FRUCTIFICATIONS OF GLOSSOPTERIDAE FROM INDIA

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ABSTRACT

Three new species of *Scutum*, one species of *Cistella* and a new genus of one winged seed, *Indocarpus*, are described in this paper. *Scutum sahnii* has been found attached to a leaf with venation of *Glossopteris longicaulis* type. *Scutum* is interpreted as a gymnospermous female reproductive organ of some *Glossopteris* species consisting of a bilaterally symmetrical receptacle bearing a large number of naked ovules, and covered on one side by a protective scale-leaf with *Glossopteris* type of venation. Both the scale-leaf and the ovule bearing receptacle are carried on a common pedicel which, in its turn, is attached to the petiole of a *Glossopteris* leaf. *Dictyopteridium* is also shown to be a fructification similar in organization to *Scutum*, possessing a cylindrical ovule bearing head and a scale leaf covering one side of the fructification. It is also suggested that some *Cistella* type of fructifications might be the seedless receptacles of *Scutum*.

INTRODUCTION

IN 1952 Plumstead described reproductive organs of six species of *Glossopteris* and created two genera, viz. *Scutum* and *Lanceolatus*, for their reception. *Scutum* is described as a pedicellate bilaterally symmetrical cupule which grows from the midrib of a leaf of *Glossopteris*. The cupule may be round, oval, lanceolate or ovate with a raised central head and a flat surrounding wing which is often fluted or striated. The fertile half of the cupule is described as containing a number of small oval sacs, embedded in the central head. Later Plumstead (1956) interpreted the cupule as a bisexual flower, the fertile half containing the seeds, and the protective half bearing bract-like staminate organs which carried pollen. The other genus *Lanceolatus* has been found only on the leaves of *Glossopteris retifera* and, like *Scutum*, the fertile head consists of a number of small oval sacs. It has neither a wing nor a pedicel and the cushioned surface on which the sacs grow is the leaf surface itself. The cupule in *Lanceolatus* is described as fused with the leaf.

Plumstead (1958a) described *Ottokaria*, which was earlier reported by Zeiller (1902), and placed *Scutum*, *Lanceolatus* and *Ottokaria* under a new class *Glossopteridae*. In 1958b she described three new fructifications under the *Glossopteridae*, *Hirsutum*, *Cistella* and *Pluma*. *Scutum dutoitides* was placed under a new genus *Hirsutum* because its pollen organs were like thin filaments, instead of bract-like flat projections as in *Scutum* and also the wing being much narrower in the former. *Cistella* is described as an unwinged fructification with certain features common to both *Scutum* and *Lanceolatus*. In *Cistella* the cupule is like a heart-shaped casket and is wingless. It consists of two halves, the female half with well developed oval sacs and the protective half concave and made up of harder tissue. *Pluma* is a fructification which grows from the petiole with a characteristic curved droop and a pendulous fringe, which is reminiscent of ostrich feather.

Scutum has 9 species, *Hirsutum* 2, *Lanceolatus* 3, *Ottokaria* 3, *Cistella* 2 and *Pluma* 2 (Plumstead, 1958).

Out of these six types of fructifications, five have been recorded from India. Sen (1955) recorded an ovulate organ from Mohuda coal seam, which Plumstead later (1958b) included under *Lanceolatus communis*. There is also another record of poorly preserved *Lanceolatus* from the lower Barakars of Pachwara coalfield, Bihar (Chatterjee & Sen, 1963). Two impressions (Varma, 1963) from Chintalpudi sandstones were assigned to *Scutum leslium* and *Hirsutum dutoitides* (*Scutum dutoitides*), but the preservation is too poor even for correct generic identification. Mukherjee *et al.* (1966) described a fructification closely resembling *Scutum leslium* attached to the leaf of *G. browniana*. Maceration of the central head yielded unwinged, bilateral, monolete spores and seed-like bodies. They also reported *Scutum dutoitides* attached to a leaf of *G. indica*. Surange & Maheshwari (1970) described *Scutum* and *Cistella* from Orissa. Maheshwari (1965) described a new species, *Cistella indica*, from the Raniganj coalfield. *Ottokaria bengalensis* was instituted earlier by Zeiller (1902) from the Karharbari beds, which, according to

Mukherjee *et al.* (1966) is attached to the leaf of *Glossopteris indica*.

The specimens described here were collected from a thick bed of hard, compact, clayey shale, exposed at Hinjrida Ghati in Dhenkanal district of Orissa.

DESCRIPTION

1. *Indocarpus* gen. nov.

Surange & Maheshwari (1970) reported several " ovule bearing scales ", which they assigned to *Scutum* type of fructification. In our collection also a large number of such seeds are present and for which a new generic name, *Indocarpus*, is proposed here.

Generic diagnosis — One winged seed; stalk short, not always visible; nucellus round at chalazal end, pointed or bifid at the micropylar end; wing one, large, flat, extended on one side well beyond nucellar end.

Type species — *Indocarpus elongatus* sp. nov.

Holotype— 35090.

Horizon — Raniganj Stage.

Locality — Handappa, Orissa, India.

Pl. 2 and 4, Figs. 5, 14; Text-figs. 1, 2 illustrate the seeds described under this genus. They are present in large numbers in our collection. The seed has one, expanded, flat wing, projected on one side

TEXT-FIG. 1 — *Indocarpus elongatus* gen. nov. et sp. nov. A group of one winged seeds lying round of squashed axis. × 4.

TEXT-FIG. 2 — One winged seed of *Indocarpus elongatus*. Note the short stalk and bifid micropylar end of the nucellus. × 7.

far beyond the micropylar end. The seed including the wing measures 8-10 mm. in length and 3-4 mm. in breadth (Text-fig. 2). Towards the chalazal end, a few seeds show a short stalk but in majority of them no stalk is seen and the chalazal end looks rounded. The nucellus measures 4 × 2 mm. and occasionally a seed shows pointed or bifid micropylar end (Text-fig. 2). The wing can be regarded as an expansion of the integument of the seed. It is narrow on the sides, which almost closely encloses the nucellus and then expands and extends far beyond the nucellar end for about 3-4 mm. or more. Free part of the wing is flat and measures 4-6 mm. in length from the micropylar end and 3-5 mm. in breadth. Pl. 4, Fig. 14 shows a seed which has thick walled nucellus and a long wing with longitudinal markings. The asymmetrical expansion of wing on one side makes the seed look like an ovule-bearing ovuliferous scale. Earlier Surange & Maheshwari (1970) interpreted the wing as a scale and the inner ovate body as an ovule or seed. The one-winged seed, therefore, was described by them as a ovule-bearing scale. They further assigned these seeds to *Scutum*, suggesting that the wing-like marginal expansion seen in *Scutum* must have been caused by overlapping of the free half of the "scales" (wing). The seed is, however, too large to suggest any relation with the comparatively smaller specimens of *Scutum* present in the collections from this locality. But some South African specimens of *Scutum* seem to possess long and large seeds, giving a broad winged appearance to fructifications. Such large specimens of *Scutum* might have possessed this type of seed, but at present there is no such evidence.

