shapes are evident in each specimen and may indicate a stage of development. The surface of most of the "bracts" is covered with fine longitudinal striae, very closely spaced. In some cases, but not in all, there is a crowding of these in the median region producing a dark line and suggesting a vascular strand (PL. 2, FIGS. 4, 6). A few of the "bracts" have a harsh, dark surface (PL. 1, FIG. 3). It is not known whether all the "bracts" had a striated surface facing inwards and a dark harsher surface facing outwards, or whether there was an outer whorl of harsh-textured "bracts". The latter explanation seems more probable judging by the far larger number of striated "bracts". All the "bracts" are rougher in texture than the vegetative leaves, but less harsh than the surface of the cup so that a marked change of both colour and texture can be observed at the junction between cup and "bracts" and where the latter overlap a leaf. Most of the "bracts" project stiffly upwards and outwards but an occasional curved one can be seen (PL. 2, FIG. 7). This specimen with a number of bracts embedded in the matrix, presents a very different aspect from its counterpart on Pl. 2, Fig. 4, but even in the photographs certain matching features are apparent.

Before discussing the nature of the fructification and the possible functions of each part, attention should be drawn to specimens V11 and V12 on Pl. 3, Fig. 10. The larger object is made up of a number, at least seventeen, of "bracts" of equal length with rounded ends. These are crowded in fan-shape towards the base which is trun-

cated just below a curved junction marking a change of texture. The latter is so harsh and dark that it is traversed by a number of contraction cracks producing an effect of regular rhombic scales. The dimensions agree with those of the larger "bracts" of other specimens, and the whole may represent the fully mature *Vannus*. An advanced stage of development is suggested by several factors which include the uniform length of the "bracts", their harsh texture, and the fact that they appear to be flatter and thinner than in other specimens and more nearly in one plane. This could be interpreted to mean either that the bracts became thinner and more scale like with age or even that the outer whorl of "bracts" had fused together into a sterile cup and that this specimen represents, therefore, the only complete external view of a fructification.

The smaller object on the same specimen lies only 2 cm. away. It too has a tapering fan shape and a ridge of hard tissue is preserved. It is not divided into "bracts" and, therefore, cannot represent a young form of *Vannus* but the shape and size are not incompatible with the cup portion which is missing from the larger specimen. The radiating marks on the cup are comparable with those on Pl. 3, Figs. 8 and 9. The whole object is convex. These two specimens are provisionally included in the genus *Vannus*.

c) *Possible Interpretation of Vannus* — That *Vannus* is a reproductive organ appears to be highly probable but whether it is male, female, or bisexual cannot yet be determined. If it were a male organ, the "bracts" might be microsporophylls or pollen organs, similar to the stiff male organs found in the "floral" stage of *Scutum* (PLUMSTEAD, 1956b). Alternatively the "bracts" might have been thick, flat, petaloid stamens on which anthers occupied the small hollows near the top, in much the same way as in *Williamsoniella* (THOMAS, 1915).

Interpretation as a female fructification is less probable. Naked seeds might have been borne in the hollow scars near the top of each "bract" but this position is not in keeping with any known form of gymnosperm.

Finally, a bisexual interpretation is not impossible. On first sight the appearance of the fructifications suggested a longitudinal view of a Bennettitalean flower. Although several specimens resembling this order of plants have been found on the same horizon (PLUMSTEAD, 1961, PL. 9, FIGS. 1, 2, 3), they were considerably larger, had far more "bracts" and had a central axis. Of the latter there is no sign in any of the present specimens. If, however, the "bracts" were petaloid stamens and grew, as suggested, from the flat top of the cup, the function of the latter is still unanswered. Is it possible that the hollow cup served the purpose of an ovary inside which seeds ultimately developed? Such an interpretation implies true angiospermy but only time and new specimens can elucidate these problems.

d) *Position of Growth* — From the only attached specimen (PL. 1, FIGS. 1, 2, 3) it appears that the fructification was borne in the axil of a sessile leaf, for the tapering bases of both coincide and must have been closely pressed against the stem on which they grew. It is improbable that there was any organic connection between them and the preservation of this composite specimen is particularly fortunate because the weight and the stiff texture of the fructification would no doubt have accelerated an early separation from the leaf, in the event of both being torn simultaneously from the plant. Further composite specimens may therefore be even more rare than in those Glossopteridae where actual attachment exists between leaf and fructification.

