Organic-walled microfossils of doubtful origin in Permian and Triassic sequences on peninsular India

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The Permian and Triassic succession of the Indian Gondwana Sequence, with the exception of Lower Permian Talchir Formation, has been considered to be deposited in fluviatile-lacustrine environment. Palynological investigations of these deposits have revealed the presence of rich assemblages of spores, pollen and other organic-walled microfossils of doubtful origin (OMIDO) belonging to the group Acritarcha in its broader sense. Recent discoveries of marine signatures from these deposits depicted by sedimentological, biotic and chemical features strongly prompt for a detailed investigation of OMIDOs for their authentic application in determining the palaeoenvironment. Sporadic or consistent occurrence of OMIDOs has been recorded from Talchir to Panchet formations at various time intervals. The increase in the brackish water regime on to the Indian Peninsula near the deltaic sea-shore regions could have provided suitable environment from time to time for the growth of OMIDOs. This could have occurred due to the well known global transgressions during Permian and Triassic times. It is, therefore, important that the non-marine nature of Indian Gondwana should be skeptically viewed in order to find possible marine signatures in this sequence. The present study reveals that there had been three major diversity acme phases of OMIDOs during Permian, viz., (i) Talchir/Karharbari, (ii) Upper Barakar, and (iii) Upper Raniganj formations. They broadly coincide with the onset of regression. Although the data is meagre, a similar trend in occurrences of OMIDOs has been observed in the Triassic.

Key-words — Palynology, Organic-walled microfossils, Permian, Triassic (India).

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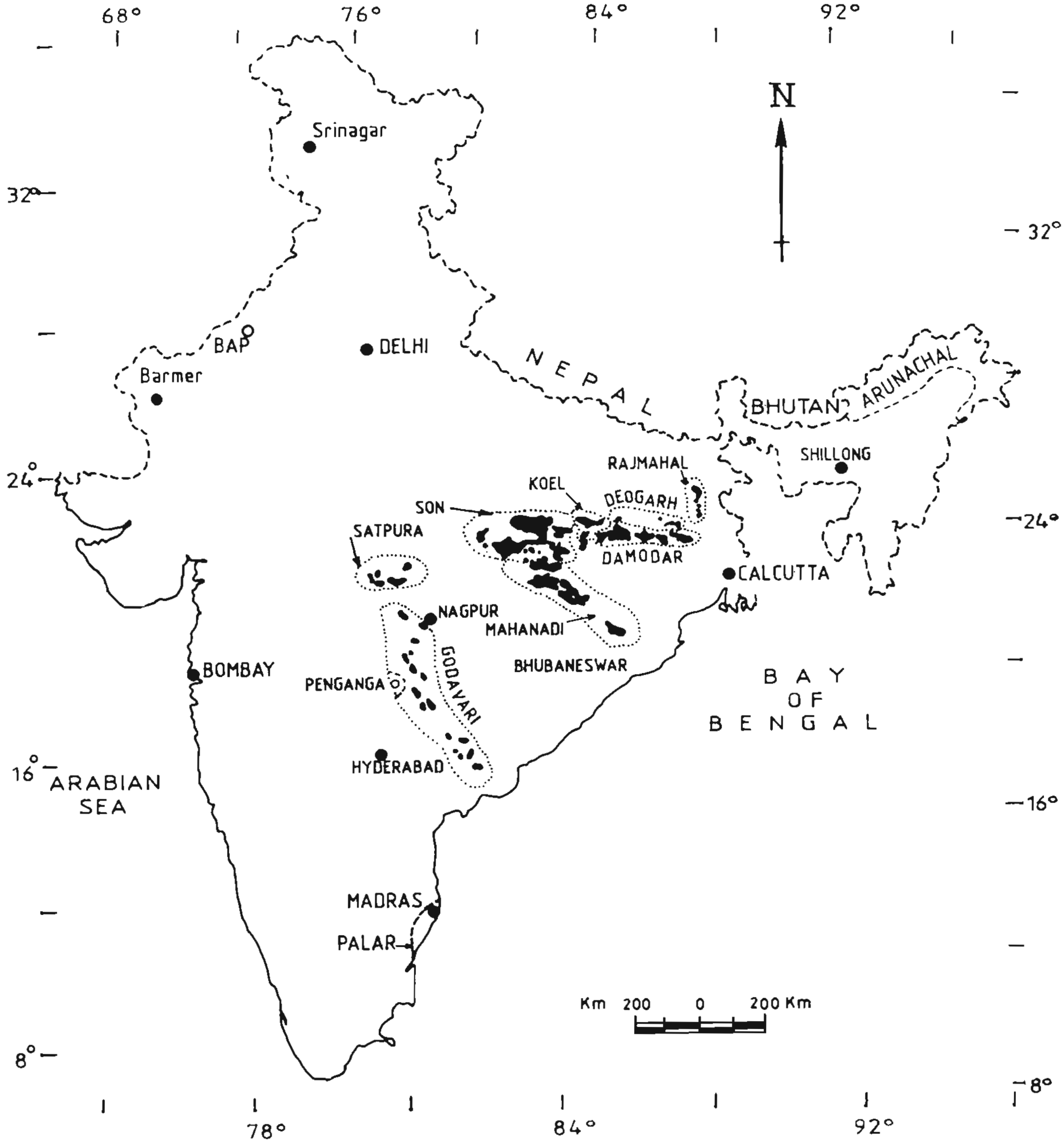
साराँश

प्रायद्वीपीय भारत के परमी एवं त्रिसंघी युगीन अनुक्रमों में संदेहात्मक उत्पत्ति वाले कार्बनिक भित्तिदार सूक्ष्मजीवाश्म

रामशंकर तिवारी, अर्चना त्रिपाठी एवं विजया

भारतीय गोंडवाना अनुक्रम में अधरि परमी तलचीर शैल-समूह को छोड़कर परमी एवं त्रिसंघी अनुक्रम सरोवरी-नदीय वातावरण में निक्षेपित हुए थे। इन निक्षेपों से बीजाणुओं, परागकणों एवं संदेहात्मक उत्पत्ति वाले ऍक्रीटार्का समूह से सम्बद्ध कार्बनिक भित्तिदार सूक्ष्मजीविता से भरपूर समुच्चय उपलब्ध हुई है। अवसादिक, जीविता सम्बन्धी एवं रासायनिक संलक्षणों के आधार पर अभी हाल में इन निक्षेपों से प्राप्त समुद्री अवयवों के कारण कार्बनिक भित्तिदार सूक्ष्मजीवाश्मों का विस्तृत अध्ययन आवश्यक हो गया है। तलचीर एवं पंचेत शैल-समूहों में विभिन्न स्तरों में कार्बनिक भित्तिदार सूक्ष्मजीवाश्मों की यदा-कदा अथवा अविरल उपस्थिति अभिलिखित की गई है। भारतीय प्रायद्वीप पर डेल्टीय समुद्री तट क्षेत्रों के निकट खारे जल के क्षेत्र में विस्तार के फलस्वरूप कार्बनिक भित्तिदार सूक्ष्मजीवाश्मों की वृद्धि हेतु समय-समय पर उपयुक्त वातावरण विद्यमान रहा है। ऐसा परमी एवं त्रिसंघी काल में सुविदित भूमण्डलीय समुद्री सतह के उठाव के कारण हुआ है। अतएव यह अत्यन्त महत्वपूर्ण है कि भारतीय गोंडवाना की असमुद्री प्रकृति का इस अनुक्रम में समुद्री अवयवों की उपस्थिति हेतु और विस्तृत अध्ययन किया जाये। प्रस्तुत अध्ययन से व्यक्त होता है कि परमी कल्प में कार्बनिक भित्तिदार सूक्ष्मजीवाश्मों की तीन मुख्य विषम चरम अवस्थायें थीं – (i) तलचीर/करहरबारी, (ii) उपरि बराकार, एवं (iii) उपरि रानीगंज शैल-समूह। प्रधानतया ये पश्चगमन की घटना से मेल खाती हैं। यद्यपि उपलब्ध आँकड़े बहुत कम हैं, कार्बनिक भित्तिदार सूक्ष्मजीवाश्मों में भी इसी प्रकार की प्रवृत्ति प्रेक्षित की गई है।

OMIDOs—the acronym for the "organic-walled microfossils of doubtful origin", include organic bodies commonly termed as alete spores and acritarchs. As opined by Traverse (1988, p. 5) a group of a large range of presumed algal bodies, and indicating marine to fresh water environment, is included in acritarchs which means of 'doubtful origin'. The OMIDOs are recorded in palynological prepara-



Text-figure 1—Map showing major Gondwana basins on peninsular India and the areas in Himalaya to illustrate Permian and Triassic sequences considered in the present study.

tions of the Gondwana Sequence from almost all the basins on the Indian Peninsula. The palaeoenvironmental significance of these OMIDOs has been a matter of discussion for the last three decades. Are these microfossils indicators of marine environments? Most of these forms do not possess prominent ornamentation or processes. They are recorded from several levels in the Permian and Triassic successions which are conventionally considered as non-marine. These forms are, however, also found to be richly associated with the sediments containing marine invertebrate fauna, i.e., eurydesmid and productid, and brachiopod in the Talchir Formation. The presence of this fauna is an unequivocal evidence for marine environment, and the rich association of OMIDOs with this fauna initiated a thinking that the OMIDOs could be the indicators of increased salinity (Venkatachala & Tiwari, 1988).

The report of *Quadrisporites* Henn. emend. Potonié & Lele 1961 from Talchir sediments was the first record as alete spores from Indian Gondwana, which is now proved to be similar in its morphography to the spore tetrad of extant *Riccia personii* Khan (Pant & Singh, 1991). Thereafter, Tiwari (1965) and Maheshwari (1967) observed smooth-walled and low-ornamented forms in the Barakar Formation of Korba, West Bokaro and Bansloi Valley coalfields. During the last two decades, a number of publications have appeared as a result of extensive palynostratigraphical studies, reporting the presence of OMIDOs assemblages from different horizons in various basins (Banerjee & D'Rozario, 1988; Venkatachala & Tiwari, 1988; Tiwari & Ram-Awatar, 1990; Srivastava & Jha, 1992a, 1992b).

Table 1 —Showing stratigraphy and biohorizons through Permian and Triassic sequences on Indian Peninsula (adapted after Vijaya & Tiwari, 1992)

my	Period	Age	Formation	Bio-horizon
250	T_1 LOWER TRIASSIC	Early Scythian	Panchet	VIII
	P_2 UPPER PERMIAN	End Permian	Raniganj	VII
270			Kulti	VI
	P_1 LOWER PERMIAN	Early Permian	Barakar	V
			Karharbari	IV
		L. Sakmarian		III
		E. Sakmarian	Talchir	II
290		L. Asselian		I

extra-peninsular region has also been incorporated for comparison.

MATERIAL

The material for the present study has been selected from the already published data encompassing Permian and Triassic sequences (Table 1) in all major basins of India (Text-figure 1). Several palynological preparations (Table 2) have been examined in order to assess the qualitative as well as quantitative distribution of different forms of the Group — Acritarcha. Data from Himalaya in the

OMIDOs ASSEMBLAGE

The forms described so far by various workers from the Indian Gondwana Sequence as Acritarcha, Aletes and *Incertae sedis* are enlisted below under the Group Acritarcha sensu Tappan (1980). In view of the polyphyletic nature of assemblages of this group representing a variety of life stages, the concept of the term Acritarcha adapted by Tappan (1980) is most expressive.

Table 2 – Details of material considered for the present study

Basin	Area/Coalfield	Lithology	Formation/Horizon	References
Rajmahal	N.E. Part, B.H. RJNE-32	Clay, Shale	Upper Permian	Present study
	B.H. RJR-2	Clay, Siltstone	Dubrajpur	Tripathi, Tiwari & Kumar, 1990
	Bansloi	Carbonaceous shale	Barakar	Maheshwari, 1967
	Chuperbhita	Carbonaceous shale	Barakar	Banerjee & D'Rozario, 1990
	Hura	Khaki green shale, Siltstone	Talchir	D'Rozario & Banerjee, 1987
		Coal, Shale, Sandstone	Barakar	Banerjee & D'Rozario, 1990
Damodar	Jharia	Siltstone, Mudstone, Khaki green shale	Talchir	Tiwari, Srivastava, Tripathi & Singh, 1981
	West Bokaro	Siltstone	Talchir	Lele, 1975
		Siltstone, Carbonaceous shale	Talchir, Karharbari	Anand-Prakash, Srivastava & Tiwari, 1979
		Carbonaceous shale	Barakar	Tiwari, 1965
		Carbonaceous shale	Karharbari	Banerjee, 1988

Contd.

Basin	Area/Coalfield	Lithology	Formation/Horizon	References
	South Karanpura		Karharbari	Bharadwaj & Anand-Prakash, 1972
		Coal, Shale, Carbonaceous shale	Barakar	Bharadwaj & Dwivedi, 1981
			Barakar	Lele & Kulkarni, 1969
	Raniganj	Coal, Shale	Barakar	Tiwari, 1973
		Khaki green shale	Panchet	Bharadwaj, Tiwari & Anand-Prakash, 1979
		Silty shale	Supra-Panchet	Tiwari & Rana, 1980
		Khaki green shale, Silty shale	Panchet, Supra-Panchet	Tiwari & Rana, 1981
Deogarh	Jayanti	Needle shale, Siltstone	Talchir	Lele & Karim, 1971
		Needle shale, Siltstone, Carbonaceous shale	Talchir, Karharbari	Lele & Makada, 1972, 1974
	Giridih	Mudstone	Talchir	Srivastava, 1973a
		Coal	Barakar	
Koel	Hutar	Sandstone, Siltstone	Talchir, Karharbari	Lele & Shukla, 1980; Shukla, 1983
	Auranga	Carbonaceous shale	Karharbari	Lele & Srivastava, 1980;
		Coal	Barakar, Kulti, Raniganj	Present study
		Carbonaceous shale, Coal	Barakar	Srivastava & Anand-Prakash, 1973
Son	Singrauli	Shale, Coal	Barakar	Tiwari, 1969
		Coaly shale, Coal	Barakar, Raniganj	Sinha, 1969; Bharadwaj & Sinha, 1969; Tiwari & Srivastava, 1984
	Korba	Coal	Barakar	Tiwari, 1965
		Green-grey needle shale, yellow-green sandstone	Talchir, Karharbari	Bharadwaj & Srivastava, 1973
		Carbonaceous shale	Barakar	
		Green-grey needle shale, yellow-green sandstone	Talchir	Srivastava, 1973b
		Carbonaceous shale	Barakar	Rawat, 1984
	Umaria and Manendragarh	Green and red sandy shale, black shale	Talchir	Lele & Chandra, 1972 Bharadwaj, Srivastava & Anand-Prakash, 1979
	Umaria	Coal, Carbonaceous shale	Karharbari	Srivastava & Anand-Prakash, 1984
	Chirimiri	Siltstone, khaki green shale	Talchir	Chandra & Lele, 1979
		Coal	Barakar	Chandra & Srivastava, 1986
	Korar	Shale, Sandstone	Upper Permian	Tiwari & Ram-Awatar, 1987
	Johilla	Carbonaceous shale, Coal	Karharbari	Anand-Prakash & Srivastava, 1984; Chandra & Lele, 1979
	Pali	Carbonaceous shale	Pali	Tiwari & Ram-Awatar, 1986
	Bisrampur	Coal	Barakar	Bharadwaj & Srivastava, 1970; Chandra & Srivastava, 1986
Satpura	Dodhara	Buff, red, khaki green, grey shale	Talchir	Bharadwaj, Tiwari & Anand-Prakash, 1978
	Pench-Kanhan	Siltstone, Shale	Talchir	Bharadwaj, Navale & Anand-Prakash, 1974
	Betul	Khaki-green shale	Talchir	Srivastava, Anand-Prakash & Sarate, 1989
	Kamptee	Sandstone	Karharbari	Sarate, 1985
	Mohpani	Needle shale	Talchir	Bharadwaj, Navale & Anand-Prakash, 1974

Contd.

