Reconsideration of *Savitrispermum* from Triassic of Gondwanas

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Study of additional specimens of *Savitrispermum crateriformis* has furnished new data to interpret the structural organisation of the seed. On the basis of details of the cutinized membranes of this seed-genus, a reconstruction has been suggested. The distribution of the taxon throughout the gondwanic continent has been dealtwith. The botanical affinities have been ascertained with the pteridosperms on the relationship of *Savitrispermum* with that of *Umkomasia* a seed fructification quite frequent in *Dicroidium* flora and its biostratigraphical significance has been discussed.

Key-words-*Savitrispermum*, seed, Triassic, India.

INTRODUCTION

THE seed genus *Savitrispermum* was instituted by Manik (1988) for small, bilaterally symmetrical (platyspermic) compressed and smooth integumented seed from the Triassic sediments of Nidpur, India. In the light of new specimens studied, a reconstruction of *Savitrispermum* has been suggested and is considered to be a gymnospermous seed in view of having a pollen chamber containing pollen grains, and cutinized megaspore membrane.

In the structural similarities with the isolated seed of *Umkomasia*, *Savitrispermum* could be inferred to be borne upon the seed-fructification *Umkomasia*. However, these seeds appear to have been borne directly on the axis because they did not possess cupule. *Savitrispermum*, quite prolific in Nidpur assemblage, is distributed all over the Gondwanic continents.

Division - Gymnosperm

Sub Division - Pteridospermophyta

Class - Pteridospermopsida

Order - Pteridospermales

Family - Corystospermaceae

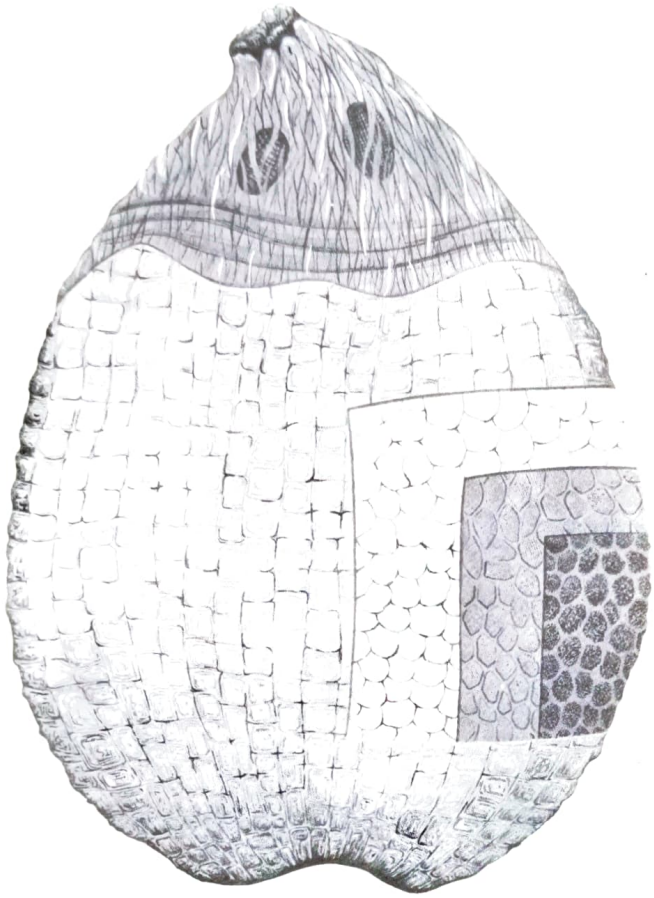
Genus-*Savitrispermum* Manik, 1988

Type species - *Savitrispermum crateriformis* Manik, 1988

***Savitrispermum crateriformis* Manik, 1988**

P1.1, figs 1-18; P1.2, figs 1-8; Text-figs 1-4

Specific Diagnosis (Designated here): Seed broadly oval, measuring 2 mm in length, 1.5 mm in breadth, platyspermic, when laterally compressed seemingly elongated oval, overall seed outline entire, occasionally ± undulated, seed coat smooth, sometimes fine ridges of creases apparent; micropylar end curved or at time when curvature not well pronounced appearing to be obtusely pointed, micropylar hole usually bowl or crater-shaped, when unexposed protuberate or obtusely pointed, laterally looking somewhat crescent-shaped; chalazal end generally rounded, thick cuticle of outer integument investing seed from microplylar end to chalazal end, non-stomatiferous, epidermal cells squarish or rectangular, 31.58 µm x 38.42 µm in size, anticlinal walls straight, periclinal walls smooth rarely pitted or reticulate, at places fine creases randomly traversing over the entire surface or more often obscuring cell walls; pollen chamber distinctly delimited from nucellus, well defined, more or less dome-shaped, differentiating zone marked by transversely oriented robust creases almost girdling the entire outer investment; cells of micropylar region short, isodiametric, narrowly elongated having straight or thickly cutinized anticlinal walls, periclinal walls smooth, longitudinally arranged, at times tending to be oblique in orientation; converging towards thickly cutinized repand



Text-fig. 1: Reconstruction of seed *Savitrispermum crateriformis* Manik, showing curved micropyle associated with pollen chamber containing pollen grains;outer integument cut open to show diagrammatically inner nucellar & megaspore membrane X Ca 50.

micropylar hole, unevenly cutinized, not discernible, when hole unexposed micropylar end protrude or bulge out; inner cuticle of integument extremely thin; closely appressed to the nucellus, cell outlines obscure; nucellus depressed or excavates, nucellar membrane thicker than outer integument, confluent with inner integument, cells polygonal, anticlinal wall straight, sunken, periclinal wall raised uneven or smooth or grannulated megaspore membrane represented by dark brown mass, exhibiting no cellular details, intimately fused with the nucellus, occupies 3-4 part of a seed; pollen grains present inside pollen chamber.