e) *Comparisons* — The only known specimens from Permo-carboniferous rocks, anywhere in Gondwanaland, which resemble the present fructification, are fossils from the Karharbari Beds of India which were originally described as *Schizoneura wardi* Zeiller (1902, pp. 27-29, PL. VI, FIGS. 7, 8, 9). Figs. 5-9 on the same plate were included in Zeiller's new species but although Figs. 5 and 6 are probably equisetalean there is, I think, a considerable doubt about Figs. 7-9 in which the leaflets are both longer and wider. Zeiller believed that the clear junction between the two portions, represented a node on a smooth stem and that the numerous "bracts" which fanned out erectly above it, were part of a leaf whorl of which the segments were "partly joined near the base or quite free". They appear to be too numerous for this interpretation. He mentioned that these leaflets were thick in texture and longitudinally striated but thought a grouping of the striae in the

median region constituted a more or less distinct median nerve. The dimensions he gave were slightly below those of the Transvaal specimens.

Recently, Höeg & Bose (1961, p. 31; Pl. IV, Fig. 3) illustrated a similar specimen from the Permian transition beds of Greinerville horizon f5, of the Lukuga Series of the former Belgian Congo. This specimen is less well preserved than the Indian specimens but it too presents all the essential features of *Vannus*. The authors named it *Schizoneura* sp. and drew attention to its similarity to *S. wardi* Zeiller.

The Indian specimens (Zeiller 1902, Pl. VI, Figs. 7-9) are so remarkably like the present specimens of *Vannus* that I have little doubt that they are generically and possibly even specifically identical. The "bracts" may be a little narrower and the apices are not very clear but in both Figs. 8 and 9 the markedly spathulate shape can be seen and on the lower left-hand side of Fig. 8, several of the "bracts" appear to have a rounded depression in the widest part, near the tip. The original specimens will have to be re-examined to prove the degree of relationship and I hope that this task will be undertaken in the near future by fellow palaeobotanists in India. In addition to the remarkable similarity between these supposed equisetalean remains and the present fructifications, several other factors are significant. The characteristic features are not only unusual and some of them unknown in the genus *Schizoneura* but in the sixty years since they were first described, no other specimens resembling this species have been found to my knowledge, anywhere in Gondwanaland, until the Congo and Vereeniging occurrences mentioned above. Secondly, it appears to be remarkable that each example had been severed with exactly the same amount of stem and a single whorl of leaves. Thirdly, and perhaps of greatest importance, is the fact that Zeiller's *Schizoneura wardi* was found in the same area and from the identical horizon — namely Passerabia 17c bed No. 3, Karharbari basin — as *Ottokaria bengalensis*. This specimen which was originally described as *Feistmantelia bengalensis* (Zeiller, 1902, p. 34; Pl. IV, Figs. 8, 9, 10) was likewise believed by Zeiller to be a vegetative structure but it is now known to be the only fructification of *Gangamopteris* recorded up to now from India (Plumstead, 1956a). In the circumstances it would appear that a renewed search of this horizon at Passerabia, for other fructifications of Glossopteridae might prove profitable.

Even if the Indian specimens should prove on re-examination to be identical with those from the Transvaal the present interpretation of the fossil differs so greatly from that of Zeiller that his generic name could scarcely be retained and the plant should be transferred to the new genus *Vannus*.

THE LEAF

a) *Description of the associated Leaf — Gangamopteris* cf. *clarkeana* Feistmantel (Pl. 1, Figs. 1-3, Pl. 3, Figs 11, 12).

Only two specimens of this leaf have been recognized at Vereeniging but in each the preservation is good, and both have counterparts. Specimens 1 and 2 (Pl. 1, Figs. 1-3) bear the axial fructification which masks part of the leaf, so that the details can best be seen in specimens 13 and 14 (Pl. 3, Figs. 11, 12). The margin is entire and is so clearly defined that the leaf was probably thick. The shape is ovate and spathulate and the size, $8 \times 3{\cdot}8$ cm., with the greatest width, approximately 2·5 cm. from the apex which is rounded, but with a small pointed tip. Specimen 1 is a little smaller and the apex is less pointed. The leaf tapers to a base, approximately 1 cm. wide, which is abruptly truncated. The lowest 5 mm. is quite smooth and probably represents the portion of the sessile leaf which was wrapped around the stem, but above this narrow strip, approximately nine thick parallel veins arise and fan outwards, by bifurcation, as the leaf widens. Anastomoses are distinct but not common. The mesh is elongate, often between 2 and 3 cm. long, and acute angled at either end. The veins are a little less than 1 mm. apart but are slightly more crowded in the centre, especially near the base of the leaf, where they produce a darker median zone but there is no mid-rib. The absence of the latter and the small degree of reticulate venation together place the leaf without doubt in the form-genus *Gangamopteris* in which species of this size are rare.