However, there is also a strong possibility that these seeds were borne on a stalked, pad-like disc type of organ. Text-fig. 1; Pl. 2, Fig. 4 show a group of seeds lying close together, as if they have been crushed out of a fructification. There is an impression of a squashed object of irregular shape, lying in the centre of the crowded seeds. One or two seeds appear to have been attached to it, but the attachment is not clearly seen (Text-fig. 1).

The type of seed described here is not comparable to any of the known seeds of the Glossopteris flora and so it is placed under a new name, *Indocarpus elongatus* gen. et sp. nov.

2. *Scutum sahnii* sp. nov.

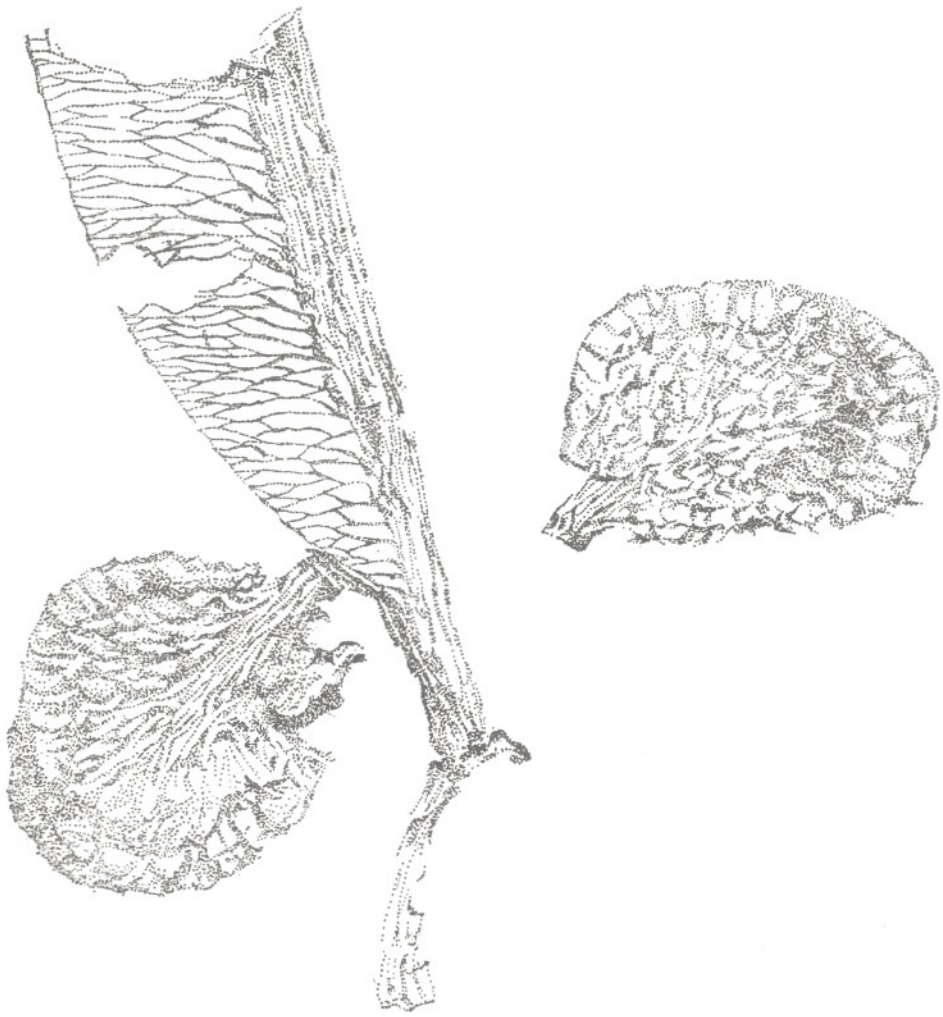
Diagnosis— Fructification attached to leaf showing venation of *Glossopteris longicaulis* type; fructification almost round, consisting of seed bearing head or receptacle and a veined scale leaf borne on common pedicel; scale leaf with distinct midrib, dissolves halfway upwards into bifurcating, secondary veins; secondary veins form meshes; seed bearing head or receptacle convex, lense-shaped, bear ovules or seeds; wing-like rim all round except at the base.

Holotype — 35093.

Horizon — Raniganj Stage.

Locality — Handappa, Orissa, India.

The fructification is attached to a leaf of *Glossopteris* (Pl. 1, Fig. 1; Text-fig. 3). The leaf is incomplete, but the venation indicates that it belongs to *Glossopteris longicaulis* type (Text-fig. 3). The leaf has a long petiole measuring 3 cm. in length and 3 mm. in breadth. The petiole continues into the lamina as a prominent midrib, which in the basal region is as broad as the petiole. The secondary veins are prominent and form broad meshes, lying almost at right angles to the midrib. Each secondary vein arises at an acute angle and bifurcates immediately close to midrib, at the same time curving outwards almost at right angles to it. Each bifurcation



TEXT-FIG. 3 — Holotype of *Scutum sahnii* attached with a long pedicel to a leaf with *Glossopteris conspicua* type of venation. On the right is shown the seed bearing receptacle and on the leaf is its attached counterpart, the veined scale leaf. × 3.

again forks, one of the fork either joins the adjoining vein or gives out a small cross connection which meets the adjoining vein, thus enclosing a mesh. Each secondary vein forks three or four times during its course up to the margin. The meshes near the midrib are large and broad, becoming slightly narrower towards the margin. Near the base the meshes are smaller than those in the middle region of the leaf. Each mesh is diamond-shaped, hexagonal or pointed at both ends, and is much longer than broad. The meshes are straight and not arched.

The fructification is attached to the petiole by a long stalk, 1·3 cm. in length and 2 mm. in breadth (Pl. 1, Figs. 1, 2). The stalk is partly preserved and it is seen lying along the side of the petiole and ultimately joining with it (Text-fig. 3).

The fructification appears to be a bilaterally symmetrical organ, almost round to oval in shape and measures 2×1·8 cm. (Text-fig. 3). The type specimen (Pl. 2, Fig. 2) and its counterpart (Pl. 1, Fig. 1) have left quite different impressions on the rock. The counterpart (Pl. 1, Fig. 1) is a round to oval organ with a short stalk, concave in the middle or saucer-shaped, with 2 mm. wide wing-like rim all round, except at the base, where it is broken by

the stalk. Plumstead has described one half of *Scutum* as veined. This organ is also distinctly veined, with a thick midrib, almost as wide as the stalk and, about halfway upwards, dissolving into dichotomizing secondary veins. The midrib also gives out lateral secondary veins, which further bifurcate and anastomose, forming meshes. This type of venation pattern is similar to that of *Glossopteris* leaves or the scale leaves, which are usually associated with reproductive organs described by Surange & Chandra (1973). In our opinion, therefore, the so-called "veined half" of *Scutum* should be regarded as foliar in nature, equivalent to a scale-leaf, a spathe or a protective foliar organ.

