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CLARIFICATION OF THE GENUS *PALAEOVITTARIA* FEISTMANTEL

by

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ABSTRACT

Ever since the genera *Palaeovittaria* and *Noeggerathiopsis* were first established it seems that separating them has posed problems for many palaeobotanists, yet the original definitions noted clear and unambiguous generic differences in their leaf venation; these characters are now applied in the identification of South African leaves. In *Palaeovittaria* leaves the veins run toward the margin over the entire length of the lamina, and they radiate fan-wise in the apical portion. In *Noeggerathiopsis* , on the other hand, the veins appear to run parallel to the margins over the whole length of the lamina, from base to apex, and they intersect the margin only in the apical region. Interpretation of the chronostratigraphic distribution of *Palaeovittaria* Feistmantel, 1876 has also been problematical. It has been regarded on the one hand as a genus restricted to late Permian floras, and on the other as a very early member of *Glossopteris* floras, thus implying an early Permian age. The reason for this discrepancy is discussed. It is concluded that by direct interpretation of the available data, *Palaeovittaria* must be regarded as a late Permian taxon.

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INTRODUCTION

The genus *Palaeovittaria* was described by Feistmantel (1876a) on the basis of material collected from the Raniganj Coalfield, Raniganj Stage of the Damuda Series of India. He noted that most Lower Gondwana plants that were then known came from this Stage. The stratigraphic position of the Raniganj Stage as the highest horizon of the Damuda Series was already well established by the time Feistmantel began his study of the floras. This stratigraphic interpretation has not altered since, in spite of considerable disagreement among 19th century geologists and palaeontologists about its age. (Feistmantel (1876a: 334) designated the highest horizon in the Damuda Series the "Raniganj-Kamti group". In the present paper the terminology of Lakhanpal, Maheshwari and Awasthi (1976) is followed, and accordingly the Indian fossiliferous beds discussed are referred to as "Raniganj Stage".)

The precise description of *Palaeovittaria kurzii* (the only species of the genus known by Feistmantel), combined with knowledge of other components of the well known Raniganj floras and of their stratigraphic position, have offered a stable basis for further studies. However, in spite of this, certain initial uncertainties and later misconceptions have continued to hinder proper understanding of the genus *Palaeovittaria*. The main problem concerns its chronostratigraphic distribution — a consequence of a longstanding debate on the age of several geological horizons, including the Raniganj Stage. Another problem has been the difficulty of separating *Palaeovittaria* from other genera, notably *Noeggerathiopsis*; this difficulty is compounded by the old argument on the distinction between *Cordaites* and *Noeggerathiopsis*. Furthermore, classification of *Palaeovittaria* in the same suprageneric category as *Glossopteris* is considered questionable. These problems are discussed in the light of Feistmantel's conception of the genus *Palaeovittaria*.

THE GENUS *PALAEOVITTARIA* FEISTMANTEL 1876.

Definition of the genus *Palaeovittaria* and of the species *P. kurzii* by Feistmantel.

Nine leaves, evidently all coming from a common point, were recognised by Feistmantel (1876a) as constituting a new genus of fossil ferns. He thought the aggregation of leaves was not due to insertion on a common stalk, but rather to associated growth out of the rhizome (Feistmantel, 1876a: 369). According to Dr. Kurz, then Curator of the Botanical Gardens of Calcutta, the character of the nervation was similar to that of the living fern genus *Vittaria*, hence the generic name *Palaeovittaria* given to the fossils by Feistmantel.

Feistmantel (1876a: 368) described the new genus as follows: "There is a distinct midrib (rachis, costa) in the lower part of the frond, pretty broad, becoming thinner upwards and vanishing completely in the apical portion.

"The secondary veins pass at very acute angles towards the margin, where they are a little incurved; they are single and forked as in *Taeniopteris* . . .

"Diagnosis: Frondibus simplicibus, oblongato-ovalibus, costa apicem versus evanescente. Nervis secundariis sub angulo acutissimo eggredientibus. Nervatio Vittariae."

In his description of *P. kurzi (= P. kurzii)* he added the following characters (Feistmantel, 1876a: 368-369): the leaves are "generally oblong-spathulate, entire on the margins, but they are sometimes deeply emarginated and therefore bilobate at the apex"; the veins are "pretty straight towards the margin", in the apical portion they "radiate fan-wise", and they are "alternately single and forked; the furcation occurs at different parts of the length of the veins, all of which are regularly equally distant from one another"; no distinct peduncle could be observed.

Diagnosis of *P. kurzii*: *"Frondibus aggregatis, simplicibus, oblongato-ovato-spathulatis, margine integris, nonnunquam apice excisis, nervo medio (costa) inferiore in parte crassiore, dimidiam partem versus evanescente; nervis secundariis sub angulo acutissimo e rhachide exeuntibus, in parte apicali radiantibus, simplicibus et furcatis; marginem versus incurvatis, sequente precedentem ea in parte attingente"* (Feistmantel, 1876a: 368).