Basin	Area/Coalfield	Lithology	Formation/Horizon	References
	Pathakhera	Black shale	Karharbari	Anand-Prakash, 1972 Bharadwaj & Anand-Prakash, 1974 Sarate, 1986
		Coal, Shale, Sandstone	Karharbari, Barakar	Srivastava & Sarate, 1989
Mahanadi	Athgarh	Khaki green shale	Talchir	Tiwari, Tripathi, Dutt & Mukhopadhyay, 1987
	Talcher	Grey shale, Carbonaceous Shale, Coal	Karharbari, Barakar	Srivastava, 1984; Tripathi, 1993
Penganga	Irai	Siltstone with dispersed clasts	Talchir	Lele, 1984
Godavari	Khammam,	Talchir to Kamthi	Srivastava & Jha,1992a	
	Kothagudem, Khammam		Barakar	Srivastava, 1987
	Yellendu, Manuguru		Karharbari to Kamthi	Srivastava & Jha, 1992b
	Chintalpudi	Shale, Coal	Karharbari to Kamthi	Srivastava & Jha, 1993
	Chelpur		Kamthi	Srivastava & Jha, 1987
	Godavari		Barakar	Tiwari & Moiz, 1971
	Chandrawelli area	Claystone	Talchir	Rawat & Jain, 1985
Palar	Chingleput	Khaki green shale	Talchir	Venkatachala & Rawat, 1973
Rajasthan	Near Nawagaon	Silty greyish claystone	Talchir	Venkatachala & Rawat, 1984
	Jaisalmer	Claystone, Carbonaceous shale	Pre-Lathi, Upper Permian	Lukose & Misra, 1980
Himalaya	Kashmir	Grey shale with siltstone band	Lower Triassic	Nautiyal, 1975
	Arunachal	Khaki green shale, Black shale, Calcareous and greenish-grey micaceous sandstone	Talchir, Karharbari	Srivastava & Dutta, 1977
		Carbonaceous shale	Karharbari	Singh, 1987
		Coal	Karharbari	Dutta, Srivastava & Gogoi, 1988
		Siltstone,	Talchir	Srivastava, Anand- Prakash &
		Carbonaceous Shale,	Karharbari	Singh, 1988
		Coal, Shale	Barakar	
	West Pakistan	Shale	Upper Permian	Balme, 1970
		Shale	Lower Triassic	Sarjeant, 1970

Group — Acritarcha

Subgroup — Sphaeromorphitae

Genus—*Leiosphaeridia* (Eisenack) Downie & Sarjeant 1965

L. crescentica Sinha 1969

L. simplex Sinha 1969

L. talchirensis Lele & Karim 1971

L. indica Lele & Chandra 1972

L. umariensis Lele & Chandra 1972

L. bokaroensis Lele 1975

L. minuta (Staplin) Downie & Sarjeant 1965

L. cf. *L. wenlokia* in Nautiyal 1977

Genus—*Pilasporites* Balme & Hennelly emend. Tiwari & Navale 1967

P. calculus Balme & Hennelly 1956

P. brevis Sinha 1969

P. ovatus Lele & Makada 1974

Genus—*Kildinella* Timofeev 1966

K. ghoshii Lele 1984

Genus—*Lophosphaeridium* Timofeev ex. Downie 1963

Lophosphaeridium sp. in Lele 1984

Genus—*Origmatosphaeridium* Timofeev 1966

Origmatosphaeridium sp. in Lele 1984

Genus—*Trachyminuscula* Naumova 1937

Trachyminuscula sp. in Lele & Chandra 1972

Genus—*Margomassulina* Naumova 1937

Margomassulina sp. in Lele & Chandra 1972

Genus—*Protomassulina* Naumova 1937

Protomassulina sp. in Lele & Chandra 1972

Genus—*Singraulipollenites* Sinha 1969

S. indicus Sinha 1969

S. finitimus Sinha 1969

Genus—*Hindisporis* Bharadwaj & Sinha 1969

H. senii Bharadwaj & Sinha 1969

Subgroup—Netromorphitae

Genus—*Foveofusa* Lele & Chandra 1972

F. perforata Lele & Chandra 1972

F. obsesa Lele & Chandra 1972

F. cylindrica Lele & Chandra 1972

F. mutabilis Lele & Chandra 1972

F. pumila Lele & Chandra 1972

F. attenuata Lele & Chandra 1972

Genus—*Leiofusa* Eisenack 1938

Leiofusa sp. in Venkatachala & Rawat 1984

Genus—*Dictyolofusa* Eisenack 1938

Dictyolofusa sp. in Venkatachala & Rawat 1984

Subgroup—Herkomorphitae

Genus—*Dictyotidium* Eisenack 1938

Dictyotidium sp. in Lele & Chandra 1972

Genus—*Maculatasporites* Tiwari 1965

M. gondwanensis Tiwari 1965

M. karanpuraensis Lele & Kulkarni 1969

Genus—*Greinervillites* Bose & Kar 1967

G. undulatus Bose & Kar 1967

G. irregularis Sinha 1969

Greinervillites sp. in Sinha 1969

Subgroup—Schizomorphitae

Genus—*Hemisphaerium* Hemmer & Nygreen 1967

H. signum Hemmer & Nygreen 1967

H. singrauliensis Sinha 1969

H. punctatus Anand-Prakash 1972

Genus—*Circulisporites* de Jersey emend. Norris 1962

C. parvus de Jersey emend. Norris 1962

Genus—*Peltacystia* Balme & Segroves 1967

P. venosa Balme & Segroves 1967

Genus—*Brazilea* Tiwari & Navale 1967

B. punctata Tiwari & Navale 1967

B. crassa Tiwari & Navale 1967

Genus—*Gondisphaeridium* Tiwari & Moiz 1971

G. levis Tiwari & Moiz 1971

Genus—*Globulaesphaeridium* Tiwari & Moiz 1971

G. densus Tiwari & Moiz 1971

Globulaesphaeridium sp. in Tiwari & Moiz 1971

Genus—*Balmeella* Pant & Mehra 1963

B. gigantea Bose & Maheshwari 1968

B. densicorpa Tiwari & Navale 1967

B. punctata Tiwari & Navale 1967

B. tetragona Pant & Mehra 1963

Subgroup—Disphaeromorphitae

Genus—*Spongiocysta* Segroves 1967

Spongiocysta sp. in Srivastava 1973

Subgroup—Polygonomorphitae

Genus—*Veryhachium* Deunff emend. Downie & Sarjeant 1963

V. irregulare Jekhowsky 1961

V. valensii (Valensi) Downie & Sarjeant 1964

Veryhachium sp. (present study)

Subgroup—Tasmanititae

Genus—*Tasmanites* Newton emend. Schopf 1944

T. talchirensis Lele 1984

Tasmanites sp. (=Type A, in Tripathi *et al.* 1990)

Subgroup—Porata

Genus—*Tetraporina* Naumova ex. Naumova emend. Kar & Bose 1976

Tetraporina sp. in Banerjee & D'Rozario 1988

Genus—*Schizosporis* Cookson & Dettmann 1959

S. scissus (Balme & Hennelly) Hart 1965

Subgroup—Acanthomorphitae

Genus—*Deunffia* Downie 1960

D. unispinosa (Schonfeld) Sarjeant 1970

Genus—*Micrhystridium* Deflandre 1937

M. alteratoides Deflandre emend. Sarjeant 1967

M. circulum Schonfeld 1967

M. inconspicum (Deflandre) Deflandre 1987

Genus—*Wilsonastrum* Jansonius 1962

W. colonicum Jansonius 1962

Genus—*Polyedryxium* Deunff 1954

Polyedryxium sp. in Sarjeant 1970

Type A in Tripathi 1993

The palaeoenvironmental significance of each taxon in the above list cannot necessarily be derived. However, based on the available data, such derivations, at least on the basis of subgroups, are possible as given in Tables 3 and 4.

DIVERSITY OF FORMS

The OMIDOs associated with the spore-pollen assemblages are of varied kinds in their morphography (Pl. 1, figs 1-10; Pl. 2, figs 1-13; Pl. 3, figs 1-9). In order to understand their diversity, the overall shape, exine pattern and exterior-communicating

Table 3—Palaeoenvironmental interpretation based on occurrences and varied composition of the Group Acritarcha as interpreted by various workers

Group	Generic Diversity	Occurrence	Remarks	Reference
Acanthomorphitae	—	—	Favours an inshore partly enclosed environment	Wall, 1965
Prasinophytes	*Tasmanites, Leiosphaeridia Lophosphaeridium*	Abundance	Near-shore environment	Prauss & Riegel, 1989 Wicander & Playford, 1985
Leiosphaerids	Low diversity	Dominance	Near-shore and shallow water environment	Tappan, 1980; Jacobson, 1979; Dorning, 1982
Baltisphaerid, Veryhachids, Polygonium, Netromorphitae			Open sea area	Tappan, 1980; Jacobson, 1979; Wright & Meyers, 1981; Wall, 1965
Netromorphitae	Elongate to fusiform taxa	Dominance	Closest to land, includes brackish deposits	Tappan, 1980
Spinysphaers		Dominance	In-shore basinal environment	
Micrhystridium	Low processes		Near-shore perhaps shallow	Dorning, 1981;
Micrhystridium, Laevigate types *Veryhachium*	Low diversity	Low to moderate abundance	water environment	Davey, 1970
Micrhystridium Baltisphaeridium	—	—	In-shore environment	Wall, 1965
Sphaeromorphitae	—	—	Near-shore environment	Gray & Boucot, 1972
Acanthomorphitae	Diverse assemblages		Off-shore environment	
Acritarch	Diversified	Dominance	In fine-grained silty shale and siltstone and rocks of considerable carbonate content	Tappan, 1980
	Complex taxa Simple taxa	—	Off-shore environment Near-shore environment	Tappan, 1980; Downie, 1979; Traverse, 1988
Leiosphaerids, Veryhachids	—	Dominance	Near-shore shallow water environment	Wright & Meyers, 1981
Acritarchs	—	Abundance	In phosphorite containing rocks	Jacobson, Wardlaw & Saxton, 1982
Foraminifera	—	Meagre	Low salinity	Harris & Mc Gowrn, 1971 in Foster, 1974

ways are the main features to be considered. For determination of their distribution through time, the biohorizons demarcated by Vijaya and Tiwari (1992) in the Permian and Triassic successions on the peninsular India have been used as key levels (Table 1).

Earliest Permian (? Early Asselian)

The palynoassemblages recovered from Biohorizon-I level, (Talchir Formation) in Athgarh and Damodar basins contain a non-diversified palynoflora consisting mainly of monosaccate pollen. These assemblages are associated with OMIDOs which are spherical having unornamented exine, and without any splitting mode on body-surface (Tables 5, 6; Text-figure 2).

Early Permian (Late Asselian-Early Sakmarian)

With the increased morphological complexity characterizing the palynological assemblages from Biohorizons - II and III within Talchir Formation, the OMIDOs also show diversity, although their frequency fluctuates in various basins (Tables 5, 6; Text-

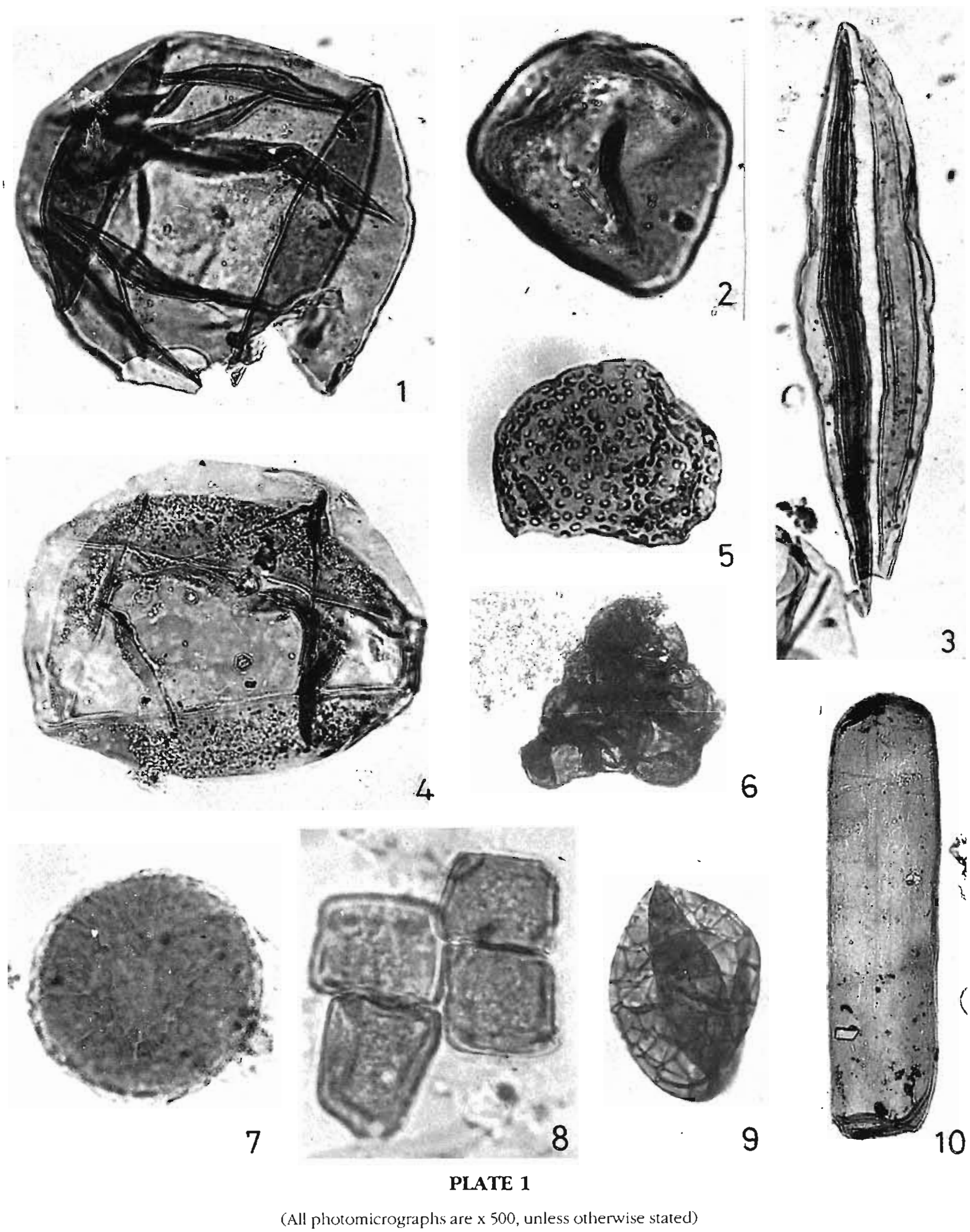


PLATE 1

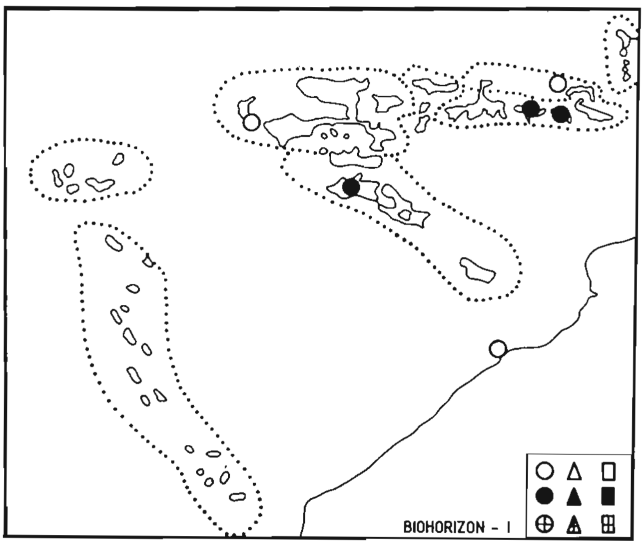
(All photomicrographs are x 500, unless otherwise stated)

1. *Leiosphaeridia*
2. *Pilasporites*
3. *Foveofusa*
4. *Kildinella* x 750
5. *Singraulipollenites*
6. *Protomassulina*
7. *Hindisporis*
8. *Margomassulina* x 750
9. *Dictyotidium*
10. *Foveofusa*

Table 4—Palaeoenvironmental interpretation

Specific diversity in population	Remarks	Reference
Single species population	In-shore condition	Tappan, 1980
Highly diverse heterogeneous assemblage, moderate abundance	Off- shore	Tappan, 1980; Dorning, 1981
Species with reduced processes	Tolerance turbulent conditions	Tappan, 1980
Species with low delicate processes	Quite deposition	Tappan, 1980
Species diversity and varied generic morphology	Transgressive phases and open sea environment	Tappan, 1980; Vidal & Knoll, 1983 in Traverse, 1988
Decreased diversity	Regressive phases, deposition of coarser sediments	Tappan, 1980
Low diversity assemblages	Towards near-shore in marine environment	Tappan, 1980; Traverse, 1988
	Coastal environment	Vidal & Knoll, 1983 in Traverse, 1988
High diversity bloom	Shallow water with poor circulation	Dorning, 1981

figures 3, 4). This kind of change is widespread at this level and it indicates that the OMIDOs are at the transforming phase in their morphology. The overall variations in shape observed are : spherical, spindle-like to squarish (*Leiosphaeridia, Foveofusa, Balmeella*); the excystment is either longitudinal



Text-figure 2—Distribution pattern of OMIDOs at the level of Biohorizon-I, Lower Talchir Formation, Early Permian, in different basins on peninsular India. The Acritarcha Group is non-diversified and low in frequency. The symbols represent — circle = rare (1-4%), triangle = common (5-10%) and square = abundant (11-25%). The qualitative diversity within the OMIDOs is depicted as blank symbols which represent non-diversified state, the filled symbols are of mediumly diversified state (2-4 types), and plus mark within each symbol indicates high form-diversity (more than 5 types). These symbols are followed as such in Text-figures 3-11.

