

DICTYOPTERIDIUM SPORIFERUM FEISTMANTEL — FEMALE CONE FROM THE LOWER GONDWANA OF INDIA

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ABSTRACT

Dictyopteridium sporiferum Feistmantel is a stalked, linear lanceolate cone, studded with small oval seeds. The seeds are attached all round the cone axis on cushions. The seeds fell off leaving the marks of cushions on the cone and most of the fossil specimens are found in this condition. This cone was perhaps borne by one of the Glossopteridean plant.

INTRODUCTION

PLUMSTEAD (1970) regarded *Dictyopteridium sporiferum* as a potentially valuable index plant fossil occurring at the same horizon in three continents, viz, India, Australia and South Africa, but at the same time this fossil was also regarded as one of the most controversial of all the Gondwana fossils.

The confusion regarding *Dictyopteridium* is due to the fact that although Feistmantel (1881) introduced the name *Dictyopteridium sporiferum*, he did not provide detailed description or circumscription of the genus or species. Furthermore, he gave four illustrations of *Dictyopteridium* in his "Fossil flora of the Gondwana System", Volume III, Part II (1881, Plate XXIII A, Figs. 4, 5, 6 & 14) which included two or more different types of fossil plants. For the sake of convenience photographs of Feistmantel's original specimens of *Dictyopteridium* are reproduced here (see Pl. 1, Figs. 1, 5, 6, 7 & 9). One can clearly see that specimens illustrated in Feistmantel's figures 4 & 5 belong to one type (see Pl. 1, Figs. 1 & 5) whereas that in figure 6 (see Pl. 1, Fig. 8) clearly denotes another type of plant. Again in figure 4 on Plate XLII A of the same volume (1881) he illustrated a leaflet (see Pl. 1, Fig. 7) which he thought "might probably be in some relation with those peculiar apparently fertile leaflets figured on Plate XXIII A figures 4-6". This specimen undoubtedly represents a small *Glossopteris* frond as Zeiller (1902)

had already observed. In 1886 Feistmantel again included under *Dictyopteridium* another fossil specimen from the South Rewa (Pl. 1, Fig. 9) which is a *Cistella* type of fructification. Different types of plants are thus included by Feistmantel under the name *Dictyopteridium sporiferum*.

Further, Feistmantel not only gave no precise circumscription of the genus, but made some wrong observations too. In explanation of figs. 4-6 & 14, Pl. XXIII A (Feistmantel, 1881) he wrote as follows:

"In the above group peculiar leaflets occur four figures of which are given. They all exhibit nearly the same shape, are covered with small tubercles within and larger ones along the margin. When examined with a lens a very fine net venation can be observed in some of them. They appear to be fertile leaflet of some fern, which, however, is impossible to identify. But they are in so far of interest as they occur in Raniganj and Barakar group equally".

Feistmantel's specimens of *Dictyopteridium* reproduced here do not show any trace of net venation, except the one (Pl. 1, Fig. 7) which is a small *Glossopteris* leaf and not a *Dictyopteridium* at all. Subsequent authors later on included different types under *Dictyopteridium*, adding confusion to an already confused genus.

From India Saksena (1962) reported *Dictyopteridium* from Pali beds of the South Rewa Gondwana basin and Maheshwari (1965) described *Dictyopteridium sporiferum* from the Raniganj stage.

Zeiller (1902) described another specimen (Pl. 1, Fig. 6) which does not look like a *Dictyopteridium*. White (1962) referred some fossils to *D. sporiferum* which do not appear to resemble Feistmantel's original specimen as shown here in Pl. 1, Fig. 1.

The name *Dictyopteridium*, in our opinion, should be restricted to those specimens similar to that illustrated by Feistmantel (1881) in figure 4 on Plate XXIII A.

The specimens described here were collected from a thick bed of compact buff coloured shale, exposed in a road cutting near Hinjrida Ghati in Dhenkenal district of Orissa, India. Some compressions, in addition to impressions, were also collected from the Raniganj coalfield which have been referred here to *Dictyopteridium sporiferum*.

DESCRIPTION

Genus — *Dictyopteridium* Feist.

Diagnosis — A pedicellate female fructification of linear-lanceolate shape about 3.5 cm. long and 1 cm. broad; the cone axis or receptacle covered over with round to oval seed cushions or seeds, seed cushions or seeds crowded on the cone axis in close spirals, seeds arranged on two margins in regular rows, one below the other; seed small, oval with obtusely pointed neck and round or concave chalazal end.

Dictyopteridium sporiferum Feist.

Diagnosis — Stalked, linear-lanceolate female cone, 3.3-3.5 cm. long and about 0.8-1 cm. broad at the broadest part; stalk about 2 mm. broad; the lanceolate cone axis covered with oval to round elevations or depressions of seed cushions, seeds attached in regular, alternate, longitudinal rows, seeds oval with, 1.1-1.5 mm. \times 0.5-0.8 mm. in size, with obtusely pointed neck and round or concave chalazal end, integument cells near the micropyle elongated with wavy longitudinal cell walls, cells at the chalazal end somewhat small and square.