Feistmantel (1876a) distinguished *Palaeovittaria* from *Sagenopteris* by the lack of anastomoses in the former, and from *Taeniopteris* by the more acute angle at which the secondary veins pass out from the midrib in *Palaeovittaria*. He noted, moreover, that *Taeniopteris* has a midrib extending to the apex of the leaf, whereas in *Palaeovittaria* the midrib is confined to the lower part of the leaf.

He later compared *Palaeovittaria* with *Noeggerathiopsis* Feist. and *Rubidgea* Tate, noting that the latter two genera are distinguished from *Palaeovittaria* by their lack of a midrib. He observed that the veins radiate from the base in *Noeggerathiopsis*. The veins of *Rubidgea* are much more oblique than those of *Palaeovittaria* and are curved, not straight (Feistmantel, 1881: 91).

The distinguishing character given for *Palaeovittaria* — presence of midrib — is similar to that of *Glossopteris*, and has been the cause of much of the confusion. Pant and Verma (1964a) examined Feistmantel's type material, and they spoke of "ill-defined midrib . . .", and "closely arranged parallel veins . . ." in *P. raniganjensis* Pant and Verma, indicating that they could find no clear midrib in the *Palaeovittaria* leaf. Even the drawings of *Palaeovittaria* leaves that illustrated the original description (Feistmantel, 1876a: pl. XIX, figs 3-4) show no distinct midrib in any of the specimens.

From Feistmantel's description and illustrations the following diagnostic characters of the genus *Palaeovittaria* can be gleaned: veins in the central zone of the basal portion lie parallel to each other, while those lateral to this parallel-veined zone pass out at acute angles and intersect the margin along its entire length from base to apex; they are straight, incurving slightly only at the margin; they are single and forked, and equidistant from one another.

Although these generic characters make separation possible, *Palaeovittaria* has nonetheless often been confused with other genera by later authors.

Separation of *Palaeovittaria* from other genera

Although Feistmantel himself did not compare *Palaeovittaria* with *Glossopteris*, the single and forked veins lacking anastomoses of the former separate it not only from *Sagenopteris*, as he noted, but also from *Glossopteris*. Pant and Verma (1964a: 46) drew attention to the fact that misidentifications have occurred in the past when leaves with anastomosing venation have been referred to *Palaeovittaria*. More recently, the leaves with anastomosing and arching venation referred by Anderson and Anderson (1985: 109) to *Palaeovittaria goedehoopensis* have been similarly misidentified; they are *Glossopteris* leaves.

Although Feistmantel distinguished *Palaeovittaria* from *Rubidgea*, Anderson and Anderson (1985) considered *Rubidgea* Tate 1867 a synonym of *Palaeovittaria* Feistmantel 1876, but they did not put forward any reasons to support their proposal. These authors also overlooked the fact that Seward (1907) regarded *Rubidgea* as a synonym of *Glossopteris*, and Seward's conclusion was later confirmed (Kovács-Endrődy, 1977). Other problems regarding *Palaeovittaria* and *Rubidgea* relate to chronostratigraphic considerations; this will be returned to below.

Separation of *Palaeovittaria* from *Glossopteris* is not difficult if the diagnostic characters of both genera are not ignored; mere comparison of the formal definitions of *Palaeovittaria* and the erstwhile *Rubidgea* (Tate, 1867) will reveal obvious differences between them. However, discrimination between *Palaeovittaria* and *Noeggerathiopsis* presents real problems because Feistmantel himself did not separate these two genera clearly. Comparison of his diagnoses (Feistmantel, 1876a: 368; 1879: 23), shows a lack of distinct diagnostic characters other than the presence or absence of a midrib. The definitions of the two genera by Pant and Verma (1964a: 48; 1964b: 23) similarly offer no help in generic separation of their leaves. However, by reference to the definition of *Noeggerathia hislopii* (Bunbury, 1861: 334), the two genera can be distinguished on the basis of their venation. This is based on Feistmantel's (1879) view that his new genus *Noeggerathiopsis* "comprises all the Indian leaves formerly mentioned as *Noggerathia* .... Sir Ch. Bunbury's figure represents a very fragmentary specimen from which it would scarcely be possible to recognise the species again. But from his description it can be seen that he had several portions before him from which he formed the diagnosis; and there are also in the Geological Museum several specimens of this fossil in the collection from the Nagpur district, so that there is no doubt in identifying this plant from other localities." He then repeated the whole of Bunbury's (1861) description of *Noeggerathia hislopii* (Feistmantel, 1879: 23-24). Thus the type species of *Noeggerathiopsis* is based on Bunbury's published definition, and it has no type specimen to represent the taxon. Bunbury's description has evidently been overlooked by several subsequent authors. Pant and Verma (1964b: 22) stated that in "1861 Bunbury described an impression of the basal fragment of a *Cordaites*-like leaf" and "Feistmantel (1879) made a new genus, *Noeggerathiopsis*, for Bunbury's leaf fragment...". Anderson and Anderson (1985: 144) also consulted Bunbury's "sketch of (a) very fragmentary specimen".