b) *Comparison with Other Gangamopteris Species* — The Transvaal leaves approximate so closely in both size and other features to *Gangamopteris clarkeana* Feistmantel (1890, Pl. XX, Fig. 3, p. 131) from the Bacchus

Marsh beds of Victoria, Australia, and also from the Bowenfels of New South Wales, that there is very little doubt of their relationship. Feistmantel described the leaf as follows: " Frond spathulately rounded, of medium size, coriaceous entire, symmetrical, rounded above but gradually tapering towards the base, whence radiate the somewhat thick and distant veins forking and forming an oblong network. It reminds one of *Gangamopteris spathulata* McCoy[1]".

The only feature in which the Transvaal leaves differ from this description is in the apex, for the Australian leaf is symmetrically rounded without the small point which occurs in the present specimens. It is however possible that the mucronate leaf is a reflection of a stage of development and not a constant feature, because the point differs in degree in the two Transvaal specimens and because the " bracts " of the fructification — which in related organs often reflect the shape of vegetative leaves — show markedly pointed as well as symmetrically rounded forms. Until more leaves have been found, it is probably wiser to adopt the term *G.* cf. *clarkeana* rather than to assume specific identity.

Gangamopteris spathulata McCoy with which Feistmantel compared *G. clarkeana* may be discounted in this case because it is considerably larger and also petiolate.

Besides Feistmantel's two references to this species (1878, p. 93; PL. XV, FIG. 9) which I have not seen, and the English version of the same publication in 1890 (PL. XX, FIG. 3, p. 131), it has been mentioned but not illustrated by both Tenison Woods (1883, p. 127) and by Johnston from Tasmania (1886, p. 380) but has not to my knowledge been recorded since then from any other part of Gondwanaland.

Arber (1905, p. 108) included *Gangamopteris clarkeana* with *G. obovata* (formerly *G. cyclopteroides*) but the venation is quite different and far coarser. It is possible however, that in the past, a number of specimens, if not very well preserved, might have been mistaken for small leaves of *G. obovata*. This discovery in Africa of so similar a leaf indicates that Feistmantel's species should be restored. It may be of interest to record that Höeg & Bose (1961, PL. IX, FIGS. 1, 2) illustrated two fragments of leaves which they named *Gangamopteris* sp. in which the venation resembles *G. clarkeana*. Unfortunately, in each case only the upper part of the leaf was preserved. The specimens were from the Greinerville District of the former Belgian Congo and were found in horizon f6 of the Lukuga Series, while the specimen of *Schizoneura* cf. *wardi*, referred to above, came from horizon f5 of the same area.

AFFINITIES OF THE PLANT

The connection of *Vannus* with a *Gangamopteris* leaf places it in the class Glossopteridae but it appears to have little in common with any of the previously described fructifications save in the blade-shaped possible microsporangia and the fact that it shares a high degree of development. It can, with little difficulty, be fitted into the scheme recently outlined by Melville (1960), as the Gonophyll theory of the origin of Angiosperms from a possible early stock of Glossopteridae. Although *Vannus* is not yet well enough known to be allocated to any exact stage of development there are possibilities that it may prove to be the most advanced form yet described, for in several ways it anticipates a capitulum type of inflorescence. The differences between *Vannus* and *Ottokaria* fructifications foreshadow that the leaf *Gangamopteris* cf. *clarkeana* must in due course be separated from the form-genus *Gangamopteris*.

AGE AND RELATIONSHIP OF *VANNUS GONDWANENSIS* WITH THE GONDWANA FLORA

It has not been possible to compare the type fossils of *Schizoneura wardi* Zeiller, and of *Gangamopteris clarkeana* Feistmantel with the present fossils save only through published figures and descriptions. If however the relationships implied in this paper are acceptable, these rare fossils provide a remarkable link between widely separated areas of Gondwanaland, namely — the lower Transvaal Coal Measures, horizons f5 and f6 of the Lukuga beds of the former Belgian Congo, an horizon at Giridih in the Karharbari basin of India, and two horizons in Australia. Of the latter, the Bacchus

1. Attention is drawn to a misprint in the description opposite Pl. XX in Feistmantel 1890. The name of Fig. 3 is given as *Gangamopteris clarkei* and the page of reference as 123, which actually applies to *Glossopteris clarkei* a completely different species. The name should have read *Gangamopteris clarkeana* and the reference page as 131.