(*Schizosporis*) or equatorial (*Peltacystia*). Diversity has also occurred in exine pattern from smooth to reticulate (*Leiosphaeridia, Maculatasporites, Dictyotidium*). An increase in percentage but low species diversity are recorded in Koel, Deogarh, Damodar, Satpura and Mahanadi Basin coalfields (Tables 5, 6; Text-figures 3, 4, 11).

Mid-Early Permian (Late Sakmarian-Early Artinskian)

The generic and species diversity of pollen and spores has prevailed from the older sequence during the *Crucisaccites* Interbiohorizon zone. Not much is added to the group of OMIDOs during Upper Talchir and Lower Karharbari formations (Tables 5, 6; Text-figures 5, 11). Interestingly, a sudden decline in the kind and number of these forms in the subsequent horizons, i.e., during Upper Karharbari and Lower Barakar (Tables 5, 6) is recorded.

Late Early Permian

Next phase in the course of diversification is identified in the Mid-Upper Barakar Formation, the *Barakarites* Interbiohorizon, as seen in the Rajmahal, Damodar, and Godavari basins (Tables 5, 6; Text-figures 6, 11). Diversity has prevailed in the mixed population of the OMIDOs, represented mainly by the subgroups — Herkomorphitae and Schizomor-

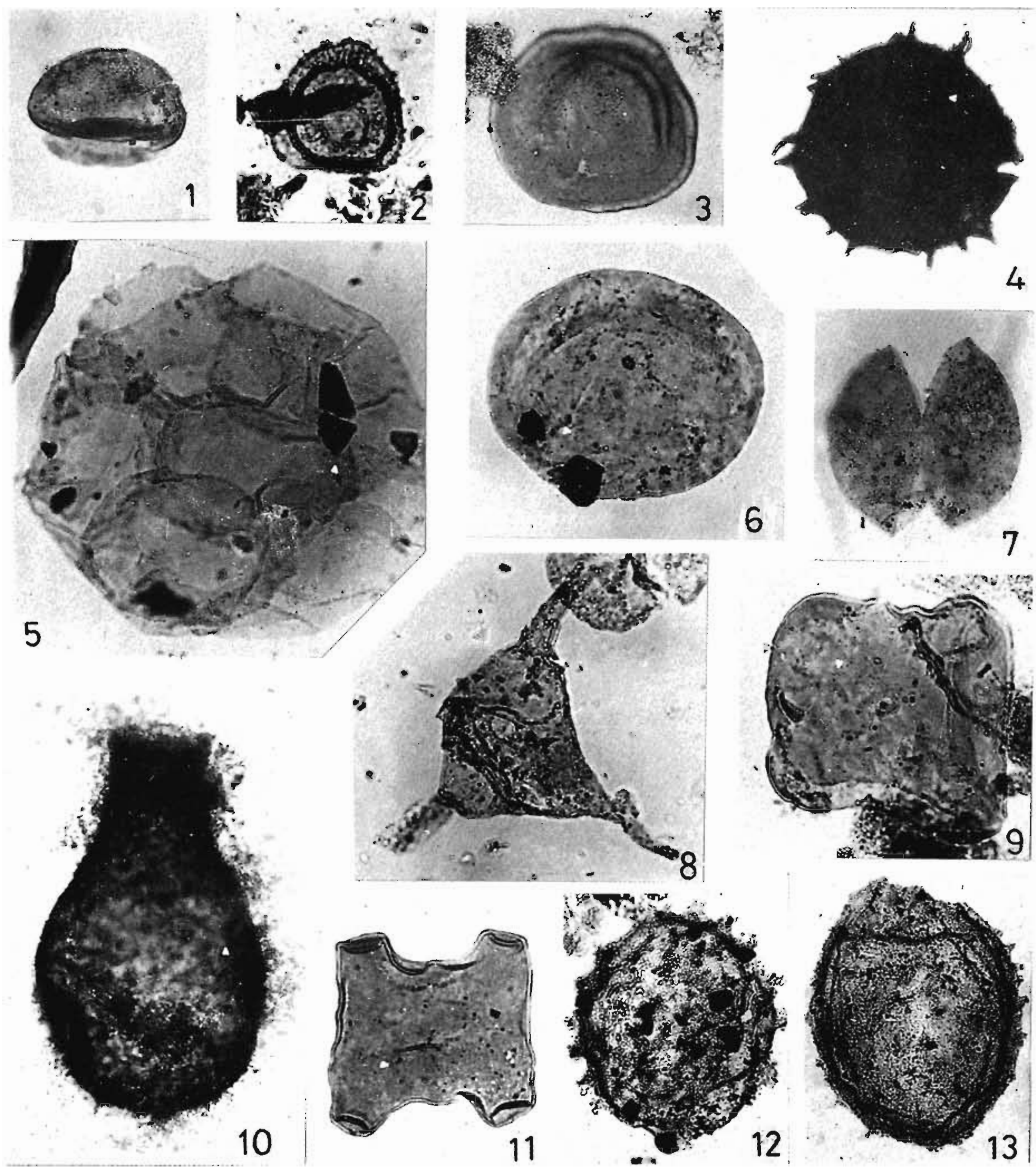


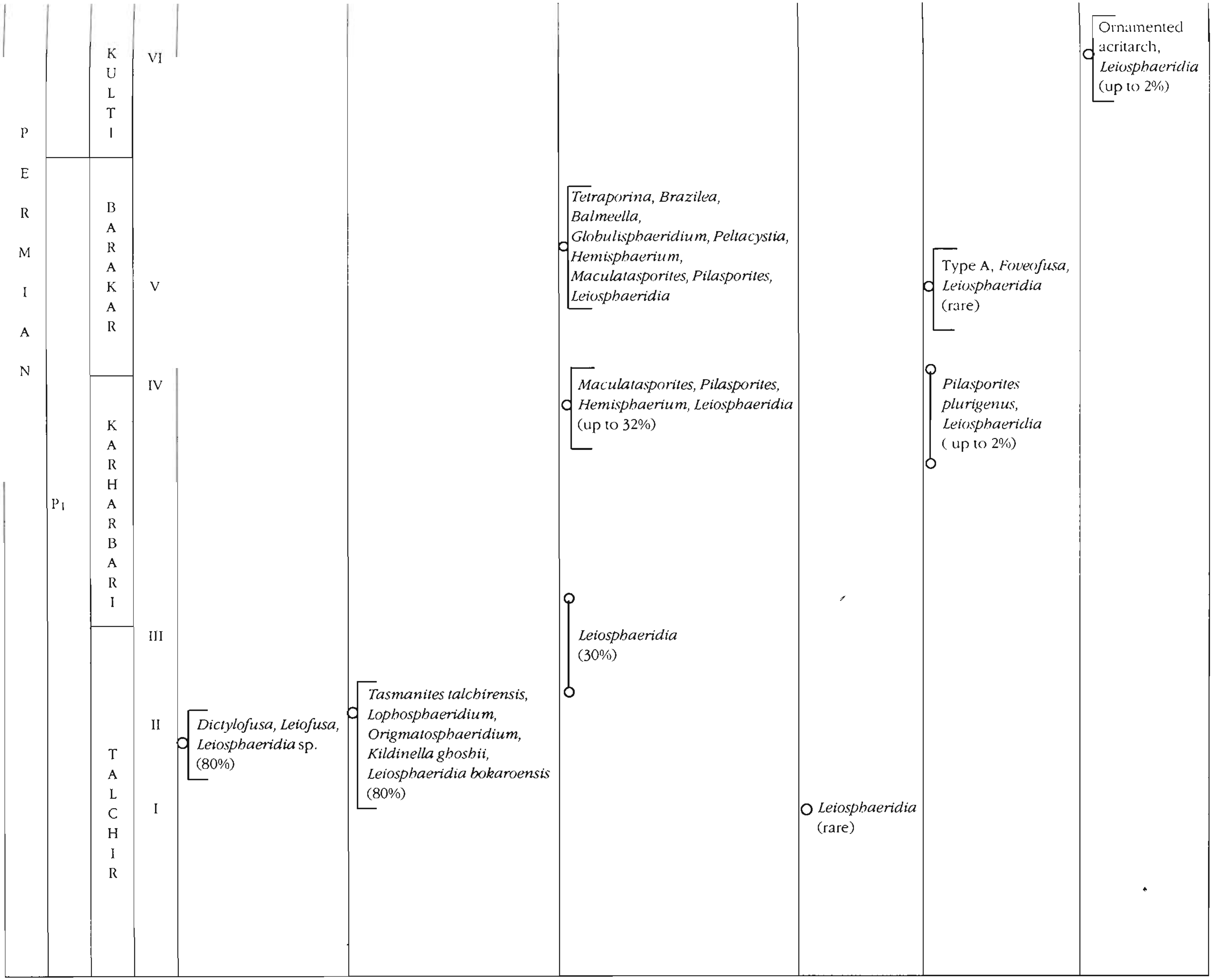
PLATE 2

(All photomicrographs are x 500, unless otherwise stated)

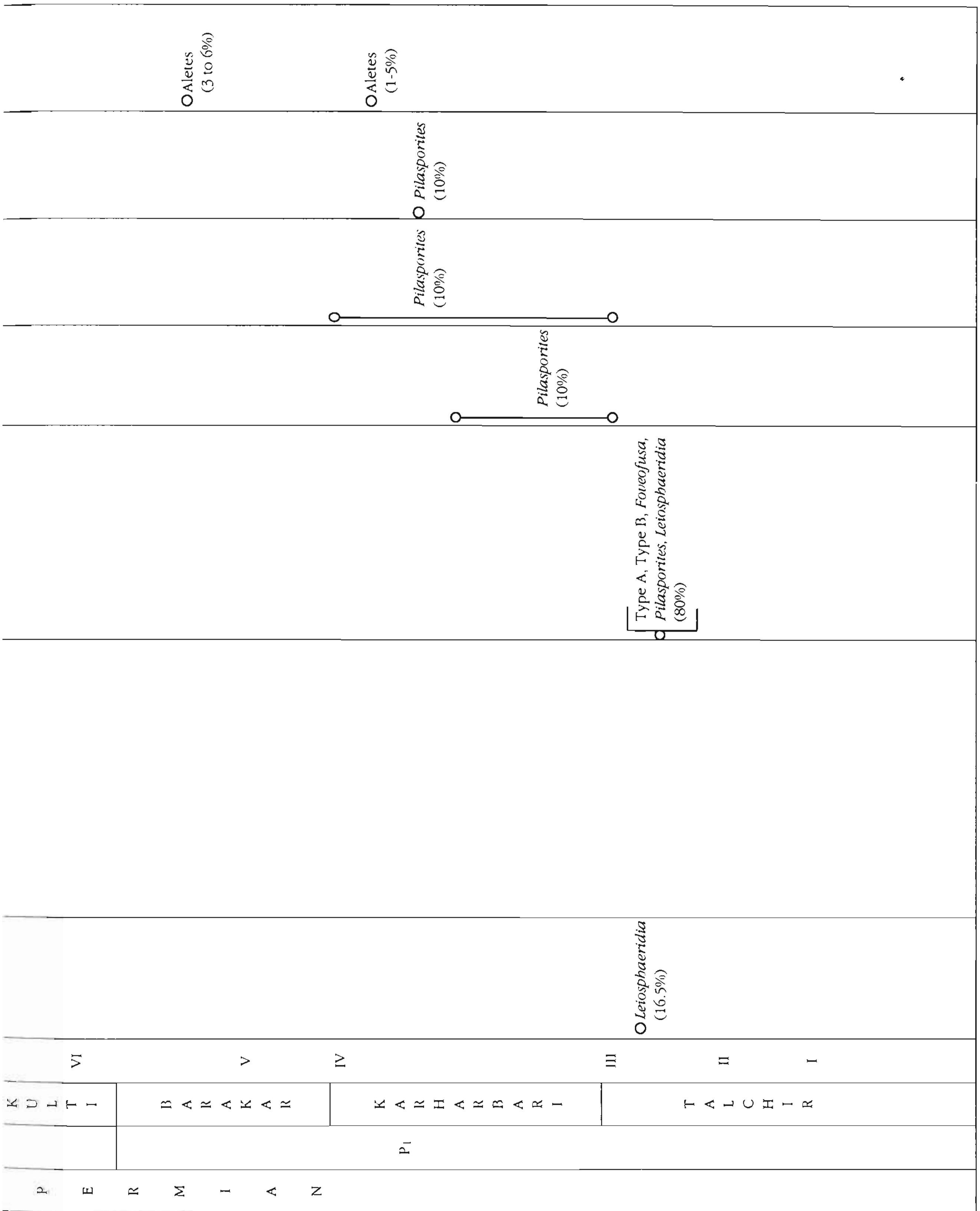
1. *Origmatosphaeridium* x 250
2. *Peltacystia*
3. *Tasmanites* x 250
4. *Micrhystridium*
5. *Greinervillites*
6. *Hemisphaerium*
7. *Brazilea*
8. *Veryhachium*
9. *Balmeella*
10. Vase-shaped body
11. *Tetraporina*
12,13. Type A in Tripathi, 1993

Table 5 — **Distribution of organic-walled microfossils of doubtful origin in different coalfields/areas of various basins on Indian Peninsula at different time levels. The listing of taxa up to species level and occurrence of OMIDOs with their frequency has been made where available. Data from Himalaya and West Pakistan has been included for comparison. The data-base is as given in Table 2. The circles indicate the range of OMIDOs assemblage.**

PERIOD	EPOCH	FORMATION	BIOHORIZON	PALAR	PENGANGA	GODAVARI	MAHANADI		
							ATHGARH	TALCHER	IB-RIVER
TRIASSIC	T_3	DUBRAJPUR	IX						
	T_2								
	T_1	DUBRAJPUR / PANCHET	VIII						
	P_2	RANIGANJ	VII			*Singraulipollenites*, *Leiosphaeridia* (25%) *Maculatasporites gondwanensis*, *Pilasporites* sp., *Leiosphaeridia talchirensis* (up to 5%)			


PERMIAN
P1
KULTI
BARAKAR
KARHARBARI
TALCHIR
VI
V
IV
III
II
I
Dictylofusa, Leiofusa, Leiosphaeridia sp. (80%)
Tasmanites talchirensis, Lophosphaeridium, Origmatosphaeridium, Kildinella ghoshii, Leiosphaeridia bokaroensis (80%)
Tetraporina, Brazilea, Balmeella, Globulisphaeridium, Peltacystia, Hemisphaerium, Maculatasporites, Pilasporites, Leiosphaeridia
Maculatasporites, Pilasporites, Hemisphaerium, Leiosphaeridia (up to 32%)
Leiosphaeridia (30%)
Leiosphaeridia (rare)
Type A, Foveofusa, Leiosphaeridia (rare)
Pilasporites plurigenus, Leiosphaeridia (up to 2%)
Ornamented acritarch, Leiosphaeridia (up to 2%)

PERIOD	EPOCH	FORMATION	BIOHORIZON	RAJASTHAN: BAP	RAJASTHAN: JAISALMER	SATPURA: DO-DHARA	SATPURA: MOHPANI	SATPURA: PENCH-KANHAN	SATPURA: UMRER	SATPURA: PATHAKHERA
TRIASSIC	T_3	DUBRAJPUR	IX		*Inaperturopollenites indicus*, *Micrbystridium*					
	T_2									
	T_1	DUBRAJPUR / PANCHET	VIII							
	P_2	RANIGANJ	VII		*Wilsonastrum*, *Micrbystridium alteratoides*, *M. circulum*, *M. inconspicum*, *M. densispinosum*, *Veryhachium irregulare*, *V. valensii*, *Leiofusa* sp.					