The other half, the so-called "fertile half", is a stalked central head or a receptacle, oval to round and convex, and with a wing-like rim as broad as seen in the counterpart (Pl. 2, Fig. 2). The central head shows some oval impressions of what must have been the seeds, and at some places irregular cavities from which the seeds had been torn off. That the central head can be regarded as a receptacle or a swollen, seed-bearing head is clear from comparison with other species of *Scutum* (see Pl. 3, Figs. 6, 7, 8 & 9). The morphology of *Scutum* is discussed in the latter part of this paper.

Pl. 4, Fig. 10 and Text-fig. 4 shows another detached fructification which is round and incomplete, preserved upside down with the scale leaf or the spathe-like foliar covering lying underneath the seed bearing receptacle. A part of the scale leaf

TEXT-FIG. 4 — A seed bearing receptacle of *Scutum sahnii*. A part of the scale leaf lying below the receptacle is seen on the right. × 5.

is seen coming out from below on the right side, somewhat displaced and crushed, forming a sort of wing-like rim (although incomplete) round the seed bearing receptacle.

Comparison— Plumstead (1958b) described *Pluma* type of fructification on *Glossopteris longicaulis* leaf. Our specimen does not compare with *Pluma* or any of the species described under *Scutum* so far. *Scutum leslium* is also a round fructification, but it has very wide " wing " as compared to the " head ". *Scutum sahnii* has a narrow rim. *Scutum thomasii* has a 3 mm. wide " wing ", but the specimen is egg shaped. *Scutum draperium*, which is borne on *Glossopteris conspicua* (Plumstead, 1958b), is also different from *Scutum sahnii* in possessing large oval head with narrow fluted wing. Most of the South African species appear to possess wider " wings " than the Indian specimens described here. Our specimen is also distinct from *Scutum leslium* and *Scutum dutoitides* described by Mukherjee *et al.* (1966) from India and *Scutum elongatum* and *Scutum indicum* described in this paper.

3. *Scutum elongatum* sp. nov.

Diagnosis — Female reproductive organ; scale-leaf or spathe-like covering veined; seed or ovule bearing receptacle oval-elongate, almost twice as long as broad; marginal seeds large, crowded, arranged in a row, forming a definite rim; seed cushions or seeds on central part of receptacle large, almost round, with small round marking in the centre.

Holotype — 35095.

Horizon — Raniganj Stage.

Locality — Handappa, Orissa, India.

Pl. 4, Fig. 11 illustrates the type specimen which is a cast. Its counterpart shows a poorly and incompletely preserved scale-leaf or a spathe-like covering, with an indication of a midrib on it. Secondary venation is not clearly preserved. There is, however, no doubt that the counterpart is a veined organ and it is not a negative impression of the seed bearing head.

The fructification is elongately oval, measuring 2 cm. in length and 1·2 cm. in breadth with a short stalk, about 2 mm. in breadth. It is broadest in the middle, tapering more rapidly towards the apex than towards the base. The apex and base are rounded; the apex may be somewhat narrower than the base. The marginal ovules or seeds are arranged in a row, overlapping one another and forming a definite " wing-like " rim all round, except at the base, where the receptacle is attached to the stalk. The position of each ovule or seed is marked from the other on the rim by cross markings. The wing-like rim is 2 mm. in breadth which is almost the size of the seed. The marginal seed must have been laterally compressed during preservation and so they are seen here lying in a row, forming a wing-like rim.

Text-fig. 5 shows an incomplete, obliquely preserved specimen, with laterally compressed seeds on the margin, attached to round cushions on the receptacle. The seeds in the middle region were pressed vertically downwards and so are seen preserved as circular mounds, about 2 mm. in diameter, and showing a central circular scar of the micropylar end in the centre. The seed is large and measures about 2·5-3 $\times$ 1 mm.

Pl. 3, Fig. 9 illustrates another specimen placed under this species. The fructification is 2 cm. long and 1 cm. broad.

Comparison — Scutum elongatum differs from *S. sahnii* and *S. indicum* in shape and size. The seeds of *S. elongatum* are larger than those of *S. sahnii* and shorter than those of *S. indica*. Its scale leaf also has a different type of venation. All the three fructifications look quite distinct from one another. *S. elongatum* does not also resemble with any of the South African species of *Scutum* described by Plumstead. The organization of *Scutum* being the same, the specific differences will naturally be found in shape and size of the seed bearing receptacle and the details of seed structure. In impressions or casts, the details of seed structure being not available, the specific distinctions would necessarily be based on the size, shape and other details of the receptacle and the impressions of seeds.

4. *Scutum indicum* sp. nov.

Diagnosis— Fructification broad, flat, apex as wide as base, slightly more long than broad; seeds large, elongated.

Holotype — 35097.

Horizon — Raniganj Stage.

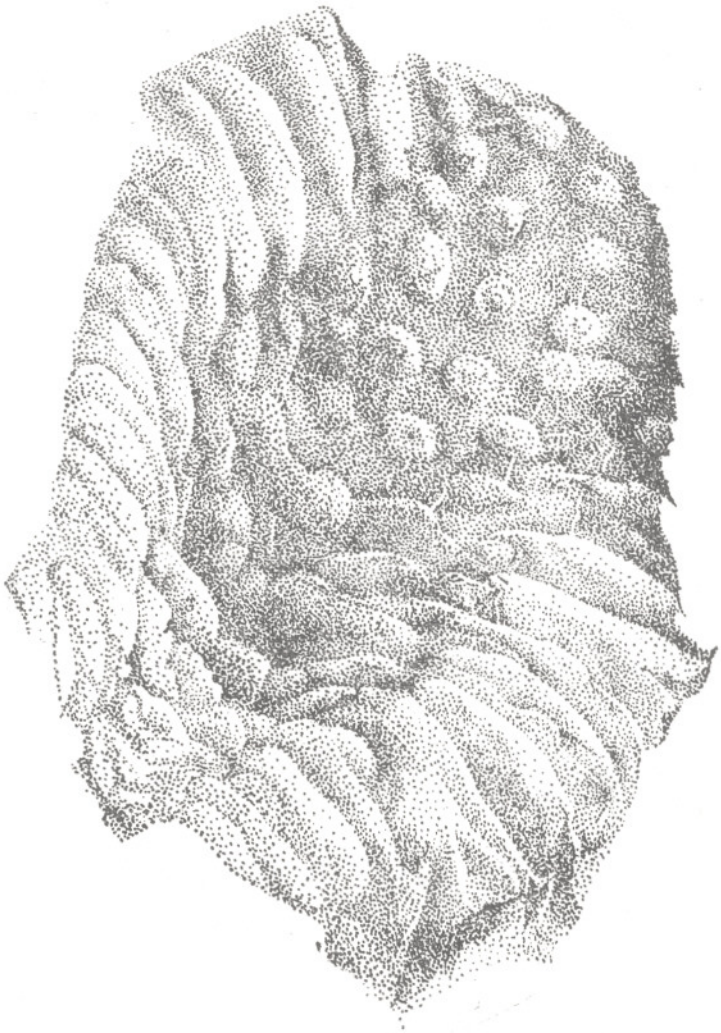
Locality — Handappa, Orissa, India.