Marsh beds of Victoria are usually regarded among the lowest of the Glossopteris bearing beds of Australia and of Permo-Carboniferous, or at least lower Permian age. They are thus comparable with the Karharbari beds of India and the Vereeniging lower Coal Measure beds of South Africa, but the Bowenfels beds of New South Wales were grouped by Feistmantel in the Upper Coal Measures and therefore, as possibly, of Middle Permian age. Geographical and stratigraphical links of this kind are of considerable importance in the elucidation of Gondwana horizons.

RELATIONSHIPS OF *VANNUS GONDWANENSIS* WITH THE ANGARA FLORA

Within recent years there have been several claims of relationships between the Gondwana and Angara floral provinces (NEIBURG, 1948, 1954). *Vannus gondwanensis* exhibits a striking but possibly superficial resemblance to *Vojnovskya paradoxa*, a fructification from the lower Permian beds of the Pechora basin (NEIBURG, 1955). This strange plant was arborescent and bore simple leaves which were deciduous and had wide bifurcating venation. Growing in the axes of some leaves were " umbrella " like, bisexual fructifications with a strong tapering stalk — corresponding to the cup of *Vannus* — from the flat top of which a large number of blade-like micro and macrosporophylls projected. Neiburg's illustration of a branch bearing several leaves and fructifications has been reproduced recently by Andrews (1961, FIG. 12-2; p. 352) and this may serve for comparison where the original publication is not available. A detailed examination, however, reveals a number of important differences. The leaves were of the genus *Nephropsis* Zalessky to which Neiburg added a number of species including the present *N. rhomboidea* (NEIBURG, 1948, PL. LXIII, FIGS. 5-8), of which the leaves have long, broad petioles and the shape is rhomboid and broader than long. They resemble Ginkgoales rather than Glossopteridae in both shape and venation although the venation spacing is superficially like *Gangamopteris clarkeana*, the leaves do not exhibit a single anastomosis.

The similarity of the fructifications too may be more superficial than real. Neiburg interprets the lower half as a thick solid stalk covered with tiny hooked leaflets, and not as a hollow cup. The blade-like projections include microsporophylls with a small ring of microsporangia near the apex in a position similar to that suggested by the oval hollow areas on *Vannus* " bracts ". No mention of pollen was made. There are a few macrosporophylls resembling small *Samaropsis* seeds, but there appears to be a slight doubt about their actual connection with the plant. I cannot determine from the description whether Neiburg found sterile " bracts " in addition to the fertile ones, or whether the fertile condition was a late development, for in the illustration a marked difference of shape is shown between male and female sporophylls respectively and the majority of what may be sterile scales. In *Vannus* no such difference was apparent in any specimen, a fact which might be attributed to an early stage of development or might imply a basic morphological difference. The Angara fructifications are approximately one-third to one-half of the size of the Gondwana ones. Neiburg made this plant the type of a new order, the Vojnovskyales in which she placed also the reproductive genera *Gaussia*, *Taibia* and *Niazonaria* which were illustrated by her in 1948 (*Gaussia*, PL. XXI, FIGS. 1-6; PL. LXX, FIGS. 6, 6a, 7, 7a; *Taibia*, PL. LXXI, FIGS. 7, 8, 9 and *Niazonaria*, PL. LXXII, FIGS. 1-8). These three genera are all more Bennettitalean in appearance and all the preservations are transverse compressions rather than the longitudinal ones which characterize *Vannus* and *Vojnovskya*. It is not yet possible to suggest any relationship between the Vojnovskyales and some of the Glossopteridae but the present resemblances are important, especially since they are not known to have been shared by any Palaeozoic representatives of either the Euramerican or Cathaysian floras. The similarities moreover are not confined to the plants under immediate discussion, but include plants like several species of *Noeggerathiopsis*, *Ginkgophyllum*, *Barakaria*, *Gondwanidium*, " *Glossopteris* " *uralica* Zallesky (NEIBURG, 1948, 1954) and others. Not all of these exhibit close resemblances to the Gondwana genera of the same name and further investigation may either increase or refute the relationship suggested by the common use of these generic names but the present evidence is sufficient to indicate that a different

direction, or possibly a different rate, of evolution existed in the floral provinces of Gondwanaland and Angara land from those elsewhere in late Palaeozoic times.

