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PALYNOSTRATIGRAPHY AND ENVIRONMENT OF DEPOSITION IN THE LOWER GONDWANA SEDIMENTS OF CHUPARBHITA COALFIELD, RAJMAHAL HILLS

MANJU BANERJEE AND ASHALATA D'ROZARIO

DEPARTMENT OF BOTANY, UNIVERSITY OF CALCUTTA, CALCUTTA - 700 019

ABSTRACT

Palynological study of the Lower Gondwana sediments of Chuparbhita coalfield, Rajmahal hills has been made with three bore core samples obtained from Coal India Ltd. 72 genera and about 145 species recovered from the samples include spores, pollen grains, acritarchs and a few megaspores. The palynostratigraphic sequence reveals environment of deposition in the Chuparbhita coalfield. Three macroenvironment or prolonged climatic zones, viz., monosaccate *Plicatipollenites —Parasaccites* zone, non-striate disaccate *Scheuringipollenites* zone and striate-disaccate *Striatopodocarpites — Striatites* zone corresponding to cool, temperate and warm climate respectively are revealed. Ten distinct assemblages of different ecofacies of deposition are recognised within these three Macroenvironment zones. The assemblages of ecological significance are considered as Microenvironment zones. Among the ten, two microenvironment zones viz., MiZ.C.6 and MiZ.C.9 within Maz. *Scheuringipollenites* are suggested as marker horizons due to the restricted occurrence of two new trilete genera one in each marker horizon and the diverse and quantitatively rich acritarch genera in the palynoassemblages. The occurrence of diverse acritarch swarms in continental deposits may be an indication of marine transgressional phase.

INTRODUCTION

Palynological study of Indian Lower Gondwana sediments have been extensively carried out by various workers since about the last fifty years. From the initial phase, the spores and pollen grains have been studied to utilise the science for deciphering the environment of deposition and also correlation of coal horizons (Virkki, 1937, 1939, 1946; Sahni, 1940 and Sen, 1944). The stratigraphic distribution of spores and pollen grains in the Indian Lower Gondwana has been studied in almost all the coal basins and palynostratigraphic zonations proposed (Bharadwaj, 1966, 1971; Tiwari, 1973, 1974). These zonations are primarily established on the basis of appearance, dominance and disappearance of different types of saccate pollen grains viz., radial monosaccates, non-striate disaccates and striate disaccates which are also supposed to be cold, temperate and warmer climate indicator taxa respectively (Bharadwaj, 1966, 1974; Tiwari, 1973; Lele, 1976; Kar, 1976). A gradual change from cool to warm climatic phases of deposition between Talchir to Raniganj formations of Indian Lower Gondwana are suggested on the basis of the relative abundance of the respective climate indicator taxa. The ecological phases of deposition within each climatic phase are however yet to be understood more exhaustively for a better understanding of the environment of deposition and palaeogeography of the individual basin. Such analysis is expected to be more useful for lateral correlation of the horizons within a basin or isolated basins and throw more light on the history of deposition of peninsular Gondwana. Ecological analysis of the various spores and pollen taxa of Lower Gondwana is difficult due to meagre information of *in situ* occurrence as also insufficient data about the ecofacies of the megaflora producing the miospores. Data available from the Lower Gondwana and also of the similar taxa of northern hemisphere Carboniferous coal swamp have been considered for suggesting the ecological condition of the different palynoassemblages of Chuparbhita coalfield.

The climatic phases are controlled primarily by the latitude, longitude position, topography of an area or the physical phenomenon viz., glaciation or tectonic movements. All these factors are prolonged time ranging factors, whereas the ecofacies of the same climatic phase changes due to short time controlled factors as well as changing facies of occurrence within the swamp (Scott and Collinson, 1983). The ecofacies may be controlled by heavy precipitation, siltation, changing soil character, eustatic change during intermittant deglaciation within a prolonged glacial period, minor tectonic activities, etc.

The influence of the climate indicator saccate taxa for a prolonged phase of deposition is thus considered as Macroenvironment zone. The taxa recognised as indicator of macroenvironment zone may not necessarily be the dominant or subdominant representative of the assemblage, but occurrence of

such taxa in the assemblage may also be accounted to resolve the influence of the climatic factor. Variations in frequency may be due to diverse factors viz., source area proximity to depositional site, dispersal range, direction of wind, etc. Influence of the ecological factors for the changing facies of deposition within a prolonged Macroenvironment zone is considered as Microenvironment zone. Marker horizons are identified on the basis of significance of assemblage pattern viz., occurrence of a marker taxa, influence of particular facies viz., brackish water etc. Miofloristic study of the Lower Gondwana sediments of Chuparbhita coalfield, one of the five coalfields of Rajmahal group of coalfields, has been attempted in this paper to reveal the Macro and Microenvironmental phases of deposition of the basin through stratigraphic zonations. Macroenvironment and Microenvironment zones are abbreviated as Maz and Miz respectively. The letter C is used as suffix for identifying the zones of Chuparbhita coalfield.

Earlier Ghosh *et al.* (1984) recorded an Upper Barakar palyno-assemblage from coal seams of Chattgram area of Chuparbhita coalfield. Bharadwaj and Srivastava (1986) recorded a Lower Barakar palynoassemblage from bottom seam in Gomani river section in this coalfield.

LOCATION AND GEOLOGY

Chuparbhita coalfield is situated in the Rajmahal Hills area, Santhal Parganas, Bihar between 24°43′ -24°47′ N Lat. and 87°28′ - 87°30′E Long. (Fig. 1).

The geology of the coal-bearing sediments of Rajmahal hills has been studied by Ball (1877), Feistmantel (1880), Pascoe (1959) and recently by the Geological Survey of India (Raja Rao, 1977; Guha, Mukherjee and Mitra, 1978; Madabhushi, 1979). The generalized geological sequence of the Gondwanas in Chuparbhita coalfield as suggested by these workers is as follows (Table 1).

Table 1 Geological sequence in the Chuparbhita coalfield.

Alluvium	Recent
Rajmahal Traps	Upper Gondwana
Dubrajpur Formation	
Unconformity and overlap	
Barakar Formation	Lower Gondwana
Karharbari Formation	
Talchir Formation	
Unconformity	
Archaean	

The Barakar Formation is flanked on the north by a thin capping of Dubrajpur Formation, which in turn is overlapped by Rajmahal traps and intertraps. On the south and east, coal measures are covered directly by Rajmahal traps without the Dubrajpur Formation. In this coalfield both Karharbari and Barakar coal measures are well developed resting partly on Talchir and partly on the undulating Archaean basement (Guha, Mukherjee and Mitra, 1978).

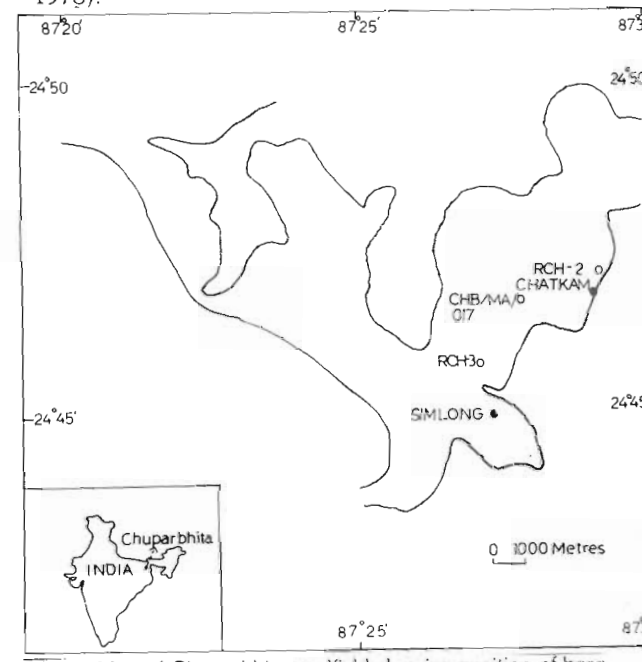


Fig. 1. Map of Chuparbhita coalfield showing position of bore holes from which samples have been collected for the present investigation.

Exploration work undertaken by Geological Survey of India has revealed 13 regionally persistent coal seams within Barakar Formation divisible into Upper and Lower coal-bearing strata with an intervening barren zone of coarse-grained sandstone, while 3 coal seams are persistent within the Karharbari Formation.

