

## BARJORASPORITES N. GEN. — A TRILETE SPORE WITH SCULPTURED PERISPORE FROM PERMIAN OF INDIA

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### ABSTRACT

The present paper records a fossil spore genus which is characterized by the sculptured perispore, a feature rare among fossil spores, and is reported from the Barakar Formation (Middle Permian) in the Barjora Coalfield, Damodar Basin, India. The new trilete microspore, *Barjorasporites indicus* n. gen. and n. sp., is globose to subglobose, tetrahedral (size range 80-100 µm), showing circular to subcircular or convexly triangular shape. The characteristic features of the new taxon are : distinct trilete mark, rays of 2/3 to 3/4 length of the radius; slightly raised, 2-4 µm thick labra; 2-4 µm thick, laevigate exine which is enveloped by a very closely adhering, verrucosely sculptured perispore membrane, often giving the impression of being low baculate. In proximal and proximo-distal view, verrucae are fused together, often forming a negative reticulum. The overall shape and perispore nature of the microspore suggest that *Barjorasporites indicus* is close to the extant spore genus *Dennstaedtia* and shows affinity with the family Pteridaceae.

### INTRODUCTION

The perispore or perine is an extra-exinous layer of the sporoderm, containing sporopollenin. It is a special protective coat, hung over the exine in addition to the outer exine and inner intine layers and is found in some spores of Cryptogams, especially in the fern taxa (Filicineae). The nature of the perispore is not very well understood. It develops after the sexine, presumably from the tapetal layer. The conventional perispore, under light microscope, appears as a membranous, hyaline to light brown, thin cover, assuming various shapes according to the group of plants. SEM and TEM studies (Lugardon, 1974; Devi, 1980) on the extant pteridophytic spores revealed that the perispore also carries different types of processes such as granulae (*Cheilanthes aemula* Maxon, *Notholaena aschenboriana* Klotz.), rugulae (*Cheilanthes leucopoda* Link), rugulae-verrucae [*Dryopteris sieboldi* (Van Houtte) O. Ktze.], spines [*Cystopteris fragilis*, (L.) Bernh.; *Tectaria fuscipes*

(Wall.) C. Chr.], verrucae [*Pyrrosia adnascens* (Forst.) Ching, *P. heteractis* (Mett.) Ching], spines-rugulae (*Cheilanthes chusana* Hook.), perforations-reticulations (*Asplenium bulbiferum* Forst), etc. (Devi, 1980). However, in fossil record spores with sculptured perispore are rare. *Retispora* Staplin (In Jansonius and Hills, 1976, Genera Card No. 2392), for example, is externally characterized by granulose-punctate to reticulate perispore. In *Ricaspora* Bharadwaj and Salujha (In Jansonius and Hills, 1976, Genera Card No. 2426), the laevigate exine is enveloped by thin granulose perispore which forms a flange. In *Gabonisoris* Boltenhagen emend. Srivastava (In Jansonius and Hills, 1976, Genera Card No. 1079), the perispore has setaceous, funnel-shaped or papillose processes. In monolete *Hezarfenosporites* Akyol (In Jansonius and Hills, 1976, Genera Card No. 1257), the perispore bears punctae, granules or warts (verrucae) (Table 1).

Table 1: Comparison of perinous spores in extinct and extant taxa

Genus	Age	Aperture	Size range µm	Spore wall		Amb
				Exine	Perine	
A. EXTINCT SPORES						
<i>Retispora florida</i> Staplin	U. Mississippian (Chesterian); W. Canada	Trilete	37-60	smooth?	granulose-punctate to reticulate	subcircular to convexly triangular with a spore body
<i>Ricaspora granulata</i> Bharadwaj & Salujha	U. Permian (Raniganj Fm.); India	Trilete	60-80	smooth	granulose	circular
<i>Gabonisoris vigourouxii</i> Boltenhagen emend. Srivastava	Senonian (less common in Turonian, Cenomanian); Africa	Trilete	30-45	smooth	setaceous, funnel shaped or papillose	subtriangular to spherical
<i>Ghoshispora scollardiana</i> Srivastava	Maestrichtian, Alberta; W. Canada	Trilete	80-95	fine reticulate	reticulate with variable strands	circular
<i>Baldurnisporites cernuus</i> Delcourt & Sprumont	Wealden; Belgium	Trilete	75-90	smooth?	perinate? folds or plications	rounded triangular with concave sides, narrow irregular zona