Holotype- Manik 1988, p1.1, figs 1-2

Isotype- No. 37123/S

Locality- Nidpur, Sidhi District, Madhya Pradesh

Age- Middle Triassic

Remarks : The study is based on the observation of one hundred (100) seed specimens preserved as compactions, which were isolated by bulk maceration from carbonaceous shale of Nidpur, South Rewa Basin. After studying the morphography, the seeds were treated with the acid and the outer integument liberated at times appeared to be adhered with the nucellar membrane. In some specimens the entire outer integument could be released from the micropylar to the chalazal end. Besides, the micropylar opening are usually varied-shaped, but the crateriform opening which is quite frequent look at times like a bulge. Nucellar membrane when dissected break into pieces because it is not completely separable. Megaspore membrane is deeply cutinized exhibiting no cellular details. Pollen grains inside micropylar chamber are not identifiable.

Comparison: Among the known seeds from Nidpur, *Savitrispermum crateriformis* is clearly distinguishable from *Rugaspermum* (*R. insigne*, *R. media* and *R. obscura* described by Pant & Basu, 1977 from Nidpur) in the absence of wrinkles all over the outer integument. In *Rugaspermum* the outer integument is robust consisting of isodiametric, elongated-polygonal cells. In general, surface wall of the cells of *R. insigne* and *R. obscura* are non-papillate except for wrinkled region where the cells

Plate 1

Figures 1-18. *Savitrispermum crateriformis* Manik

1-6. Unmacerated seed exposed in glycerine, showing outline & shape. Specimen Nos. 37145/247-1, 37122/146-2, 37124/429-3 37175/398-4 37183/211-5 37185/458-6 (Specimen consumed). X 10; 7. Compressed seed after acid treatment showing distinct micropylar end and nucellus, Specimen No. 37128/328-7. X 20; 8. Compressed seed magnified in glycerine. Specimen No. 37138/32-8X20. 9. Complete macerated seed showing micropylar chalazal end associated with nucellus and outer integument, Specimen No. 9728/53-9 X25; 10.A compressed seed after acid treatment showing the cuticular membrane being separated out. Specimen No. 37177/632-10.X50; 11. A whole mount of seed specimen showing pollen chamber, nucellus and megaspore sac. Specimen No. 37186/366-11 (Specimen consumed) X 25; 12. Upper half of macerated seed showing micropylar hole and pollen chamber associated with radiating cells. Specimen No. 37187/375-12.X50; 13. An uppermost part of macerated seed, showing pollen chamber region along with depressed micropylar end a portion of outer integument overlapping distinct nucellar membrane. Specimen No. 37188/251-13 (Specimen consumed). X50; 14. Macerated seed showing curved micropyle and pollen chamber. Specimen No. 9727/342-14.X50; 15. Macerated seed showing cutinized micropylar tip and elongated cell of pollen chamber; portion of outer and inner integument distinctly coaleasced. Specimen No. 37128/328-15.X50; 16. Outer investment of seed with distinct epidermal cell. Specimen No. 37189/355-16.X50; 17. Both the faces of outer integument associated with protruding micropylar end associated with squarish cell. Specimen No. 37124/429-17.X75; 18. Macerated seed showing distinctly micropylar opening, pollen chamber, outer integument and nucellar membrane. Specimen No. 37171/32-18x50.