Pl. 3, Figs. 6, 7, 8 and Text-figs. 6, 7 show casts of fructifications described under this specific name. In shape and size they are different from those described above

TEXT-FIG. 5 — An obliquely compressed specimen of *Scutum elongatum*. Marginal seeds are laterally compressed and are seen attached to round cushions. Cushions on the right side are round with a circular mark in the middle.

under *S. sahnii* and *S. elongatum*. The stalked fructification in Pl. 3, Fig. 8 is 2·3 cm. long and 1·5 cm. broad. The stalk measures 4 mm. in length. The lateral sides of the fructification are almost parallel to each other, converging into a broad apex and so the fructification looks broad and flat. The marginal seeds are very large, and laterally compressed, and are seen arranged in a row round the margin, thereby forming a broad wing-like rim. The counterparts of all specimens described under this species were lost while breaking the shales. The seeds are large and measure 3-2·5 mm. × 1·5 mm.

The specimen illustrated in Pl. 3, Fig. 7; Text-fig. 6 is a well preserved cast of a seed bearing receptacle in which large, marginal, laterally compressed seeds are clearly seen attached to round seed cushions on the receptacle. The specimen is incomplete and measures 1·5 cm. in length and 1·5 cm. in breadth; the central portion in between the marginal seeds is narrow and about 7 mm. broad. Towards the apex in the middle are seen scars of circular seed cushions, about 1 mm. in diameter. Seeds in this region were perhaps knocked off during preservation, or they were shed in usual course. In the basal region, some seeds are seen obliquely compressed. Marginal seeds were compressed laterally and so were flattened lengthwise. Some of them are seen still attached to the seed



TEXT-FIG. 6 — Holotype of *Scutum indicum* sp. nov. Note the laterally compressed marginal seeds still attached to the cushions. × 8.

cushions (Text-fig. 6). The seed measures 4×2 mm. in size.

In Pl. 3, Fig. 6 and Text-fig. 7 is shown another specimen of seed bearing receptacle with large, marginal seeds and narrow central region with round scars of seed cushions. This specimen was somewhat obliquely compressed so that the marginal seeds were pushed on to the central part of the receptacle and the scale-leaf lying below it appeared as a rim outside the ovules on the left side. Some marginal seeds on the right are half removed, revealing underneath the impression of a scale-leaf or a spathe-like foliar covering. The wing-like rim seen on the left upper side is also a part of the same scale-leaf. The fructification in this case is preserved with the seed bearing head lying above the scale leaf.

Comparison — *Scutum indicum* is distinct from *S. sahnii* and *S. elongatum* in possessing very large seeds and in shape and size of the receptacle. It is also distinct from other species of *Scutum* described from South Africa.

5. *Cistella ovata*

Diagnosis — Fructification stalked, unwinged, oval; ovate head of receptacle with

TEXT-FIG. 7 — A seed bearing receptacle of *Scutum indicum*. × 8.

round seed scars, spirally arranged; seed cushion round with circular, raised impression in centre.

Holotype — 35100.

Horizon — Raniganj Stage.

Locality — Handappa, Orissa, India.

Pl. 4, Fig. 13 shows a small fructification measuring 1·4 cm. in length and 7 mm. in breadth. It does not possess a wing-like rim all round as in *Scutum* and, therefore, this specimen is placed under the genus *Cistella*. The fructification has a small stalk, about 2 mm. long and 1 mm. broad. The ovate seed bearing receptacle is dotted with large, spirally arranged, round scars on which the seeds must have been attached. Each scar is distinct, and although those on the margin appear to be arranged in a row one below the other, they do not form a wing-like rim round the fructification.

Each scar measures about 1 mm. in diameter and shows in its centre a round raised impression which must be that of a seed stalk. The counterpart of the specimen shows faint impressions of the seed scars and looks like a negative impression of the specimen. It is not a scale leaf or a veined foliar spathe-like organ, which is absent here.

Pl. 4, Fig. 12 shows another specimen of *Cistella*. It has a long stalk, 1 cm. long and 4 mm. broad. The seed bearing head or receptacle is elongated, almost cylindrical with bluntly rounded apex and measures 2 cm. in length and 7 mm. in breadth.

Text-fig. 8 shows an incomplete, oval receptacle of *Cistella* studded with large round

TEXT-FIG. 8 — Receptacle of *Cistella ovata* studded with round seed cushions. Each seed cushion with central circular marking. × 8.

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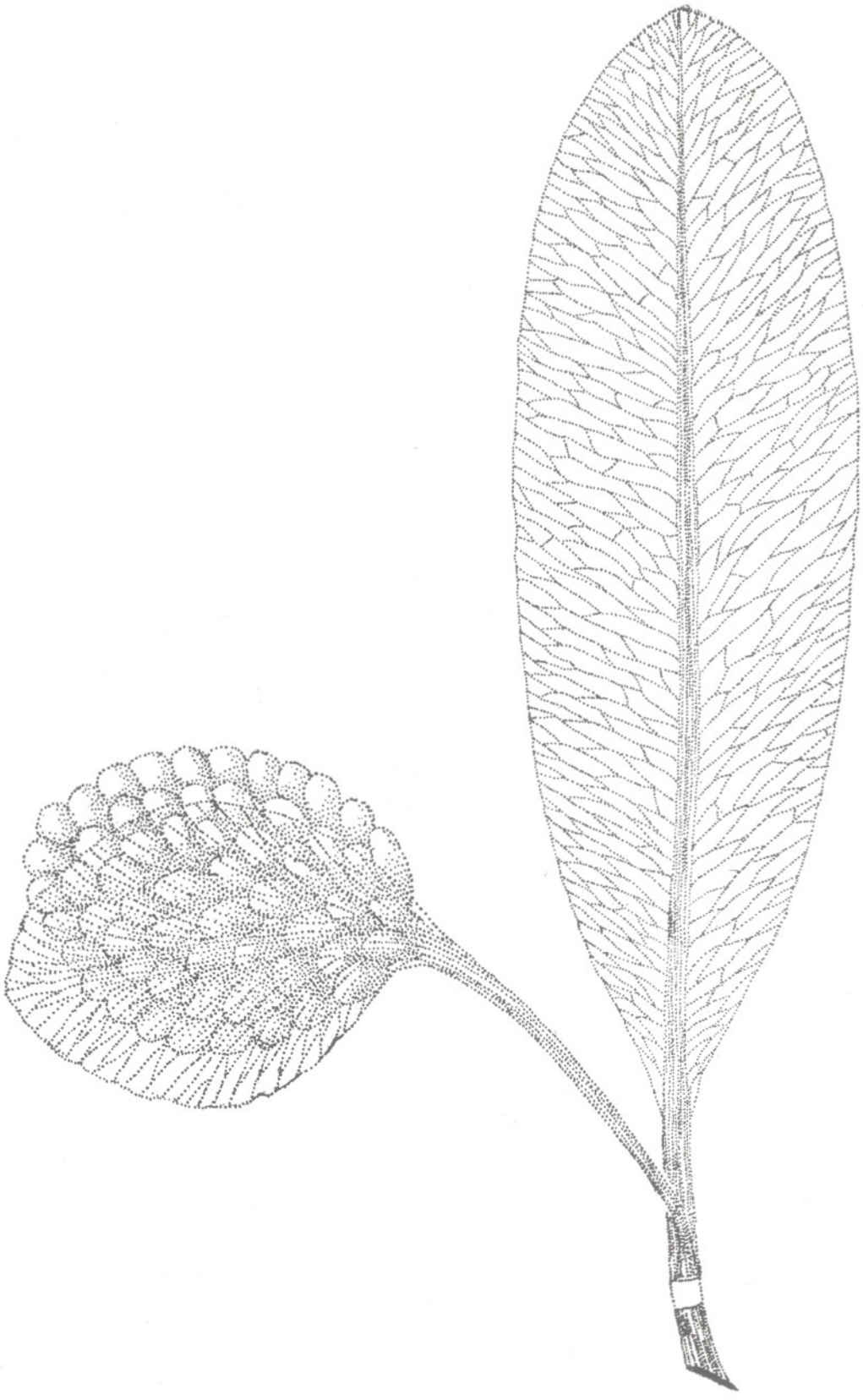
TEXT-FIG. 9 — A reconstruction of *Scutum* attached to a *Glossopteris* by a long pedicel. The scale leaf is partially covering the naked ovule bearing head.