Aletes (3 to 6%)
Aletes (1-5%)
Pilasporites (10%)
Pilasporites (10%)
Pilasporites (10%)
Type A, Type B, *Foveofusa*, *Pilasporites*, *Leiosphaeridia* (80%)
Leiosphaeridia (16.5%)
VI
V
IV
III
II
I
KULTI
BARAKAR
KARHARBARI
TALCHIR
P1
PERMIAN

PERIOD	EPOCH	FORMATION	BIOHORIZON	SON-VALLEY: KORBA	SON-VALLEY: CHIRIMIRI	SON-VALLEY: JOHILLA	SON-VALLEY: UMARIA	SON-VALLEY: MANENDRAGARH	SON-VALLEY: SINGRAULI	KOEL-VALLEY: AURANGA	KOEL-VALLEY: HUTAR
TRIASSIC	T_3	DUBRAJPUR	IX								
	T_2										
	T_1	DUBRAJPUR / PANCHET	VIII			Type A, Type B (< 1%)					
	P_2	RANIGANJ	VII			Type A, *Peltacystia*, *Leiosphaeridia* (5-10%)			*Spongiocysta*, *Balmeella*, *Peltacystia*, *Circulisporites*, *Greinervillites irregularis*, *G. undulatus*, *Maculatasporites gondwanensis*, *Singraulipollenites indicus*, *S. finitimus*, *Hemisphaerium*, *Hindisporis*, *Pilasporites*, *Leiosphaeridia* (0.5-2.5%)		

PERMIAN		KULTI	VI			*Balmeella, Brazilea, Peltacystia, Circulisporites, Hindisporis, Pilasporites, Leiosphaeridia* (1-2%) (range VI to Karharbari)				*Verybachium, Spongiocysta, Globulaesphaeridium, Balmeella, Brazilea, Peltacystia, Hemisphaerium, Greinervillites, Maculatasporites, Pilasporites, Leiosphaeridia* (5-6%)	
		BARAKAR	V	(range V to I)	*Maculatasporites* (1.5%)						
	P_1	KARHARBARI	IV	*Tetraporina, Hemisphaerium, Singraulipollenites, Hindisporis, Pilasporites, Leiosphaeridia* (upto 10%)			*Foveofusa perforata, F. mutabilis, F. attenuata, F. obsesa, F. pumilla, F. cylindrica, Protomassulina, Margomassulina, Trachyminuscula, Leiosphaeridia indica, L. umariensis* (dominant)			*Balmeella, Leiosphaeridia* (<1%)	*Balmeella tetragona, B. gigantea, Foveofusa obsesa, F. mutabilis, F. cylindrica, F. perforata, Brazilea punctata, Greinervillites undulatus, Pilasporites calculus* (present)
			III	*Maculatasporites, Balmeella, Pilasporites, Leiosphaeridia* (up to 10%)				Spinose acritarch, *Schizosporis, Balmeella, Hemisphaerium, Dictyotidium, Foveofusa, Pilasporites, Leiosphaeridia* (5-10%)			
		TALCHIR	II	*Maculatasporites, Pilasporites* (up to 1%)							
			I								

PERIOD	EPOCH	FORMATION	BIOHORIZON	DAMODAR: KARANPURA	DAMODAR: WEST BOKARO	DAMODAR: JHARIA	DAMODAR: RANIGANJ	DEOGARH: GIRIDIH	DEOGARH: JAYANTI	RAJMAHAL	HIMALAYA	WEST PAKISTAN: SALT RANGE
TRIASSIC	T_3	DUBRAJPUR	IX							*Foveofusa obsesa*, *F. cylindrica*, *Tasmanites* sp. (up to 2%)		
	T_2						*Inaperturopollenites nebulosus*, *Maculatasporites indicus*, *Maculatasporites* sp., *Pilasporites plurigenus* (< 1%)				*Tasmanites* sp. 1, *Tasminites* sp. 2, *Leiosphaeridia minuta*, *Leiosphaeridia* cf., L. *wenlockia*, *Leiosphaeridia* sp. (fare occurrence)	
	T_1	PANCHET	VIII									*Schizosporis scissus* (20-80%)
	P_2	RANIGANJ	VII							*Inaperturopollenites nebulosus*, *Tetraporina*, *Balmeella*, *Brazilea*, *Greinervillites*, *Hemisphaerium*, *Leiosphaeridia* (25%)		*Polyedrixium*, *Wilsonastrum*, *Inaperturopollenites nebulosus*, *Schizosporis scissus*, *Peltacystia venosa*, *Verybachium*, *Micrhystridium* *Leiofusa*, *Deunffia*, (up to 60%)

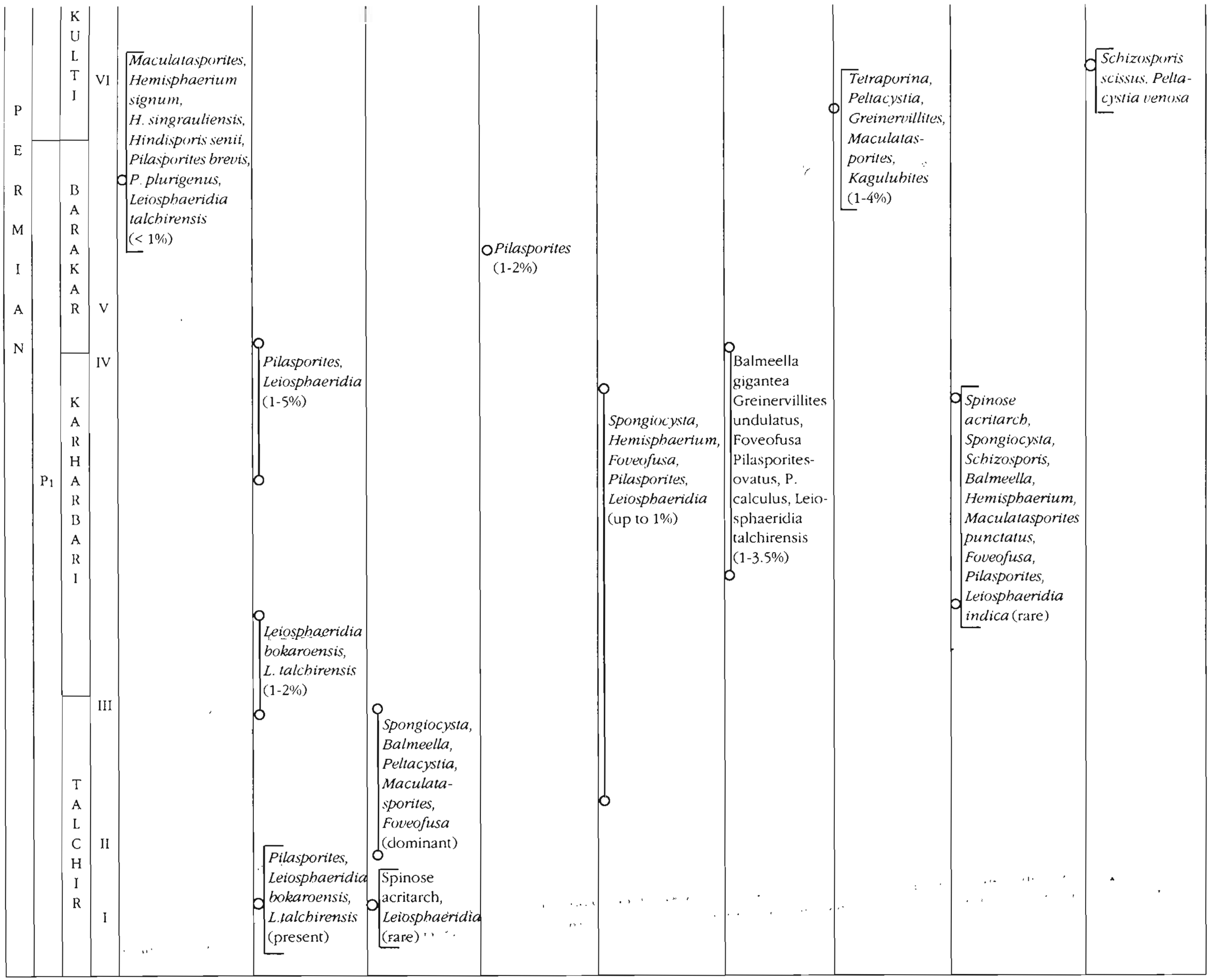
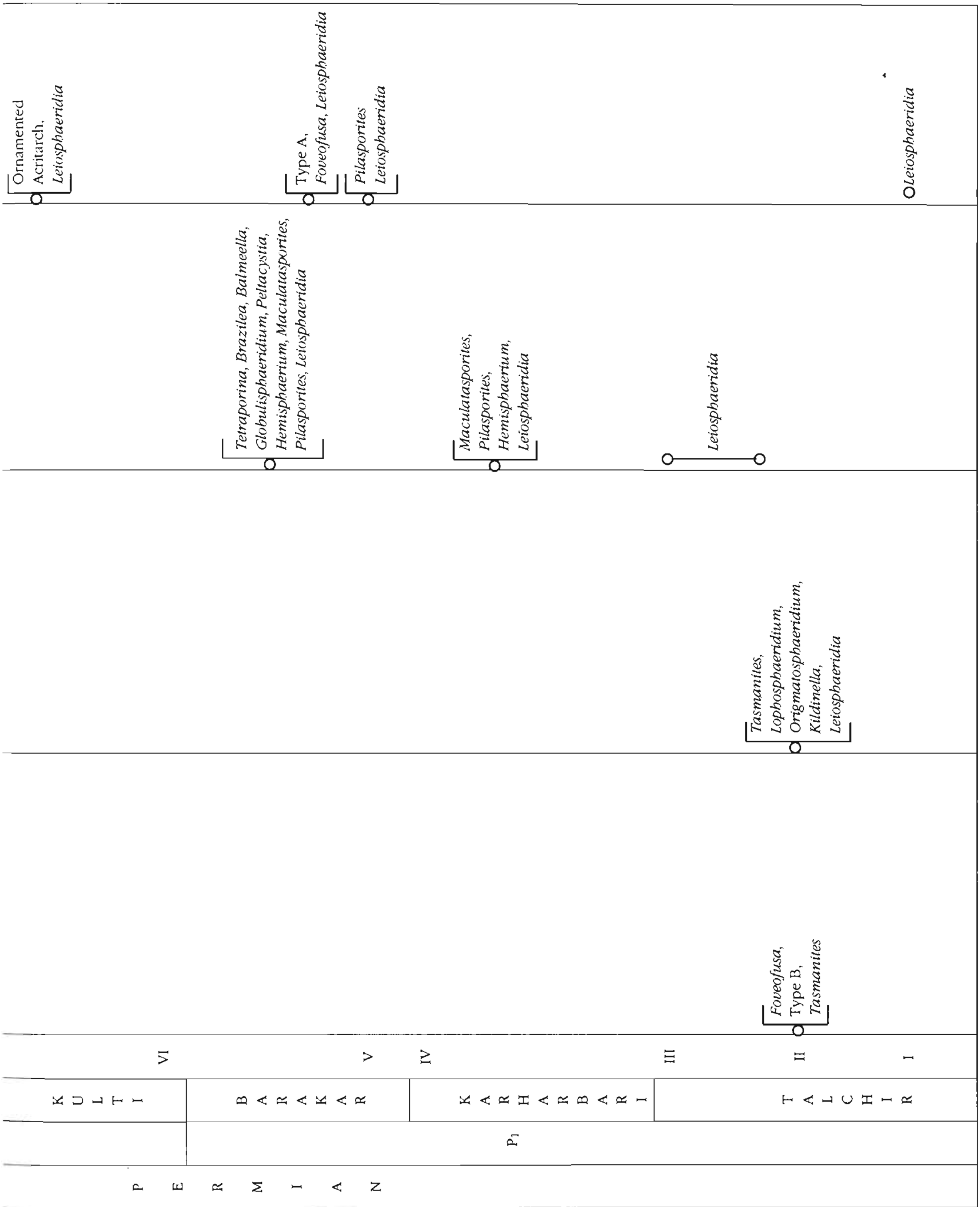

PERMIAN
P1
KULTI
BARAKAR
KARHARBARI
TALCHIR
VI
V
IV
III
II
I
Maculatasporites, Hemisphaerium signum, H. singrauliensis, Hindisporis senii, Pilasporites brevis, P. plurigenus, Leiosphaeridia talchirensis (< 1%)
Pilasporites, Leiosphaeridia (1-5%)
Leiosphaeridia bokaroensis, L. talchirensis (1-2%)
Pilasporites, Leiosphaeridia bokaroensis, L.talchirensis (present)
Spongiocysta, Balmeella, Peltacystia, Maculatasporites, Foveofusa (dominant)
Spinose acritarch, Leiosphaeridia (rare)
Pilasporites (1-2%)
Spongiocysta, Hemisphaerium, Foveofusa, Pilasporites, Leiosphaeridia (up to 1%)
Balmeella gigantea Greinervillites undulatus, Foveofusa Pilasporites-ovatus, P. calculus, Leiosphaeridia talchirensis (1-3.5%)
Tetraporina, Peltacystia, Greinervillites, Maculatasporites, Kagulubites (1-4%)
Spinose acritarch, Spongiocysta, Schizosporis, Balmeella, Hemisphaerium, Maculatasporites punctatus, Foveofusa, Pilasporites, Leiosphaeridia indica (rare)
Schizosporis scissus, Peltacystia venosa

Table 6 —Distribution of OMIDOs assemblages in various basins through Permian and Triassic sequences on Indian Peninsula. The data from Himalaya and West Pakistan have been incorporated for comparison. The data-base is as given in Table 2. The circles indicate the range of OMIDOs assemblage.