Lectotype — G.S.I. No. 5210.

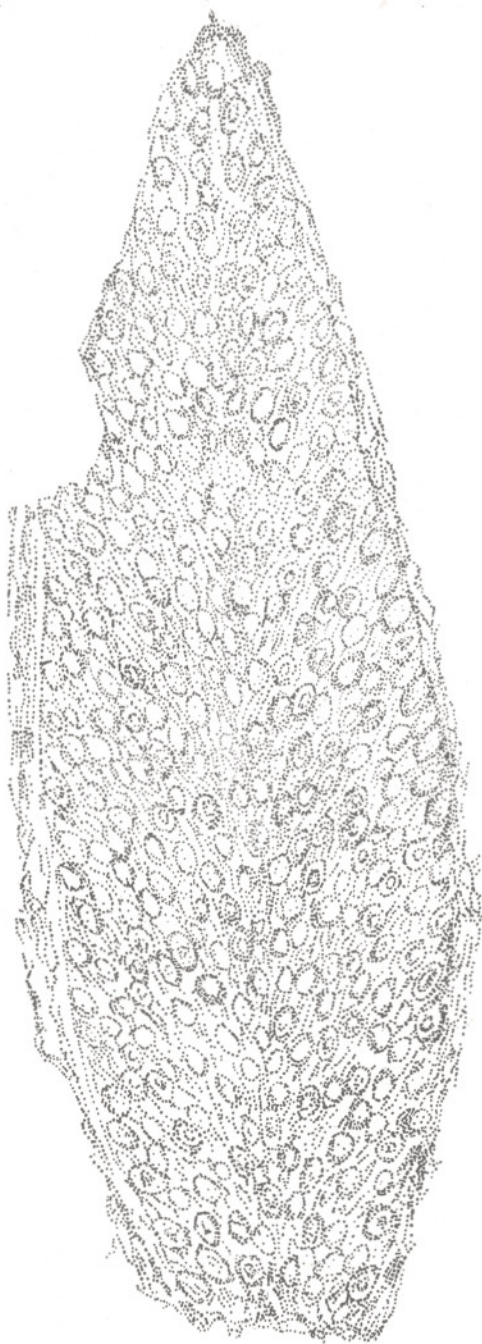
In our collection we have specimens of *Dictyopteridium* preserved in different ways. The specimens shown in Pl. 1, figs. 2 and 3; Text-figs. 1 & 2 are partial casts, whereas that in Pl. 2, fig. 12 is a compression of almost the entire cone. Pl. 3, fig. 17 and Pl. 4, fig. 22 show broken pieces of compressed cones, exposing small, regularly arranged seeds. All these compressed specimens were recovered from one shale piece collected in the Raniganj coalfield.

The specimen of *Dictyopteridium* shown in Pls. 1 and 2, figs. 3 and 10 is preserved in such a way that it shows the characters of the specimen illustrated in Pl. 1, fig. 2

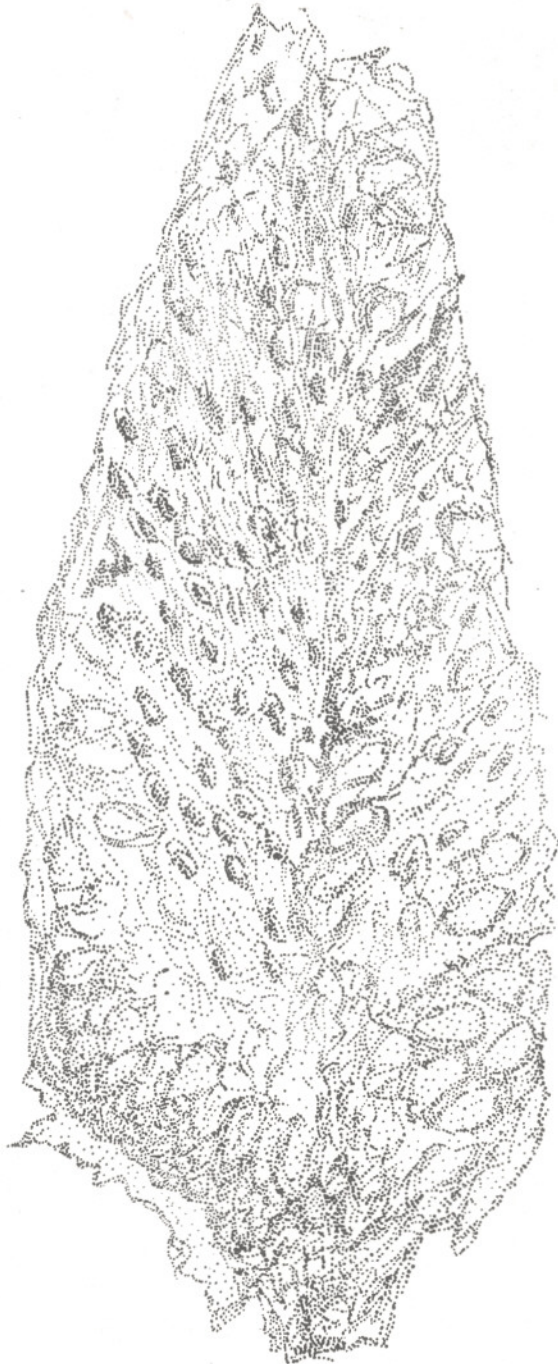
and also of that specimen shown on Pl. 2, fig. 12. It connects the fossils preserved as impression and compression, thereby indicating that all the three specimens, although preserved in different ways, belong to the same genus. The specimen in Pl. 1, fig. 3 is shown enlarged on Pls. 2 and 4, figs. 10 and 18. Impressions of seeds are seen here mostly in the lower part of the cone which look identical with the seeds in the compressed specimens as illustrated in Pls. 2 and 4 and figs. 12 and 22. The rest of the cone (Pl. 2, Fig. 10) shows preservation at a level where the seeds have already been shed off, exposing only the impressions of small, round seed cushions, (Text-figs. 1 & 2) similar to those as seen in the specimen illustrated in fig. 2 on Plate 1. On examining the three specimens in detail no doubt is left that all of them belong to *Dictyopteridium sporiferum* as originally recognised by Feistmantel.