Genus	Age	Aperture	Size range µm	Spore wall		Amb
				Exine	Perine	
<i>Barjorasporites indicus</i> . n. gen. and n. sp.	M. Permian (U. Barakar); India	Trilete	80-100	smooth	verrucose	circular, subcircular or convexly triangular
<i>Hezarfenosporites verrucatus</i> Akyol	L. Permian; Turkey	Monolete	60-110	smooth or infra-punctate	verrucose? (punctae, granules or warts)	bilateral, planoconvex
<i>Peromonoletes bowenii</i> (Erdtman) Couper	Cretaceous; New Zealand	Monolete occasionally Alele	?	sub-verrucose?	sub-verrucose	bilateral, spherical
B. EXTANT SPORES (Based on Nayar & Devi, 1967, 1968; Devi, 1979, 1980)						
<i>Cheilanthes multifida</i> Swartz	Recent	Trilete	32-40 x 40-52	smooth	granulose, adhering, with flap-like reticulate folds	subcircular or convexly triangular with rounded angles
<i>Adiantopsis radiata</i> (L.) Fee	Recent	Trilete	20 x 32	smooth	smooth, folds spinose	convexly triangular with broad rounded corners
<i>Notholaena dealbata</i> (Pursh.) Kze.	Recent	Trilete	36-48 x 44-56	smooth to granulose	granulose, loose, sinuous, flap-like folds	subcircular or convexly triangular with rounded angles
<i>Aspidotis schimperii</i> (Kze.) Pic.-Ser.	Recent	Trilete	25-35 x 36-44	smooth	smooth, rugulose folds	triangular with narrow corners and slightly convex sides
<i>Pellaea breweri</i> Eat.	Recent	Trilete	36-52 x 48-60	smooth	smooth to granulose, folds rugulose-reticulate	subcircular to triangular
<i>Doryopteris ludens</i> (Wall.) J. Sm.	Recent	Trilete	28-36 x 36-48	smooth	smooth to granulose, folds spinose to reticulate	circular, sub-circular to convexly triangular
<i>Hemionites arifolia</i> (Baurm.) Moore	Recent	Trilete	36 x 48	smooth	smooth, folds reticulate	convexly triangular
<i>Bommeria hispida</i> Und.	Recent	Trilete	36 x 42	smooth	granulose	circular
<i>Paraceterach muelleri</i> (Hooker) Copel.	Recent	Trilete	24-36 x 36-44	smooth	rugulose, no folds	triangular with rounded corners and straight sides
<i>Gymnopteris vestita</i> (Wall.) Und.	Recent	Trilete	48-60 x 60-68	smooth	granulose, folds flap-like	subcircular
<i>Adiantum assamicum</i> Nayar	Recent	Trilete	28-36 x 32-40	smooth	verrucose	triangular with straight to slightly convex sides
<i>A. caudatum</i> Linn.	Recent	Trilete	36-40 x 40-52	smooth	verrucose	triangular with nearly straight sides to sub-circular
<i>Sphenomeris biflora</i> (Klf.) Ching.	Recent	Monolete	39x48x 36	smooth	granulose, no folds	Bilateral, planoconvex (lat.), oblong (pol.)
<i>Leptolepia novae-zelandiae</i> (Col.) Kuhn.	Recent	Trilete	20-26 x 28-36	smooth	smooth	triangular with straight to slightly concave sides and broad corners
<i>Cibotium glaucum</i> (Sm.) Hook & Arn.	Recent	Trilete	34-40 x 48-60	smooth	granulose	subcircular to convexly triangular
<i>Lindsaea chiineii</i> Ching.	Recent	Trilete	18x36	smooth	rugulose	triangular with nearly straight sides and narrow corners
<i>Lindsaea cultrata</i> (Willd.) Sw.	Recent	Monolete	32x48x 30	smooth	granulose	bilateral, planoconvex (lat.) oblong (pol.)
<i>Dennstaedtia Bernh.</i>	Recent	Trilete	20-40 x 28-52	smooth	verrucose	circular, subcircular or triangular with slightly concave to convex sides
<i>Dennstaedtia wilfordii</i> Christ	Recent	Trilete	35-42x 36-48	smooth	verrucose	triangular with broad corners and nearly straight sides
<i>Sphenomeris bifolia</i> (Klf.) Ching	Recent	Monolete	39x48 x36	smooth	granulose	bilateral planoconvex to oblong