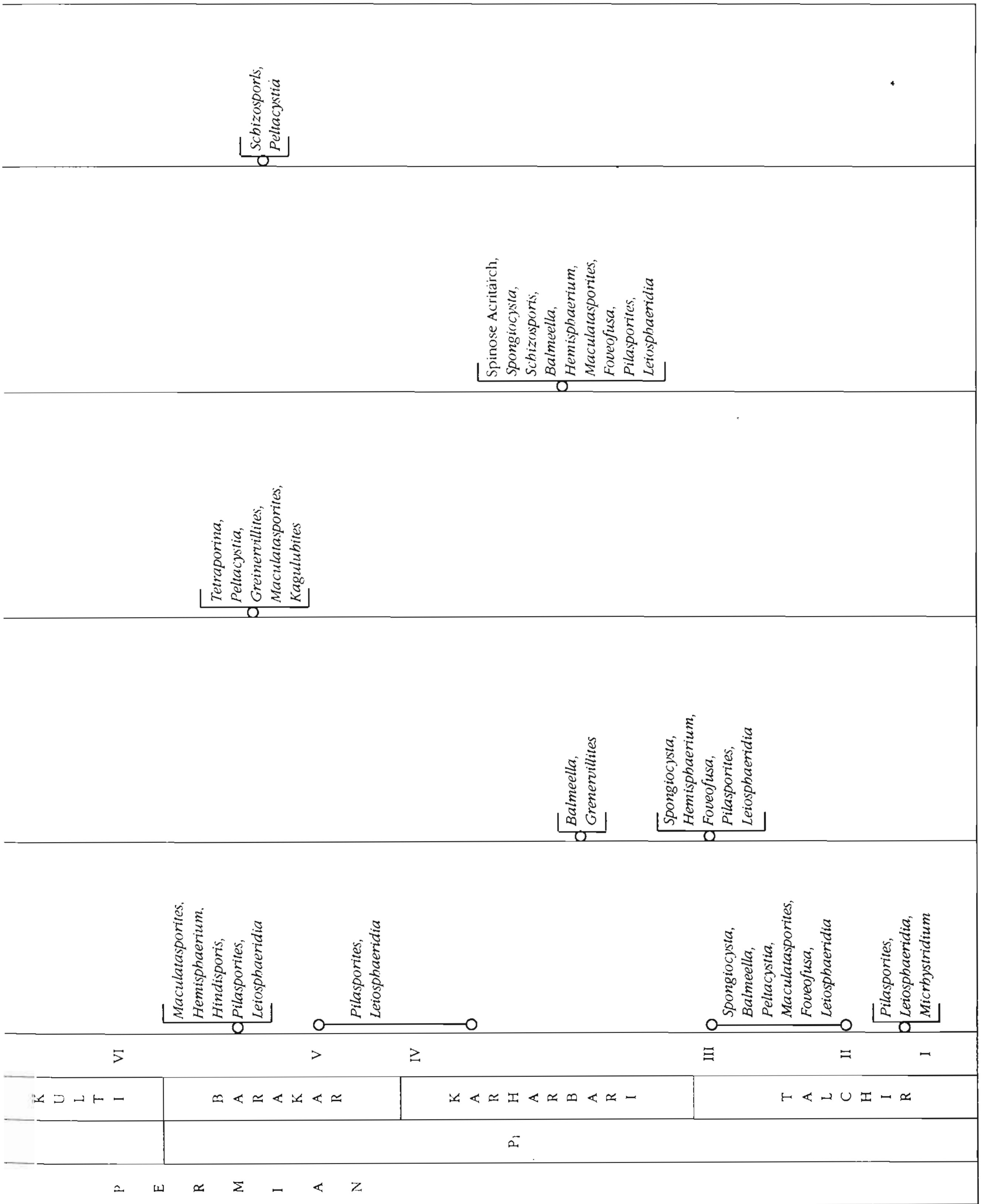
PERIOD	EPOCH	FORMATION	BIOHORIZON	PALAR	PENGANGA	GODAVARI	MAHANADI
TRIASSIC	T_3	DUBRAJPUR	IX				
	T_2						
	T_1	DUBRAJPUR / PANCHET	VIII				
	P_2	RANIGANJ	VII			○ *Singraulipollenites, Leiosphaeridia Maculatasporites, Pilasporites,*	

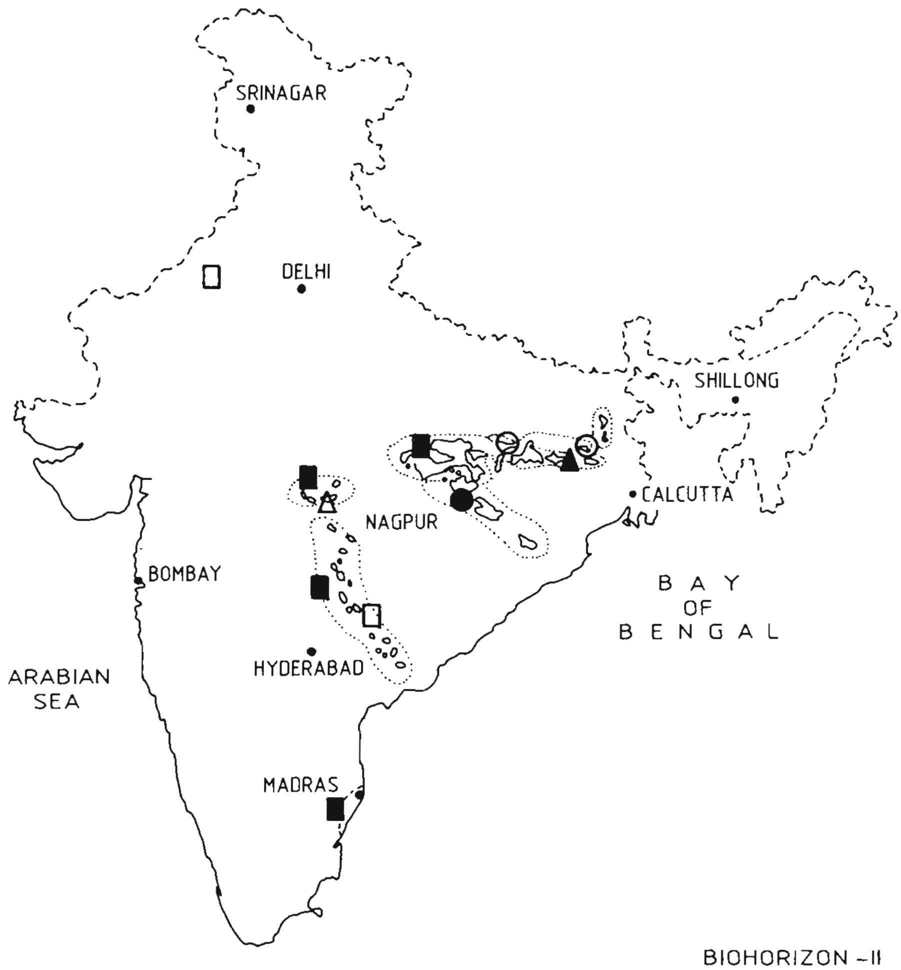

Ornamented Acritarch, *Leiosphaeridia*
Type A, *Foveofusa*, *Leiosphaeridia*
Pilasporites *Leiosphaeridia*
Leiosphaeridia
Tetraporina, *Brazilea*, *Balmeella*, *Globulisphaeridium*, *Peltacystia*, *Hemisphaerium*, *Maculatasporites*, *Pilasporites*, *Leiosphaeridia*
Maculatasporites, *Pilasporites*, *Hemisphaerium*, *Leiosphaeridia*
Leiosphaeridia
Tasmanites, *Lophosphaeridium*, *Origmatosphaeridium*, *Kildinella*, *Leiosphaeridia*
Foveofusa, Type B, *Tasmanites*
VI
V
IV
III
II
I
KULTI
BARAKAR
KARHARBARI
TALCHIR
P1
PERMIAN

PERIOD	EPOCH	FORMATION	BIOHORIZON	RAJASTHAN	SATPURA	SON-VALLEY	KOEL-VALLEY
TRIASSIC	T_3	DUBRAJPUR	IX	*Inaperturopollenites, Micrhystridium*			
	T_2						
	T_1	DUBRAJPUR / PANCHET	VIII			Type A, Type B	
	P_2	RANIGANJ	VII	*Wilsonastrum, Micrhystridium, Veryhachium, Leiofusa*		Type A, Spongiocysta, Balmeella, Peltacystia, Circulisporites, Greinervillites, Maculatasporites, Singraulipollenites Hemisphaerium, Hindisporis, Pilasporites, Leiosphaeridia	

PERMIAN		KULTI	VI			*Balmeella, Brazilea, Peltacystia, Circulisporites, Hindisporis, Pilasporites, Leiosphaeridia*	*Spongiocysta, Globulaesphaeridium, Balmeella, Brazilea, Peltacystia, Hemisphaerium, Greinervillites, Maculatasporites, Pilasporites, Leiosphaeridia*
	P_1	BARAKAR	V		Aletes		
		KARHARBARI	IV		Aletes	*Tetraporina, Hemisphaerium, Singraulipollenites, Hindisporis, Pilasporites, Leiosphaeridia*	*Veryhachium, Balmeella, Foveofusa, Brazilea, Greinervillites, Pilasporites*
					Pilasporites	*Foveofusa, Protomassulina, Margomassulina, Trachyminuscula, Balmeella, Maculatasporites, Pilasporites, Leiosphaeridia*	
		TALCHIR	III	*Leiosphaeridia*			
			II		Type A, Type B, *Dictyotidium, Foveofusa, Pilasporites, Leiosphaeridia*	*Micrhystridium, Schizosporis, Balmeella, Hemisphaerium, Dictyotidium, Foveofusa, Maculatasporites, Pilasporites, Leiosphaeridia*	
			I				

PERIOD	EPOCH	FORMATION	BIOHORIZON	DAMODAR	DEOGARH	RAJMAHAL	HIMALAYA	WEST PAKISTAN
TRIASSIC	T_3	DUBRAJPUR	IX			*Foveofusa*, Type B, *Tasmanites*		
	T_2	DUBRAJPUR						
	T_1	DUBRAJPUR / PANCHET	VIII	*Inaperturopollenites*, *Maculatasporites*, *Pilasporites*			*Tasmanites*, *Leiosphaeridia*	*Schizosporis*
	P_2	RANIGANJ	VII			*Inaperturopollenites*, *Tetraporina*, *Balmeella*, *Brazilea Greinervillites* *Hemisphaerium*, *Leiosphaeridia*		*Wilsonastrum*, *Polyedrixium*, *Inaperturopollenites* *Schizosporis*, *Peltacystia*, *Verybachium*, *Micrhystridium*, *Leiofusa*, *Deunffia*


PERMIAN
P1
KULTI
BARAKAR
KARHARBARI
TALCHIR
I
II
III
IV
V
VI
Pilasporites, Leiosphaeridia, Micrhystridium
Spongiocysta, Balmeella, Peltacystia, Maculatasporites, Foveofusa, Leiosphaeridia
Pilasporites, Leiosphaeridia
Maculatasporites, Hemisphaerium, Hindisporis, Pilasporites, Leiosphaeridia
Spongiocysta, Hemisphaerium, Foveofusa, Pilasporites, Leiosphaeridia
Balmeella, Grenervillites
Tetraporina, Peltacystia, Greinervillites, Maculatasporites, Kagulubites
Spinose Acritarch, Spongiocysta, Schizosporis, Balmeella, Hemisphaerium, Maculatasporites, Foveofusa, Pilasporites, Leiosphaeridia
Schizosporis, Peltacystia



Text-figure 3 — Occurrence of OMIDOs in Early Permian Talchir Formation at the Biohorizon II. For symbols, see the legend in Text-figure 2

phitae. The smooth-walled forms, although rare, continue to occur. The taxa beset with high ornament are found in Godavari and Mahanadi basins.

Late Permian

Only a single record of Group Acritarcha is known in *Verticipollenites* Interbiohorizon which represents early Late Permian Kulti Formation (Tables 5, 6; Text-figures 7, 11). At the level of Biohorizon VII — Late Permian Raniganj Formation, a varied composition of OMIDOs is exhibited. However, the data is known only from few areas. In Rajmahal Basin, the form-diversity is medium but significantly high frequency is recorded. In Son Valley much diversified assemblage is reported. In southern part of Godavari Graben; dominance of smooth-walled OMIDOs is observed in a distinct Kamthi (=Raniganj) palynoassembage (Tables 5, 6; Text-figures 8, 11).

Early Triassic (Scythian)

Scanty records of OMIDOs are known from the Panchet Formation and that too only in the Damodar Basin. The group is represented by two genera with low species diversity (Tables 5, 6; Text-figures 9, 11).

Late Triassic (Carnian)

Only one record of OMIDOs is from the Dubrajpur Formation on Indian Peninsula. The representative group consists of three genera of morphographically primitive state with low species diversity (Tables 5, 6; Text-figures 10, 11).

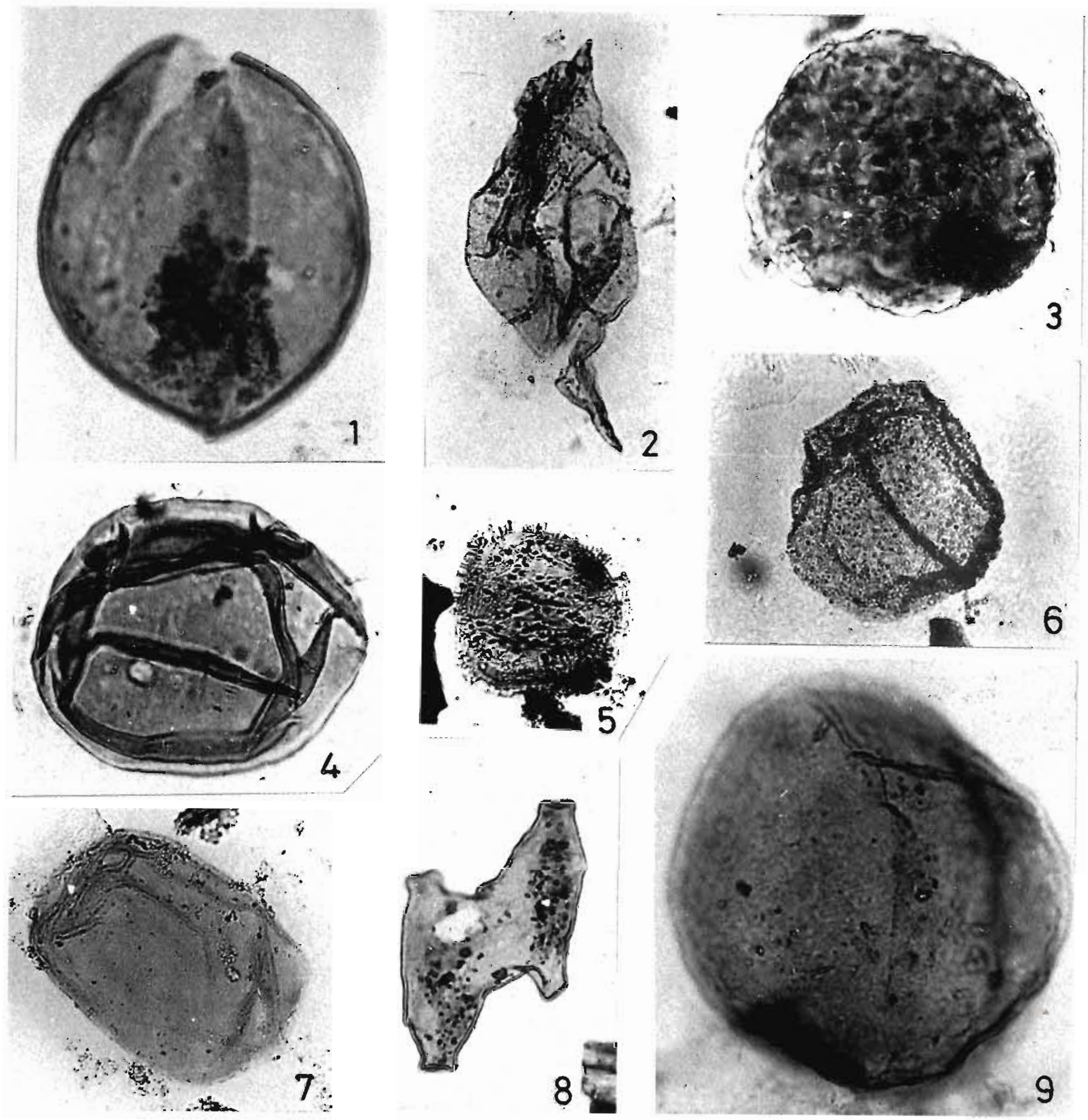


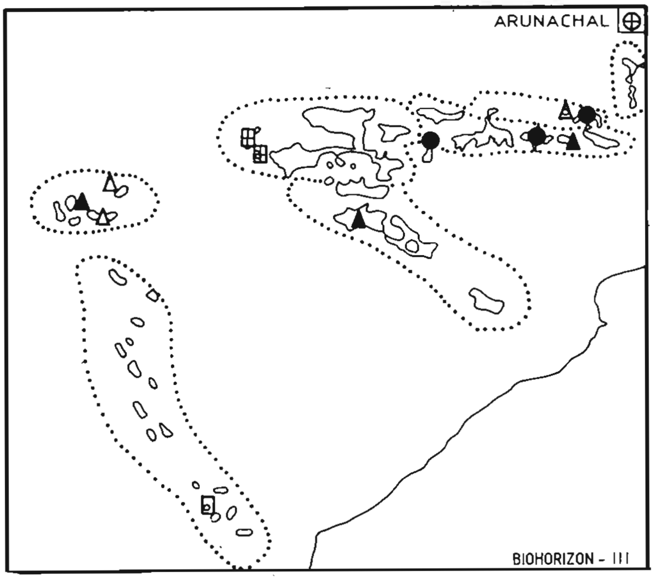
PLATE 3

(All photomicrographs are x 500, unless otherwise stated)