Pl. 1, fig. 1 shows the original specimen of Feistmantel illustrated by him in fig. 4 of Plate XXIII A in his "Fossil flora of Gondwana System", Volume II, Pt. II (1881) and, therefore, should be regarded as lectotype for *Dictyopteridium sporiferum*. The close resemblance between Feistmantel's specimen (Pl. 1, Fig. 1), Maheshwari's specimen (Pl. 1, Fig. 4) and our specimen (Pl. 1, Fig. 2) is quite clear. Feistmantel also included other specimens under *Dictyopteridium sporiferum* (Pl. 1, Figs. 7, 8 & 9) which obviously do not belong to this genus at all and, therefore, should be kept out of this genus.

Dictyopteridium sporiferum is a stalked female cone, linear-lanceolate in shape, measuring 3.4 cm. in length and 0.8-1 cm. in breadth. The stalk is about 2 mm. in breadth (Text-figs. 1 & 2). The cone axis, or if we may call it receptacle, is studded over with small round seed cushions (Pls. 1 & 2, Figs. 2 & 11) measuring about 0.5 cm. in diameter (Text-fig. 3). Those on the margin are arranged in a row, one below the other. The seed cushions are crowded near the base, but are placed farther apart above, sometimes appearing as arranged in small arcs (Pl. 2, Fig. 11). Feistmantel's and Maheshwari's specimens also show this feature. Some seed cushions appear circular and show a swollen knob-like protrusion in the middle, which might indicate the position of vascular bundle supplying the seed or ovule. Faint wrinkles are seen in



TEXT-FIG. 1 — A drawing of the *Dictyopteridium sporiferum* specimen from Orissa studded with oval seed cushions. Some of the cushions show round mark in the middle. $\times 6$. B.S.I.P. 35031.



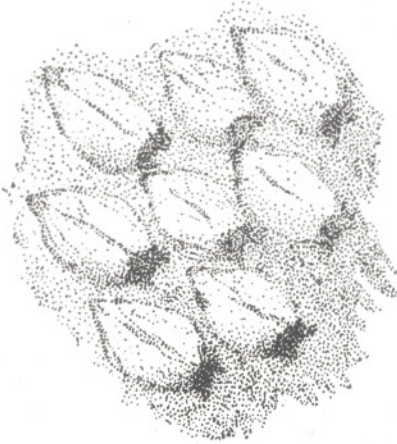
TEXT-FIG. 2— A drawing of another specimen of *Dictyopteridium sporiferum* from Orissa. The cone has a small stalk. Impressions of oval seeds are seen on the lower side of the cone and the seed cushions are seen in the middle part of the cone. $\times 6$. B.S.I.P. No. 35032.



TEXT-FIG. 3— Seed cushions enlarged. The circular marking in the middle of each cushion might be that of the vascular bundle supplying the seed. $\times 15$.

between the seed cushions, which perhaps were mistaken for faint venation by Feistmantel and others. *Dictyopteridium sporiferum* is commonly preserved as impression in this form of a naked cone axis or receptacle from which the seeds had already been shed, leaving only round to oval marks of seed cushions.

Small, naked seeds without megasporophylls or ovuliferous scales are attached on the seed cushions (Text-fig. 4) and arranged in close spirals round the cone



TEXT-FIG. 4— A drawing showing how the seeds are attached on the cushions. $\times 15$.

axis (Pl. 1, Figs. 18 and 22). Figs. 17 and 22 on Plates 3 and 4 show seeds which are compressed sideways overlapping one another, so that they appear to be arranged in rows and the seeds of one row alternating with those of the other row. The seed is attached almost by its entire chalazal end. The broken, almost concave chalazal end of the seed is clearly seen in figs. 13, 14, 15 and 20 on Plates 3 and 4.