MATERIAL

Samples for the present investigation were collected from three bore cores drilled by Coal India Ltd. and MECL (Fig. 1). Sampling has been made for each lithology from the bore cores drilled by Coal India (CHB/MA/017). But only the basal samples were available from the bore cores of MECL (RCH-2, RCH-3) (Fig. 2). Thirty eight samples were collected, of which 22 yielded mioflora. Other samples are either barren or yielded negligible mioflora.

METHODOLOGY

The usual method of maceration with Schulz solution and dilute alkali (5-10% KOH) has been followed to macerate the samples after treatment with 40% HF to remove silica. Macerated samples are preserved in 50% glycerine and slides prepared in glycerine jelly using 22 x 50 mm coverglass. Material and slides are preserved in the repository of the Palaeobotany Laboratory, Department of Botany, University of Calcutta.

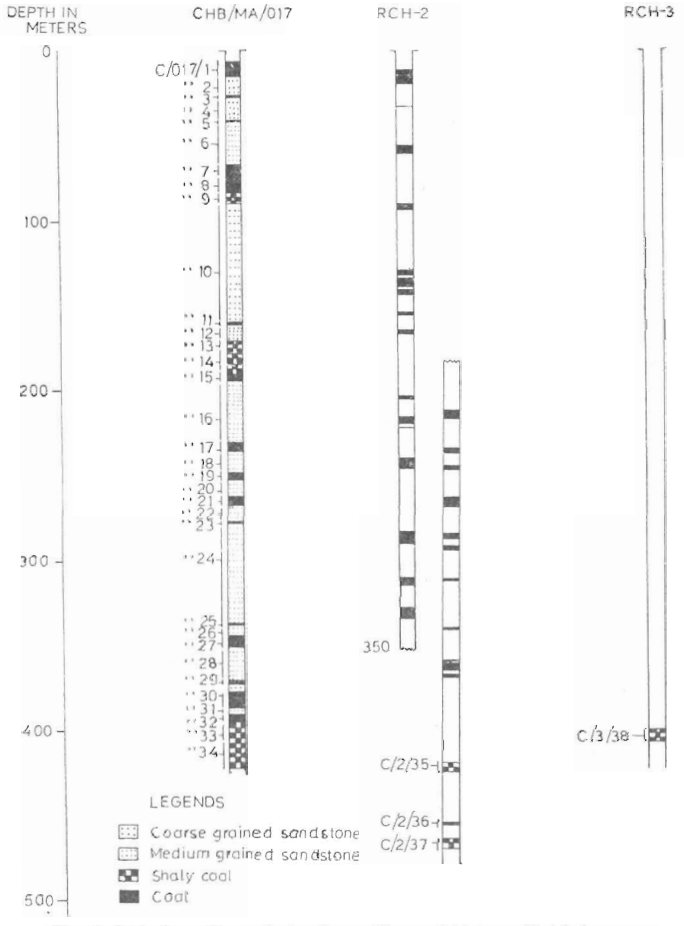


Fig. 2. Litholog of bore holes from Chuparbhita coalfield showing sample positions.

QUALITATIVE ANALYSIS OF PALYNOMORPHS RECOVERED FROM THE LOWER GONDWANA SEDIMENTS OF CHUPARBHITA COALFIELD

Altogether 72 genera and 145 species (Table 2, Pls. I-III) have been recovered from the various samples collected from Chuparbhita coalfield, of which two genera viz., *Lalmatiasporites* with two species *L. barakarensis*, *L. indicus* (Pl. II - 4 & 5), *Ghoshiatriletes gondwanensis* (Pl. II - 9 & 10) and one species *Horriditriletes rajmahalensis* (Pl. II - 7) were described and illustrated by D'Rozario and Banerjee, 1987a.

Table 2.

List of Palynomorphs recorded in the present study

Callumispora barakarensis
C. tenuis
C. tenuis var *minor*
Lalmatiasporites barkararensis
L. indicus
Leiotriletes brevis
L. erectus
Psilalacinites triangulus
P. minutus
Retusotriletes diversiformis
Cyclogranisporites gondwanensis
Granulatisporites parvus
Verrucosisporites diversus
Acanthotriletes filiformis
A. jhariaensis
Apiculatisporis inconspicuus
Lophotriletes rarus
L. rectus
Brijrajisporites distinctus
Cyclobaculispora indicus
Horriditriletes bulbosus
H. curvibaculosus
H. novus
H. rajmahalensis
H. splendidus
Lobatisporites gondwanensis
Brevitriletes communis
B. levis
B. unicus
Didecitriletes bellus
D. horridus
Jayantisporites pseudazonatus
Lacinitriletes minutus
Microbaculispora barakarensis
M. indica
M. tentula
Microfoveolatispora bokaroensis
M. directa
M. foveolata
M. indica
Dictyotriletes sp.
Eupunctisporites poniatiensis
Ghoshiatriletes gondwanensis
Indospora clara
I. laevigata
I. macula
Triquitrites sp.
Dentatispora gondwanensis
D. indica
Lycospora sp.
Indotriradites korbaensis
I. sparsus
I. surangei
Potonieitriradites barakarensis

Altimonoletes flavatus
Laevigatosporites colliensis
L. flexus
Tiwariasporis flavatus
Ghoshiasporites didecus
Densipollenites indicus
D. brevis
Parasaccites korbaensis
P. talchirensis
P. obscurus
P. rimosus
Tuberisaccites varius
T. jhingurdahiensis
Crucisaccites indicus
Caheniasaccites indicus
Plicatipollenites indicus
P. gondwanensis
P. trigonalis
Potonieisporites densus
Barakarites indicus
Corisaccites alutas
Labiisporites densus
Sahnites thomasi
S. barrelis
Sahnites sp.
Alisporites sp.
Scheuringipollenites maximus
S. barakarensis
Cuneatisporites sp.
Platysaccus crassimarginatus
P. brevizonatus
Raniganjiasaccites sp.
Primuspollenites levis
P. densus
P. dicavus
Rhizomaspora indica
R. monosulcata
Schizopollis disaccoides
S. extremus
S. distinctus
Crescentipollenites fuscus
C. korbaensis
C. notabilis
Faunipollenites varius
F. parvus
Lahirites raniganjensis
L. Singularis
Striatites notus
S. rhombicus
S. solitus
S. communis
S. tentulus
S. gopalensis
S. barakarensis
Striatopodocarpites magnificus
S. brevis
S. ovatus
S. haploxylonoides
S. subcircularis
Verticipollenites secretus
V. debilis
Distriatites indicus
Hindisporis senii
Marsupipollenites triradites
Marsupipollenites sp.
Gnetaceaepollenites sinuosus
Ginkgocycadophytus cymbatus
Ginkgocycadophytus sp.
Vittatina africana
Peltacystia venosa
Circulisporites parvus
Tetraporina sp.
Quadrisporites horridus
Haplocystia pellucida
Maculatasporites indicus
Kagulubeites verrucosus
Kagulubeites sp.
Megaspores
Srivastaveaesporites karanpuraensis
S. dijkstrae
Talchirella raniganjensis
Biharisporites distinctus
Singhisporites surangei
S. radialis

Microfossils previously considered as alete forms but presently included under acritarchs and Prasinophyta (Tappan, 1980) have been recorded from this coalfield as also a few megaspores (Table 2, Fig. 3c).

PALYNOSTRATIGRAPHIC, MACRO-MICRO ENVIRONMENT ZONES AND MARKER HORIZONS OF LOWER GONDWANA SEDIMENTS IN CHUPARBHITA COALFIELD

Frequency distribution of palynomorphs in the sedimentary succession of Chuparbhita coalfield has revealed distinctive palyno-assemblage pattern (Histogram 1). Atleast ten palynostratigraphic zones are identified along the entire succession studied (Table 3, Fig. 3).

Each of the palynostratigraphic zones of Chuparbhita coalfield has been considered as microenvironmental zone. These ten MiZ.C are found to be deposited under the influence of three prolonged MaZ environment (climatic) zones. The MaZ recognised from the Chuparbhita coalfield from older to younger sequence are

I MaZ.C *Plicatipollenites — Parasaccites*
II MaZ.C *Scheuringipollenites*
III MaZ.C *Striatopodocarpites — Striatites*

Percentage frequency of the taxa recorded from each sample and the composition of the palynostratigraphic zones are enumerated in Histogram 1, Figs. 2 and 3, and Table 3. Stratigraphic age and environment of deposition are discussed from the compositional pattern of the palynostratigraphic zones.