According to Bunbury's (1861: 334) description, the veins are "numerous, all equal and uniform... strong and rather coarse, radiating from the base, but spreading very gradually and forming very small angles with one another, so that for any short distance they appear nearly parallel; they are once or twice forked..., the branches diverging very gradually, and all end in the terminal margin".

Analytical reading of the descriptions, and comparison of the illustrations of the two genera (e.g. Feistmantel, 1876a: pl. XIX; 1881: pls XLIV, XLV), discloses the main distinctive characters: in *Palaeovittaria* leaves, the more laterally placed longitudinal veins diverge toward the margin even in the basal portion of the lamina; the veins near the midline are more nearly parallel. In contrast, *Noeggerathiopsis* leaves have longitudinal veins that appear parallel over the entire lamina; these veins do not intersect the margin in the basal portion, but tend to do so only towards the apex of the lamina. Although examination of a series of *Noeggerathiopsis* leaves shows that some veins do indeed intersect the margin before the apex, the general and uniform appearance of parallelism of the venation over the whole *Noeggerathiopsis* leaf is typical and unmistakable.

A possible misidentification by Feistmantel himself must be mentioned: he identified Australian leaves as *Noeggerathia spathulata (sic, = N. spatulata Dana)* and *N. media* Dana, which he thought to form one species, and he also placed Dana's species into *Noeggerathiopsis*. However, the three illustrated leaves clearly show a midrib-like midline, and in one drawing the veins in the basal portion run to the margin (Feistmantel, 1890: 154, pl. XXI, figs 3-5). These leaves, as judged from the illustrations, belong to *Palaeovittaria*. The significance of this possible misidentification lies in a conception of Dana's species *Noeggerathia spatulata* that differs from the conceptions of both Dana and Feistmantel—it can include several different genera and species from several different horizons, including amongst them *Palaeovittaria* itself.

Taxonomy of non-cuticular cordaitalean leaves.

The argument of Rigby, Maheshwari and Schopf (1980: 17-21) is based on a preconception: that in cordaitalean leaves only epidermal characters have diagnostic value. They rejected the importance of shape, apex, base and venation characters for specific identification. Consequently, these authors regard as indistinguishable such species as *N. spatulata* Dana, with short leaves about 60 mm (2½ inches) long, which are spatulate with very fine, rather indistinct venation (Dana, 1849: 715), and *N. hislopii* Bunbury, which has narrow, wedge-shaped leaves, the largest fragment being about 140 mm (5½ inches) long, with strong and rather coarse venation (Bunbury, 1861: 334). They proposed that all non-cuticular cordaitalean leaves identified from Lower Gondwana strata to date be given the name *Cordaites spatulata* (Dana) Rigby, Maheshwari & Schopf. Thus, since *Cordaites spatulata sensu* Rigby, Mahesh-

wari and Schopf lacks preserved cuticle, it had to be diagnosed on the basis of external characters, notwithstanding the fact that these authors consider such characters unimportant in specific determination. Consequently, they delimited the "species" so broadly that their diagnosis is applicable to any "cordaitalean" leaf, including the original illustration of *Palaeovittaria kurzii* itself (Feistmantel, 1876a: pl. XIX, figs 3-4). These authors also include under *Cordaites spatulata* the three drawings by Feistmantel (1890: pl. XXI, figs 3-5) mentioned above, in which the illustrated leaves bear the characters of *Palaeovittaria*.

One of the most important misconceptions in the paper under discussion is the authors' mistaking the mode of preservation for a diagnostic character. Rigby, Maheshwari and Schopf (1980) spoke of species lacking cuticle; species, however, do not "lack cuticle" — only fossil specimens do. According to the authors, cuticular species require new genera. Consequently, when the epidermal structure of one particular leaf is illustrated (Seward and Sahni, 1920: pl. 1, figs 1-5), it is not listed under *Cordaites spatulata*; but the same leaf, as illustrated by Feistmantel (1881: pl. XXIX, fig.2.), is included in the "species".