Since the existing plant classifications were built on the basis of Euramerican fossil floras, there is no room in them for the new fructifications discovered recently in these two provinces. Attempts have been made by Lam (1957) and Pant (1957) to fit the Glossopteridae into adapted classifications but neither is entirely satisfactory. I have on several occasions suggested that the Glossopteridae might have provided a direct line towards Angiospermae and that they exhibited a closer relationship with the flowering plants than with any other known class of plants. Neiburg (1955) too, has faced this difficulty and while regarding Vojnovskyales as a new order of gymnosperms, because she found naked seeds, has pointed out that the fructifications were more reminiscent of very primitive bisexual flowers and must have developed during Carboniferous times. It is generally accepted that Glossopteridae made their first appearance in South America, Africa and Queensland during the Carboniferous Period.

ACKNOWLEDGEMENT

I should like to express my gratitude to Mr. S. F. le Roux who found the specimens described; to the C.S.I.R. of South Africa and to the Council of the Witwatersrand University for research grants towards the expenses of photography and travelling in the preparation of this paper, to Dr. George F. Hart for translating the relevant parts of Russian publications and to Mr. Mark Hudson for technical assistance.

REFERENCES

ANDREWS, HENRY N. JR. (1961). Studies in Palaeobotany. John Wiley & Sons Inc. *New York and London.*

ARBER, E. A. NEWELL (1905). Catalogue of the Fossil Plants of the Glossopteris Flora in the British Museum. *London.*

FEISTMANTEL, O. (1878). Palaeozoische und mesozoische Flora des östlichen Australiens. *Palaeontographica*, Suppl. iii, Lief 3.

Idem (1890). Coal and Plant-bearing Beds of Palaeozoic and Mesozoic Age in Eastern Australia and Tasmania. *Mem. Geol. Surv. New South Wales Palaeont.* No. 3.

HÖEG, O. A. & BOSE, M. N. (1961). The Glossopteris Flora of the Belgian Congo. *Ann. du Musée Royal du Congo Belge.* Serie 8°; *Sci. Geol.* **32**.

JOHNSTON, R. M. (1886). General observations regarding the classification of the upper Palaeozoic and Mesozoic Rocks of Tasmania. *Proc. Roy. Soc. Tasmania* 1885.

LAM, H. J. 1957. Comments on Greguss's phylogenetical tree of plants. *Blumea* **8**(2): 528-531.

MELVILLE, R. (1960). A new theory of the Angiosperm Flower. *Nature*, **188**(4744): 14-18.

NEIBURG, MARIA F. (1948). *Palaeontology of U.S.S.R.* **12**, pt. 3.

Idem (1954). Description of the phytostratigraphic comparisons of the upper Palaeozoic deposits of Angara and Gondwana. *Problems of the Geology of Asia* **1**; *Acad. Sci. of U.S.S.R.*

Idem (1955). A New Representative of the Lower Permian Flora of Angara. *Rep. Acad. Sc. U.S.S.R.* **102**(3): 613-616.

PANT, D. D. (1957). The Classification of Gymnospermous Plants. *The Palaeobotanist* **6**: 65-70.

PLUMSTEAD, EDNA P. (1952). Description of two new genera and six new species of fructifications borne on Glossopteris leaves. *Trans. geol. Soc. S. Afr.* **55**: 281-328.

Idem (1956a). On *Ottokaria*, the Fructification of *Gangamopteris*. *Trans. geol. Soc. S. Afr.* **59**: 211-236.

Idem (1956b). Bisexual Fructifications borne on Glossopteris leaves from South Africa. *Palaeontographica.* **100B**: 1-25.

Idem (1958). Further Fructifications of the Glossopteridae and a Provisional Classification based on them. *Trans. geol. Soc. S. Afr.* **61**: 52-75.

Idem (1961). The Permo-Carboniferous Coal Measures of the Transvaal, South. Africa — an example of the contrasting stratigraphy in the Southern and Northern Hemisphere. Quatrième Congrès pour l'avancement des études de stratigraphie et de geologie du carbonifere. *Heerlen.* 1958, **2**: 545-550

SRIVASTAVA, P. N. (1956). Studies in the Glossopteris Flora of India 4. *Glossoteris, Gangamopteris* and *Palaeovittaria* from the Raniganj Coalfield. *The Palaeobotanist.* **5**(1): 1-45.

SURANGE, K. R. & SRIVASTAVA, P. N. (1956). Studies in the Glossopteris Flora of India 5. Generic status of *Glossopteris, Gangamopteris* and *Palaeovittaria*. *The Palaeobotanist.* **5**(1): 46-49.