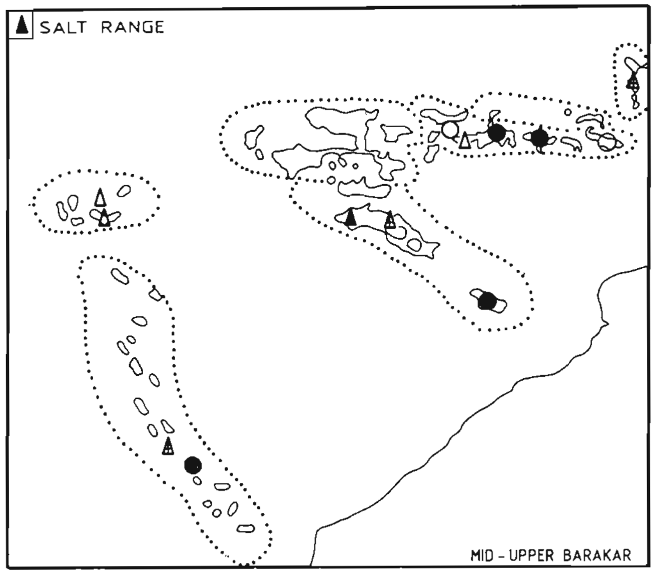
1. *Brazilea*
2. *Varyhachium*
3. *Botryococcus*
4. *Leiosphaeridia*
5. *Tasmanites*
6. *Lophosphaeridium*
7. *Foveofusa*
8. *Tetraporina*
9. *Brazilea*

PALAEOENVIRONMENT

The present Gondwana basins are the remanant of much larger spatial dimension of depositional areas, where the mega-drainage system had a vital role to play in the making of depositional environment and evolution of the biota. The drainage system was aligned SE-NW (Casshyap & Tewari, 1984;



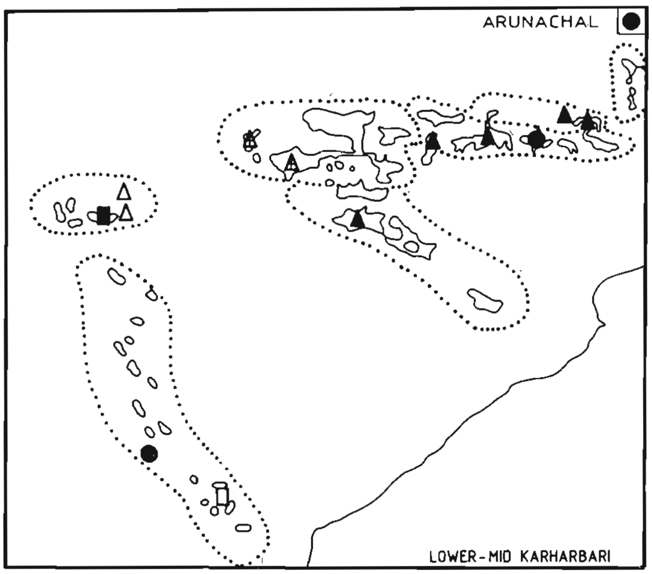
Text-figure 4 — Occurrence of OMIDOs in Early Permian Talchir Formation at the Biohorizon-III. Diversity in kind and number that begins at Biohorizon II, attains its maxima at Biohorizon-III. For symbols, see the legend in Text-figure 2.



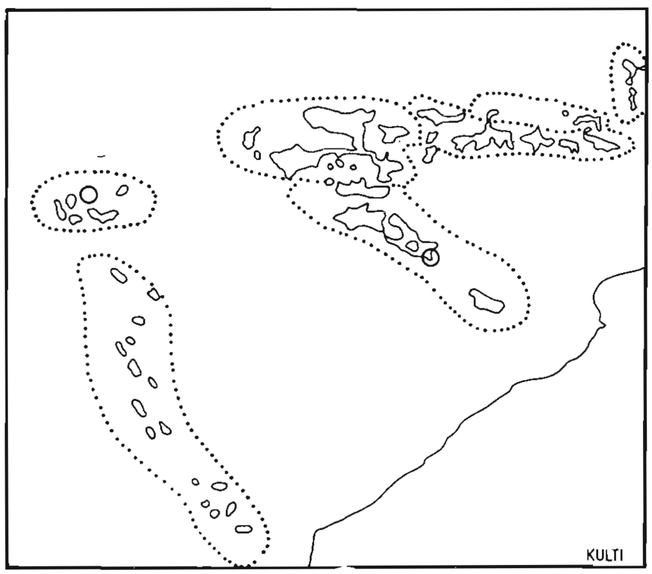
Text-figure 6—In the Middle-Upper Barakar horizons, locally few taxa attain maximum diversity, whereas the general occurrence is less diversified. For symbols, see the legend in Text-figure 2.

Niyogi, 1987) during Permian and so also in the Triassic with a slight shift towards west (Casshyap & Tewari, 1988). Evidently the outlet was in the northern and western part of the peninsula.

The Gondwana Sequence represented by different depositional settings are conventionally thought to be of non-marine origin (Sastry *et al.*, 1977) due to the non-availability of faunal evidences, in most of the horizons considered here, except for Talchir Formation. However, recent evidences of signatures for marine environment, such as records of boron, organic sulphur, phosphatic nodules, algal



Text-figure 5—OMIDOs with established qualitative and quantitative diversity in Lower-Middle Karharbari sediments on Indian Peninsula and Arunachal Pradesh. For symbols, see the legend in Text-figure 2.



Text-figure 7—Showing scanty occurrence of acritarchs in the sediments of Kulti Formation. For symbols, see the legend in Text-figure 2.

Table 7—Record of independent evidences other than OMIDOs from peninsular India to support brackish/marine environment during Permian and Triassic time

Basin	Formation	Area/Coalfield	Biota	Geochemical	Sedimentological	References
Koel-Damodar Deogarh	Talchir	Deogarh Coalfield, Raniganj Coalfield	Ichnofossils Invertebrates Foraminifers			Guha, Mukhopadhyay & Das, 1994
		Jharia Coalfield	Vase-shaped bodies			Dutta & De, 1994; Tiwari, Srivastava, Tripathi & Singh, 1981
		Daltonganj	Sponge spicules			Banerjee & Das, 1983
		Bokaro Coalfield	Sponge spicules			Lele & Srivastava, 1974
	Barakar	Hazaribagh	Myalinids, Ichnofossils			Dutt & De, 1994; De, 1993
		Saharjuri	Microforum, Ostracods			Banerjee, 1994
		West Bokaro Coalfield		Microcrystal		Banerjee & Das, 1983
	Kulti		Foraminifers			Pal, Sen, Ghosh & Das, 1994
			Bryozoans			Ahmed & Gyan Chand, 1994
	Raniganj	Raniganj, South Karanpura, West Bokaro, Auranga	Myalinids, Foraminifers		Wave ripples	Dutt & De, 1994; Chaudhuri & Mukhopadhyay, 1994
		Hutar	Coccolith, Foraminifers		Wave ripples	Chaudhuri, 1988
		Daltonganj	Bioturbidites		Deltaic facies	Niyogi, 1987
Mahanadi	Talchir	Athgarh	Vase-shaped bodies			Tiwari, Tripathi, Dutt & Mukhopadhyay, 1987
					Lithofacies association paucity of large scale trough, cross stratification, occasional flat bedding, wave ripple, wave ripple bedding, calcareous nodules and shale preponderance of green colour	Casshyap & Tewari, 1988
	Barakar		Myalinids			Dutt & De, 1994
	Kulti		Bioturbidites	Phosphatic nodule		Anon, 1986
	Raniganj	Ib-River Coalfield	Myalinids			Dutt & De, 1994
					Wave ripples	Chaudhuri & Mukhopadhyay, 1994
Son	Talchir		Bivalves, Brachiopods. Trace fossils			Casshyap & Arora, 1994

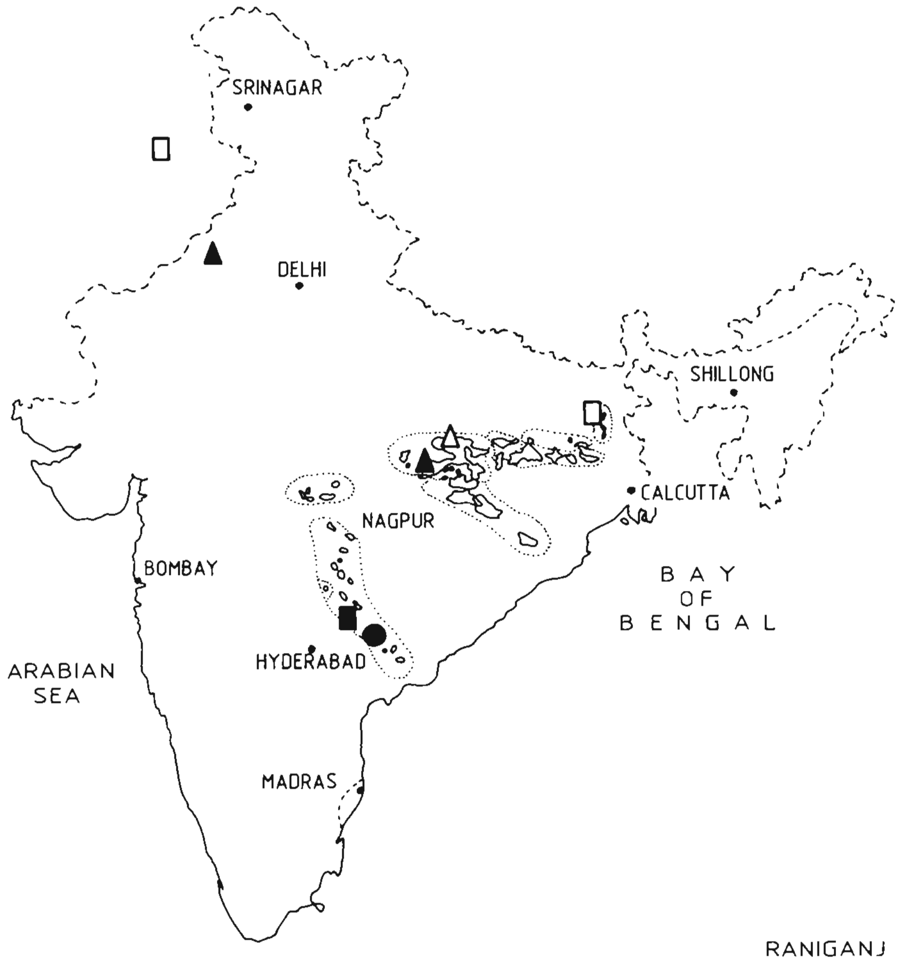
Contd.

Basin	Formation	Area/Coalfield	Biota	Geochemical	Sedimentological	References
		Korba Manendragarh			Lithofacies association, paucity of large scale trough, cross stratification, occasional flat bedding, wave ripple bedding, flaser bedding, calcareous nodules and shale preponderance of green colour	Casshyap & Tewari, 1988
	Barakar		Myalinids			Dutt & De, 1994
	Raniganj		Myalinids			Dutt & De, 1994
	Upper Pali		Conchostrachus			Dutt & De, 1994
Satpura	Talchir		Bivalves, Brachiopods, Trace fossils			Casshyap & Arora, 1994
			Invertebrates, Ichnofossils			Dutt & De, 1994; Casshyap & Arora, 1994
	Kulti		Foraminifers, Microplankton	Boron, organic sulphur, phosphatic nodule		Dutt & De, 1994
		Pench-Kanhan			Limestone	Anon, 1986
Wardha	Barakar			Boron		Anon, 1986
				Boron, Phosphatic nodule, Organic sulphur		Dutt & De, 1994
				Organic sulphur		Rao, Menon, Joshi, Khanwalkar & Meshram, 1993
Darjeeling	Talchir		Invertebrates			Acharyya, Ghosh, Ghosh & Shah, 1975
Arunachal	Karharbari Barakar		Invertebrates			Srivastava, Anand-Prakash & Singh, 1988

limestones, bivalves, ichnofossils, ?bryozoans and ?foraminifers at various levels indicate that there could have been marine influence in certain regions of the peninsula (Table 7). In view of these facts the OMIDOs may also be considered, along with other evidences, to determine the reflection of increased salinity.

Early Permian

The data synthesized here indicates three successive modes in the course of evolution of morpho-characters of OMIDOs during Talchir Formation (Text-figures 11, 12). At the oldest level Biohorizon-I, the OMIDOs assemblage is poor as well as non-diversified in composition. It has been recorded from the areas of Athgarh, Damodar and Son Valley (Tiwari *et al.*, 1981, 1987; Bharadwaj & Srivastava, 1973). At Biohorizon-II, the generic diversity has increased and these forms are abundant in Palar, Penganga and Satpura basins (Venkatachala & Rawat, 1973; Bharadwaj *et al.*, 1978; Lele, 1984). In addition, an assemblage with low diversity but high frequency is observed in Bap Boulder bed, Rajasthan

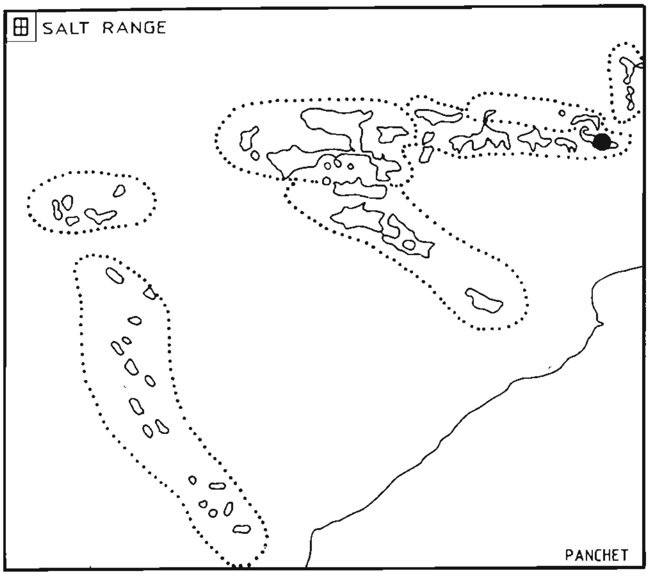


Text-figure 8—In the Mid-Upper Raniganj Formation, the occurrence is sparse and the collective group diversity is fair but restricted locally. For symbols, see the legend in Text-figure 2.

(Venkatachala & Rawat, 1984). At Biohorizon-III, the assemblages of OMIDOs are fairly diversified and with high frequency, as in Son Valley (Bharadwaj & Srivastava, 1973) and Godavari Basin (Srivastava & Jha, 1992a, b). In other areas studied here, they are moderately diversified and rare to common in occurrence (Text-figure 11).