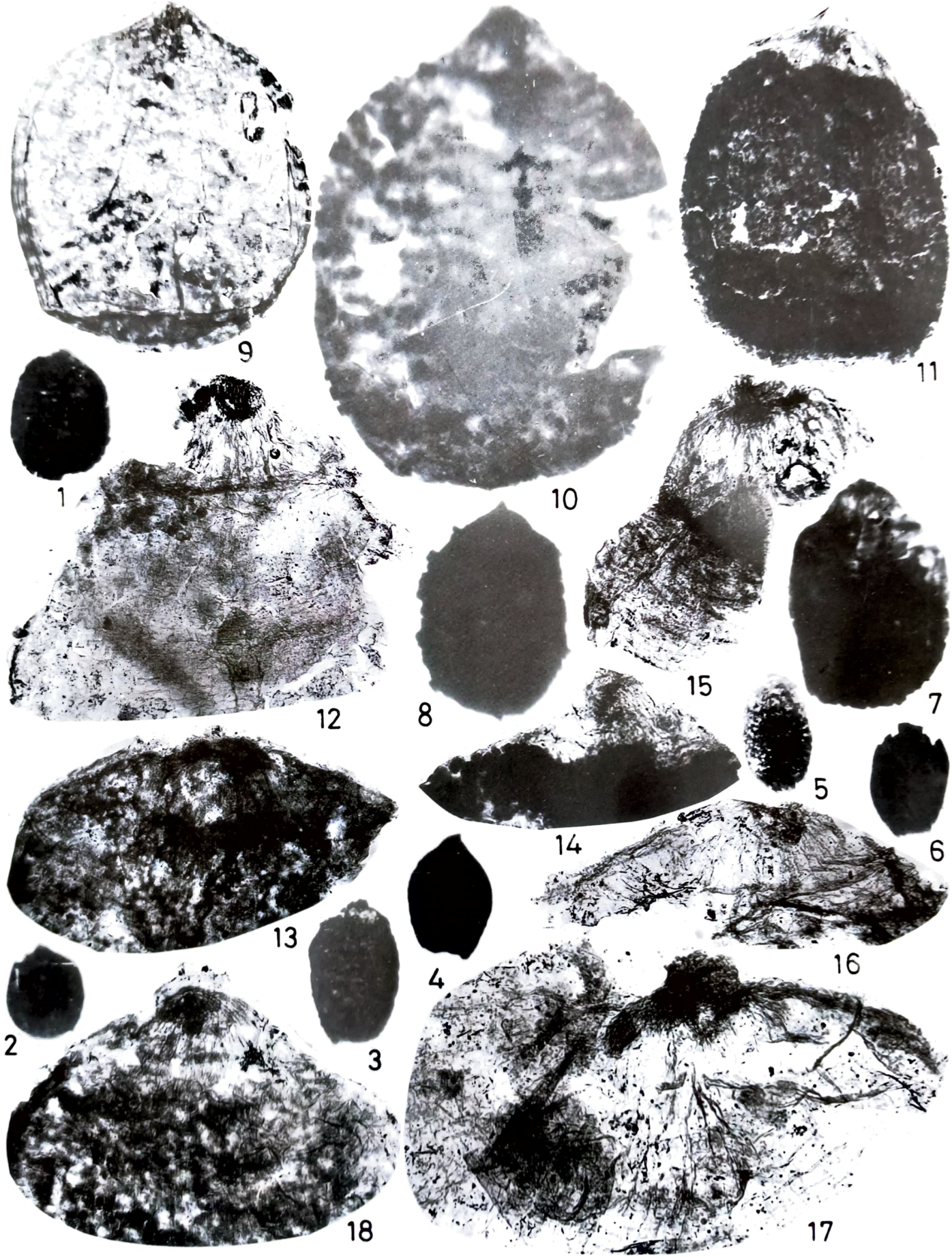
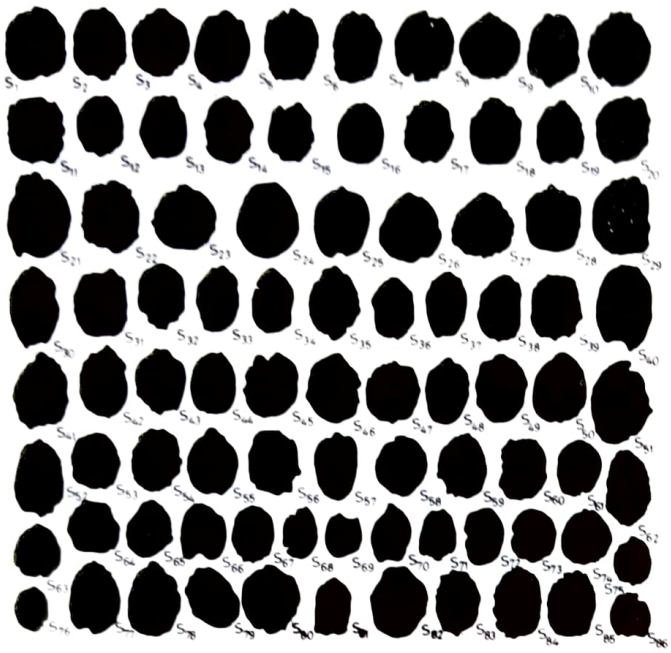


Plate 1



Text-fig. 2: Compressed seed dipped in glycerine showing varied shape and size. Isotype No. 37123/-S1; 37181/287-S2, 37141/465-S3, 37142/650-S4,37192/S5,37147/577-S6,37146/244-S7,9728/S3-S8, 37190/557-S9,237134/140-S10,37193/248-S11,37174/245-S12, 37194/85-S13,37195/251/S14,37168/502-S15,37150/87-S16, 37195/641-S17,37125/203-S18,37196/41-S19,37155/105-S20, 37179/418-S21,37196/645-S22,37161/43-S23,37165/496-S24, 37149/178-S25,37197/318-S26,37153/66-S27,37198/266-S28, 37199/142-S29,37164/129-S30,37132/651-S31,37206/355/S32, 37131/678-S33,37128/328-S34,37201/702-S35,37202/338-S36, 37124/429-S37,37159/706-S38,37144/604-S39,371203/90-S40, 37166/135-S41,37204/113-S42,37163/404-S43,37145/247-S44, 37205/306-S45,37206/448-S46,37207/224-S47,372208/7-S48, 37209/15-S49,37210/326-S50,37211/382-S51,9727/342-S52, 37212/18-S53,37152/344-S54,37123/151-S55,37184/212-S56, 37172/345-S57,37214/483-S58,37137/125-S59,37125/184-S60, 37166/288-S61,37183/211-S62,37182/192-S63,37162/330-S64, 37143/188-S65,37158/394-S66,37216/252-S67,37156/132-S68, 37217/823-S69,37218/398-S70,37219/458-S71,37167/411-S72, 37151/403-S73,37220/479-S74,37156/130-S75,37122/146-S76, 37135/194-S77,37171/52-S78,37176/152-S79,37221/480-S80, 37136/232-S81,37122/3-S82,371220/238-S83,37170/593(013)-S84, 37173/03-S85,37133/388-S86

form one cell-high band and terminal papillae but in *R. media* cell surface possessess a median papilla and form 3-4 cell high band. Thus *S. crateriformis* may be compared upto certain extent in the surface texture with *R. insigne* and *R. obscura*, however, in the absence of distinct wrinkles *R. obscura* approaches to some extent *S. crateriformis* but the former sharply differs from the latter in possessing stomatiferous outer integument, and in bearing a nucellar membrane made up of sinuous cells. In any case, *R. media* is quite distinct from *S. crateriformis* in having papillae throughout the surface.

In addition a seed described as *Spermatites* sp. cf. *S. orbicularis* Miner (Banerji *et al.* 1978) resembles the present form externally from Upper Triassic of Janar Nala Section (Harai) of Son valley, South Rewa Basin but for the lack of cellular details, no definite comparison is possible.

Savitrispermum crateriformis compares closely with the seeds of *Umkomasia macleani* reported by Thomas (1933) from Molteno Formation (Middle-Upper Triassic) of South Africa. The seed *Savitrispermum* is identical with the seeds borne on *Umkomasia* in having curved micropyle and smooth periclinal wall. Not only the attached seeds, but also the detached seed (fig. 33 F, Thomas, 1933) from Molteno sediments show similar structural features. This indicates that *Savitrispermum* type of seeds were borne upon *Umkomasia* type of seed fructification. Their structure and arrangement of epidermal cells having smooth surface wall, resemble *Savitrispermum crateriformis* but the latter differs from the former in its small size and outer integument being composed of squarish epidermal cells with fine creases. In *S. crateriformis* the pollen chamber is well differentiated with crater-shaped micropylar opening. However, in isolated seeds of *Umkomasia* these features could not be observed for want of proper photographs and drawings.