The seed is unwinged, small, oval with almost obtusely pointed neck at the micropylar end and a broad round or concave chalazal end (Pl. 3, Figs. 13, 14 and 15). They resemble the seeds of water-melon in shape. A seed is 1.5 to 2 mm. long and about 1 mm. broad. Similar seeds are seen loose on the Raniganj specimens of Maheshwari (1965) also; one of them is shown here in fig. 4 on Plate 1.

Seeds from some of the compressed specimens as shown in figs. 17 and 22 were macerated. Some of the macerated seeds are shown in figs. 13, 14 and 15 on Plate 3. The seed cuticle is thin. The outer cuticle (integument) has long, rectangular cells arranged end to end and with slightly undulating longitudinal cell walls (Text-fig. 5). The cells at the micropylar end have more wavy walls and are shown in figs. 16 and 21 on Plates 3 and 4. The cells at the chalazal end (Pl. 4, Fig. 19) are short and square with straight cell walls. Nucellar membrane is thin and without any cellular markings. The seed is generally broken at the micropylar and the chalazal ends.

RECONSTRUCTION

Dictyopteridium as we understand it now is a female fructification or cone consisting of a stalk and a linear-lanceolate receptacle or cone axis, studded with cushions, on which are attached naked ovules or seeds without megasporophyll or ovuliferous scale (Text-fig. 6). When mature, the seeds were shed off, leaving the receptacle with round to oval scars of seed cushions on its surface. Most of the specimens of *Dictyopteridium* are found preserved in this condition (Pl. 1, Figs. 1, 2 & 3). The seed cushions and the mode of attachments of seeds are shown in Text-figs. 3 & 4.

This type of organization of a female reproductive organ recalls the Indian Mesozoic genus *Rajmahalia paradoxa* (Bose, 1965) which includes the genus *Ontheostrobilus sessilis* of Ganju (1947). In *Rajmahalia* seeds are closely arranged all round an elongated receptacle (or cone axis) as in *Dictyopteridium*. When the seeds fell off, they left impressions of circular scars in *Rajmahalia*. The organization of *Dictyopteridium* is similar to that of *Rajmahalia*. Mesozoic Pentoxylean genus *Carnoconites*, too, shows the same type of organization



TEXT-FIG. 5 — Cells of the outer cuticle (integument) of a seed. $\times 95$.

where the naked seeds are arranged round a cone axis in a crowded manner.

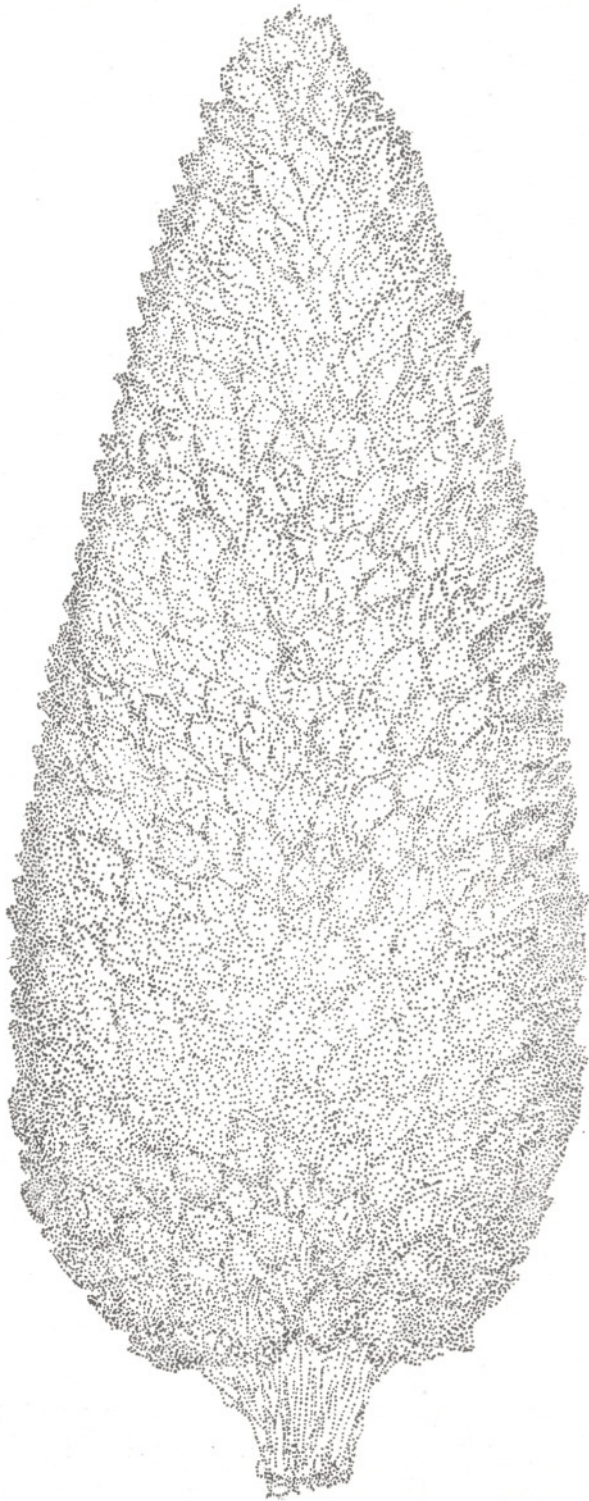
Other fructifications of Glossopteridales such as *Scutum* and *Cistella* also can be interpreted to have the same type of organization. *Scutum* and *Cistella* represents a receptacle or cone axis from which the seeds have been shed, exposing the scars on which the seeds were attached.