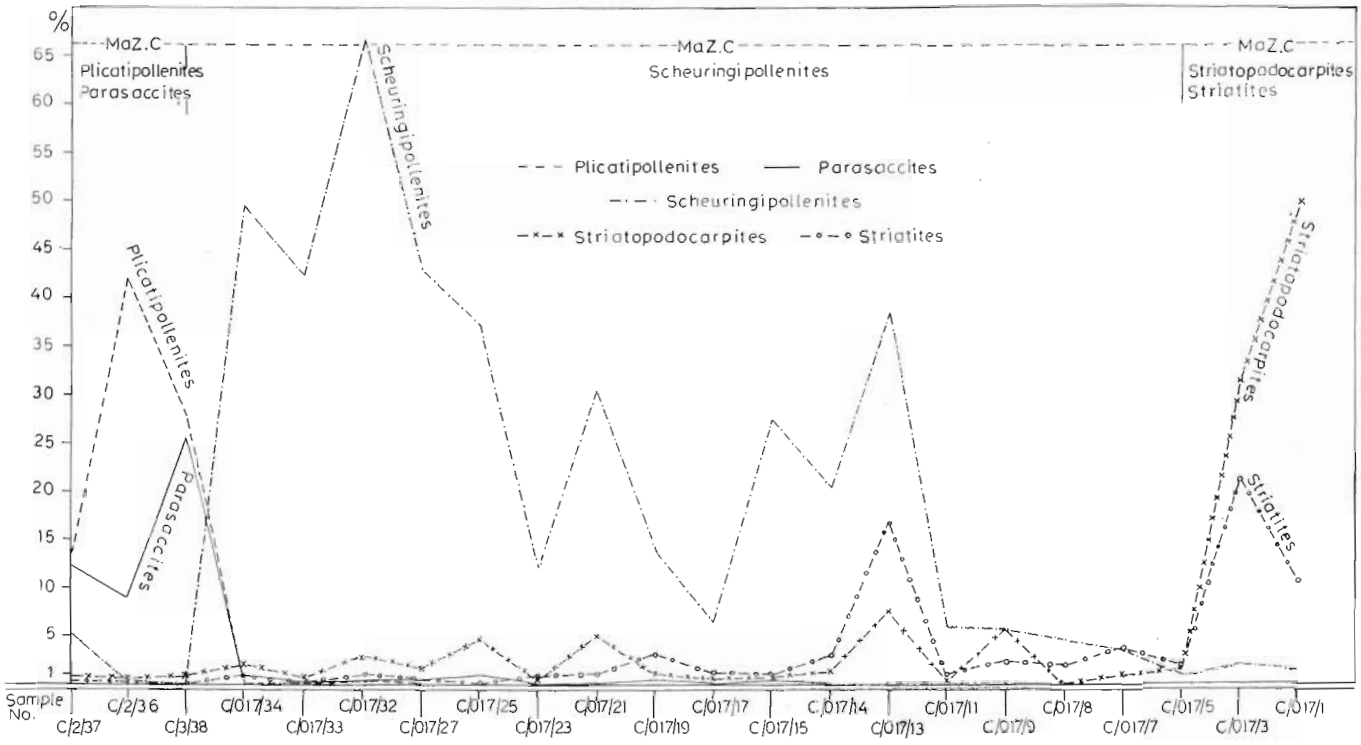


Fig. 3a. Frequency of occurrence of macroenvironment indicator taxa along the vertical sequence of horizons.

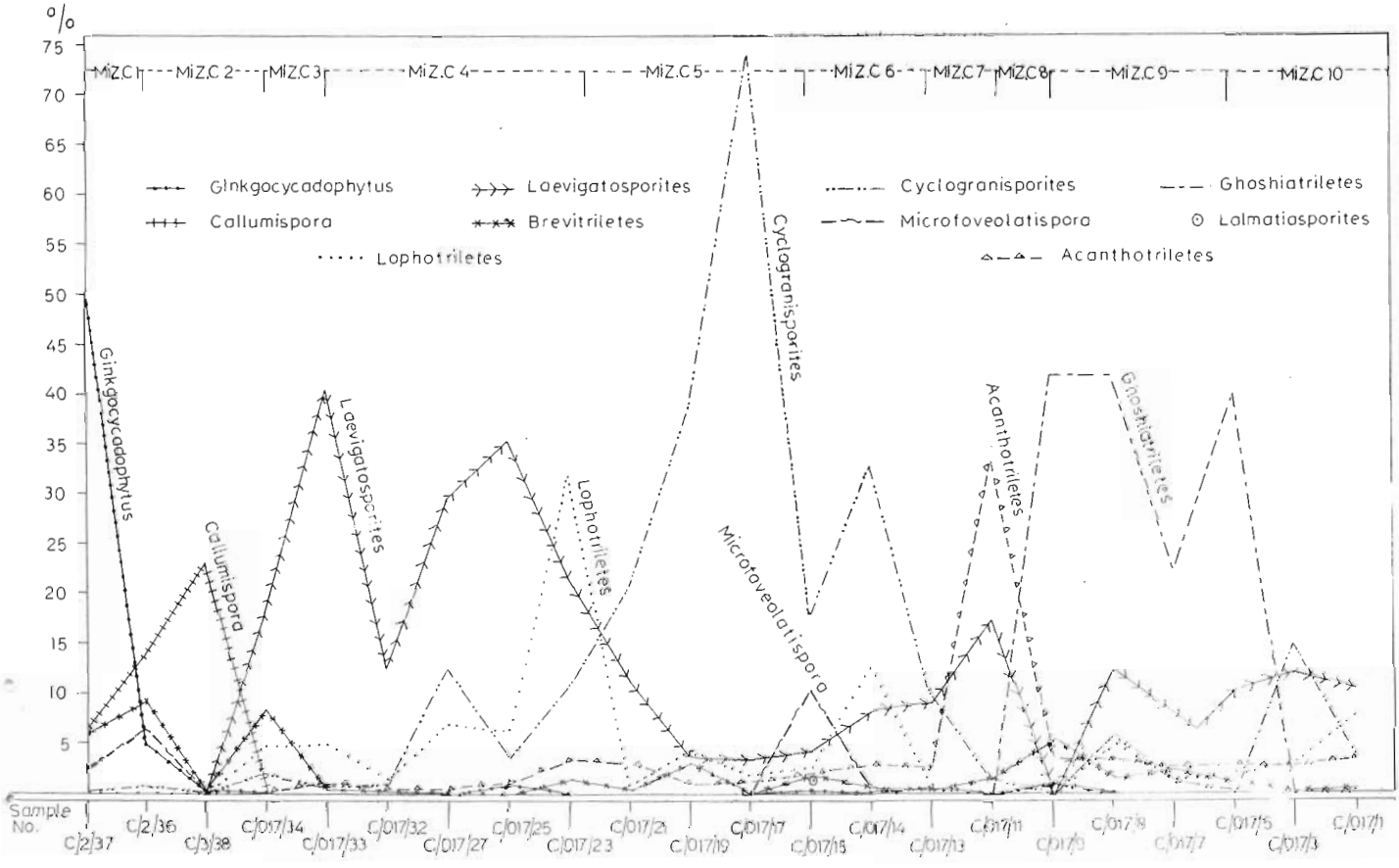


Fig. 3b. Frequency of occurrence of microenvironment indicator taxa along the vertical sequence of horizons.

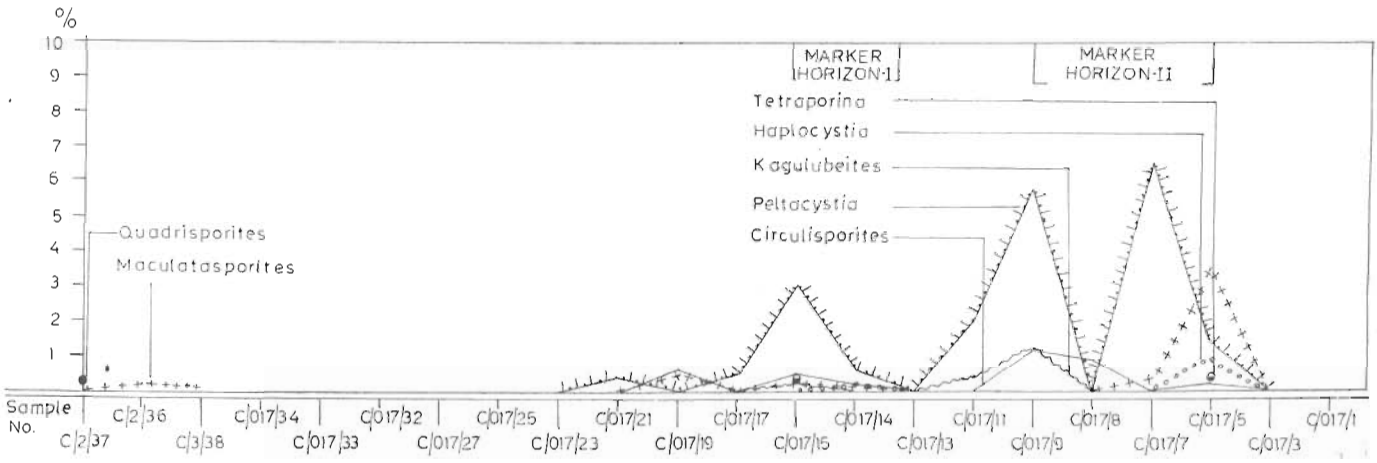


Fig. 3c. Variations in the occurrence of acritarchs and tasmanids in the different horizons.