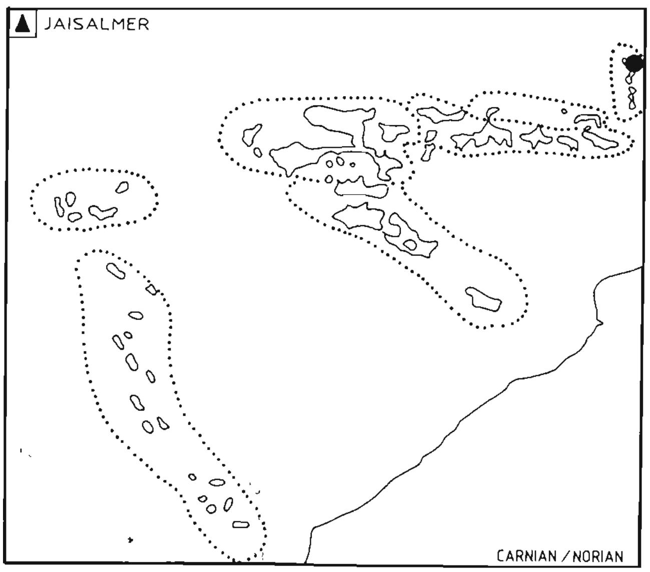
These three successive phases of increasing prominence during the Talchir Formation could be related with the global sea level fluctuation as shown in Text-figure 12 (after Hallam, 1989, p. 400). The group Sphaeromorphitae represented by *Leiosphaeridia* makes its appearance at the lowest level and gradually attains the diversity and dominates in the subsequent two biohorizons. This occurrence reflects a near-shore, shallow water condition (Tappan, 1980; Dorning, 1982) which is supported by the local sea incursions during Talchir (Anon, 1986). However, the incoming of *Foveofusa* as a common element of the assemblages at Biohorizons-II and III is significant. It probably indicates an open epicontinental marine environment (Traverse, 1988) in Dodhara, Satpura (Bharadwaj *et al.*, 1978) and Umaria, Son Valley (Lele & Chandra, 1972); Hutar, Koel Valley (Lele & Shukla, 1980). In other areas the assemblage is dominated by Leiosphaerids which are indicative of land proximity towards brackish water. In the Lower Karharbari Formation the diversity of the Sphaeromorphitae attains its maxima. The available data on global sea incursion (Hallam, 1989) in Early Permian suggests that the beginning of regression coincides with the maximum diversity phase of the Leiosphaerids at this level.

The occurrence of eurydesmids-Productids and



Text-figure 9 — Illustrates scattered and a less diversified nature of OMIDOs assemblage in Panchet Formation. For symbols, see the legend in Text-figure 2.

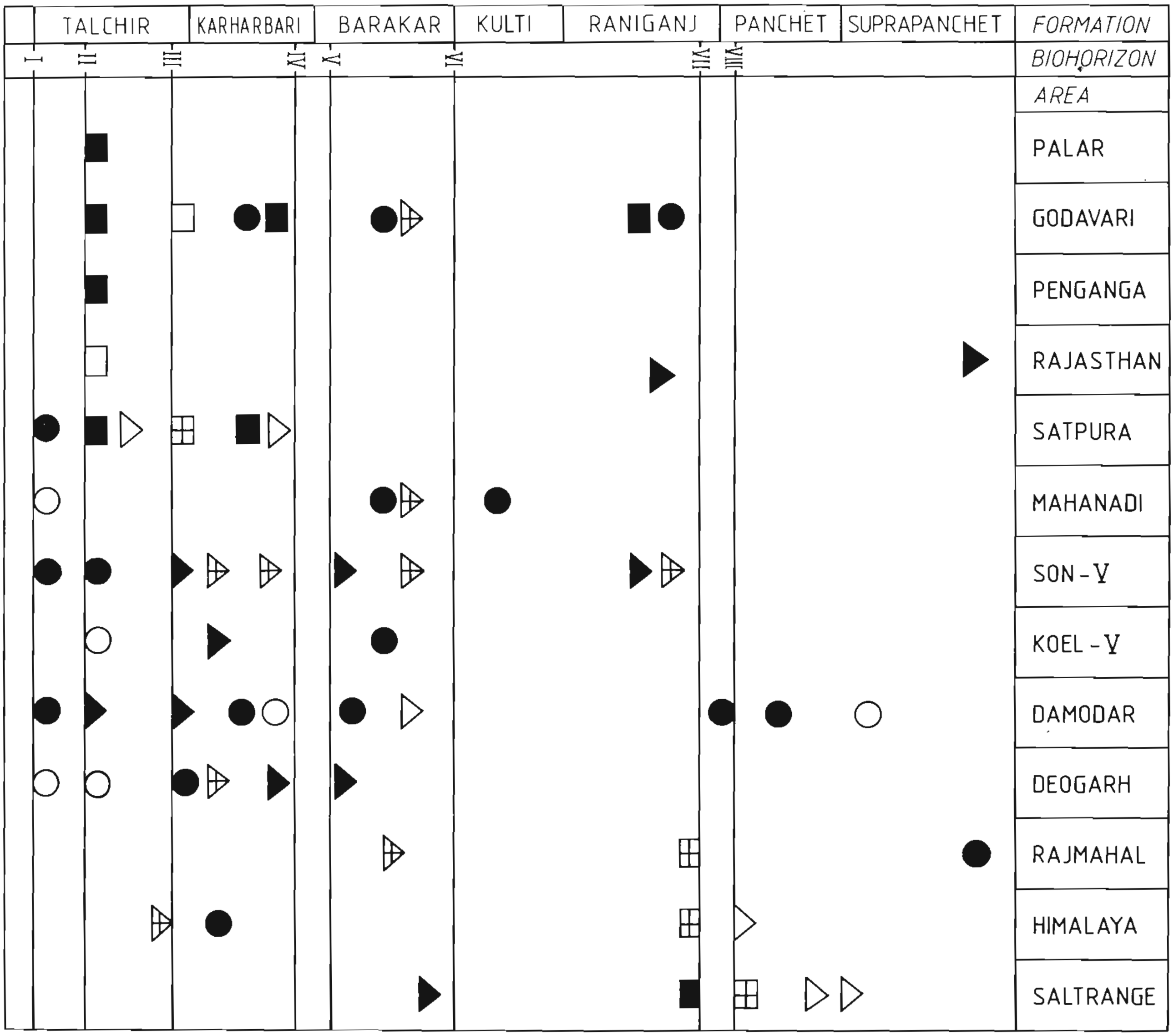
Fenestella fauna (Sastry *et al.*, 1977) from different levels of Talchir Formation in association with OMIDOs is on record. The invertebrate fossils indicate definite marine environment. Sedimentological evidences also favour for a wide-spread marine incursion during Talchir (Casshyap & Tewari, 1988). In Koel-Damoder Valley, shore-ward, the distal or deltaic facies with bioturbation is preserved in Daltonganj Coalfield which evidences for a Pre-Karharbari (Asselian) marine transgression in this region (Niyogi, 1987). Similarly, Chaudhuri (1988) has argued for a marine influence in Hutar Coalfield on the basis of sedimentary features, such as wave ripple, bedding-lamination and a probable (?) evidence of coccolith and foraminiferal fauna. Moreover, the oldest Talchir sedimentaries marked by olive green colour reflect mixed facies of glacio-fluvial and shallow marine to tidal flat environment (Niyogi, 1987).



Text-figure 10 — Illustrates scattered and a less diversified nature of OMIDOs assemblage in Dubrajpur Formation. For symbols, see the legend in Text-figure 2.

In the assemblages from Early Talchir deposits, the 'vase-shaped' chitinous bodies (could be *Tympanicysta*) have been recorded from the Talchir Formation (Tiwari *et al.*, 1981, 1987), but their occurrence has been doubted to be as reworked from older horizons. However, as there is no sign of reworking in the total palynoflora, such bodies can be accepted as the *in-situ* components. Likewise, sponge spicules are also on record from Daltonganj (Lele & Srivastava, 1974) and Bokaro coalfields (Banerjee & Das, 1983).

A sudden decline in the occurrence of OMIDOs is observed in the Upper Karharbari and the Lower Barakar formations (Text-figures 11, 12). The re-occurrence of older forms in the Mid-Upper Barakar sequence is recorded in most of the basins (Text-figure 11). In the Barakar Formation, record of *Tetraporina* (Banerjee & D'Rozario, 1988) and *Veryhachium* (present observations) is significant. Additionally, Leiospharids are the most common constituents of the OMIDOs assemblage at this level (Tables 5, 6). Presence of the former two forms in typical marine assemblages (Lukose & Misra, 1980; Sarjeant, 1970; Tappan, 1980) reinforces their significance as indicator of marine environment. Banerjee and Das (1983) have discussed the palaeoenvironment of Barakar Sequence in the West Bokaro Coalfield on the basis of sponge-spicule-like microcrystals. Thus varying degree of salinity could have been experienced at this level. The geochemical signatures of high organic sulphur in Wardha Valley Coalfield (Rao *et al.*, 1993) and high boron in coal further provides evidences for the near-shore environment (Anon, 1986). De (1993) has proposed minor marine events in the Barakar Formation in Hazaribagh District on the basis of skolithos ichnofacies.

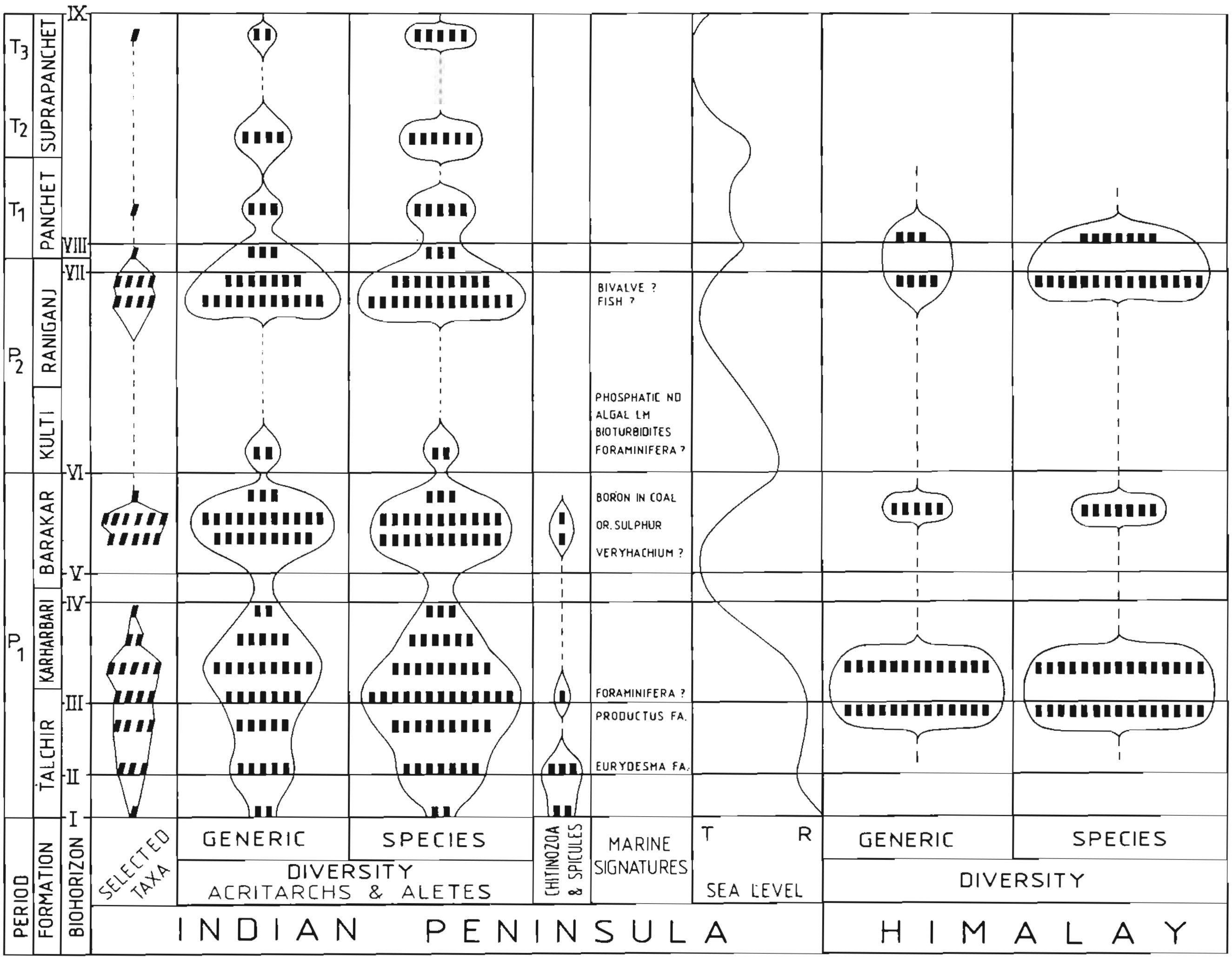


Text-figure 11 — Shows relative diversity within the OMIDOs assemblage in different areas on peninsular India and Himalayan sediments through Permian and Triassic sequences. The oldest biohorizon exhibits a non-diversified nature, which gets progressively varied in subsequent horizons.

Late Permian

The records of OMIDOs in Kulti Formation are not many (Text-figure 11). The presence of limestones and report of foraminifera in Pench-Kanhan in Motur Formation, equivalent to Kulti Formation, could be taken as probable signatures of increased salinity; so also the phosphatic bed and bioturbidites in Ib-River Coalfield. For the phosphatic nodule formation, however, an euxigenic environment could as well be suggested.

In the Upper Raniganj Formation the OMIDOs assemblages having fairly high generic diversity with common to abundant occurrences in some basins, have been recorded (Text-figure 11). Subgroups — Schizomorphitae and Herkomorphitae are the main constituents of the assemblage. The findings of fish scales and bivalves (Chandra & Betekhina, 1990; Chandra, 1994) at this level prompt for further search of such fossils in other areas.



Text-figure 12 — Composite figure to evaluate the present state of knowledge in the variation of acritarch, scattered marine signatures and sea level changes. Selected taxa are figured separately to bring out a compact configuration. For comparison the data from Himalayan sediments also compiled (Sea level changes adapted after Hallam, 1989). The solid bars represent the number of taxa present at different levels indicating qualitative diversity. Selected taxa comprise those given in conclusion.

The morphological characteristic of estheriids also indicates an adaptation for the increased salinity during the Late Permian (Ghosh, 1993), although estheriids primarily thrive in terrestrial environment. The reports of brackish water myalinid fauna within the Raniganj Formation evidences for the high palaeo-salinity during their deposition (Anon, 1986).

Triassic

In the Early Triassic Panchet Formation the OMIDOs are rare. No other independent record of marine signature is known. In the Dubrajpur Formation, Rajmahal Basin the OMIDOs assemblage is less diversified and poorly represented. At this level, too, presently there is no record of other marine signature.

CONCLUSIONS

It is concluded that through the Permian and Triassic sequences, the OMIDOs reveal a set pattern of their distribution. From amongst the enlisted taxa under the Group Acritarcha, some of the characteristic forms at each level of their abundance (Text-

12) are : (i) Talchir and Karharbari formations - Epibole I having *Leiosphaeridia, Foveofusa, Dictyotidium, Tasmanites,* (ii) Barakar Formation - Epibole II includes *Hemisphaerium, Singraulipollenites, Hindisporis, Peltacystia, Brazilea, Balmeella, Veryhachium, Tetraporina* and Type A; and in (iii) Raniganj Formation-Epibole III, the same group of OMIDOs continued with species diversity.

The qualitative distribution of the OMIDOs along the temporal scale suggests a non-diversified state of morphology at the Early Permian Talchir Formation — the oldest level. Subsequently, three major diversity acme zones have been observed, i.e., the Talchir/Karharbari, Mid-Upper Barakar and the Raniganj formations. These epiboles broadly coincide with the beginning of regressive phases in the sea level (Text-figure 12).

Scattered marine signatures, though feeble at the present state of knowledge, corroborate a possibility of acritarchs being good indicators of brackish water, deltoid region and closed water bodies with increased salinity (Table 7).

The salinity in certain area of the mega-drainage system during Lower Gondwana time could have increased during transgressive phases, particularly at distal region of the channels. The theory of closed huge-lakes formed from time to time during Lower Gondwana (Niyogi, 1987), could explain the rise in salinity in some areas on Indian Peninsula. The present study contributes to the idea that the peninsular India during Lower Gondwana period had experienced marine environment of various degrees, from time to time through its span. The OMIDOs are good indicators for marine signature, if evaluated in conjunction with other components of the environmental system.

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REFERENCES

Acharyya SK, Ghosh SC, Ghosh RN & Shah SC 1975. The continental Gondwana Group and associated marine sequence of Arunachal Pradesh (NEFA), eastern Himalaya. *Him. Geol.* **5** : 60-82.

Ahmed GU & Gyanchand 1994. Biostratigraphy of Barren Measures Formation, Raniganj Coalfield and its palaeoenvironment. *9th Int. Gondw. Symp., Hyderabad* : **59** (Abstract).

Anand-Prakash 1972. Sporae dispersae in the coals of Pench-Kanhan and Pathakhera Coalfield (M.P.), India. *Palaeobotanist* **19** : 206-210.