TEXT-FIG 9.

seed scars. Each round scar shows a small, prominent circular marking in the centre.

"Unwinged" *Cistella*, at least some of them, appear to be *Scutum* minus the seeds. *Cistella* perhaps represents a *Scutum* receptacle, covered only with scars of seed cushions, after all the seeds were shed off. Seeds and the scale leaf in *Scutum* were dropped, leaving behind only seedless receptacle studded with seed scars. Such an organ would leave negative impression on the counterpart (not that of a scale leaf) and that is what we found in specimens of *Cistella* in our collection.

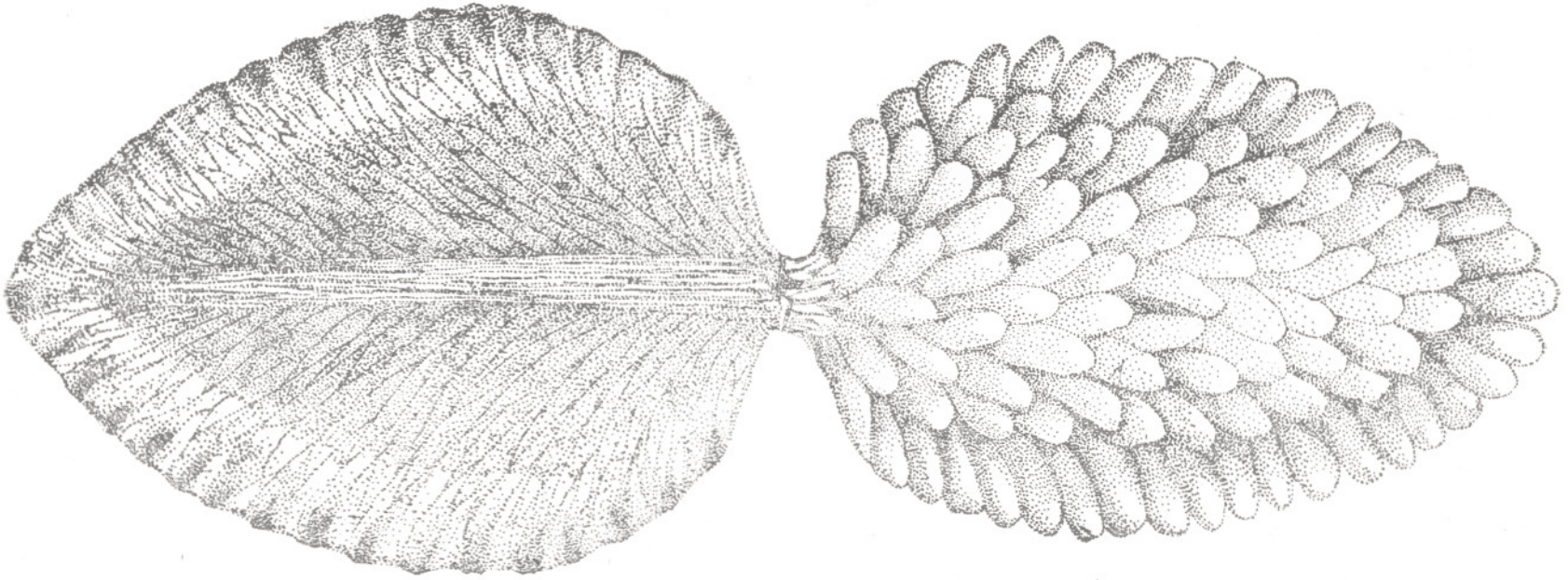
MORPHOLOGY OF *SCUTUM*, *CISTELLA* AND *DICTYOPTERIDIUM*

Scutum

Scutum, according to Plumstead (1952, 1956, 1958b), is a bilaterally symmetrical, two sided cupule, borne on its own pedicel which is attached to the midrib or the top of the petiole of a *Glossopteris* leaf. The cupule may be round, oval or lanceolate. The whole cupule splits into two halves. Each half consists of a central part or head and has fan-shaped venation and a surrounding wing which is fluted, striated or dentate. The adaxial half, called the fertile half, bears on the inside a number of small oval sacs embedded in the tissue of the central head, whilst in the vast majority of cases the opposite abaxial half is empty and apparently only protective. In some specimens, however, the abaxial half, instead of being empty, bore varying number of long, broad bracts or microsporophylls, extending well beyond the wing. Clusters of pollen grains were found on these bracts. *Scutum* (and also *Lanceolatus*) is thus considered by Plumstead as a bisexual organ having so many angiospermic characteristics as to make these members of the Glossopteris flora the Permian forerunners of the Angiosperms.

From our observations on Indian material of *Scutum* (some of which is preserved as casts) we find that *Scutum* is undoubtedly a bilaterally symmetrical, two sided organ which, when split up, shows two quite different surface features on its two halves. One half shows a veined surface, the venation is Glossopteris type, while the other half shows a seed bearing head, surrounded by a wing-like rim of varying breadth, depending upon the species of *Scutum*. Thus *Scutum* appears to be composed of two separate entities (organs) which are closely fitted on each other. Where the two organs join would thus become a weak zone and when the rock containing *Scutum* is split, it breaks along this weak zone, separating the two organs, one veined foliar organ and the other seed bearing head. This is how *Scutum* is generally found in the rocks. When broken into two halves, the two halves are not the negative and positive impressions (as it should be if two halves are parts of one organ) but two impressions with separate surface features. *Scutum*, therefore, appears to consist of two separate organs and not one.