There is no doubt that *Dictyopteridium* is one of the fructification of the southern hemisphere Glossopteridales. Is it likely that Mesozoic Pentoxyleae and plants such as *Rajmahalia*, which have not been found in the northern hemisphere, have evolved from the southern hemisphere glossopteridean stock?

COMPARISON AND DISCUSSION

The specimen shown in Pl. 1, fig. 2 is similar to that illustrated by Feistmantel (1881) on his Pl. XXIII A, fig. 4 (here reproduced on Pl. 1, Fig. 1). *Dictyopteridium* is neither a fertile leaf of some fern as regarded by Feistmantel and later by other authors, nor a fleshy rhizome bearing scars of caducous hairs as thought of by Zeiller (1902). It is undoubtedly a female reproductive organ of a gymnospermous plant — most probably belonging to Glossopteridales.

Zeiller (1902) included a larger specimen from the South Rewah, measuring 7.5 cm. long and 1.5 cm. broad under the name



TEXT-FIG. 6 — A reconstruction of a *Dictyopteridium sporiferum* cone. $\times 6$.

Dictyopteridium (see Pl. 1, Fig. 6). It showed irregularly arranged small round depressions, which he compared with the circular marks of *Stigmaria*. He did not agree with Feistmantel's interpretation that the round depressions were left by receptacles, around which were arranged sporangia. He has also not been able to observe venation on the body as mentioned by Feistmantel. Zeiller did not believe that *Dictyopteridium* was a fertile fern frond. He, on the other hand, thought that it was a root or some kind of a fleshy rhizome or an appendicular organ comparable to that of *Stigmaria*. In our opinion, Zeiller's specimen does not belong to *Dictyopteridium* at all and, therefore, should be taken out of this genus.

Rao (1935) suggested a resemblance between *Rhizomopsis gemifera* Goth & Ze, a rhizome from China and *Dictyopteridium sporiferum* from India. This view is no longer tenable as the former represents a rhizome and the latter a female fructification.

Walkom (1922) described a single specimen of *Dictyopteridium* from the Lower Bowen Series of Australia as identical with Zeiller's and Feistmantel's specimens from India. The Australian specimen is 5 cm. long but only 6 mm. wide. It is narrower than the Indian specimens including the ones described here. Walkom observed irregularly arranged small circular scars and traces of few veins. His figure (Pl. 9, Fig. 48), however, does not show any details and, therefore, without seeing Walkom's original specimen, it is not possible to say whether the Australian specimen really belongs to *Dictyopteridium*. However, if White's (1963) specimen is any guide, which she thought resembles Walkom's specimen, then the latter could be a *Dictyopteridium*.

Maheshwari's (1965) specimen from the Raniganj coalfield definitely belongs to *Dictyopteridium sporiferum* (see Pl. 1, Fig. 4). He described this organ as pedicellate with its body covered with oval to circular scars, with faint venation in between the scars. This "venation" is of course nothing but wrinkles which are observed in between the scars as in our specimens. He made a transfer preparation of the specimen which, according to him, revealed a net venation resembling that of *Glossopteris angustifolia*. This observation is intriguing but as the specimen is not available, it is not possible

to confirm it. *Dictyopteridium* should have seeds attached all round the cone axis or receptacle and the net venation on the other side does not seem possible. Maheshwari further mentioned that the epidermal characters as discovered by him, however, were not of *G. angustifolia* type. White (1962) had earlier suggested that *Dictyopteridium sporiferum* is the fertile leaf of *Glossopteris angustifolia* which, without present understanding of the fructification, is not correct. It is still not proved that *Dictyopteridium* is borne by *Glossopteris angustifolia*. It is also unlikely that a fructification would have such unusual structure, seeds on one face and net venation on the other.

White (1962) reported fertile material of *Glossopteris angustifolia* in a collection of plant fossils from Upper Bowen sediments in the Mount Coolen area in Queensland. She described scale fronds with narrow, gangamopteroid laminae and shallow scales, bearing sporangia on the surface as representing *Dictyopteridium sporiferum* of Feistmantel. She believed them to be the male organs of the plant. From the description White's specimens appear to be quite different from the *Dictyopteridium sporiferum* of Feistmantel and ours as described here in detail.

White described perhaps the same collection in detail in 1963. The fragments of fertile laminae as figured by her in Plate XXII, fig. 5 with round or oval sporangia (referred by her to "*Dictyopteridium sporiferum*") are not the *Dictyopteridium* of Feistmantel and, therefore, should not be included in that genus. However, her (1963) specimen illustrated in figure 12, Plate XXIV could be a *Dictyopteridium*, but the circular bodies scattered on the surface should not be interpreted as sporangia, they could be impressions of seed cushions.