Taken as a whole in gross characters, isolated seed (Thomas, 1933) is so much similar upto generic level that these specimens alongwith others have been placed under the genus *Savitrispermum* with a new assignation *Savitrispermum umkomasii* (Thomas) comb. nov.

Apart from this, detached seeds which have not yielded cuticle and have been recorded by Anderson and Anderson (1984, 1985) from Molteno Formation (S. Africa) are also comparable with *S. crateriformis* in the curvature of micropyle, size range and dome-shaped pollen chamber. Because of these structural similarities

Plate 2

Figures 1-8. *Savitrispermum crateriformis* Manik.

1. Outer integument showing squarish epidermal cells with fine reticulation over the surface wall. Specimen No. 37170/013-1.X150; 2. Micropylar end of macerated seed magnified to show nucellar beak associated with distinct pollen chamber and outer integument. Specimen No. 37122/146-2.X250; 3. Pollen chamber showing exposed micropylar opening. Specimen No. 37190/557-3 (consumed) X 150; 4. Showing excavated pollen chamber. Specimen No. 37191/338-4 (consumed) X 150; 5. Micropylar opening showing perforation. Specimen No. 37127/488-5.X200; 6. Macerated seed showing depression at chalazal end associated with nucellar membrane. Specimen 37173/03-6..X 75; 7. Micropylar end of seed showing excavated pollen chamber containing pollen grain. Specimen No. 37126/15 (consumed) X 150; 8. Cellular structure of curved micropyle and pollen chamber. Specimen No. 37129/342 (consumed) X 300.

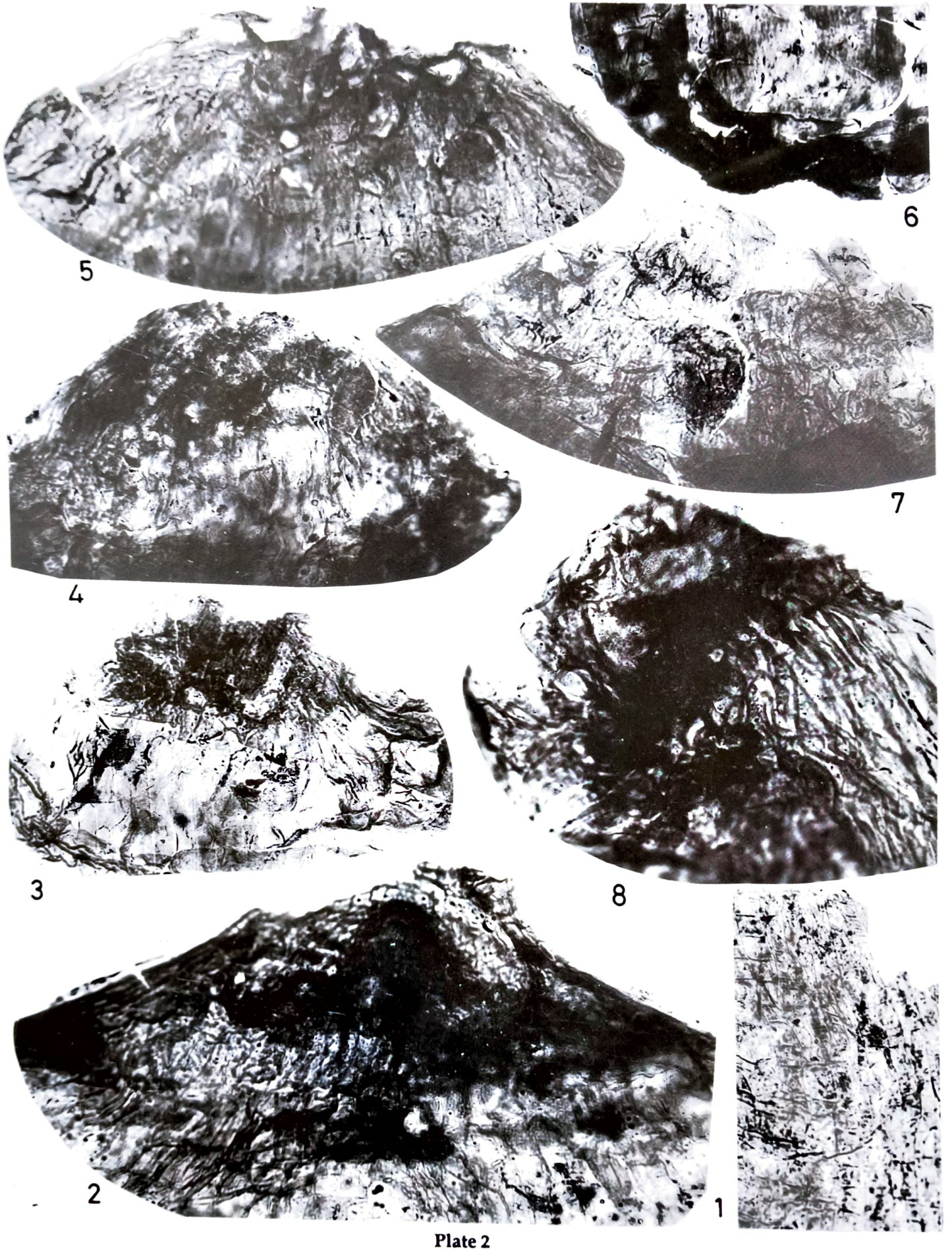
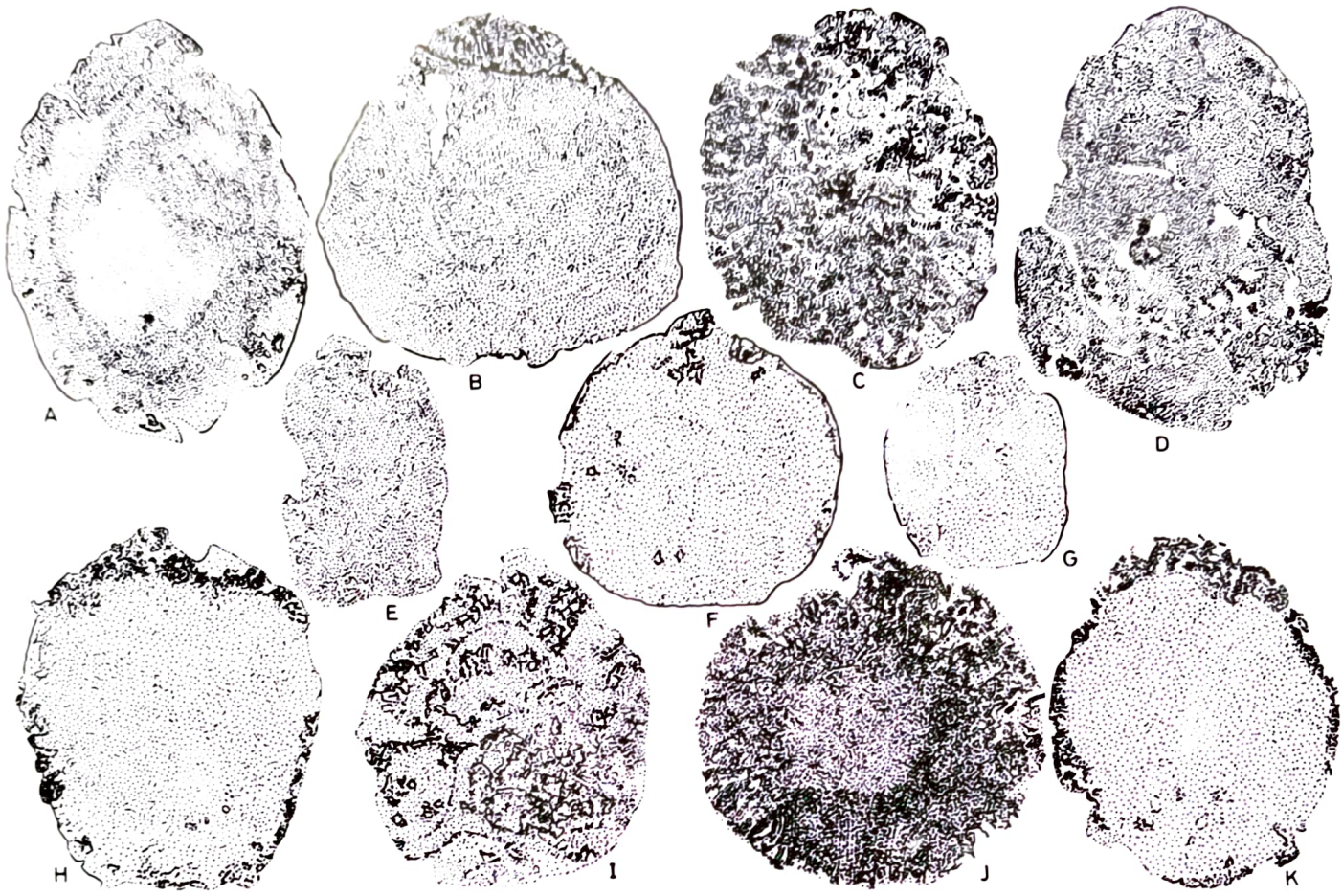