MAZ.C.I. PLICATIPOLLENITES-PARASACCITES

Two MiZ. are recognised within the monosaccate phase of MaZ deposition.

MIZ.C.I. GINKGOCYCADOPHYTUS
(Sample No. C/2/37)

Ginkgocycadophytus	49.7% MiZ. representative
Plicatipollenites	13.08% MaZ representative
Parasaccites	12.4% MaZ representative
Callumispora	6.7% MiZ. representative
Acritarch	*Quadrisporites*

Ginkgocycadophytus occur with maximum representation in the assemblage of the lower-most strata studied in the coalfield. The MaZ representatives *Plicatipollenites-Parasaccites* occur as subdominant taxa followed by *Callumispora*. *Quadrisporites* is another representative of this assemblage which is suggested to be an acritarch (Tappan, 1980). Morphological organisation of *Ginkgocycadophytus* has been suggested by Meyen (1987) as a folded saccate pollen grain asseming boat-shaped appearance and simulating a monocolpate pollen.

Higher incidence of *Ginkgocycadophytus* is recorded in the assemblage recovered from Talchir sediments in the Anuppur area of Birsingpur Pali, M.P., South Rewa Gondwana Basin (Chandra and Lele, 1979); the climate indicator taxa viz., *Parasaccites* and *Plicatipollenites*, however, occur as dominant and rare members respectively in the Anuppur assemblage. The variation in order of dominance may be due to local geographical factor.

Cool climate and Talchir age is suggested for the lowest palynostratigraphic zone within MaZ.C.I of Chuparbhita coalfield.

MIZ.C.2 CALLUMISPORA
(Sample Nos.C/3/38 and C/2/36)

Plicatipollenites	42-28% MaZ. representative
Parasaccites	25-10% MaZ. representative
Callumispora	23-14% MiZ. representative
Brevitriletes	9%
Acritarch	*Maculatasporites*

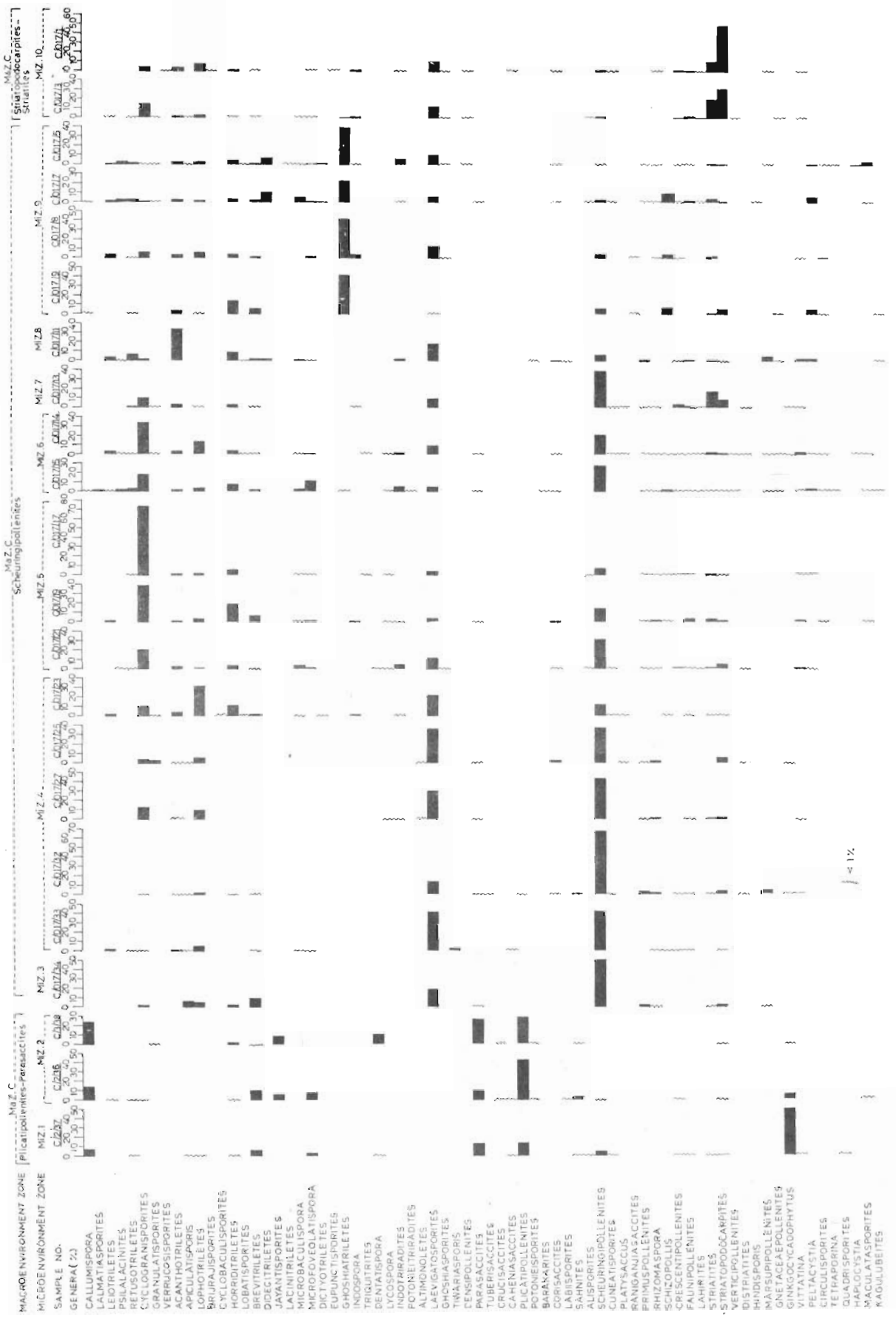
The radial monosaccates which were subdominant members in the previous zone gains predominance, constituting major part of the flora with *Callumispora* in closer frequency. This microzone assemblage can be compared to the assemblages recovered from Karharbari sediments of Ganjra nalla beds of South Rewa Gondwana basin (Lele and Maithy, 1964, 1969), Giridih coalfield (Maithy, 1965), South Karanpura coalfield (Lele and Kulkarni, 1969) and Hutar coalfield (Sukla, 1983).

The MaZ representatives indicate cooler climate.

Maculatasporites, a Prasinophyte member of Tasmanitaceae (Tappan, 1980) occur sporadically in this zone; the ecology of this taxon has been suggested to be of marine habitat.

MAZ.C.II SCHEURINGIPOLLENITES

This zone shows a clear distinction from the previous zone and a change in miofloral phase is noticed from monosaccate rich assemblage to non-striate disaccate *Scheuringipollenites* phase. This is an extensive vegetational phase of deposition in Chuparbhita coalfield. Majority of the samples of this zone show dominance of *Scheuringipollenites*. Occasionally trilete taxa dominate over *Scheuringipollenites* in the assemblages. Preponderance of *Striatopodocarpites* —*Striatites* over *Scheuringipollenites*



Histogram 1. Frequency distribution of spores dispersae in the different samples.

observed in one of the MiZ. in this MaZ. suggest for a temporary change in the climatic condition. Seven Mizones are recognised within this MaZ. *Scheuringipollenites*.

Dominance or prevalence of non-striate disaccate *Scheuringipollenites* is mainly recorded from samples of Middle Barakar Formation of Indian Lower Gondwana (Tiwari, 1973, 1974). The MaZ.C. *Scheuringipollenites* with seven MiZ.C. are comparable with the assemblages of Middle Barakar Formation, Lower Permian. This extensive *Scheuringipollenites* phase reveals temperate climatic condition.