The present paper reports a fossil spore genus with sculptured perispore from the Middle Permian (Upper Member, Barakar Formation) of the Barjora Coalfield, Damodar Basin, West Bengal, India (fig. 1). The spore genus, considered new in this study, is characterized by the presence of a very closely adhering verrucate perispore on the sporoderm.

## MATERIAL AND METHOD

The spores for the present study were isolated from a carbonaceous shale collected from borehole No. BOR/MA/075, Barjora Coalfield, West Bengal, at the depth of 68.34 m (sample no. 103, fig. 2). Barjora Coalfield is situated between the latitudes  $23^{\circ} 25' \text{N}$  -  $23^{\circ} 27' \text{N}$  and longitudes  $87^{\circ} 12' \text{E}$  -  $87^{\circ} 18' \text{E}$ , south of the Raniganj Coalfield, with strike running N-S. The samples collected were chemically processed in the laboratory, following the usual maceration technique, for the release of miospores. Slides were prepared in glycerine jelly for detailed morphotaxonomic study of the palynomorphs. The prepared slides are deposited in the museum of the Department of Geology, University of Lucknow, Lucknow-226 007, India (No. BOR/Pal./1-16).

## SYSTEMATIC DESCRIPTION

*Anteturma Sporites* H. Potonié (1893) emend.  
Bharadwaj, 1974

*Subanteturma Atenuitatis* Bharadwaj, 1974

*Turma Noncurvaturati* Bharadwaj, 1974

*Subturma Nontriquettri* Bharadwaj, 1974

*Infrasubturma Nonstructurati* Bharadwaj, 1974

*Infraturma Sphaerae* Bharadwaj, 1974

*Subinfraturma Nonoperculati* Bharadwaj, 1974

*Genus Barjorasporites* n. gen.

*Type species Barjorasporites indicus* n. sp.

*Derivation of name* : The spore genus is named after the type locality "Barjora Coalfield", West Bengal, India.

*Diagnosis* : Globose to subglobose tetrahedral microspores; trilete mark distinct; amb circular to sub-circular or convexly triangular with rounded angles; exine thick, laevigate, enveloped by a very closely adhering, verrucosely sculptured, perispore layer (perine).

*Description* : Globose to subglobose tetrahedral palynomorphs, amb circular, subcircular or triangular with convex sides and smoothly rounded corners. Size 80 - 100  $\mu\text{m}$ . Trilete mark distinct, rays of  $2/3$  to  $3/4$  the radius (30-40  $\mu\text{m}$ ), more or less reaching the inner margin of the exine. Labra 2-4  $\mu\text{m}$  thick and slightly raised. Exine laevigate, some times with fold, 2-4  $\mu\text{m}$  thick, sexine nearly as thick as nexine and enveloped by a very closely adhering perispore membrane. Perispore sculptured by verrucae of various sizes; 1 to 3  $\mu\text{m}$  in