Plate 2



Text-fig. 3. A. Seed after acid treatment. Specimen No. 37180/382..X 50; B. Seed after acid treatment showing pollen chamber. Specimen No. 37130/318.X 50;C. Seed after acid treatment showing outer integument being separated. Specimen No. 37135/194X 50; D. After alkali treatment showing nucellar investment. Specimen No. 37135/19.X 50; E. Seed after acid treatment completely separated from outer coat. Specimen No. 37136/232.X 50; F. Seed after acid treatment showing distinct micropylar and chalazal end Specimen No. 37178/436 X 50; G. Processed after being acid treatment seed showing cutinized membranes being separated. Specimen No. 37133/388.X50; H. Acid treated seed showing membrane being cleared out. Specimen No. 37139/375 X 50; I. Acid treated seed showing membrane being cleared out. Specimen No. 37139/375. X 50; J&K. Seed showing macerated condition after alkali treatment. Specimen No. 37140/479 37184/212.X 50.

in basic morphographic features, they have been designated here as *Savitrispermum* sp. The institution of this species has been done in order to avoid considerable confusion which has arisen because of the inclusion of taxa found in impression form but have been placed with the compressed and petrified seeds. Similarly seed specimens described by Douglas (1969) from Triassic of Victoria, Australia, also show structural similarity with *S. crateriformis* in overall size range, smooth cell surface, well defined pollen chamber, obtusely pointed micropylar end and other cellular details. Nevertheless, the Victorian seeds differ in having pitted anticlinal walls associated with occasional patches over the surface wall. However, these characters are less constant and therefore, such forms are herewith assigned to seed genus *Savitrispermum* under a new specific name *S. douglasii* (Douglas) comb. nov.

The seed types described by Holmes (1982) from Middle Triassic of Benolong, N.S.W., Australia, appears to be quite similar externally in their general shape, size and micropylar feature but owing to paucity of phytolemma in these specimens, a detail comparison is not possible. Since these specimens have been found in intimate association of *Umkomasia*, it is strongly believed that these seed type too, must have been the seed of *Umkomasia*, and thereby should be a species of *Savitrispermum*. Any way for the lack of adequate data, for the time being it is placed separately as *Savitrispermum* sp.