MIZ.C.3 — LAEVIGATOSPORITES-BREVITRILETES
(Sample No. C/017/34)

Scheuringipollenites	49.5% MaZ. representative
Laevigatosporites	18.4% MiZ. representative
Brevitriletes	9% MiZ. representative

Laevigatosporites and *Brevitriletes* contribute significantly to this assemblage in addition to *Scheuringipollenites*.

Brevitriletes rich assemblages are known from Lower Barakar to basal Middle Barakar sediments of Pench — Kanhan coalfield (Bharadwaj, 1971), Mohpani coalfield (Bharadwaj and Anand Prakash, 1972), Pathakhera coalfield (Anand Prakash, 1972) and Giridih coalfield (Srivastava, 1973).

MIZ.C.4 — LAEVIGATOSPORITES-LOPHOTRILETES
(Sample Nos. C/017/33-C/017/23)

Scheuringipollenites	66.6%-13% MaZ. representative
Laevigatosporites	40.6-13% MiZ. representative
Lophotriletes	32-5% MiZ. representative
Marsupipollenites	4%

Table 3. Palynostratigraphy and Environment of Deposition of Chuparbhita Coalfield.

Palynoassemblages recorded from Chuparbhita coalfield have revealed macro- and microenvironment zones of deposition along the sedimentation succession. The palynostratigraphic zones and the macro- and microenvironment palynozones are summarised to explore the environment of deposition in the Chuparbhita coalfield.

Stratigraphic age on the basis of palynoassemblage	Sample Nos. from younger to older stratigraphic sequence.	Polynostratigraphic Zones		Environment of deposition		Remarks
		Macroenvironment palynozone (MaZ)	Microenvironment palynozone (MiZ)	Microenvironment	Macroenvironment	
Upper Barakar Formation (Lower Permian)	C/017/1 C/017/3	Maz. C *Striatopodocarpites-Striatites*	Miz. C-10 *Leavigatosporites - Cyclogranisporites* Zone, acritarchs absent	Swampy, humid	Warm	
	C/017/5, C/017/7, C/017/8, C/017/9		Miz. C-9 *Ghoshiatriletes* Zone with rich representation of acritarchs, viz., *Peltacystia, Circulisporites, Tetraporina, Kagulubeites* and tasmanids, *Maculatasporites, Haplocystia*	Swampy, humid with possible pronounced influence of brackish water	MARKER HORIZON II	Marker horizon possible marine transgressional phase
	C/017/11		Miz. C-8 *Acanthotriletes - Laevigatosporites* Zone with few acritarch genera viz., *Peltacystia, Kagulubeites*	Swampy humid, with possibly slight influence of brackish water	Temperate to warm, dry	

Stratigraphic age on the basis of palynoassemblage	Sample Nos. from younger to older stratigraphic sequence.	Polynostratigraphic Zones: Macroenvironment palynozone (MaZ)	Polynostratigraphic Zones: Microenvironment palynozone (MiZ)	Environment of deposition: Microenvironment	Environment of deposition: Macroenvironment	Remarks
Middle Barakar Formation (Lower Permian)	C/017/13	Maz. C *Scheuringipollenites*	Miz. C-7 *Striatites* - *Cyclogranisporites* Zone, acritarchs absent	Warm-humid		
	C/017/14, C/017/15		Miz. C-6 *Cylogranisporites*- *Microfoveolatispora*- *Indotriradites* - *Lalmatisporites* Zone with significant representation of acritarch taxa, viz., *Peltacystia, Circulisporites, Tetraporina, tasmanids, Haplocystia, Maculatasporites*	Swampy humid with possible pronounced influence of brackish water	MARKER HORIZON I	Maker horizon possible marine transgressional phase
	C/017/17, C/017/19, C/017/21	Miz. C-5 *Cyclogranisporites* Zone - with few acritarchs viz., *Peltacystia, Circulisporites*, tasmanids *Maculatasporites*	Swampy humid with possible influence of brackish water			
	C/017/23, C/017/25, C/017/27, C/017/32, C/017/33		Miz. C-4 *Laevigatosporites* - *Lophotriletes* Zone acritarchs absent	Swampy humid		
	C/017/34	Miz. C-3 *Laevigatosporites* - *Brevitriletes* Zone acritarchs absent.		Swampy humid		
Karharbari Formation (Lower Permian)	C/2/36, C/3/38	Maz. C *Plicatipollenites* -*Parasaccites*	Miz. C-2 *Plicatipollenites* - *Parasaccites* - *Callumispora* Zone with rare tasmanids *Maculatisporites*	Possible influence of brackish water.		
Talchir Formation (Lower Permian)	C/2/37		Miz. C-1 *Ginkgocycadophytus* zone, with the characteristic acritarch genus *Quadrisporites* (Bharadwaj, 1966)	Possible influence of brackish water	Cold, dry	

Lophotriletes is fairly well represented in association with *Scheuringipollenites* and *Laevigatosporites*.

Significant representation of *Marsupipollenites* in sample No. C/017/32 of this zone is noteworthy. *Laevigatosporites-Lophotriletes* assemblage resembles the assemblages recorded from Middle Barakar Formation, Lower Permian of Ib-river coalfield (Navale and Tiwari, 1968).

MIZ.C.5 — CYCLOGRANISPORITES
(Sample Nos. C/017/21-C/017/17)

Cyclogranisporites	74-21% MiZ. representative
Scheuringipollenites	30.4-6.6% MaZ. representative
Acritarchs	Various forms

Cyclogranisporites constitutes a dominant or subdominant representative in this *Scheuringipollenites* assemblage.

A few acritarchs viz., *Peltacystia*, *Circulisporites* and *Maculatasporites* of Tasmanitaceae are significant representatives of the assemblage in understanding the environment of deposition.

Dominance of *Cyclogranisporites* is observed in the assemblages recovered from assemblage B of Talcher coalfield (Bharadwaj and Srivastava, 1969) and Seam II of Talcher coalfield (Srivastava, 1984) both of Middle Barakar Formation.

MIZ.C.6 — CYCLOGRANISPORITES-MICROFOVEOLATISPORA INDOTRIRADITES-LALMATIASPORITES WITH DIVERSE ACRITARCHS
(Sample Nos.C/017/15-C/017/14)
Marker Horizon-I

Cyclogranisporites	33.6-18% MiZ. representative
Scheuringipollenites	28-12% MaZ. representative
Lalmatiasporites	Restricted occurrence.
Acritarchs	Diverse and quantitatively rich

This zone also reveals high incidence of *Cyclogranisporites*. However, this assemblage is different in having *Microfoveolatispora*, *Indotriradites* and *Horriditriletes* in significant frequency. In addition, *Lalmatiasporites* which is the dominant member of the assemblage of coal horizon H-VIII of the adjoining Hura coalfield (D'Rozario and Banerjee, 1978b), occur in this zone only and has not been encountered in any other horizons of Chuparbhita coalfield. Occurrence of diverse members of acritarch and Tasmanid groups viz., *Circulisporites*, *Peltacystia*, *Tetraporina*, *Haplocystia* and *Maculatasporites* are of much significance.

MiZ.C.6 with characteristically distinguishing assemblage along with *Lalmatiasporites* and acritarchs is considered as Marker Horizon I; this particular assemblage is also encountered in the adjoining Hura coalfield.

MIZ.C.7 — STRIATITES-CYCLOGRANISPORITES
(Sample No. C/017/13)

Scheuringipollenites	39% MaZ representative
Striatites	16.7% MiZ representative
Cyclogranisporites	10.3% MiZ representative

Prevalence of striate disaccate genera *Striatites* and *Striatopodocarpites* along with *Scheuringipollenites* and *Cyclogranisporites* is a distinctive feature of this zone. The higher frequency of striate disaccate might be due to sudden change in the climatic condition.

MIZ.C.8 — ACANTHOTRILETES-LAEVIGATOSPORITES
(Sample No. C/017/11)

Acanthotriletes	34% MiZ representative
Laevigatosporites	17.7% MiZ representative
Scheuringipollenites	6% MaZ representative
Acritarchs	few

Cyclogranisporites phase which continued till the previous zone suddenly became insignificant and is replaced by *Acanthotriletes* as the dominant taxon, along with subdominant members *Laevigatosporites*, *Horriditriletes* and *Scheuringipollenites*. A few acritarchs viz., *Peltacystia*, and *Kagulubeites* are also encountered.