Seward and Sahni (1920: 7) were of the opinion that a "more thorough investigation of the details of epidermal features is likely to be of considerable assistance in specific diagnosis and as an aid to the generic affinities of fossil impressions. On the other hand the direct utility of this line of work in phylogeny is open to doubt." It is noteworthy that, ever since Zeiller (1896) first studied the cuticle of *Noeggerathiopsis* leaves, students of epidermal structures have been unable to reach unanimity on whether or not *Noeggerathiopsis* and *Cordaites* were two separate genera. Therefore the current confidence in the use of epidermal features in classification seems unjustified. If all "non-cuticular cordaitalean leaves" from all Lower Gondwana horizons are to be lumped under one binomen, neither the stratigraphic distribution nor the phylogeny of these plants will be ever known — for the great majority of leaf fossils are preserved without cuticle.

It is necessary to compare many specimens to recognise, among individual features, characters that have diagnostic value. The rarity of preserved cuticles in these fossils might explain why study of cuticles has so far been unable to provide data of value in either specific or generic identification. The major point of concern here, however, is that the method proposed by three acknowledged experts would make the separation of *Palaeovittaria* and *Noeggerathiopsis* practically impossible.

The proposition that *Palaeovittaria* and *Glossopteris* might be in kinship relation was initially based on certain similarities in epidermal features; one fragment identified as *Palaeovittaria* was investigated (Srivastava, 1957). Pant and Verma (1964a), in their study of the cuticles of *Palaeovittaria* leaves, did not suppport this conclusion. The classification of the two genera in the same higher taxanomic category is in any case questionable on grounds other than just the contradictory results of the cuticular studies.

Classification of *Palaeovittaria*.

Feistmantel classified all fern-like fronds as Filices, placing *Palaeovittaria* in the Order Taeniopterides, and *Glossopteris* in Dictyopterides (Feistmantel: 1876a). Following recognition of the pteridosperms, Feistmantel's classification lost acceptance. Later authors have placed *Palaeovittaria* in Glossopteridaceae (Sporne, 1965), Glossopteridopsida (Lakhanpal et al., 1976), Glossopteridophyta (le Roux and Anderson, 1977) and in Ottokariales = Glossopteridales (Anderson and Anderson, 1985). These few examples illustrate the indecision in the conception of "glossopterids" as a family, or a division, or a taxon of any rank in between. The lack of clarity about *Glossopteris* as a taxon or about its systematic position in the plant kingdom is plainly evident. Classification of *Glossopteris* and *Palaeovittaria* together in the same suprageneric taxon is probably meaningless as decisions in classification must be supported by character comparisons, and the characters of glossopterids that would indicate their category, and thereby their systematic position, are still unknown. As noted above, the value of the evidence offered by cuticular studies is questionable.

Might the fructification of *Palaeovittaria* be of help in determining its relationships? Plumstead (1958) described *Palaeovittaria* with the glossopterid fructification *Lanceolatus*, but this was not accepted as a valid taxon (see discussion in Rigby, 1978). Moreover, the impressions preserved on the *Palaeovittaria* leaves which were assumed to be the fructifications are so lacking in structure that they do not reveal any diagnostic characters.

Thus, for the time being the relationships of *Palaeovittaria* cannot be clarified because of lack of evidence. But this has not prevented *Palaeovittaria* from becoming incorporated into a number of hypotheses of plant phylogeny and evolution.

Stratigraphic position of the type locality of *Palaeovittaria*.

The exact locality from which the fossil plants discussed here were collected from the Raniganj Coalfield is not known, and this introduces one of the uncertainties surrounding the stratigraphic position of *Palaeovittaria*. According to Feistmantel (1881: 91, 135) the plants collected by J. Wood-Mason belonged to the flora of the Raniganj Stage, a conclusion that has never been contradicted, either by contemporary or by later geologists and palaeobotanists (e.g. Lakhanpal et al., 1976). In 1876, when Wood-Mason collected the fossils and Feistmantel published his study on them, the stratigraphic position of the Raniganj Stage as the highest unit of the Damuda Series was already well established, and this interpretation has not changed since. The Wood-Mason collection seems to have been derived from one fossiliferous bed, according to Feistmantel's (1876a) discussion of the matrices of slabs collected by the officers of the Geological Survey of Calcutta compared with those collected by Wood-Mason. Wood-Mason's specimens are preserved in a dark grey shale covered throughout with a thin film of coal (Feistmantel, 1876a: 336-337). Apart from the *Palaeovittaria* specimens, he also collected the type

specimens of *Belemnopteris* from this locality — yet *Palaeovittaria* is regarded by some authors as an early Permian genus, while *Belemnopteris* is regarded as late Permian (e.g. Anderson and Anderson, 1985). There is absolutely no evidence for different chronostratigraphic distribution of the two genera, and they share the same type locality. This difference in attributed ages for the two genera is a consequence of an old debate that is not yet over.

The "Great Debate" on bio- and chronostratigraphic correlation.

Though 1876 was only his second year in India, Feistmantel's six publications written in that year form part of the "Great Debate". Even then antagonism and disputes over the theory and practice of correlation already had a long pedigree (see references in Feistmantel's publications for the views held by the two opposing schools).