TENISON-WOODS, REV. J. E. (1883). On the Fossil Flora of the Coal Deposits of Australia. *Proc. Linn. Soc. New South Wales* **8**, Pt. 1: 127.

THOMAS, H. H. (1915). On *Williamsoniella*, a new type of Bennettitalean flower. *Phil. Trans. Roy. Soc. London.* **207B**: 113-148.

ZEILLER, R. (1902). Observations sur quelques plantes fossiles des Lower Gondwanas. *Pal. Ind. N.S.* **2**: 1-40.

EXPLANATION OF PLATES

PLATE 1

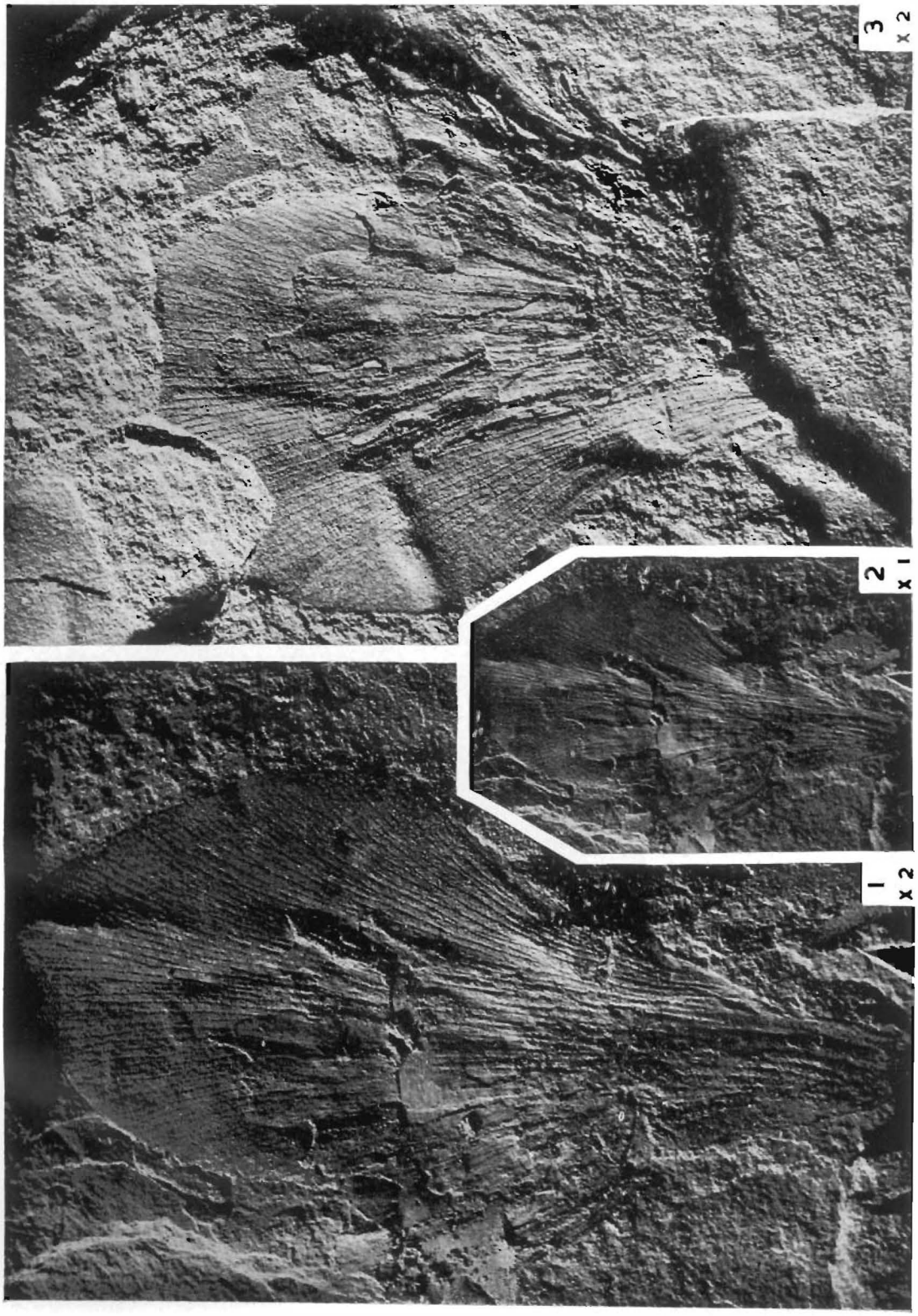
1. *Vannus gondwanensis* gen. et sp. nov. shown in an axillary position of growth on *Gangamopteris* cf. *clarkeana* Feistmantel sp. V1. × 2.
2. The same specimen as Fig. 1 × 1.
3. The counterpart of Fig. 1 (Note that a large amount of the rough-textured surface of the " cup " has adhered to this half of the plant fossil). Spec. V2. × 2.