MIZ.C.9 — GHOSHIATRILETES ZONE WITH DIVERSE ACRITARCHS AND TASMANIDS
(Sample Nos. C/017/9 — C/017/5)
Marker Horizon II

Ghoshiatriletes	42-23% MiZ representative
Horriditriletes	14-4.4% MiZ representative
Laevigatosporites	12.6-6.7% MiZ representative
Didecitriletes	11-7.2% MiZ. representative
Scheuringipollenites	6-5% MaZ representative
Acritarchs	Diverse and quantitatively rich

This zone represents another distinct phase of deposition within the MaZ.C. *Scheuringipollenites*. *Ghoshiatriletes*, a newly described genus from this coalfield appeared and dominated the assemblage for a considerable sequence of sedimentation. Although *Scheuringipollenites* is meagerly represented in this zone, its influence is evidenced due to higher frequency among the saccate representatives. Low frequency of *Scheuringipollenites* in the total assemblage might be due to distant source area or indicative of the closing phase of this MaZ.

Variable combination of trilete, monolete taxa viz., *Didecitriletes, Laevigatosporites, Indotriradites, Cyclogranisporites, Lophotriletes, Horriditriletes* and *Schizopollis* occupy subdominant positions in the frequency of occurrence in the assemblage. Acritarchs viz., *Peltacystia, Circulisporites, Tetraporina, Kagulubeites* and *Haplocystia, Maculatasporites* of Tasmanitaceae are also significantly represented in all the horizons dominated by *Ghoshiatriletes*.

MiZ. C.9. characterised by the occurrence of new taxon *Ghoshiatriletes* along with characteristic assemblage of trilete, zonate spores, *Schizopollis* and diverse acritarchs and Tasmanitaceae is recognised as a marker horizon. This typical assemblage is not encountered in any other horizons in this or other coalfields of Indian Lower Gondwana.

MAZ.C.III. — STRIATOPODOCARPITES-STRIATITES

The assemblages of the horizons above the Marker Horizon II show distinct increase in the frequency of occurrence of the striate disaccate pollen grains. This change in the vegetational pattern can be deciphered due to change in the climatic conditions. Dominance of striate disaccates is known from sediments of Upper Barakar Formation of Indian Lower Gondwana (Tiwari, 1973, 1974). Dominance of *Striatopodocarpites* is reported from Upper Barakar sediments of North Karanpur coalfield (Venkatachala and Kar, 1968), Jharia coalfield (Tiwari *et al.*, 1981).

A warmer climatic condition is suggested for this zone.

MIZ.C.10 — LAEVIGATOSPORITES-CYCLOGRANISPORITES
(Sample Nos. C/017/3 — C/017/1)

Only one MiZ has been encountered in this MaZ. The MiZ representatives are similar to those of MaZ. *Scheuringipollenites*.

DISCUSSION AND CONCLUSION

The three major climatic phases of deposition are encountered in the Chuparbhita basin similar to the majority of the Lower Gondwana basins of Indian Lower Gondwana. Each of these macroenvironment phases, however, reveal several distinct ecofacies of deposition. The characteristic ecofacies viz., *Callumispora* rich assemblage recorded from the Lower Karharbari sediments of other coalfields of Indian Lower Gondwana is not encountered in the samples studied so far from Chuparbhita coalfield. Occurrence of *Marsupipollenites* has been noted in a very few palyno-assemblages of Indian Lower Gondwana; this genus is encountered in significant frequency in one of the assemblages of MiZ.C.4 and resemble closely the palynoassemblage recorded from the extra-peninsular gondwana of Bhutan (Banerjee and Das gupta 1983; Banerjee *et al.* 1986). *Laevigatosporites* which has not been so far recorded in higher frequency from any of the assemblages of Indian Lower Gondwana is recorded as significant subdominant genus in most of the microenvironment zones of Chuparbhita coalfield. *Laevigatosporites* is suggested to be the spores of the plants belonging to Lycopsids and Sphenopsids and also *Pecopteris* (Traverse, 1988) which are swampy environment loving plants. The rich representation of *Laevigatosporites* in the MiZ. of Chuparbhita coalfield may be considered as reflecting similar swampy (humid) environment (Table 3). *Cyclogranisporites* is the other genus which shows significant abundance in the microenvironment zones of Chuparbhita coalfield. This genus has been suggested to be the spore type of various Carboniferous —Permian plants viz., Filicinean, *Archacopteris*, Lyginopterids etc. (Traverse, 1988) all of which belong to the coal forming swamps. The *Cyclogranisporites* of the Lower Gondwana sediments might have been produced by the plants of similar environment. The significant subdominant genus *Lophotriletes* of MiZ.C.4 is known to be the spore of *Neomariopteris* (Lele *et al.*, 1981) which is a common member of the coal forming *Glossopteris* swamp.

A fluctuating influence of the brackish water acritarchs is revealed in the sedimentary succession of Chuparbhita coalfield. The brackish water influence is noticed during Talchir and Karharbari period and absent during the initial phase of Barakar deposition. But significant influence of the acritarch taxa in the MiZ.C.6 and MiZ.C.9 indicate two marine transgressional facies of deposition during Middle Barakar. Alternating regressive phases of deposition is revealed due to the absence of acritarchs in the palynoassemblages of MiZ.C.3-4, MiZ.C.7 and MiZ.C.10 (Text fig. 2c). The palynoassemblages representing the MiZ.C.3-9 are closely comparable to the assemblages recorded from Middle Barakar sediments of Indian Lower Gondwana and the palynoassemblage of MiZ.C.10 resembles the assemblages of Upper Barakar Formation (Tiwari, 1973-74).

The occurrence of acritarch swarms in continental deposits may be an indication of marine transgressional phase (Balme, 1970; Balme and Helby, 1973; Schopf and Askin, 1980; Meyen 1987).

The undoubted marine influence has been

recorded during the Talchir Formation in the Peninsular Gondwana in Daltonganj, Manendragarh, Umaria, Bap and Badhaura. Definite horizons of *Eurydesma* and *Streptorynchus* have been recognised during Talchir (Sakmarian) sedimentation (Acharya, 1977; Shastry *et al.*, 1979). Brackish water acritarchs have also been recognised from the associated sediments of Talchir marine beds (Potonié and Lele, 1961; Lele and Chandra, 1972; Chandra and Lele, 1979). Occurrence of similar and other brackish water acritarchs in the Karharbari and Barakar sediments of different Indian Lower Gondwana basins (Banerjee, 1987) including Chuparbhita coalfield indicate strongly that the influence of fluctuating environment causing changes in the eustatic level continued beyond Talchir in the Peninsular Lower Gondwana. The continuation of glacial and interglacial climate during Karharbari has been observed through palynological study in the Korba coalfield by Bharadwaj and Srivastava (1973).

The environmental analysis of the Lower Gondwana sediments of Chuparbhita coalfield suggests two phases of possible influence of marine transgression during the deposition of Barakar Formation (Lower Permian) which are recognized as MaZ. *Scheuringipollenites* —MiZ.C.6-Marker Horizon I and MiZ.C.9—Marker Horizon II (Table 3).

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EXPLANATION OF PLATES

PLATE I

(All photomicrographs x 700)

1. *Plicatipollenites gondwanensis* (Balme and Hennelly) Lele
   Slide No. C/36/1
2. *Parasaccites korbaensis* Bharadwaj and Tiwari
   Slide No. C/36/2
3. *P. obscurus* Tiwari
   Slide No. C/36/6
4. *Scheuringipollenites maximas* (Hart) Tiwari
   Slide No. C/14/7
5. *S. barakarensis* (Tiwari) Tiwari
   Slide No. C/14/6
6. *Striatopodocarpites magnificus* Bharadwaj and Salujha
   Slide No C/5/2
7. *Striatites solitus* Bharadwaj and Salujha
   Slide No. C/5/3
8. *Ginkgocycadophytus cymbatus* Balme and Hennelly
   Slide No. C/36/5
9. *Callumispora barakarensis* Bharadwaj and Srivastava
   Slide No. C/37/5
10. *Laevigatosporites colliensis* (Balme and Hennelly) Venkatachala and Kar
    Slide No. C/3/6
11. *Brevitriletes unicus* (Tiwari) Bharadwaj and Srivastava
    Slide No. C/37/3
12. *Lophotriletes rectus* Bharadwaj and Salujha
    Slide No. C/23/1
13. *Cyclogranisporites gondwanensis* Bharadwaj and Salujha
    Slide No. C/15/4