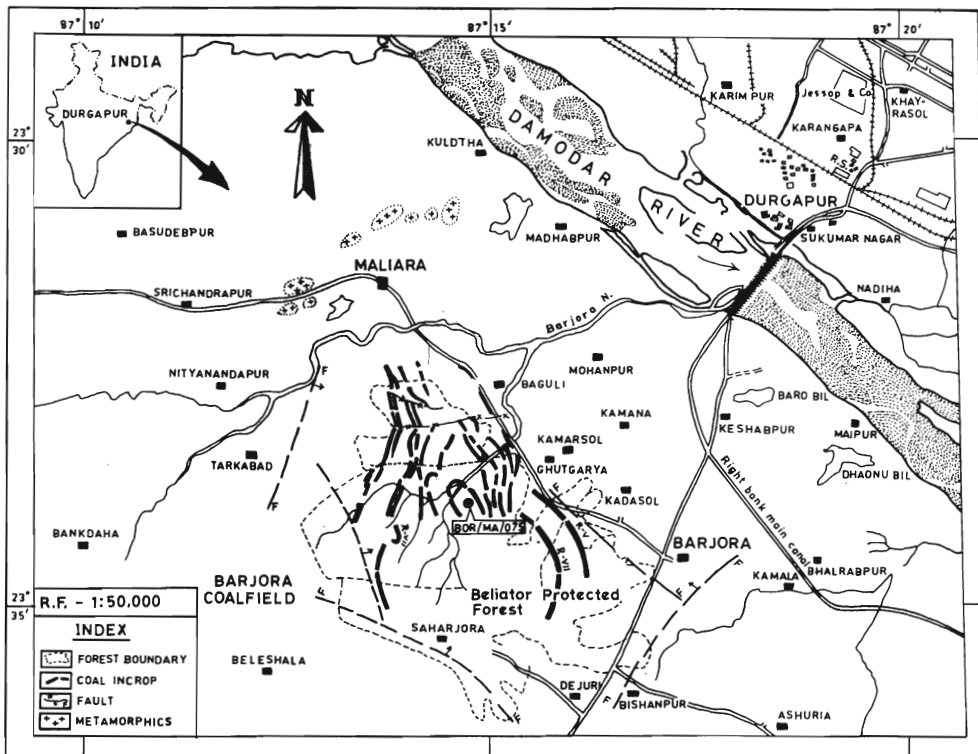


Fig. 1. Geological map of Barjora Coalfield, Damodar Basin, India.

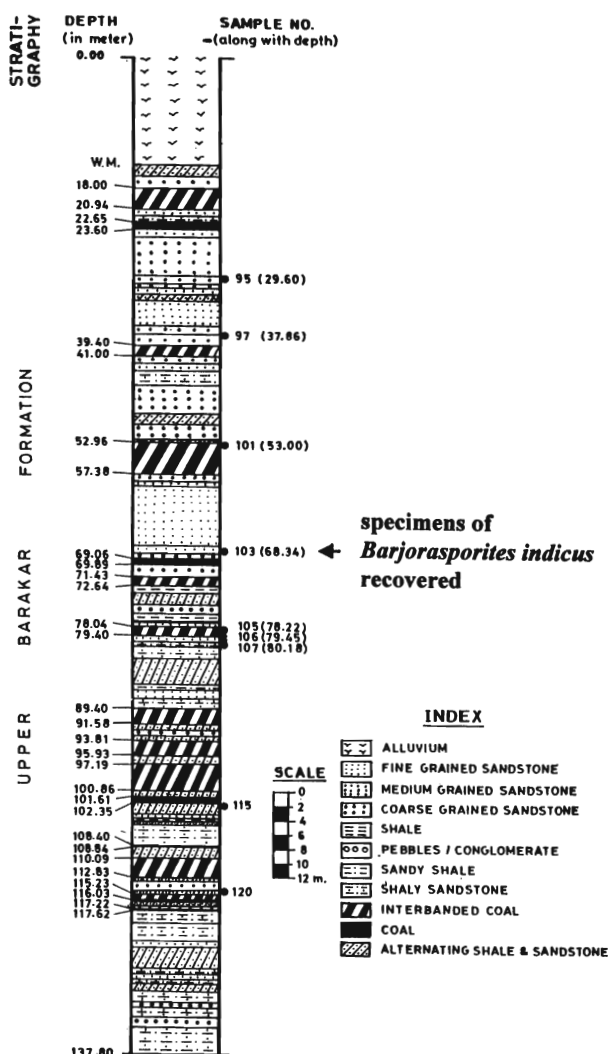


Fig. 2. Litholog of bore core BOR/MA/075, Barjora Coalfield, India.