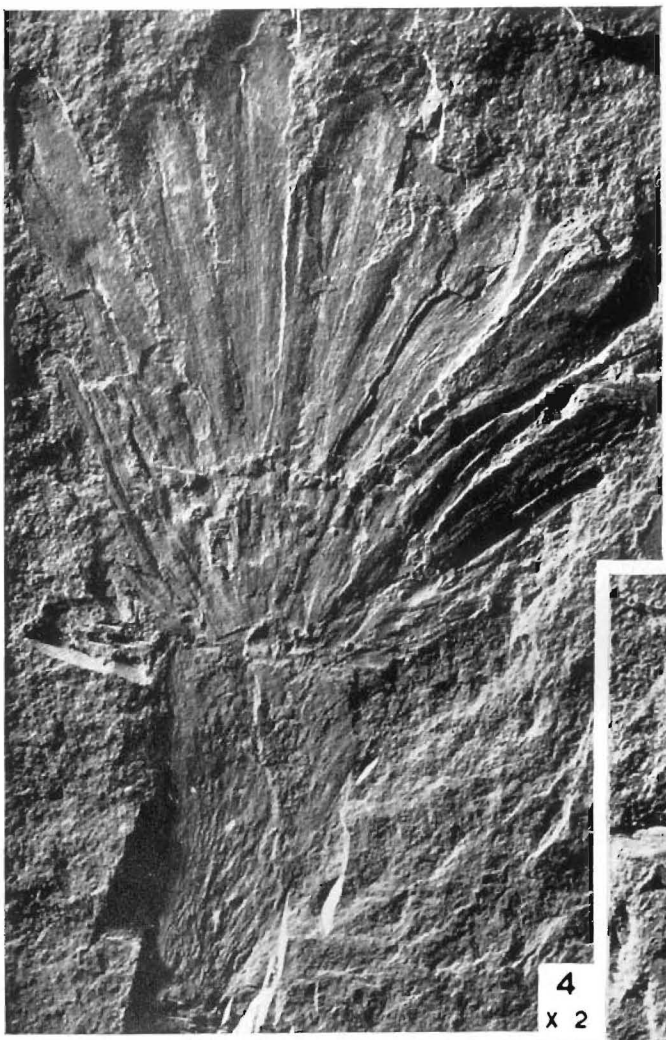
PLATE 2

4. *Vannus gondwanensis* gen et. sp. nov. (Note the inner and outer surfaces of the " cup ", the finely striated " bracts " and the rough-surfaced hollow areas near the tips of some of them). Spec. V3. × 2 — Holotype.
5. The same specimen as Fig. 4. Nat. size. (This photograph was taken with lighting from the right-hand side which emphasizes the relief.)
6. Portion of a fructification to show the variation in the shape of the apices of " bracts " and the outward bulging just above the junction with the cup. spec. V6. × 2.
7. The counterpart of Fig. 4 in which some of the " bracts " fractured in Fig. 4 are preserved on this half of the plant fossil. Spec. V4. × 2.

PLATE 3

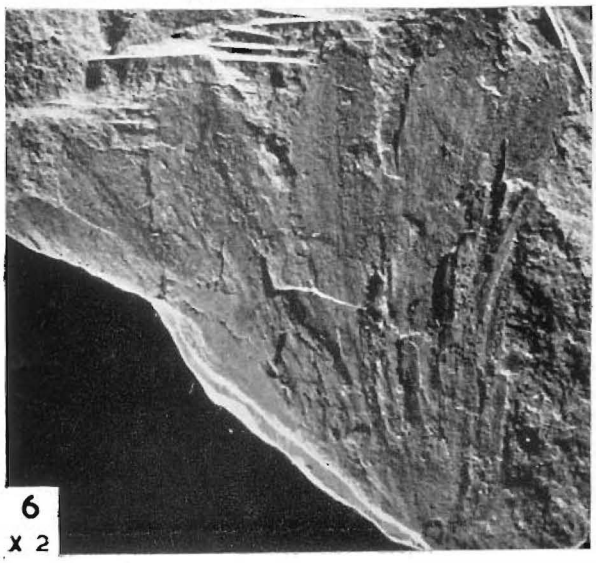
8 and 9. Counterparts of a fructification replaced by iron oxide, showing the thickness of individual bracts. Specs. V9. and V10. × 1.
10. The two plant fossils may represent the separated fanned and cup portions of a mature fructification. (Note the dark rough tissue and the equal length of the " bracts "). Specs. V11 and V12. × 1.
11. *Gangamopteris* cf. *clarkeana* (Note the smooth base of the sessile leaf). Spec. V13. × 1.
12. Counterpart of Fig. 11 to show venation. spec. V14 × 2.