PLATE II

(All photomicrographs x 700)

1. *Marsupipollenites triradiatus* Balme and Hennelly
   Slide No. C/14/9
2. *Microfoveolatispora indica* Sinha
   Slide No. C/15/10
3. *Indotriradites sparsus* Tiwari
   Slide No. C/14/6
4. *Lalmatiasporites indicus*
   Slide No. C/15/3
5. *L. barakarensis*
   Slide No. C/14/3
6. *Acanthotriletes jhariaensis* Kar
   Slide No. C/7/3
7. *Horriditriletes raimahalensis*
   Slide No. C/3/3
8. *Didecitriletes horridus* Venkatachala and Kar
   Slide No. C/9/4

9-10. *Ghoshiatriletes gondwanensis*
   Slide Nos. C/5/1, C/7/5

11. *Schizopollis disaccoides* Venkatachala and Kar
    Slide No. C/8/1

12-13. *Schizopollis extremus* Venkatachala and Kar
   Slide Nos. C/19/1, C/15/5

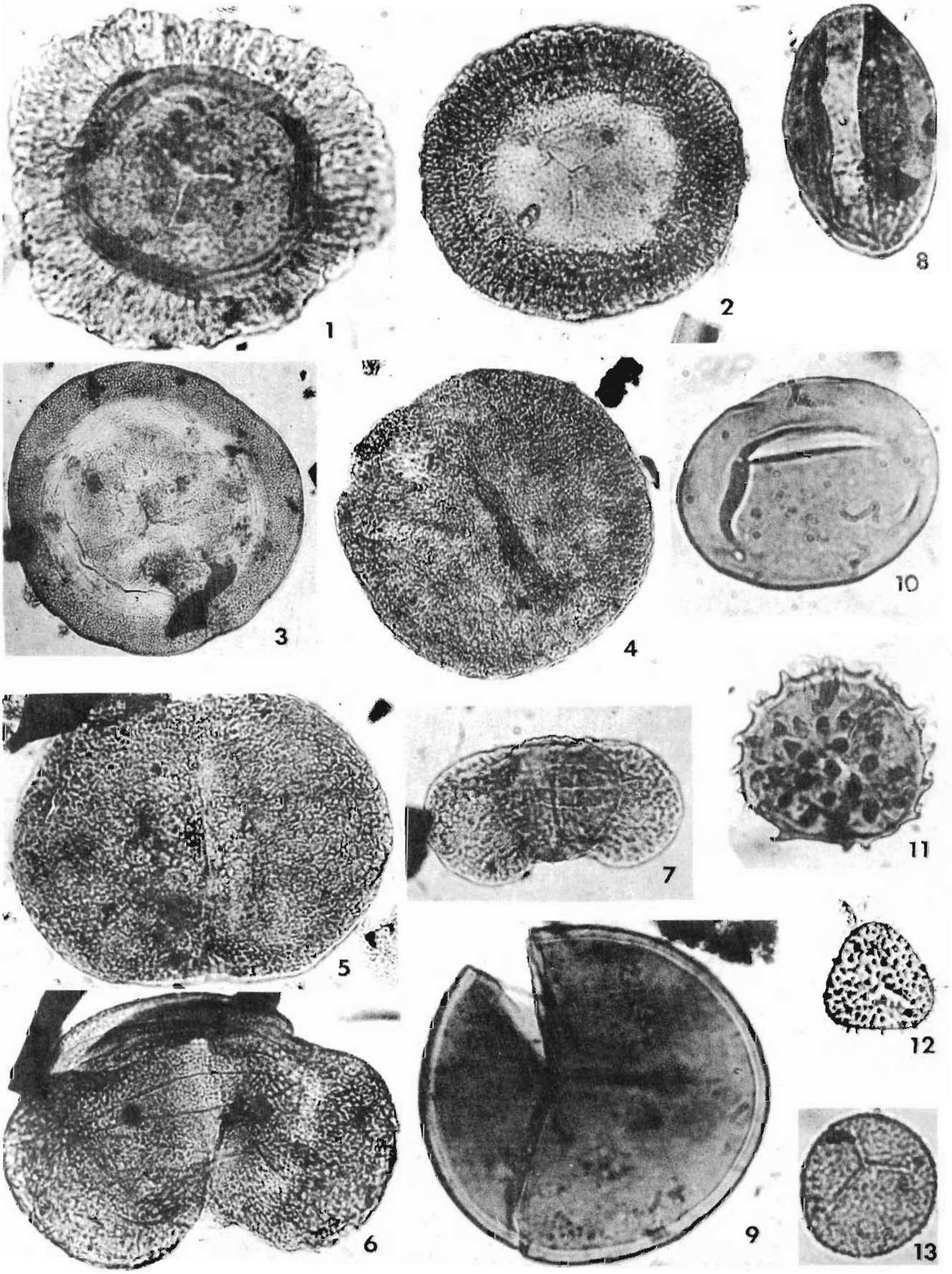
PLATE III

(All photomicrographs x 700; unless otherwise mentioned)

1. *Peltacystia venosa* Balme and Segroves, two halves
   Slide No. C/7/10
2. *P. venosa* Balme and Segroves
   Slide No. C/7/4
3. *Kagulubeites* sp.
   Slide No. C/11/1
4. *Haplocystia pellucida* Segroves
   Slide No. C/14/7