AGE OF THE ORISSA BEDS

Plumstead (1970) regarded *Dictyopteridium sporiferum* a potentially index fossil plant. It has been recorded from the Raniganj stage in India by Feistmantel (1881), Maheshwari (1965) and by us. It has also been reported from the Upper Bowen of Queensland, Australia and Upper part of the

Lower Beaufort in Zululand, South Africa (Plumstead, 1970). All these are from closely comparable horizons. The beds near Hinjrida Ghati in Dhenkanal district of Orissa, of which the age was in doubt, yielded specimens of *Dictyopteridium* and should, therefore, be regarded as equivalent to the Raniganj stage. Predominance of *Glossopteris* species also point to the same conclusion.

RELATIONSHIP

Dictyopteridium sporiferum has not been found attached to any leaf or stem. But from its association with *Glossopteris* and its similarity in organization to *Scutum* and *Cistella* (which have been found attached to *Glossopteris*), it can safely be inferred that *Dictyopteridium* also belonged to one of the Glossopteridean plant.

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EXPLANATION OF PLATES

PLATE 1

1. *Dictyopteridium sporiferum* specimen from G.S.I. (No. 5210) illustrated by Feistmantel (1881) in figure 4 on Plate XXIII in his fossil floras of the Gondwana System, Vol. III, pt. II magnified to show the shape of the fructifications and the arrangement of oval seed cushions on the cone axis. This specimen is identical to our specimen shown in figure 2 on this Plate. Feistmantel's specimen no. 5210 illustrated in fig. 1 here has been named the lectotype of *Dictyopteridium sporiferum* × Ca 4-5.

2. A specimen of *Dictyopteridium sporiferum* collected from the road cutting near Hinjrida Ghati in Dhenkanal district, Orissa, India. Note short longitudinal wrinkles on the body of the fructification in between the oval seed cushions which might have been mistaken for venation. × 3-5. B.S.I.P. No. 35031.

3. Another specimen from the same locality in Orissa. Impressions of seeds are seen on the lower part of the cone, whereas in the upper half are seen round or oval seed cushions similar to those in specimens illustrated in Figs. 1 & 2 above. Also see enlarged views of this specimen in Pl. 2, fig. 10 and Pl. 3, fig. 18. × 2-5. B.S.I.P. No. 35032.

4. Specimen (No. 32873) of *Dictyopteridium sporiferum* of Maheshwari (1965) from Raniganj enlarged to show round seed cushions arranged in the same manner as in our specimen (Fig. 2) and that of Feistmantel (Fig. 1). × 5.

5. Feistmantel's (1881) specimen (G.S.I. No. 5211) of *Dictyopteridium* illustrated by him in Pl. XXIII A, fig. 5. This could be included in *Dictyopteridium sporiferum*. × 4.

6. Specimen of *Dictyopteridium* (G.S.I. No. 7286) illustrated by Zeiller (1902) in his Pl. IV, fig. 8. The shape size and round spots on the body are different from those illustrated in figs. 1, 2 and 3. × 1.

7. Feistmantel's specimen (G.S.I. No. 5318) illustrated by him in Pl. XLII, fig. 4 from the South Rewa. This is a small leaf and not *Dictyopteridium sporiferum*. × 2-5.

8. Feistmantel's specimen (G.S.I. No. 5212) illustrated by him in Pl. XLII A fig. 6 under *Dictyopteridium sporiferum*. This specimen does not look like a *Dictyopteridium* as illustrated in figs. 1, 2, 3 and 5. × 1.

9. Another specimen of Feistmantel (1886) from South Rewa referred by him to *Dictyopteridium sporiferum*. It is obviously a *Cistella* type of fructification. × 1.

PLATE 2

10. Enlargement of the specimen shown in Pl. 1, fig. 3. Note oval seeds on the right side in the lower half and a few sockets on the left side from where the seeds have escaped. Round impressions of seed cushions (seed have already been shed) similar to those illustrated in Pl. 1, figs. 1 & 2 are seen all over the rest of the body of the fructification. $\times 4.5$.

11. Enlargement of the specimen shown in Pl. 1, fig. 2. Note the peculiar arrangements of oval seed cushions and longitudinal wrinkles in between the cushions which could probably be mistaken for venation. $\times 6.5$.

12. A compressed specimen of *Dictyopteridium sporiferum* collected by us from the Raniganj stage. Note oval seeds on the left and top right side of the fructification which are identical with those shown in Pl. 3 & 4, figs. 17 & 22. \times Ca. 10. B.S.I.P. No. 35033.

PLATE 3

13-15. Macerated seeds of *Dictyopteridium sporiferum* taken from such compressions as shown in figs. 17 & 22. Note the obtusely conical neck

with longitudinally arranged cells and torn chalazal ends. $\times 85$, $\times 46$, $\times 46$. Sl. Nos. 4459, 4460.

16. Neck of the seed shown in fig. 13 enlarged. Note rectangular cells with slightly wavy walls, arranged end to end. $\times 265$. B.S.I.P. Sl. No. 4459.