Comparison with the seed (Fig. 6c6, Retallack, 1985) from shallow marine rocks of Murihiku Super Group, New Zealand, characteristically possess curved micropylar extension seen in corystosperms (Thomas, 1933) but because of being broken at the tip, curvature of micropyle is not distinct. In all probability, the seed comes closer to *Savitrispermum* and it should also be placed under *Savitrispermum* sp. because of not having yielded the epidermal details.

Similarly, seed impressions reported by Bourke *et al.* (1977, p. 35) from Middle Triassic of Gunne beds N.S.W. Australia, by Holmes and Ash (1979, Figs 7-9) from Early Triassic of Lorne Basin, N.S.W., Australia and by Jones and de Jersey (1947, p.56) from Middle-Upper Triassic of Ipswich Coalfield, Australia should also be treated under the seed genus *Savitrispermum*.

In its curvature of the micropylar end, *Savitrispermum crateriformis* shows its identity with curved seeds of *Peltaspermum rotula* (Harris, 1937) but the former is radically different in having total absence of papillae over hanging the stomatal pit, a typical character of leaf genus *Lepidopteris*.

In the smooth nature of cell-surface of outer integument, and overall shape and size, the seeds of *Caytonia indica* (Bose & Banerji, 1984, Jurassic-Cretaceous of Kachchh) and the seed taxon *Savitrispermum* are so closely identical in their cuticular features that it is not easy to separate the two cuticles from one another. Even the presence of fine creases upon the cell surface also look quite similar. But in its shape *Savitrispermum* is quite distinct in having curved micropylar end associated with the crater shaped opening. But the seeds of *C. indica* are quite different because of their sunken opening.

Mesozoic seeds, namely, *Collospermum ovalis* and *Retortistoma crystallina* described by Pant *et al.* (1985) reveal close affiliations to *Savitrispermum crateriformis*, in their curved micropyle, but *C. ovalis* differs from *S. crateriformis* in having a simple long micropylar canal whereas *R. crystallina* stands apart in possessing fibrous outer integument and a long projected micropylar canal.

Savitrispermum umkomasii sp. nov.

1933, Isolated seeds, Thomas, pp. 227-229, Pl. 24, figs 67,68,69,70; Text-fig. 33 a-g

1947, Isolated bifid seeds, Jones & de Jersey, p. 56.

Diagnosis: Seeds platyspermic, broadly oval, flattened, varying in length 3.5 mm-7mm, 2.2 mm - 5 mm in breadth, micropylar end curved at times bifid, chalazal end rounded or depressed, seed coat throughout showing fine ridges appearing to be tough, at times near micropylar end surface showing lumps and depressions, cuticle thick, cells of outer integument elongated, more or less rectangular or varied shaped arranged in longitudinal rows, sometimes irregular, cells polygonal, isodiametric in central part, marginal cells smaller rectangular arranged in definite longitudinal rows, anticlinal walls thick showing well marked microsinuosity, periclinal walls smooth occasionally exhibiting centrally located dark spot, inner membrane well cutinized, mostly showing distinct, cellular outlines, nucellar membrane delicate, cutinization feeble, pollen chamber occasionally containing winged pollen grains.

Holotype-Thomas, 1933-Isotype Specimen No. U22, U225, U22 U229, U205, located at British Museum Natural History, London.

Locality- Umkomas, Natal, South Africa

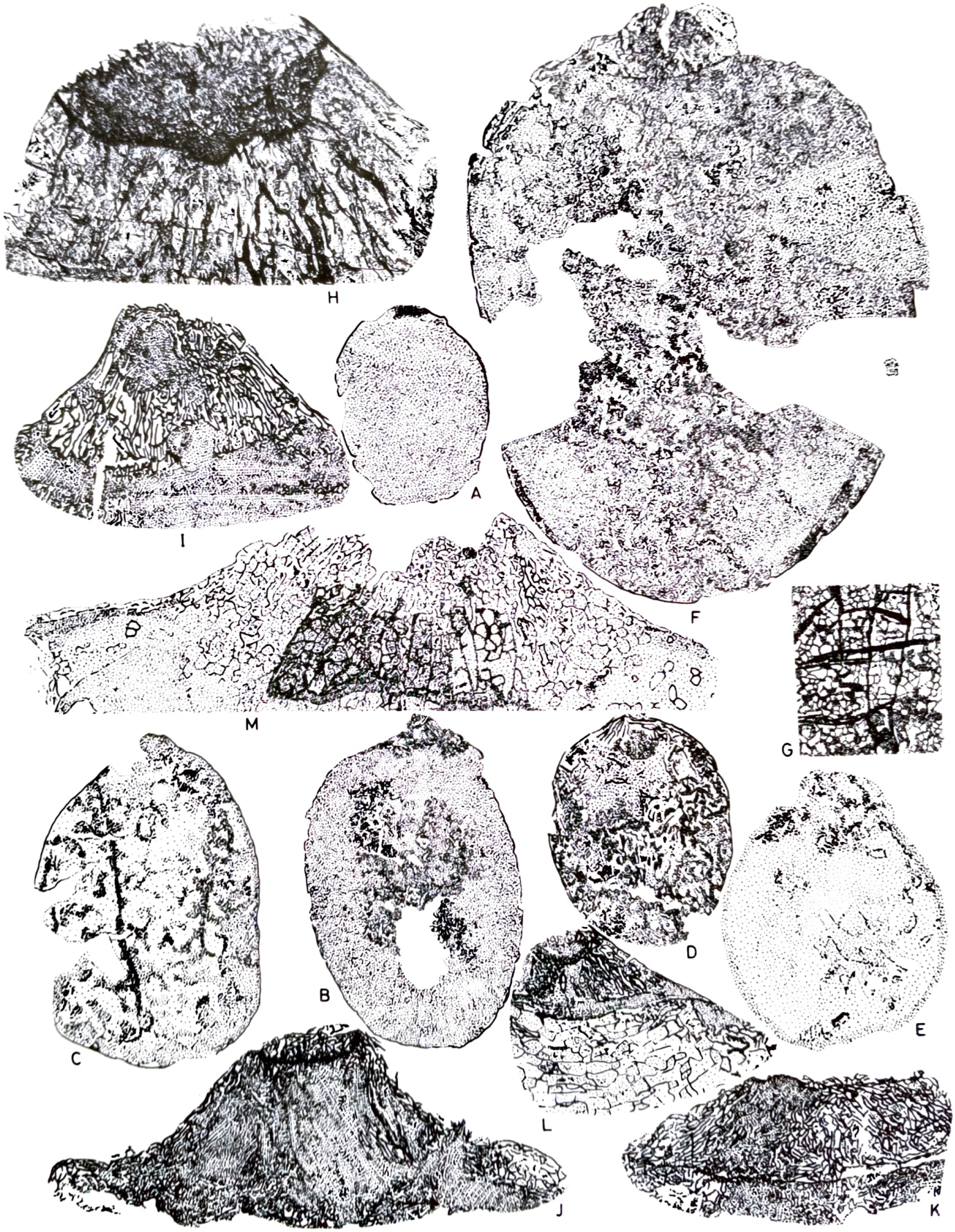
Age- Middle-Upper Triassic, Molteno Formation