In essence, the argument was based on the following: one group of stratigraphers (among which was Feistmantel) insisted that correlation must always be based on the fossils actually present in the horizon or area under investigation, irrespective of whether they were the remains of marine, terrestrial or freshwater animals or plants; the choice of the other group fell on marine animals alone, irrespective of whether such fossils were present or absent in the horizon in question. The leading geologist of the latter group was Blanford.

The reasoning procedures followed by the two schools of stratigraphers can be distinguished as "direct" and "indirect" interpretations of data, respectively. In the 19th century there were considerable discrepancies in the deduced age of practically all the horizons in Australia and India, depending on whether the age estimates were arrived at by direct or indirect interpretations of the data as outlined above. The argument was most intense on the age of Lower Gondwana strata. Before the term "Gondwana System" was introduced, the lower portion of the system was designated the "Plant-bearing Series" (Oldham, 1870: 4; Feistmantel, 1876a: 329); the Damuda Series, too, preserved only the remains of terrestrial floras. Thus, information based on direct observation was solely in the hands of palaeobotanists. According to the occurrence of fossil plants that also occurred in European floras, the palaeobotanists determined the age of the Damudas as Mesozoic (Triassic, according to Feistmantel, 1876b). However, according to marine fauna in Australia, the age of the Damudas in India would be Carboniferous (Blanford, 1876).

In the case of South African floras, Zeiller (1896) determined the age of the Transvaal floras as Permo-Triassic by direct interpretation of the fossil data, while Seward (1897), on indirect interpretation, concluded that they were late Carboniferous-early Permian, as proposed by Blanford and by Waagen, who was a specialist on marine fauna. An early Permian age for the Vereeniging floras is now also deduced from correlation with microfloral zones established for marine strata in Australia (Anderson and Anderson, 1985).The majority of authors who have published on South African floras since then seem to have been followers of Seward. Evidently the dispute between the two schools is not only over their respective conclusions about the age of the floras, but there is also disagreement over their procedures in dealing with the fossils: those who base the age estimate on direct observation of fossils in the investigated area follow the rules of traditional taxonomy; others start from an acceptance of an early Permian age for the Transvaal floras, and interpret the plants according to this age.

Chronostratigraphic conclusions concerning *Palaeovittaria* leaves.

In his last publication on southern floras Feistmantel (1890) assigned the Indian Talchir-Karharbari beds a "Permo-Carboniferous" age, by which he meant the late Carboniferous and the entire Permian. He retained a Triassic age for the Damuda Series. Later stratigraphers modified this chronostratigraphic succession, considering the Talchir and Karharbari Stages to be Lower Permian, and the upper Damuda (i.e. the Raniganj Stage) Upper Permian. In India *Palaeovittaria* is still known to be restricted to the Upper Permian Raniganj Coalfield (Lakhanpal et al., 1976).

Zeiller's (1896) age determination of fossiliferous beds in the Transvaal was based on similarities between South African and upper Damuda (Raniganj) floras, and his conclusions have not been overturned by later authors. As noted above, the difference between Zeiller's (1896) and Seward's (1897) conclusions was based on their differing approaches to biostratigraphic correlation. Direct and indirect interpretations of *Palaeovittaria* leaves in Transvaal floras also yield considerably different results. According to the direct interpretation of the data, the presence of *Palaeovittaria* is one more piece of evidence for correlating the Transvaal and Raniganj floras, and thus for assigning it a late Permian age.

Palaeovittaria leaves have been identified from the Vereeniging Ecca floras of the Transvaal, which were assumed to be Lower Permian (Plumstead, 1958); the range of the genus was extended from Upper to the Lower Permian on the grounds that it was found with *Gangamopteris* (Plumstead, 1962). Later, some other fossil leaves were found south of Middelburg, Transvaal, in a zone closely associated with tillites and considered to be Upper Carboniferous in age; according to Plumstead (1966) these leaves exhibited some features in common with *Palaeovittaria*, some with *Gangamopteris* and some with leaves described as *Noeggerathiopsis*. She interpreted them as probably transitional between the Glossopteridae and its ancestral form, the dichotomous veins, paucity of anastomoses and the absence of a midrib being regarded by Plumstead as primitive features within Glossopteridae. She informally named the leaves "Proto-Glossopteridae". The concept of Proto-Glossopteridae was further developed by others (see a short compilation in Guerra-Sommer and Cazzulo-Klepzig, 1981), one result of which was the inclusion in it of *Rubidgea*. In this way the genus *Rubidgea* came to be a genus "typical" of Lower Permian (Sakmarian) strata.