surface view (head) and 1-2  $\mu\text{m}$  in optical view (height). Perispore layer detached at few places exposing the laevigate exine (Pl. I, figs. 2, 4, 5, 7, 9, 11; Pl. II, figs. 2, 3, 4). Sculpture on perispore sometimes appears as low baculae, merging with each other. In proximal and proximodistal view, verrucae are fused together often forming a negative reticulum.

**Comparison :** In *Sporae dispersae* circular, subcircular or convexly triangular spores with verrucose exine have been described as *Verrucosiporites* Ibrahim emend. Smith *et al.*, 1964; Smith, 1971 (In Jansonius and Hills, 1976, Genera Card Nos. 3186, 3187). The new spore genus *Barjorasporites* shows close similarity with it in overall shape and morphological characters but in the former the exine is verrucose and without any perispore covering while in the latter it is laevigate and the perispore layer (perine) contains verrucae. The *Verrucosiporites* is a monolete spore without perispore layer. Few palynomorphs resembling *Verrucosiporites*

have been described as *Armatisporites* Dybova and Jachowicz (In Jansonius and Hills, 1976, Genera Card No. 169), *Rotverrucosporites* Döring (In Jansonius and Hills, 1976, Genera Card No. 2447), *Triassisporis* Schulz (In Jansonius and Hills, 1976, Genera Card No. 2953), *Mannebachia* Franke (In Jansonius and Hills, 1976, Genera Card No. 1596), *Diverrucosiporites* Roche (In Jansonius and Hills, 1976, Genera Card No. 844) and *Kewaneesporites* Peppers (In Jansonius and Hills, 1976, Genera Card No. 1389), etc. Although all these miospores also contain verrucose exine but lack distinct extra-exinous perine or perispore layer which is a characteristic feature of the *Barjorasporites* n. gen. and n. sp.

Few perinous spores have been known in the fossil record. Among them *Ghoshispora* Srivastava (In Jansonius and Hills, 1976, Genera Card No. 1104) resembles *Barjorasporites* in overall shape and size but differs in the ornamentation as the former has a reticulate perine. *Retispora* Staplin has a spore body, with granulose-punctate to reticulate perispore. In *Ricaspora* Bharadwaj and Salujha thick, laevigate exine is covered by thin granulose perispore forming a flange. In *Gabonisporis* Boltenhagen emend. Srivastava, the perispore bears setaceous, funnel shaped or papillose processes.

In overall shape and morphological characters, *Barjorasporites* shows close similarity with the extant spore genus *Dennstaedtia* Bernh. belonging to the family Pteridaceae, e.g., *D. wilfordii* Christ which is a trilete perinous spore sculptured with verrucae, triangular amb with broad corners and nearly straight sides (size range 35-42 x 36-48  $\mu\text{m}$ ). From India two species of *Dennstaedtia*, viz., *D. appendiculata* (Wall.) J. Sm. var. *elwesii* Bedd. (size 30 x 40  $\mu\text{m}$ ) and *D. scabra* (Wall.) Moore (size range 24-32 x 33-48  $\mu\text{m}$ ) have been recorded from Darjeeling and Trivandrum, respectively (Nayar and Devi, 1968, Devi, 1979). However, in comparison to these extant spores *Barjorasporites* is larger in size (80-100  $\mu\text{m}$ ). It also compares well with the extant spores *Adiantum assamicum* Nayar (size range 28-36 x 32-40  $\mu\text{m}$ ) and *A. caudatum* Linn. (size range 36-40 x 40-52  $\mu\text{m}$ ), recorded from Assam, in having verrucose perine (Nayar and Devi, 1967). Verrucose sporoderm is present in some species of *Pteris* also. *Pyrrosia adnascene* (Polypodiaceae) also bears verrucose perispore but it is a bilateral and monolete spore. So far there is no record of any other fossil palynomorph which contains extra-exinous verrucose perispore layer.