Remarks : The diagnosis of *S. umkomasii* is based upon the description of the isolated seed specimens figured by Thomas (1933) from Umkomas locality, Natal, South Africa.

Comparison: Savitrispermum umkomasii sp. nov. corresponds very colsely to *S. crateriformis* in possessing curved micropyle, rounded depressed chalazal end, non papillate cell surface and distinctive pollen chamber. However, the former shows striking difference in having curved bifid micropyle, a feature which has not been marked in *S. crateriformis*. In *S. umkomasii* cells are rectangular polygonal showing thick anticlinal walls with microsinuosity associated with spotted periclinal walls whereas *S. crateriformis* totally lacks microsinuosity of anticlinal walls and superficial spots over the cell surface.

S. umkomasii compares with the seed - bearing branched fructification of *Umkomasia macleani* Thomas in demonstrating curved micropyle, smooth outer integument. In having smooth outer integument *S. umkomasii* shows structrual similarity with the cell surface of cupules and axis of *U. macleanii*.

Text-fig. 4. A&C. Seeds after acid treatment showing outer integument being separated out. Specimen Nos. 37227/355, 9727/342, 3713/03.X. 50, B&D. Seed after alkali treatment showing nucellar membrane intact, In Figure B curved micropyle distinct. Specimen No. S 9727/342,37141/465 X 50; E. Seed after acid processing showing outer integument detached and differentiated pollen chamber. Specimen No. 37164/129. X 50; F. Seed enlarged to show (after alkali treatment) a distinct micropylar bulge & chalazal end. Specimen No. 37225/593. X 80; G. Epidermal cells of outer integument, magnified to show rectangular-squarish form of celluair organization along with smooth and finely ornamented surface wall. Specimen no. 37123/96.X 500; H. Magnified view of the micropylar opening showing crateriform shape associated with thickening of cells. Specimen No. 37226/04.X 300; I. Micropylar end of seed along with apical part of nucellus. Specimen No. 37177/632.X160; J. Micropylar end of seed with projected crateriform opening. Specimen No. 37175/398. X 160; K. Cellular organization of micropylar region. Specimen No. 37174/245.X 160; L. Cellular structure of nucellar membrane along with a part of pollen chamber and micropylar opening . Specimen No. 37226/04.X 300; M. Micropylar part of seed showing compact arrangement of cells with feeble cutinization of anticlinal wall and perforation in the mid part. Specimen No. 37172/345.X 200.



Text-fig 4

Umkomasia grannulatum (Thomas) Holmes and *U. costulatum* (Thomas) Holmes resemble *Savitrispermum umkomasii* in bearing curved bifid micropyle and smooth surface wall of outer integument. In general *U. costulatum* exhibits smooth cell surface but sometimes centrally superficial walls becomes spotted and in this character *S. umkomasii* has shown close similarity with *U. costulatum*. Since structurally *S. umkomasii* match with *U. macleani* in all respects, it could be inferred that *S. umkomasii* perhaps have been borne upon *U. macleani*.

S. umkomasii differs from *Rugaspermum obscura* described by Pant and Basu (1977) in the absence of wrinkles but they resemble in nonpapillate character of surface wall. The other species of *Rugaspermum (R. insigne & R. media)* are radically different from *S. umkomasii* in the presence of distinct wrinkles upon their outer integument.

In external appearance, seeds described by Anderson and Anderson (1984, 1985) from Molteno Formation, South Africa, by Retallack (1985) from Triassic of New Zealand, by Walkom (1925) from Early Triassic of Australia, are also comparable with *S. umkomasii* in characteristic micropylar extension, general shape and size but as the details of cellular structures are not available, comparison could not be done.

Savitrispermum douglasii sp. nov

1969, seeds, Douglas, p. 23; Pl.3, figs 1,8; Text-figs 1, 10-11

Diagnosis- Seed oval, platyspermic, length 3-4 mm, breadth 2-2.5 mm, seed outline entire, micropylar end obtusely elongated, chalazal end flattened, length of micropylar canal 250 µm, cells of outer integument irregularly rectangular, 80-180 µm long, about 50 µm wide, anticlinal wall 1 µm thick, straight or pitted, periclinal walls thin smooth occasionally modified by irregularly sized, subcircular or elongated oval patches, cells thickened in micropylar region, shorter, narrower, 20-40 µm long, 20 µm wide, general cell size reduced in chalazal region, pollen chamber well defined, nucellar membrane well preserved cellular outlines indistinct, marked by fine creases, megapore somewhat like an isolated sac represented by amorphous grannular membrane associated with short transverse fine wrinkles and folds, cellular structure obscure.