Anderson and Anderson (1985) regarded *Palaeovittaria* as intermediate between *Noeggerathiopsis* and *Gangamopteris*, implying generic relationships between the three genera, notwithstanding the fact that they classified *Palaeovittaria* and *Noeggerathiopsis* into two different classes, and rejected the name *"Gangamopteris"* — considering it a synonym of *Ottokaria*. They placed the leaves investigated by Plumstead into *Palaeovittaria*, and in this way too *Palaeovittaria* became one of the few plant taxa of the Dwyka Formation, the lowest member of the Karoo Sequence. According to Anderson and Anderson (1985), *Palaeovittaria* was widespread in Gondwana Lower Permian strata, and *P. kurzii* was primarily a Lower Permian species. *Rubidgea*, being a synonym of *Palaeovittaria*, is therefore also regarded by them as a Lower Permian genus; and yet *Rubidgea* Tate 1867 was originally described from the late Permian Beaufort Group of South Africa.

The views discussed above were based on a presupposed early Permian age for the Vereeniging floras, and on the association of tillite with the zone from which the "Proto-Glossopteridae" came. The evidence for direct glacial deposition in the latter locality is not beyond dispute (Anderson and McLachlan, 1976). I must concede that, following Plumstead, I considered certain features in a leaf from a *Mesosaurus*-bearing stratum indicative of an "advanced" form of *Glossopteris* (cited in Anderson and McLachlan, 1976: 36). Although Oelofsen and Araujo (1983) concluded that the South African Whitehill Formation and the South American Irati Formation, both of which contain mesosaurid reptiles, are contemporaneous (probably Kazanian), I regard my earlier view as now erroneous. The characters regarded by Plumstead as primitive for glossopterids occur in the leaves of several species originally described from late Permian strata, *Palaeovittaria kurzii* being one of them. Furthermore, there is no evidence for the classification of *Palaeovittaria* as a glossopterid.

The old "Great Debate" seems to have been forgotten in the intervening decades and palaeontologists, including palaeobotanists, have been unaware of the two opposing trends in biostratigraphic correlation. Consequently, many cross-references between the two antagonistic groups have occurred, relying on age determination sometimes based on direct interpretations of data, and at other times on indirect interpretations. *Palaeovittaria* as an early Permian genus, and as a primitive glossopterid, is an example of the result of indirect interpretation of data, whose validity it is difficult to prove without falling into the trap of circular reasoning.

The generic characters of *Palaeovittaria* in South African leaves

Because he knew only one species of *Palaeovittaria*, Feistmantel could not know which characters had generic or specific significance. Investigation of leaves from the flora of Hammanskraal discloses the following characters of the genus (figs 1-8): in the basal portion a few stronger veins run parallel in the midline (figs. 1,2,4). Thinner veins pass at very acute angles from the base and from the stronger veins in the midline (fig. 4) to meet the margin along its entire length (figs. 5,7), including in the basal portion of the leaf. The veins are moderately straight and regularly equidistant from one another, except where bifurcations occur (figs. 2,4,5,7). Although they bifurcate, they do not anastomose (fig. 2).

Feistmantel thought the slightly incurved veins at the margin to be a generic character, but this character is evident in only some of the leaves (figs 1, 3, 7).

The paucity of the material does not allow specific identifications, but differences in size, shape and venation suggest the presence of several species of *Palaeovittaria* in the Hammanskraal flora. For comparison of venation a *Noeggerathiopsis* leaf is illustrated (fig. 8).

Figure 1 *Palaeovittaria* leaf from Hammanskraal, Transvaal, cat. no. H.I. 183, in the collection of the Geological Survey, Pretoria.
In the basal portion the small leaf is divided into right and left halves by veins that are closely spaced and parallel in the midline, and that run towards the margins laterally.

Figure 2 *Palaeovittaria* leaf from Hammanskraal, Transvaal, cat. no. H.I. 183a, in the collection of the Geological Survey, Pretoria.
A few parallel veins are noticeable in the basal portion. In the apical portion the venation radiates fanwise.

Figure 3 *Palaeovittaria* leaf from Hammanskraal, Transvaal, cat. no. H.I. 247, in the collection of the Geological Survey, Pretoria.
The veins are moderately straight and equidistant from one another. The parallelism of the venation in the right and left halves of the lamina is clearly visible.

Figure 4 *Palaeovittaria* leaf from Hammanskraal, Transvaal, cat. no. H.I. 206, in the collection of the Geological Survey, Pretoria.
Minor veins pass from the major veins in the midline.

Figure 5 *Palaeovittaria* leaf with *Glossopteris parallela* Feist. and *G. taeniopteroides* Feist. from Hammanskraal, Transvaal, cat. no. H.I. 25, in the collection of the Geological Survey, Pretoria.
Note that in the *Palaeovittaria* leaf the veins meet the margin along the entire length of the lamina.