#### BOTANICAL AFFINITY

*Barjorasporites indicus* n. gen. and n. sp. resembles extant spores of family Pteridaceae viz., *Dennstaedtia* Bernh., *Adiantum* Linn. in having verrucosely sculptured perispore. From this affinity it is suggested that it could be a representative of moist, cool and shaded environment.

*Barjorasporites indicus* n. sp.

(Pl. I, figs. 1-12; Pl. II, figs. 1-6)

*Holotype* : Pl. I, fig. 2, size 80-86  $\mu\text{m}$ ; slide No. BOR/Pal./2

*Isotype* : Pl. I, fig. 3, size 90-98  $\mu\text{m}$ , slide No. BOR/Pal./1

*Type locality* : Bore-hole BOR/MA/075, depth 68.34 m, Barjora Coalfield, Damodar Basin, West Bengal, India.

*Type Horizon and age*: Barakar Formation (Lower Gondwana), Middle Permian, India.

*Diagnosis* : Globose to subglobose tetrahedral microspores, showing circular to subcircular or convexly triangular shape in flattened specimens. Trilete mark distinct; exine thick, laevigate, and is enveloped by a very closely adhering verrucosely sculptured perispore layer (Perine).

*Description* : Globose to subglobose tetrahedral palynomorphs, amb circular, subcircular or convexly triangular. Size 80-100  $\mu\text{m}$ . Holotype 80-86  $\mu\text{m}$ . Trilete mark distinct, rays 2/3 to 3/4 of the radius length, more or less reaching the inner margin of the exine. Labra 2-4  $\mu\text{m}$  thick and slightly raised. Exine laevigate, some times fold present, 2-4  $\mu\text{m}$  thick, sexine nearly as thick as nexine and enveloped by a very closely adhering, verrucosely sculptured, perispore membrane. Sculpture on perispore sometimes appears as low baculae, merging with each other. In proximal and proximodistal view, varrucae are fused together often forming a negative reticulum.

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## EXPLANATION OF PLATES

## Plate I

Specimens of *Barjorasporites indicus* n. gen. and n. sp.

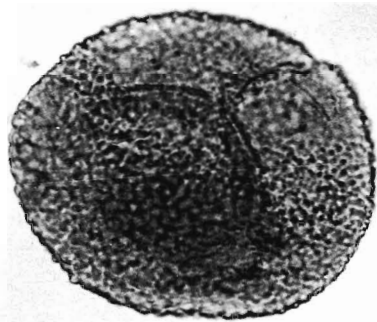
(All photomicrographs x 500)

- 1, 6, 8. Exine of microspores enveloped by a very closely adhering verrucosely sculptured, perispore membrane (slide no. BOR/Pal./5,14,10).
2. Holotype of *Barjorasporites*- perispore membrane detached at right corner exposing the laevigate exine (slide no. BOR/Pal./2).
3. Isotype of *Barjorasporites*- exine is completely covered by a verrucosely sculptured perispore (slide no. BOR/Pal./1).
- 4, 5, 7, 9, 11, 12. Specimens showing the laevigate exine partially exposed. (slide nos. BOR/Pal./5,6,3,3,10,6,1).
10. Specimen showing well developed verrucae on the perispore membrane (slide no. BOR/Pal./1).

## Plate II

SEM photomicrographs of *Barjorasporites indicus* n. gen. and n. sp.

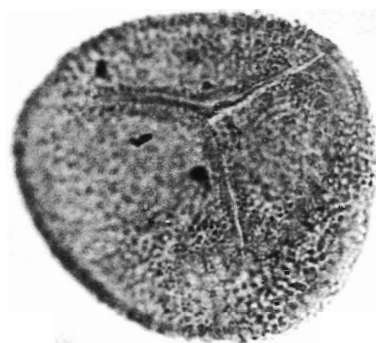
- 1, 5, 6. Specimens showing verrucosely sculptured perispore membrane in the trilete spores.
- 2, 3, 4. Specimens showing the laevigate exine partially exposed.