5-6. *Maculata sporites indicus* Tiwari
   Slide Nos. C/3/4, C/3/2

7. *Quadrisporites horridus* Potonie and Lele
   Slide No. C/37/3
8. *Tetraporina* sp.
   Slide No. C/3/3
9. *Circulisporites parvus* De Jersey
   Slide No. C/9/5
10. *C. parvus* De Jersey x 2800
    Scanning electren microphotograph.
11. *Srivastaveaesporites karanpuraensis* Bharadwaj and Tiwari x 100
    Slide No. C/14/13
12. *Singhisporites radialis* Bharadwaj & Tiwari x 100
    Slide No. C/15/12
13. *Biharisporites distinctus* Bharadwaj and Tiwari x 100
    Slide No. C/14/11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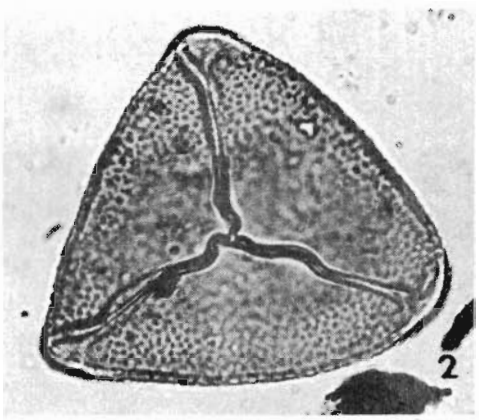
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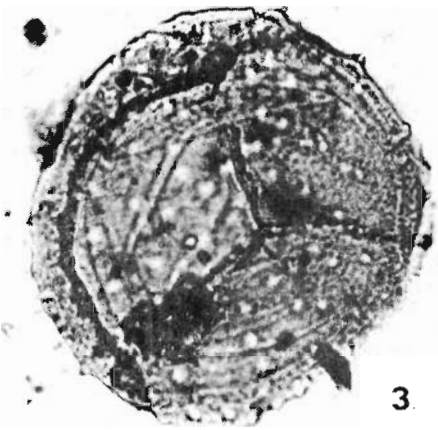
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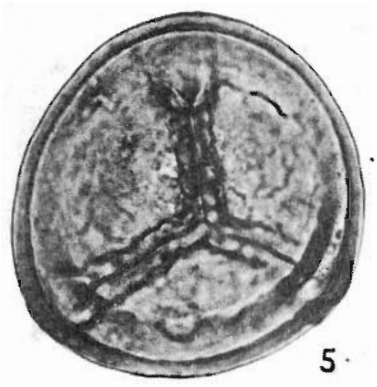
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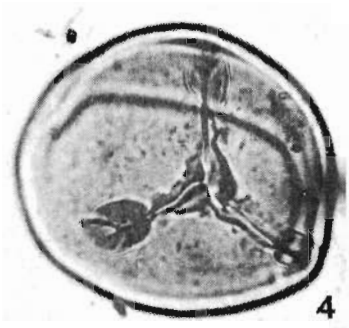
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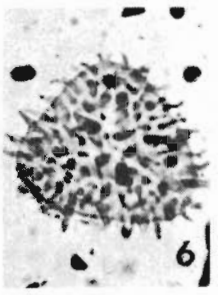
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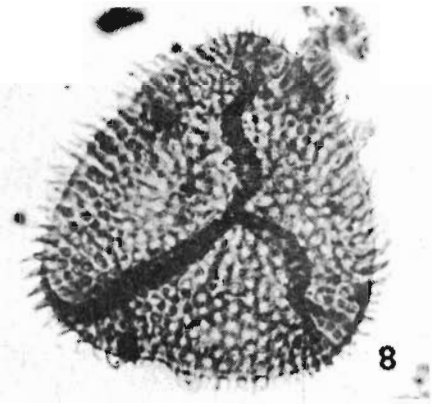
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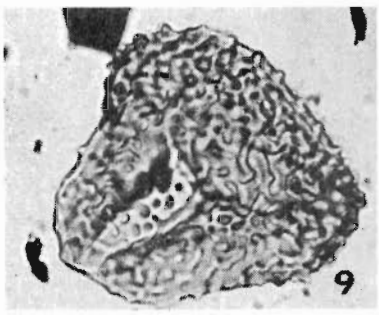
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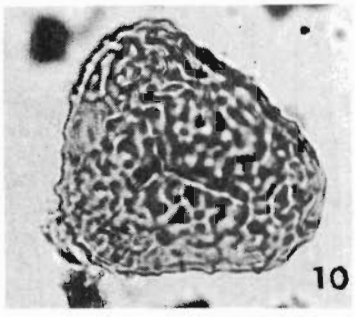
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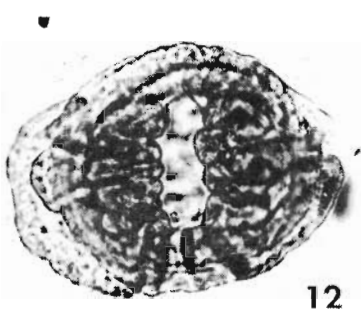
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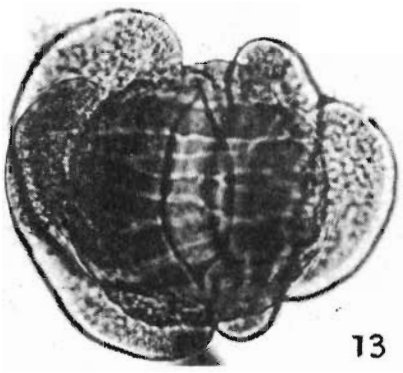
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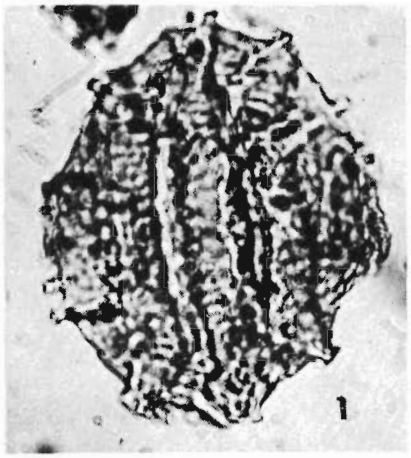
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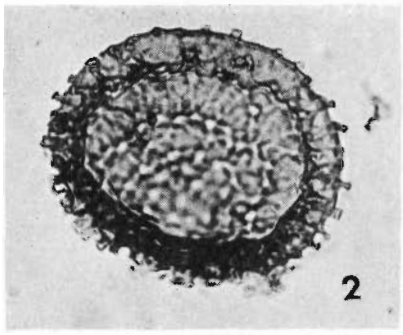
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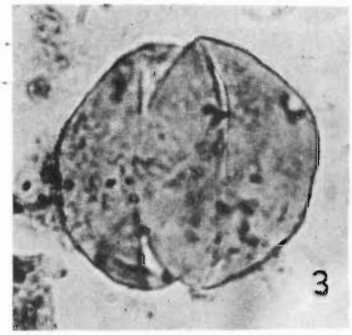
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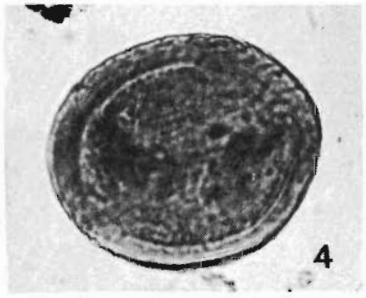
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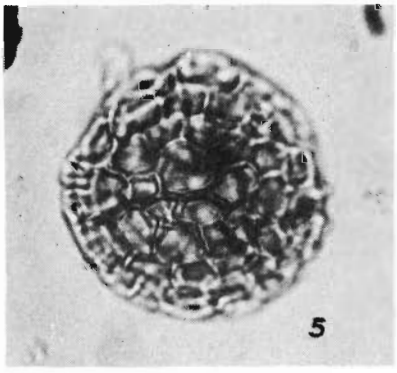
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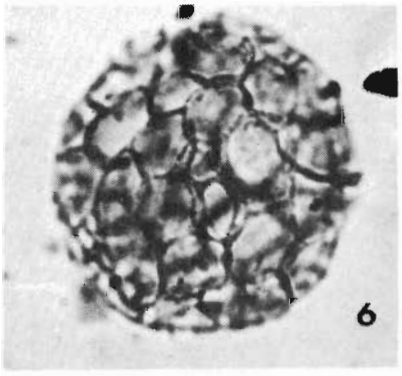
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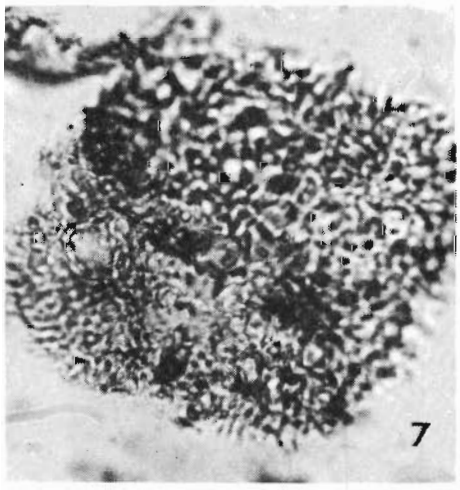
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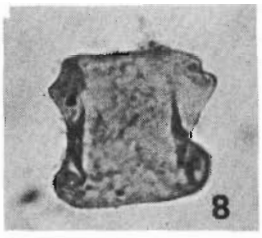
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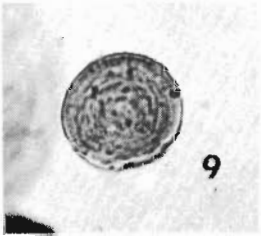
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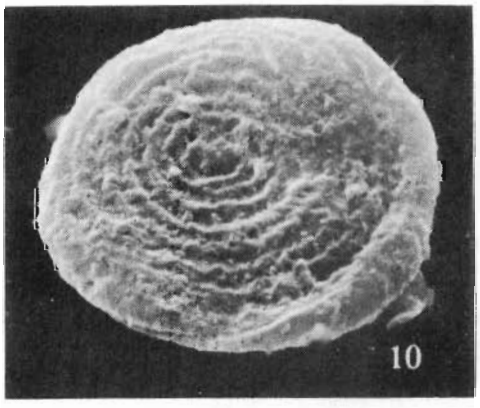
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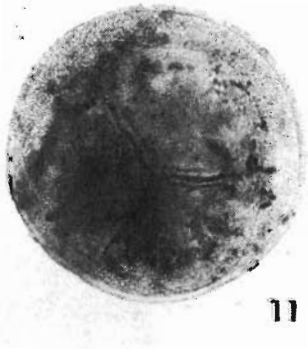
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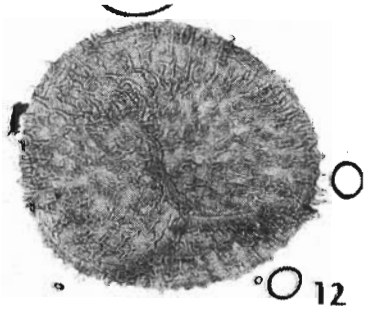
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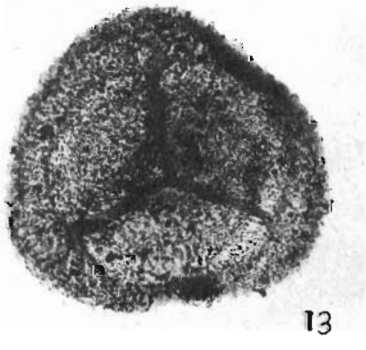
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