It is difficult to regard the veined half of *Scutum* as part of *one organ, the cupule*, as is done by Plumstead (1952). In our opinion, it would be much better to regard the veined half of *Scutum* for what it really is, a spathe-like foliar organ or an equivalent of a scale leaf, possessing normal type of venation. The Glossopterid fructifications described earlier by us (Surange & Chandra, 1973) have always been found associated with scale leaves with distinct types of venation and such innumerable detached scale leaves are present in our collection. Text-fig. 3 and Pl. 1, Fig. 1 show the veined half of *Scutum sahnii* with a distinct midrib which dissolves into secondary veins halfway upwards. It also gives out laterally anastomosing secondary veins. If this organ is found detached, there would be no hesitation in calling it a scale leaf. We are, therefore, inclined to regard the veined half of *Scutum* as equivalent to a scale-leaf. The scale-leaf in *Scutum* performs perhaps a protective function, as a spathe-like covering to immature, naked ovules borne on a receptacle. In other words, the ovule bearing receptacle is borne in the axil of the scale-leaf and the scale leaf appears to be closely fitted to the ovule bearing head. Both the scale-leaf and the ovule bearing head are carried on a common pedicel, and these two are situated so close to each other that, during preservation, the scale leaf would fall over the fructification, almost entirely covering it (Text-fig. 9). We can well imagine that at the time of fertilization the scale leaf either fell off or opened sufficiently wide to allow wind borne winged pollen grains to land on the mature ovules, attached all round the naked receptacle,



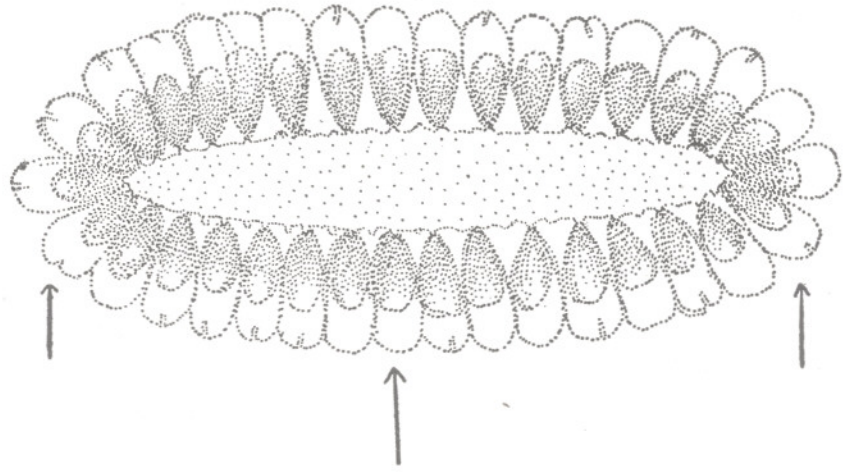
TEXT-FIG 10 — A reconstruction of *Scutum*. The veined scale leaf is shown completely opened up. Marginal seeds on the receptacle are shown arranged in a row (see Text-fig. 11) and they have left a wing-like impression on the margin of the veined scale leaf.

Text-fig. 9 shows a reconstruction of *Scutum* with the scale leaf covering partly the seed bearing head.

The other half of *Scutum* (the fertile half) is the ovule studded central head or a receptacle which is always found preserved flat. There is, therefore, no doubt that it is a bilateral organ, convex in the middle and thin at the margin. In cross section the receptacle would appear lense-shaped. Text-fig. 11 shows a diagrammatic cross section through an ovule bearing receptacle. The receptacle is shown as convex in the middle and thin at the margin, somewhat like two watch glasses joined together. Its surface is studded with small, hemispherical bulges on which the ovules are attached. During preservation such a lense-shaped organ would always lie flat on the ground and *Scutum* is generally found compressed on the rock in this condition. During fossilization the ovules on the middle convex region of the receptacle would get compressed vertically downwards into a round to oval swellings, whereas those on the margin would get compressed laterally or lengthwise (see arrows in Text-fig. 11). Thus, laterally pressed marginal ovules would become elongated, overlap and come to lie in a row, leaving a rim or a wing-like impressions on the margin of the fructification. This would explain the "wing-like" rim of *Scutum*, which is nothing but the laterally compressed marginal seeds (Text-fig. 11). The width of the "wing" or rim in *Scutum* species would depend upon the size and structure of the seeds. The larger the seed, broader would be the "wing" or rim. The laterally compressed seeds on the margin of the receptacle would also leave their imprint on the veined scale leaf which was lying over it during preservation. Text-fig. 10 shows a reconstruction of *Scutum* in surface view. The marginal ovules, because of the lense-shaped receptacle (thick in the middle, thin at the margin), would tend to lie in one row, thus forming a wing-like rim. The scale-leaf in Text-fig. 10 is shown completely open with venation and the impression of a rim as wide as the ovules on the receptacle.

If a specimen of *Scutum* splits from the scale leaf side, the veined scale leaf appears as a concave impression and the counterpart as a convex ovule-bearing head. If *Scutum* splits from the ovule bearing side, the two parts show the positive and negative impressions of the ovule bearing head. The ovules, therefore, must have been borne on all sides of the receptacle. *Scutum* cannot be regarded as a cupule with ovules borne on one side and enclosed on the other by a veined protective covering. Thus the ovule bearing receptacle of *Scutum* can be compared with the ovule bearing receptacle of *Rajmahalia paradoxa* (Bose, 1966) or that of the ovule bearing cone axis of the Pentoxyleae, *Carnoconites*.

The scale leaf and the ovule bearing head are situated very close to each other and



TEXT-FIG. 11 — A diagrammatic cross section through the receptacle of *Scutum*. It is lense-shaped with ovules attached on cushions all round it. The marginal seeds during fossilization would be compressed lengthwise and those in the middle vertically downwards as shown by arrows.

both these are very near the surface of the vegetative leaf in the axil of which they are borne (Text-figs. 9, 10). The ovule bearing head must have received protection from the scale leaf on one side and the vegetative leaf on the other. The protective function, therefore, appears to have been shared by both these foliar organs (vegetative leaf and scale leaf) when *Scutum* fructification was in young stage and when the protection was required most. It is also likely that the scale-leaf or the spathe-like foliar covering might completely surround the seed bearing head in the young developing stage. As the ovule bearing head grew bigger in size, the scale-leaf opened up and provided a partial cover on one side. When the fructification matured, the scale-leaf perhpas fell off, exposing the ovules for fertilization. *Scutum*, therefore, can be regarded as a reproductive organ of *Glossopteris* which is both functionally and structurally gymnospermous.

We have not found any evidence of male organs on the " veined half " (scale leaf) of *Scutum* in our material. From Plumstead's photographs, which are excellent (Plumstead, 1956, Pl. 9, Figs. 3 & 4) it appears that the so called " male bracts " are merely the impressions of displaced, distorted and long marginal seeds on the receptacle, which got imprinted on the veined counterpart (see Plumstead, 1956, Pl. 9, Figs. 3 & 4). The evidence of pollen from maceration of scrappings of the surfaces of so-called male bracts is untenable. Any scrappings from a shale piece, at least from Indian Lower Gondwanas, is likely to yield quite a number of spores and pollen.