17. A small part of a compressed fructification with exposed seeds. Note their arrangement. $\times 10$. B.S.I.P. No. 35033.

PLATE 4

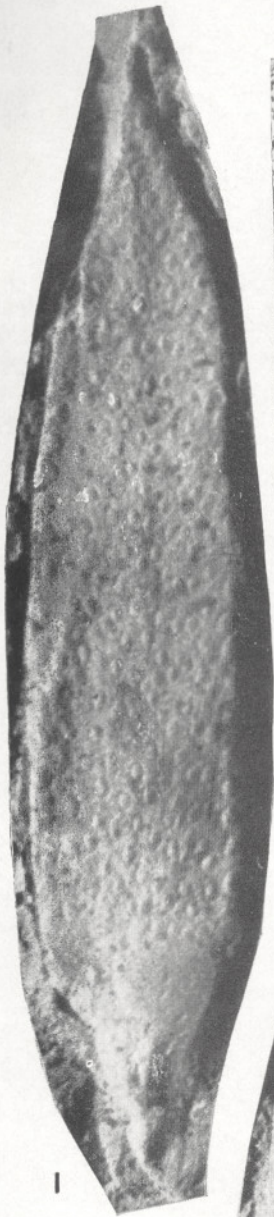
18. Enlarged lower part of fructification shown in Pl. 1, fig. 3 to show the impressions of oval seeds. The photograph is pasted upside down, the stalk is at the upper end. $\times 10$.

19. Short squarish cells at the chalazal end of the seed. $\times 150$ B.S.I.P. Slide No. 4461.

20. The chalazal end of the seed showing hemispherical concavity by which the seed is attached to the cushion. $\times 166$.

21. Cells at the micropylar end of the seed enlarged. $\times 580$.

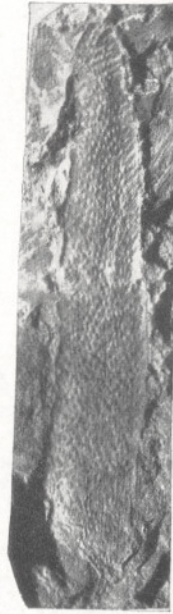
22. A small part of the cone with compressed seeds. Note the arrangement of seeds in regular alternate rows. $\times 12$. B.S.I.P. No. 35033.