Holotype- Douglas, 1969 NMVP. 22887 (Isotype Nos. P. 24134,P24142, GSV 61727), Geological Survey, Victoria, Australia.

Age- Triassic

Comparison: Savitrispermum douglasii sp. nov. is distinguishable from *S. crateriformis* and *S. umkomasii* in its fairly big size and in having pitted anticlinal walls. With its obtusely pointed micropyle *S. douglasii* closely compares with *S. crateriformis* but from *S. umkomasii*, *S. douglasii* radically differs in the absolute absence of curvature of micropyle. In presence of patches over the cell surface, cellular structure of outer integument of *S. douglasii* resembles *S. umkomasii* but the former is quite distinctive in having cells of large size as compared to the latter. From *S. crateriformis*, *S. douglasii* shows clear distinction in the absence of typical squarish cells. In *S. crateriformis* the micropylar opening is crater-shaped while in the Victorian specimen it is not exposed. Nevertheless, all the three species closely agree with one another in their general shape, size, nature of integument and cell surface.

Remarks : Associated with these Victorian seeds, are fossilized carbonized remains of palynotaxa *Alisporites australis* considered by de Jersey (1962) identical with those of *Pteruchus africanus* Thomas. It coincides well with presence of *Savitrispermum douglasii* in these beds which is indicative of the presence of seed organ *Umkomasia*. Further the presence of index form *"Dicroidium-Xylopteris"* leaf-complex is also supportive evidence for the occurrence of the corystosperm fertile organs.

Generally seed specimens preserved as impressions have shown identity in their general size, shape and nature of micropylar end, and such types occur in all the Triassic floras of Gondwanic continents with *Dicroidium*, *Pteruchus* and *Umkomasia*. Henceforth all such structurally identical seeds recorded by Walkom (1925, p. 31, figs 3-5) as *Carpolithus* sp. from the Narrabeen Formation of N.S.W., Australia, by Frenguelli (1944, pl. 12, figs 1,2) as seeds commonly associated with *Dicroidium zuberi* (Szajnocha) Archangelsky (1968), from Cortaderita Formation of Barreal Hilario Basin, Argentina, by Anderson (1974, Table-2, p.50 as seed-2 spp) from Molteno Formation South Africa, by Retallack *et al.* (1977, fig. 11 D) as large seed from Middle Triassic of Nymboida, N.S.W., Australia, by Holmes (1982, fig. 7 I,J,K) as seed type-A and seed type B from Middle Triassic flora from Benolong, N.S.W., Australia, by Anderson and Anderson (1985, pl. 196, figs 6-13) as *Dicroidium* seeds from Molteno Formation (Mid-Upper Triassic) of South Africa, by Retallack (1985, fig.6, C6, p.11) as gymnospermous seed but with broken curved micropyle have been integrated here under the genus *Savitrispermum* sp. which is widespread all over the Gondwanaland. As a consequence the range of genus *Savitrispermum* is noteworthy because of its distribution being from Lower Triassic (Narrabeen Formation) of Australia-Middle-Upper Triassic (Molteno Formation) of South Africa.

Botanical affinities

The distinctive curvature of micropylar end and an apparently well differentiated dome-shaped pollen chamber, the described features of *Savitrispermum*, are in essential agreement with those of Pteridospermales-Family Corystospermaceae. Further, in association of *Savitrispermum*, helmet or basin-shaped cap or head-like structures have also been recovered in branched and isolated state from Nidpur shale. Occurrence of such structures upon which *Savitrispermum* supposedly must have been borne in life, strongly support the assignment of this seed to family Corystospermaceae. Besides these structurally preserved organs, *Dicroidium* fronds and pollen-organ *Pteruchus* co-occur with these Nidpur seeds.

The other characters which place this genus in Pteridospermales (Corystospermaceae) are :

1. Outer integument is not at all adherent to nucellus because the entire integument is quite easily separable. This has proved that the outer integument is free from the nucellus. Occasionally, these two layers (outer membrane and nucellar membrane) appear to grade gradually into each other but more often they are rather sharply and abruptly separated.
2. Generally, nucellus is confluent with the inner integument, but outer integument is typically detached from the remainder membranes.
3. Megaspore membrane highly cutinized, strucutre not distinct. Thus the cumulative evidence of structural modifications present in the aforesaid genus has further strengthened the relationship of *Savitrispermum* to Pteridospermopsida.

CONCLUSION

The seed-genus *Savitrispermum* Manik closely resembles with the isolated seeds of *Umkomasia* in the usual feature of curved micropyle and at times zig-zag cutinization over crater-shaped opening along with a pollen chamber with simple excavation at the nucellar tip. However, the detached seed *Savitrispermum* lacks cupule and appears to have been borne directly over the axis because none has been found so far within the cupule. The tough outer integument of *Savitrispermum* is suggestive of its relationship with non-cupulate seed-bearing fructifications. The cellular arrangement of outer integument is quite symmetrical as marked by distinct squarish or rectangular cells and its easily detachable nature from remainder membranes indicate that the integument and nucellus are not adherent except for the base.

The genus *Savitrispermum* is quite prolific in Middle Triassic which could be visualized by its enormous number as *S. crateriformis* in India; *S. douglasii* in Australia; *S. umkomasii* and *Savitrisperum* sp. in South Africa. Further, the biostratigraphical significance of the seed taxon could be deterimned all over the Gondwanic continent by the occurrence of *Savitrispermum* sp. in Lower Triassic; *S. crateriformis* in Middle Triassic, *S. umkomasii* in Middle-Upper Triassic; *S. douglasii* in Upper Triassic. From this distributional pattern it appears that *Savitrispermum* sp. would have been the oldest form in progressive evolution.

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