In our opinion, therefore, *Scutum* should be regarded as a gymnospermous, female reproductive organ (and not a bisexual organ) of *Glossopteris*, consisting of a bilaterally symmetrical lense-shaped receptacle bearing a large number of naked ovules (without ovuliferous scales or megasporophylls) all round it. This ovule bearing receptacle is borne in the axil of a scale leaf, which, being protective in function, is closely appressed to it in immature stage. Both the ovule bearing receptacle and the scale leaf are carried on a common pedicel which, in its turn, is attached to the petiole of a vegetative leaf. In other words, this *scale leaf-ovule bearing receptacle complex* is itself borne in the axil of a vegetative leaf of *Glossopteris*. In mature stage, the scale leaf opened out or fell off, exposing the ovules for fertilization by wind borne winged pollen grains.

Cistella

Cistella is also a female reproductive organ of some *Glossopteris* species, possessing the same type of organization as that of *Scutum*. In *Cistella*, however, the receptacle appears to be more convex and, in cross section, it would appear oval. Small ovules are arranged all round the receptacle in close spirals, so that the seeds look as if arranged in longitudinal rows in surface view. When such a fructification is compressed or pressed flat, during fossilization, there would be no wing-like rim. Where the seeds are not preserved, the unwinged *Cistella* could well be the impression of a seedless receptacle of *Scutum*. Seedless *Scutum* receptacle would only show round seed scars on its surface as are seen in many specimens of unwinged *Cistella* in our collection.

Dictyopteridium

Pl. 2, Fig. 3 shows the veined counterpart of a specimen which can be assigned to *Dictyopteridium sporiferum*. The receptacle with seed scars (which is not figured here) measures about 1·8 cm. in length and 4 mm. in breadth at the broadest part and shows typical round to oval markings of *Dictyopteridium* type on its surface. The main interest of this specimen lies in its counterpart (Pl. 2, Fig. 3) which shows unmistakable venation, together with faint round impressions of seed scars. The venation, although not very clearly imprinted on the counterpart, shows a midrib giving out bifurcating secondary veins, which dichotomize once or twice. It means that, as in *Scutum*, this organ is also scale-leaf or an equivalent foliar organ covering one side of *Dictyopteridium* fructification. *Dictyopteridium sporiferum*, therefore, possesses an ovule bearing receptacle borne in the axil of a scale leaf and displays the same type of organization as that of *Scutum*.

It furthermore confirms Maheshwari's (1965) observation on *Dictyopteridium sporiferum* when he saw the scars on one surface only while the other surface showed

net venation. The net venation he observed must have been that of the scale leaf present on the other side of the fructification. He made a transfer preparation of his compressed specimen which removed the seed bearing receptacle revealing the veined scale leaf lying below it. Our previously described specimens of *Dictyopteridium sporiferum* (Surange & Chandra, 1973) were either preserved from the other side (not covered by the scale leaf) or the scale leaf had fallen off. A thick ridge round the specimens did suggest to us the possibility of a spathe-like covering over the reproductive organ but because of insufficient evidence, it was not mentioned.

Dictyopteridium, therefore, can now be interpreted as a female reproductive organ consisting of a cylindrical receptacle or axis, bearing, small, oval, ovules or seeds on round cushions in close spirals. The whole ovule bearing receptacle is naked in the sense that there are no ovuliferous scales or megasporophylls. The ovule bearing receptacle is borne in the axil of a scale leaf, which, being protective, closely fits on one side of the fructification.

This brings us to another genus *Isodictyopteridium* instituted by Rigby (1972) for a specimen of *Dictyopteridium sporiferum* described earlier by Walkom (1922) from Australia. According to Rigby the specimen bears tubercles (seed scars) on both surfaces. So does *Dictyopteridium sporiferum* which, as explained above, consists of a cylindrical receptacle bearing ovules or seed all round it in close spirals. Rigby's specimen might have been a mature one, in which case the scale leaf would have already been shed off, so that he could not find any impression of veined structure on the other side as Maheshwari did in his less mature specimen. His emphasis on the presence of a distinct marginal wing in the Australian specimen is untenable, which appears to be only an act of preservation. From his photograph (Rigby, 1972, Text-fig. F2) it does not look like a structural feature. Even if a so-called marginal wing is present in his specimen, this look can be given to *Dictyopteridium sporiferum* by seeds which are arranged along the margin in a single row as described by us (Surange & Chandra, 1973). A little lateral compression of marginal seeds can enhance a wing-like impression in *Dictyopteridium*. There is no justification in creating a new genus for such specimens and *Isodictyopteridium* Rigby, therefore, should be merged with the earlier known genus *Dictyopteridium*.

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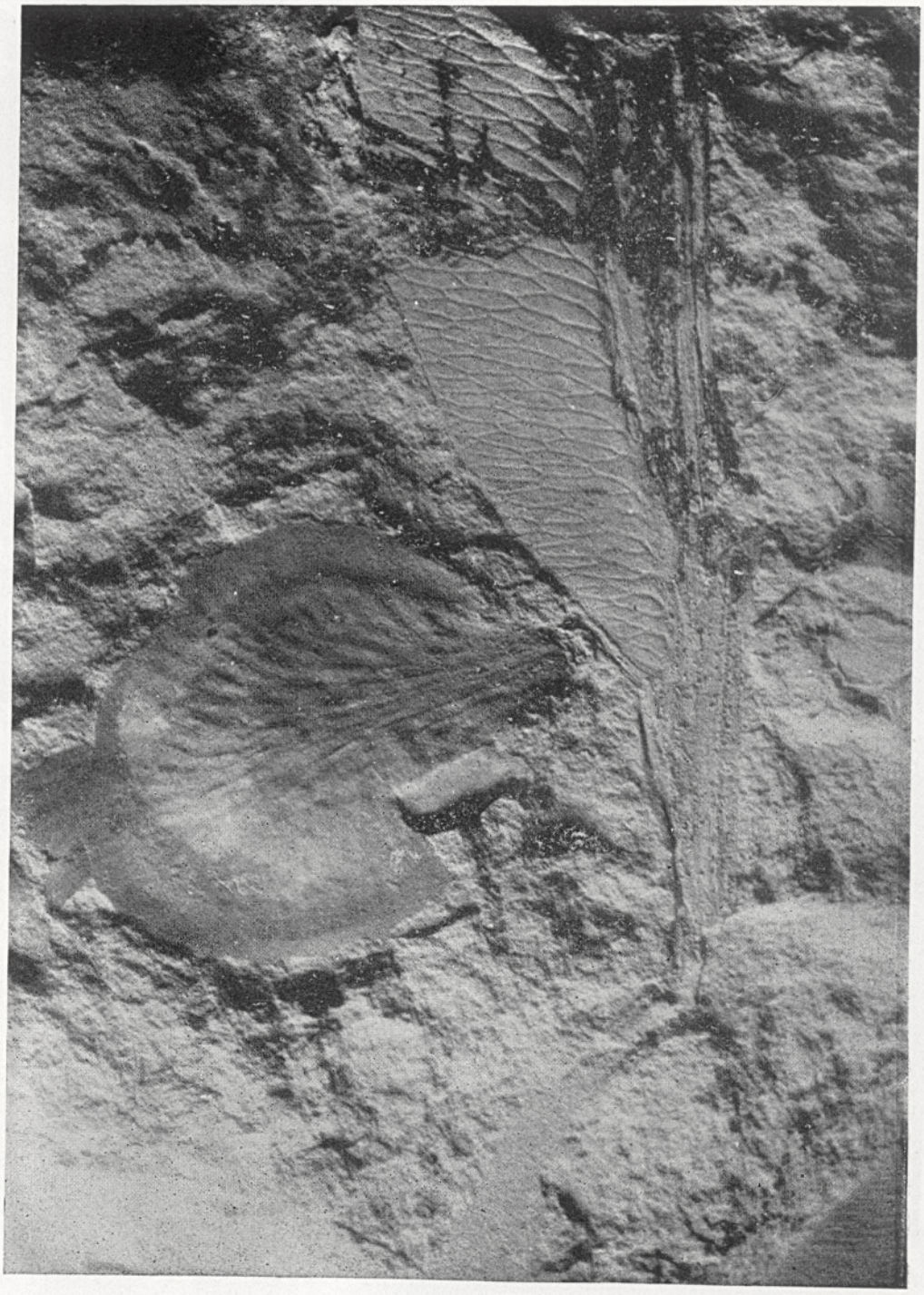