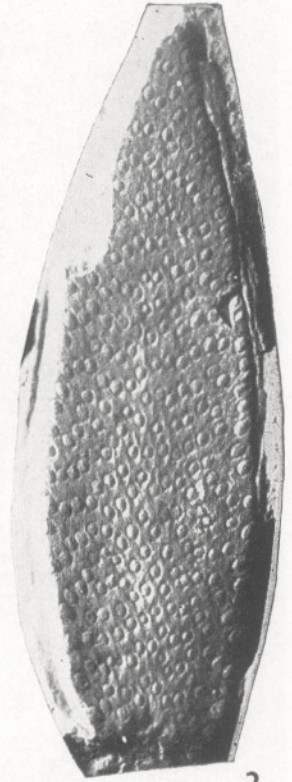
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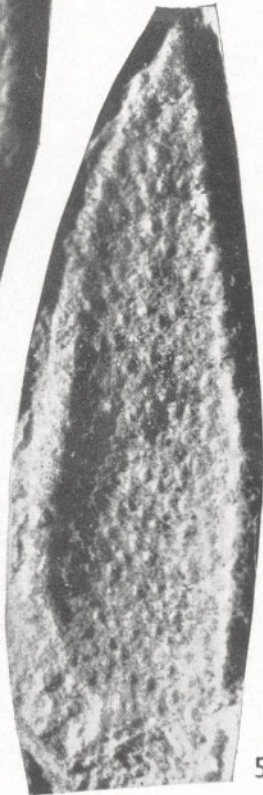
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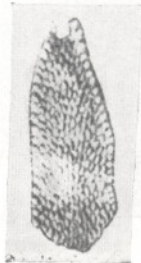
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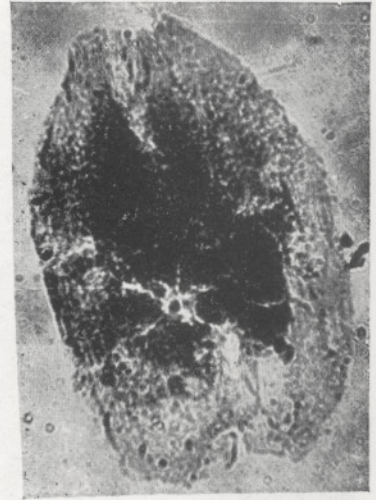
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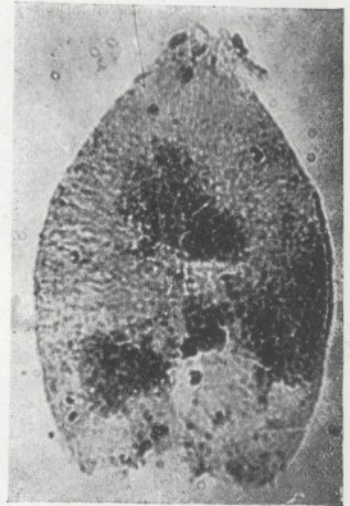
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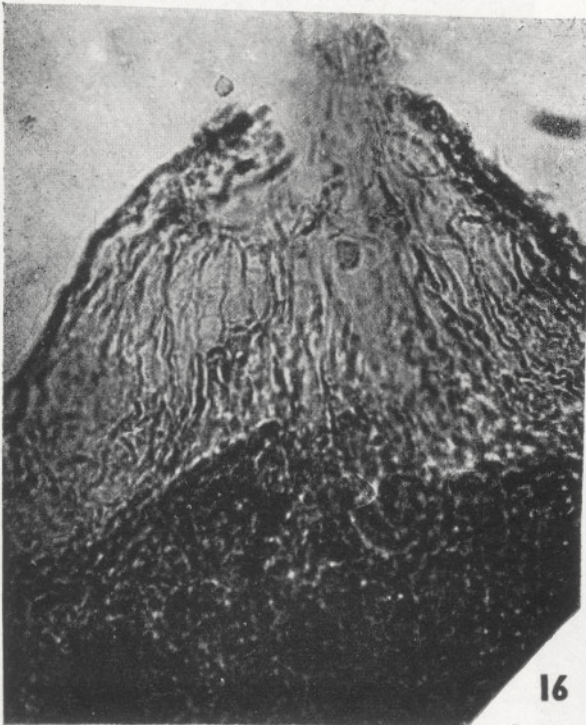
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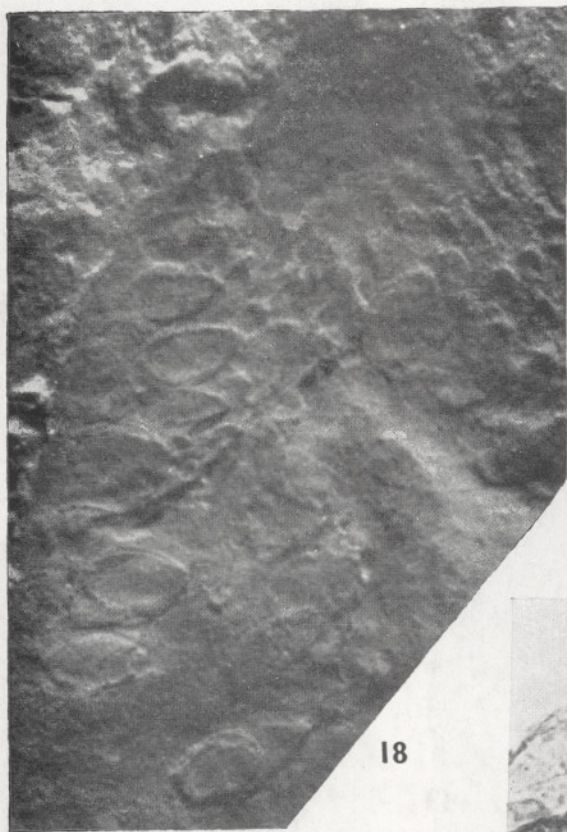
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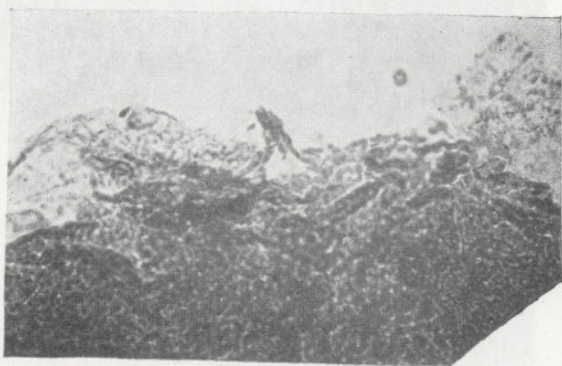
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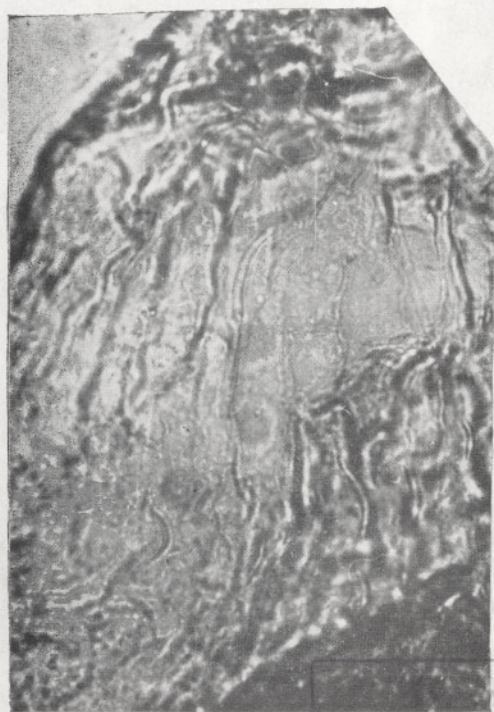
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