1
x 2
2
x 1
3
x 2



4
X 2

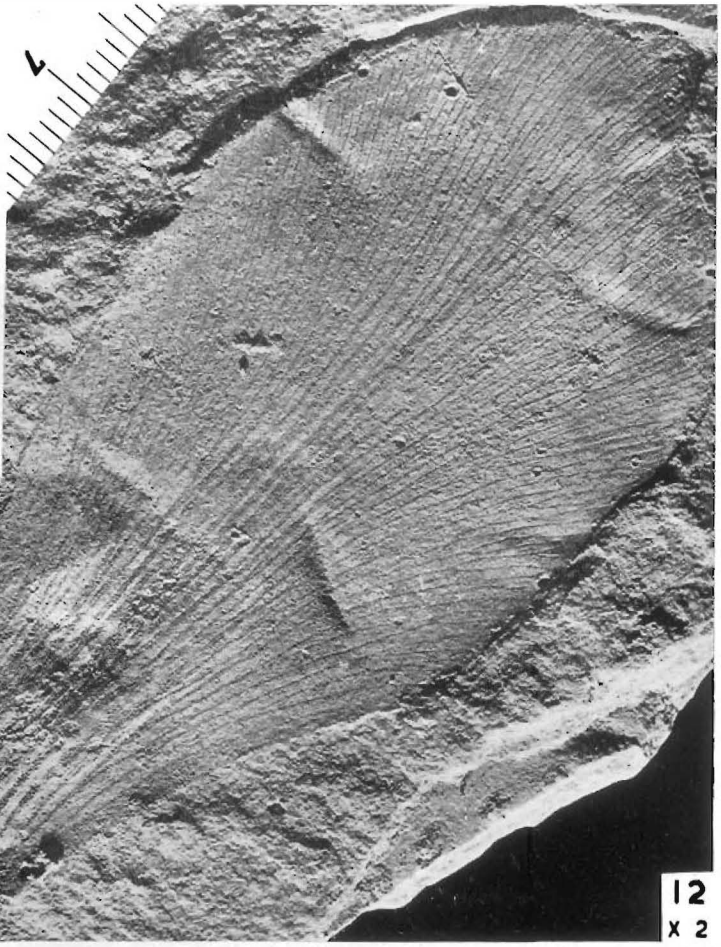
5
X 1



6
X 2

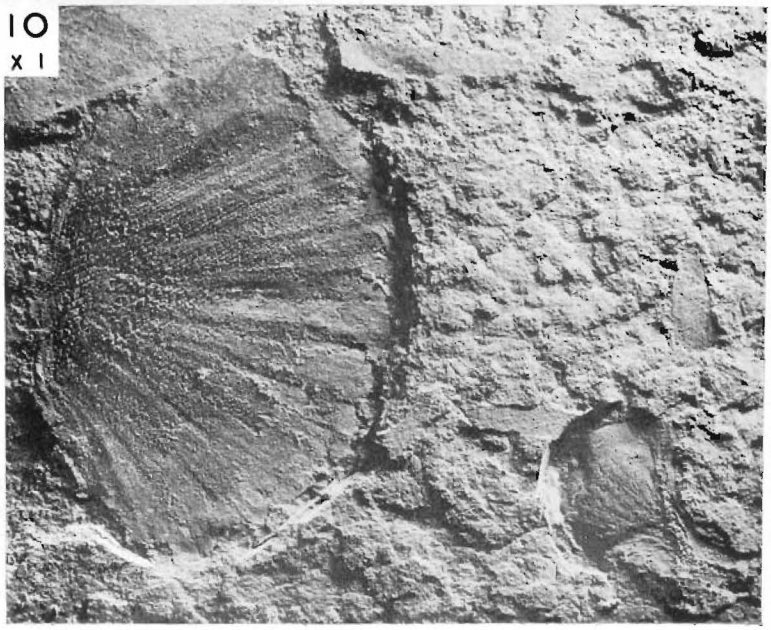
7
X 2


8
X 1


12
X 2


9
X 1


11
X 1


10
X 1