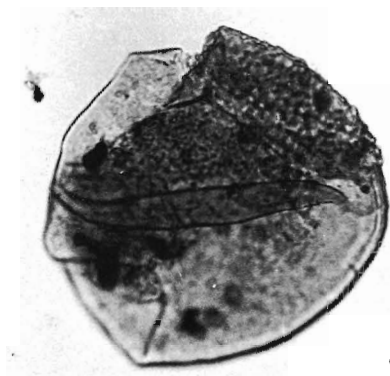
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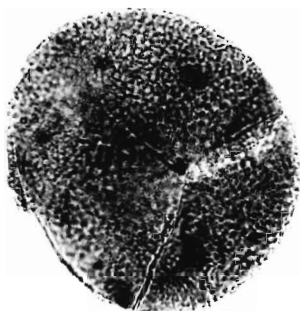
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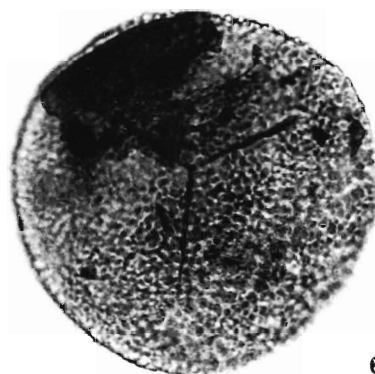
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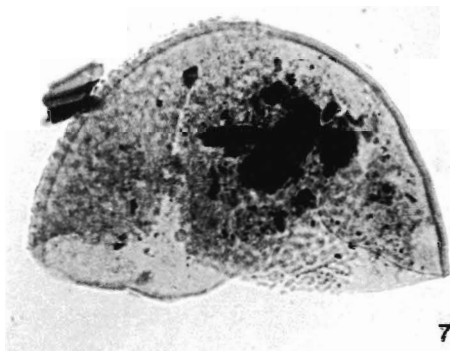
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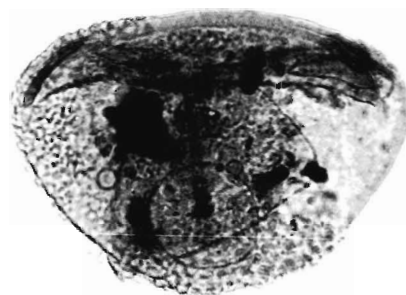
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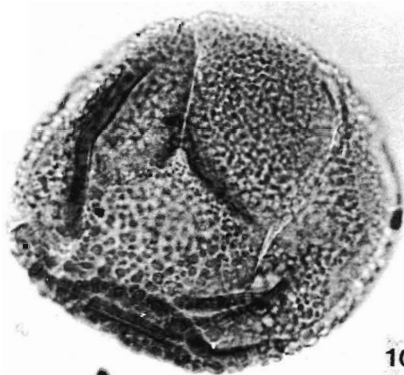
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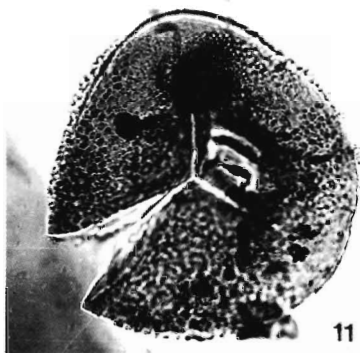
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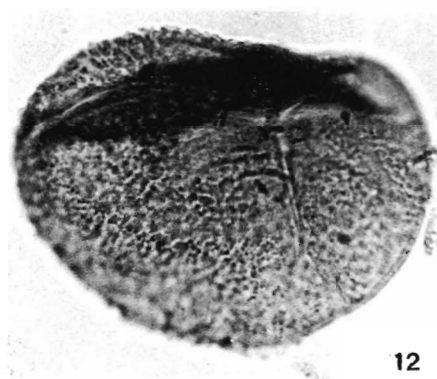
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