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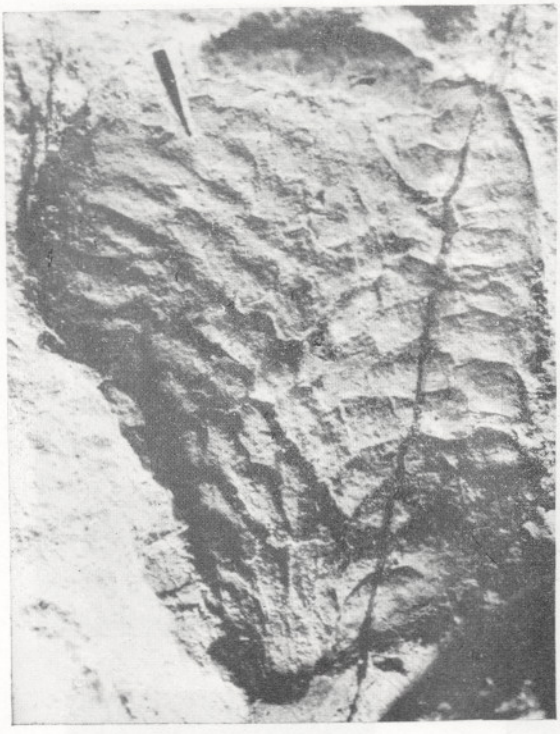

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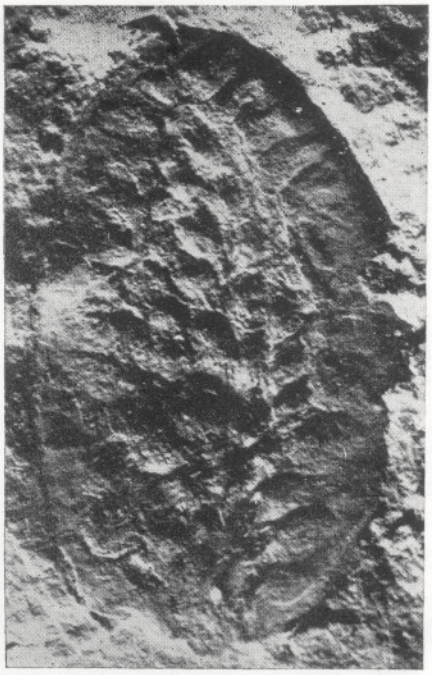

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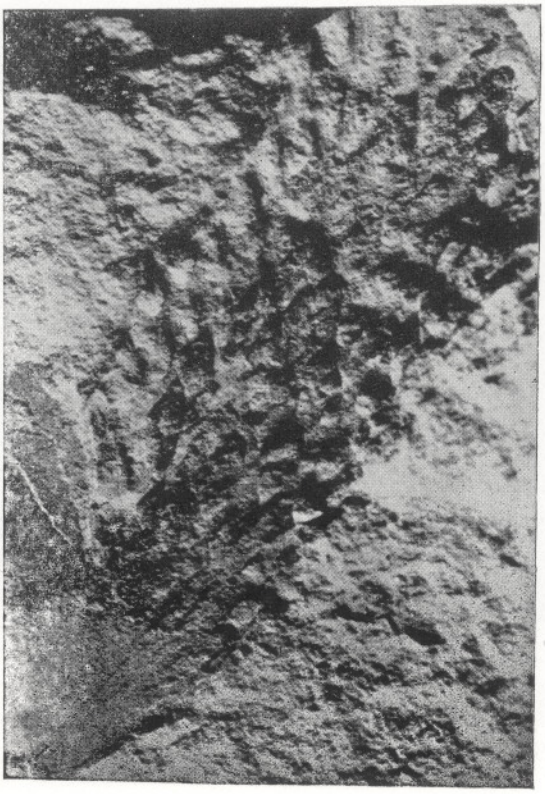

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EXPLANATION OF PLATES

PLATE 1

1. The veined scale leaf (counterpart) of holotype (No. 35093) of *Scutum sahnii* sp. nov. attached with a long stalk (longitudinally split) to the leaf showing *Glossopteris* venation. Note the midrib and the anastomosing secondary veins. × *Ca.* 3·5.

PLATE 2

2. Seed bearing receptacle of the holotype (No. 35093) of *Scutum sahnii* attached on a short stalk and with a wing-like rim all round it. × *Ca.* 6.
3. Counterpart of a fructification of *Dictyopteridium sporiferum* Feist. showing venation. × 4·5.
4. A group of winged seeds assigned to a new genus *Indocarpus*. Holotype (No. 35090). × 3.
5. A winged seed assigned to *Indocarpus elongatus*. × *Ca.* 6.

PLATE 3

6. Seed bearing head of *Scutum indicum* sp. nov. Note the large, laterally compressed seeds, some of them still attached to the seed cushions on the central head. Wing-like rim outside the seeds on the left is perhaps that of displaced scale leaf lying underneath. The same is seen on the right, where the seeds are half broken. × 6.
7. Holotype (No. 35097) of *Scutum indicum* sp. nov. showing the speed bearing receptacle. Laterally compressed marginal seeds, which form a wing-like rim round the fructification, are seen attached to cushion-like outgrowth on the receptacle. Scars of round seed cushions are seen in the apical region where seeds have been knocked off. × 4.
8. Another seed bearing receptacle assigned to *Scutum indicum*. × 4·5.
9. A seed bearing receptacle of *Scutum elongatum* sp. nov. × *Ca.* 5.

PLATE 4

10. A seed bearing receptacle of *Scutum sahnii*. × *Ca.* 4.
11. Holotype (No. 35095) of *Scutum elongatum* sp. nov. The marginal seeds from a rim round the fructification. × 4.
12. A specimen of *Cistella indica*, showing a stalked seed bearing receptacle. × *Ca.* 4·5.
13. Holotype (No. 35100) of *Cistella indica* sp. nov. the receptacle show large round seed scars. × 4.
14. One winged seed of *Indocarpus elongatus*. × 5.