Figure 6 Apex of *Palaeovittaria* leaf from Hammanskraal, Transvaal, cat. no. H.I. 150, in the collection of the Geological Survey, Pretoria.
Note the fan-wise radiation of the veins in the apical portion.

Figure 7 *Palaeovittaria* leaf from Hammanskraal, Transvaal, cat. no. H.I.165a, in the collection of the Geological Survey, Pretoria.
The straight and regularly equidistant veins meet the margin over the entire length of the leaf. The lamina is divided longitudinally into right and left halves by the stronger veins in the midline and those that run right and left towards the margin.

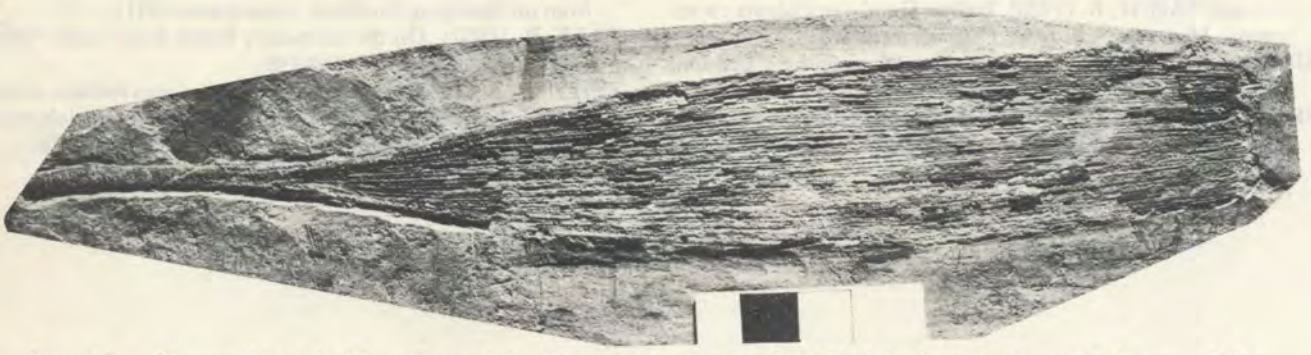

Figure 8 *Noeggerathiopsis* leaf from Vereeniging, Transvaal, cat. no. BP/2/13517, in the collection of the Bernard Price Institute for Palaeontological Research, Johannesburg.
Note that the veins run parallel to one another and to the leaf margins, except in the basal portion where they splay because the base of the leaf is narrow and wedge-shaped. There is no clear division of the lamina into right and left halves by lateral veins that run to the margins on either side, as they do in *Palaeovittaria*.

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REFERENCES

ANDERSON, J.M. and ANDERSON, H.M. (1985). *Palaeoflora of Southern Africa — Prodromus of South African Megafloras — Devonian to Lower Cretaceous*. A.A. Balkema, Rotterdam.

ANDERSON, A.M. and Mc LACHLAN, I.R. (1976). The plant record in the Dwyka and Ecca Series (Permian) of the south-western half of the Great Karroo Basin, South Africa. *Palaeont. afr.*, **19**, 31-42.

BLANFORD, W.T. (1876). Note on the geological age of certain groups comprised in the Gondwana Series of India, and on the evidence they afford of distinct zoological and botanical terrestrial regions in ancient epochs. *Rec. geol. Surv. India*, **9**(3), 79-85.

BUNBURY, C.J.F. (1861). Notes on a collection of fossil plants from Nagpur, Central India. *Q. Jl geol. Soc. Lond.*, **17**, 325-346.

DANA, J.D. (1849). Fossil plants. Appendix I/4. *In* United States Exploring Expedition, 1838-42, under the command of Charles Wilkes, U.S.N., **10**, Geology, 714-720. Philadelphia, Sherman.

FEISTMANTEL, O. (1876a). On some fossil plants from the Damuda Series in the Raniganj Coalfield, collected by Mr. J. Wood-Mason. *J. asiat. Soc. Beng.*, **45**, 329-382.

——— (1876b). Notes on the age of some fossil floras of India — I, II. *Rec. geol. Surv. India*, **9** (2), 28-42.

——— (1876c). Notes on the age of some fossil floras in India — III, IV, V. *Rec. geol. Surv. India*, **9** (3), 63-79.

——— (1876d). Notes on the age of some fossil floras in India — VI, VII, VIII. *Rec. geol. Surv. India*, **9** (4), 115-144.

——— (1876e). Fossil flora of the Gondwana System. Jurassic (Oolitic) flora of Kach. *Mem. geol. Surv. India, Palaeont. indica*, ser. 11, **2** (1), 1-80.

——— (1876f). Über das Alter einiger fossilien Floren in Indien. *Kgl. Böhm. Ges. Wiss. Math.-naturw.*, **150**, 1-15.

——— (1879). The fossil flora of the Gondwana System: Flora of the Talchir-Karharbari Beds. *Mem. geol. Surv. India, Palaeont. Indica*, ser. 12, **3** (1): 1-48.

——— (1881). The fossil flora of the Gondwana System. The flora of the Damuda-Panchet division. *Mem. geol. Surv. India, Palaeont. indica*, ser. 12, **3** (3): 78 — 149.

——— (1890). Geological and palaeontological relations of the coal and plant-bearing beds of Palaeozoic and Mesozoic age in Eastern Australia and Tasmania. *Mem. geol. Surv. N.S.W. (Palaeont.)*, **3**: 1-183.

GUERRA-SOMMER, M. and CAZZULO-KLEPZIG, M. (1981). A tafoflora do grupo Itarare no Rio Grande do Sul sua importancia biostratigrafica no Gondwana Sul- Brasileiro. *Anais do II Congresso Latino-Americano de Paleontologia, Porto Alegre*, **1**, 127-137.

KOVÁCS-ENDRŐDY, É. (1977). The taxonomic status of the genus *Rubidgea*. *Bothalia* **12** (2), 313-317.

LAKHANPAL, R.N., MAHESHWARI, H. K. and AWASTHI, N. (1976). *A Catalogue of Indian fossil plants, covering all available records from 1821 to 1970*. Lucknow, Birbal Sahni Institute of Palaeobotany.

LE ROUX, S.F. and ANDERSON, H.M. (1977). A review of the localities and flora of the Lower Permian Karoo strata at Vereeniging, South Africa. *Palaeont. afr.* **20**, 27-42.

OELOFSEN, B. and ARAUJO, D.C. (1983). Palaeoecological implications of the distribution of mesosaurid reptiles in the Permian Irati sea (Parana Basin), South America. *Revista Brasileira de Geociencias*, **13** (1), 1-6.

OLDHAM, T. (1870). Annual Report of the Geological Survey of India and of the Geological Museum, Calcutta, for the year 1869. *Rec. geol. Surv. India*, **8** (1), 1 — 10.

PANT, D.D. and VERMA, B.K. (1964a). On the structure of *Palaeovittaria raniganjensis* n.sp. from the Raniganj Coalfield, India. *Palaeontographica* **B115**, 45-50.

——— (1964b). The cuticular structure of *Noeggerathiopsis* Feistmantel and *Cordaites* Unger. *Palaeontographica*, **B115**, 21-44.

PLUMSTEAD, E.P. (1958). Further fructifications of the Glossopteridae with a provisional classification based on them. *Trans. geol. Soc. S. Afr.*, **61**, 51-76.

——— (1962). Fossil floras of Antarctica. *Transantarctica exped. (1955-1958). Sci. Rep.*, **9**, 1-154.

——— (1966). Recent palaeobotanical advances and problems in Africa. *In: Symposium on Floristics and Stratigraphy of Gondwanaland*. Palaeobotanical Society Special Session, December 1964, 1 — 12. Lucknow, Birbal Sahni Institute of Palaeobotany.

RIGBY, J.F. (1978). Permian glossopterid and other cycadopsid fructifications from Queensland. *Publs geol. Surv. Qd.*, 367, *Palaeont. Pap.*, 41, 1-21.

RIGBY, J.F., MAHESHWARI, H.K. and SCHOPF, J.M. (1980). Revision of Permian plants collected by J.D. Dana during 1839-1840 in Australia. *Publs geol. Surv. Qd.*, 376, *Palaeont. Pap.*, 47, 1-25.

SEWARD, A.C. (1897). On the association of *Sigillaria* and *Glossopteris* in South Africa. *Q. Jl. geol. Soc. Lond.*, **53**, 315-340.

——— (1907). Notes on fossil plants from South Africa. *Geol. Mag. N.S. Decade V*, **4**, 481-487.

——— and SAHNI, B. (1920). Indian Gondwana plants : a revision. *Mem. geol. Surv. India, Palaeont. indica n. ser.*, **7** (1), 1-41.

SPORNE, K.R. (1965). *The Morphology of Gymnosperms*. London, Hutchinson University Library.

SRIVASTAVA, P.N. (1957). Studies in the Glossopteris Flora of India — 4. *Glossopteris, Gangamopteris* and *Palaeovittaria* from the Raniganj Coalfield. *Palaeobotanist* **5** (1), 1-45.

TATE, R. (1867). On the secondary fossils from South Africa. *Q. Jl. Geol. Soc. Lond.* **23**, 140-149.

ZEILLER, R. (1896). Etude sur quelques plants fossiles, en particulier *Vertebraria* et *Glossopteris* des environs de Johannesburg (Transvaal). *Bull. Soc. géol. Fr.*, Ser. 3, **24**, 349-378.

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