Anand-Prakash & Srivastava SC 1984. Miofloral studies of the Lower Gondwana sediments in Johilla Coalfield, Madhya Pradesh, India. *Palaeobotanist* **32** : 243-252.

Anand-Prakash, Srivastava SC & Tiwari RS 1979. The nature of grooved pavement and palynology of overlying Talchir and Karharbari sediments in West Bokaro Coalfield, Bihar, India. *Palaeobotanist* **26** : 63-71

Anon 1986. Permian palaeogeography of Gondwana basins of India. *Coal Wing News, geol. Surv. India* **6** (2) : 8.

Balme BE 1970. Palynology of Permian and Triassic strata in the Salt Range and Surghar Range, West Pakistan. *In* Kummel B & Teichert C (Editors) — *Stratigraphic Boundary Problems : Permian and Triassic of West Pakistan. Spec Publs* **4** : 305-454. University of Kansas, Department of Geology.

Banerjee M 1988. Karharbari : A formation or biozone. *Palaeobotanist* **36** : 37-50.

Banerjee M 1994. Palaeobiology and environment of deposition of Lower Gondwana sediments of Saharjuri Basin, Deoghar Group of coalfields, Bihar, India. *9th Int. Symp. Gondw., Hyderabad* : **59** (Abstract).

Banerjee M & Das S 1983. Occurrence of microspore megaspore assemblage alongwith fungal spores, acritarchs and some microcrystals from West Bokaro Coalfield. *V Indian geophytol. Conf., Lucknow* : 11 (Abstract).

Banerjee M & D'Rozario A 1988. Palynostratigraphy and environment of deposition in the Lower Gondwana sediments of Chuperbhita Coalfield, Rajmahal Hills. *J palaeont. Soc. India* **33** : 73-90.

Banerjee M & D'Rozario A 1990. Palynostratigraphic correlation of Lower Gondwana sediments in the Chuperbhita and Hura basins, Rajmahal Hills, eastern India. *Rev. Palaeobot. Palynol.* **65** : 239-256.

Bharadwaj DC & Anand-Prakash 1972. On the palynostratigraphy of Argada 'S' seam, South Karanpura Coalfield, Bihar. *Palaeobotanist* **19** : 211-213.

Bharadwaj DC & Anand-Prakash 1974 Palynostratigraphy of Lower Gondwana sediments from Umrer Quarry, Nagpur, Maharashtra, India. *Geophytology* **4** : 130-134

Bharadwaj DC & Dwivedi A 1981. Sporae dispersae of the Barakar sediments from South Karanpura Coalfield, Bihar, India. *Palaeobotanist* **27** : 21-94.

Bharadwaj DC, Navale GKB & Anand-Prakash 1974. Palynostratigraphy and petrology of Lower Gondwana coals in Pench-Kanhan Coalfield, Satpura Gondwana Basin, M.P., India. *Geophytology* **4** : 7-24.

Bharadwaj DC & Sinha V 1969. Sporological succession and age of Jhingurdah seam, Singrauli Coalfield, M.P., India. *Palaeobotanist* **17** : 275-287.

Bharadwaj DC & Srivastava SC 1970. Sporological correlation of coal seams in Bisrampur Coalfield, M.P., India. *Palaeobotanist* **8** : 87-94.

Bharadwaj DC & Srivastava SC 1973. Subsurface palynological succession in Korba Coalfield, M.P., India. *Palaeobotanist* **20** : 137-151.

Bharadwaj DC, Srivastava SC & Anand-Prakash 1979. Palynostratigraphy of the Talchir Formation from Manendragarh, M.P., India. *Geophytology* **8** 215-225.

Bharadwaj DC, Tiwari RS & Anand-Prakash 1978. A Talchir mioflora from the northern Satpura Basin, India. *Palaeobotanist* **25** : 62-69.

Bharadwaj DC, Tiwari RS & Anand-Prakash 1979. Permo-Triassic palynostratigraphy and lithological characteristics in Damodar Basin, India. *Biol. Mem* **4**(1 & 2) : 49-82.

Casshyap SM & Arora M 1994. Lithofacies analysis of Late Palaeozoic Talchir Formation in the northern parts of Son- Satpura Gondwana basins, M.P., India : Their implications in reconstruction of palaeoenvironment. *9th Int. Gondw. Symp., Hyderabad*: **54** (Abstract).

Casshyap SM & Tewari RC 1984. Fluvial models of the Lower Permian coal measures of Son-Mahanadi and Koel-Damodar Valley basins, India. *In* Rahmani RA & Flores RM (Editors)— *Sedimentology of coal and coal-bearing sequence (Spec. Publ., Int. Assoc. sediment.)* **7** : 121-147.

Casshyap SM & Tewari RC 1988. Depositional model and tectonic evolution of Gondwana Basin. *Palaeobotanist* **36** : 59- 66.

Chandra A & Lele KM 1979. Talchir miofloras from South Rewa Gondwana Basin, India and their biostratigraphical significance. *Proc. IV Int. Palynol. Conf., Lucknow (1976-77)* **2** : 117-157. Birbal Sahni Institute of Palaeobotany, Lucknow.

Chandra A & Srivastava AK 1986. Palynological studies of coal measures in South Rewa Gondwana Basin and their biostratigraphical significance. *Palaeobotanist* **35** : 85-92.

Chandra S & Betekhina OA 1990. Bivalves in the Indian Gondwana Coal Measures. *Indian J. Geol.* **62** : 18-26.

Chandra SK 1994. Marine signatures in the Gondwanas of peninsular India and Permian palaeogeography. *9th Int. Gondw. Symp., Hyderabad*: 61 (Abstract).

Chaudhuri S 1988. Marine influence in Hutar Coalfield, Bihar *Palaeobotanist* **36** : 30-36.

Chaudhuri S & Mukhopadhyay SK 1994. Palaeoenvironment of Raniganj Formation of a part of Damodar Valley and its significance in reconstruction of Lower Gondwana palaeogeography. *9th Int. Gondw. Symp., Hyderabad*: 58 (Abstract).

Davey RJ 1970. Non calcareous microplankton from the Cenomanian of England, northern France and North America. Part II. *Bull. Br. Mus. Nat. Hist. (Geology)* **18** : 333-397.

De C 1993. Skolithos ichnofacies in the Barakar Formation from Hazaribagh, India and its fine resolution in depositional and ecological significance. *Gondwana Geol. Mag.* (Spec. Vol.) : 512-521

Dorning KJ 1981. Silurian acritarch distribution in the Ludvian Shelf sea of South Wales and the Welsh Borderland. *In* Neale & Brasier (Editors) — *Microfossils from recent and fossil shelf seas*: 31-36. Ellis Horwood Ltd., England.

Dorning KJ 1982. Early Wenlock acritarchs from the Knockgardner and Straiton Grit formations of Knockgardner, Ayrshire. *Scott. J. Geol.* **18** : 267-273.

Downie C 1979. Devonian acritarchs. *Palaeontology* **23** : 185-188.

D'Rozario A & Banerjee M 1987. Palynostratigraphy and environment of deposition of Lower Gondwana sediments of Hura Coalfield, Rajmahal Hills. *VII Indian geophytol. Conf., Lucknow* (late Abstract).

Dutt AB & De B 1994. Advances in palaeoenvironmental studies on Lower Gondwana sediments in peninsular India. *9th Int. Gondw. Symp., Hyderabad* · 53 (Abstract).

Dutta SK, Srivastava SC & Gogoi D 1988. Palynology of Permian sediments in Kameng District, Arunachal Pradesh. *Geophytology* **18** : 53-61.

Foster CB 1974. Stratigraphy and palaeopalynology of the Permian at Waterloo Bay Yorke Peninsula, South Australia. *Trans. R. Soc. S. Aust.* **98**(1) : 29-42.

Ghosh S 1993. Estheriids Niche and Gondwana palaeogeography. *Gondwana Geol. Mag.* (Spec. Vol.) : 479-490.

Gray J & Boucot AJ 1972. Palynological evidence bearing on the Ordovician-Silurian paraconformity in Ohio. *Bull. geol. Soc. Am.* **83** : 1299-1314.

Guha PKS, Mukhopadhyay SK & Das RN 1994. Trace fossils as indicator of palaeoenvironment of Talchir Formation in Raniganj and Deogarh Group of coalfields, India. *9th Int Gondw. Symp. Hyderabad*: 55 (Abstract)

Hallam A 1989. The case for sea-level change as a dominant casual factor in mass extinction of marine vertebrates. *In* Chaloner WG & Hallam A (Editors) — *Proc. Symp. Evolution and Extinction.* : 197-215. The Royal Society, London.

Jacobson SR 1979. Acritarchs as palaeoenvironmental indicators in Middle and Upper Ordovician rocks from Kentucky, Ohio and New York. *J. Palaeont.* **53** : 1197-1212.

Jacobson SR, Wardlaw BR & Saxton JD 1982. Acritarchs from the Phosphoria and Park City formations (Permian, Northern Utah). *J. Palaeont* **56**(2) : 449-458.

Lele KM 1975. Studies in the Talchir flora of India-10. Early and Late Talchir microfloras from the West Bokaro Coalfield, Bihar. *Palaeobotanist* **22** 219-235.

Lele KM 1984. Studies in the Talchir flora of India-12. Basal Talchir palynofossils from the Penganga Valley and their biostratigraphic value. *In* Sharma *et al.* (Editors) — *Evolutionary botany and biostratigraphy.* A.K. Ghosh Commemoration Volume : 267-283. Today Tomorrow's Printers & Publishers, New Delhi.

Lele KM & Chandra A 1972. Palynology of the marine intercalations in the Lower Gondwana of Madhya Pradesh, India. *Palaeobotanist* **19** : 253-262.

Lele KM & Karim R 1971. Studies in the Talchir flora of India- 6. Palynology of the Talchir boulder bed intercalation in the Jayanti Coalfield, Bihar. *Palaeobotanist* **19** : 52-69.

Lele KM & Kulkarni S 1969. Two miospore assemblages from the Argada sector, South Karanpura Coalfield, Bihar with remarks on their probable age. *Palaeobotanist* **17** : 288-294.

Lele KM & Makada R 1972. Studies in the Talchir flora of India-7. Palynology of the Talchir in the Jayanti Coalfield. *Geophytology* **2** : 41-73.

Lele KM & Makada R 1974. Palaeobotanical evidences on the age of the coal-bearing Lower Gondwana Formation in the Jayanti Coalfield, Bihar. *Palaeobotanist* **21** 81-106.

Lele KM & Shukla M 1980. Studies in the Talchir flora of India- 12. Palynology of the Talchir Formation of Hutar Coalfield, Bihar. *Geophytology* **10** : 231-238.

Lele KM & Srivastava AK 1974. Spicule-like microfossils from the Talchir Formation, Daltonganj Coalfield, Bihar. *Geophytology* **4** : 25-34.

Lele KM & Srivastava AK 1980. Lower Gondwana (Karharbari to Raniganj

Stage) miofloral assemblages from the Auranga Coalfield and their stratigraphical significance. *Proc. IV. Int. palynol. Conf., Lucknow (1976-77)* **2** : 152-164. Birbal Sahni Institute of Palaeobotany, Lucknow.

Lukose NG & Misra CM 1980. Palynology of Pre-Lathi sediments (Permo-Triassic) of Shumarwali Talai structure, Jaisalmer, western Rajasthan, India. *Proc. IV Int. palynol. Conf., Lucknow (1976-77)* **2** :. 219-227. Birbal Sahni Institute of Palaeobotany, Lucknow.

Maheshwari HK 1967 Studies in the Glossopteris flora of India- 29. Miospore assemblage from the Lower Gondwana exposures along Bansloi River in Rajmahal hills, Bihar. *Palaeobotanist* **15** : 258- 280.

Nautiyal AC 1975. Report of microplanktons in the Lower Triassic rocks of Pahlgam. *Curr. Sci.* **44** : 833-834.

Niyogi BN 1987. Evolutionary scenario of Lower Gondwana coal basins of peninsular India. *In* Singh RM (Editor) — *Proc. natn. Sem. Coal Res. India* : 14-29. Dept. Geology, Banaras Hindu University, Varanasi.

Pal AK, Sen MK, Ghosh RN & Das SN 1994. Marine incursions during Gondwana sedimentation in Damodar Valley basins, eastern India. *9th Int. Gondw. Symp., Hyderabad* : 63 (Abstract).

Pant DD & Singh R 1991. Possible fossil Sporae dispersae of Hepaticae and Anthocerotales in the fossil record. *Palaeobotanist* **39** : 20-36.

Potonié R & Lele KM 1961 Studies in Talchir flora of India-1. Sporae dispersae from the Talchir beds of South Rewa Gondwana Basin. *Palaeobotanist* **8** : 22-37

Prauss M & Riegel W 1989. Evidence from phytoplankton associations for causes of black shale formation in epicontinental seas. *N. Jb. geol. Palaont. Mh.* **11** : 671-682.

Rao KS, Menon R, Joshi AR, Khanwalkar SR & Meshram RM 1993. Studies in the distribution pattern of sulphur in high sulphur Lower Gondwana coals in the western part of the Wardha Valley Coalfield. *Gondwana Geol. Mag.* (Spec. Vol.) : 321-331

Rawat MS 1984. Palynological studies of Jatraj seam, Korba Coalfield, M.P., India. *Geophytology* **14** : 228-234.

Rawat MS & Jain AK 1985. Marine Leiosphaerids and associated palynofossils from the Talchir Formation of Pranhita Godavari Graben. *Petroleum Asia Jour.* **8**(2) : 168-173.

Sarate OS 1985. A Karharbari mioflora from the Kamptee Coalfield, Maharashtra State, India. *Geophytology* **15** : 227-230.

Sarate OS 1986. Palynological correlation of the coal seams of Pathakhera Coalfield, Madhya Pradesh, India. *Geophytology* **16** : 239-248.

Sarjeant WAS 1970. Acritarchs and Tasmanitids from the Chhidru Formation, uppermost Permian of West Pakistan. *In* Kummel B & Teichert C (Editors) — *Stratigraphic boundary problems : Permian and Triassic of West Pakistan* (Spec. Publ.) **48** : 270-304. Univ. Press, Kansas.

Sastry MVA, Acharyya SK, Shah SC, Satsangi PP, Ghosh SC, Raha PK, Singh G & Ghosh RN 1977. Stratigraphic lexicon of Gondwana formations of India. *Geol. Surv. India Misc. Publ.* no. **36** : 1-170.

Shukla M 1983. Lithostratigraphy and palynostratigraphy of the Lower Gondwana formations of the Hutar Coalfield, Palamau District, Bihar, India. *Palaeobotanist* **31** : 176-190.

Singh T 1987. Palaeoclimatic significance of fauna and mioflora of the Garu Formation (Permian), Arunachal Pradesh, eastern Himalaya. *Am. geophysical Union* : 191-194.

Sinha V 1969. Some "Acritarchs" and other microfossils from Barakar Stage of Lower Gondwana, India. *Palaeobotanist* **17** : 326-331

Srivastava SC 1973a. Palynostratigraphy of the Giridih Coalfield. *Geophytology* **3** : 184-194.

Srivastava SC 1973b. Talchir mioflora from Korba Coalfield, M.P., India. *Geophytology* **3** : 102-105.

Srivastava SC 1984. Palynological succession in Lower Gondwana sediments in a bore hole, Talcher Coalfield, Orissa, India. *In* Tiwari RS *et al.* (Editors) — *Proc. V Geophytol. Conf., Lucknow (1983)* (Spec. Publ.) : 119-128.

Srivastava SC 1987. Palynological correlation of coal seams in Godavari Graben, Andhra Pradesh, India. *Palaeobotanist* **35** : 281-296.

Srivastava SC & Anand-Prakash 1973. Palynological studies in Auranga Coalfield. *Geophytology* **3** : 106-110.

Srivastava SC & Anand-Prakash 1984. Palynological succession of the Lower Gondwana sediments of Umaria Coalfield, Madhya Pradesh, India. *Palaeobotanist* **32** : 26-34.

Srivastava SC, Anand-Prakash & Sarate OS 1989. Palynology of Talchir Formation from Betul Coalfield, Satpura Basin, India. *Palaeobotanist* **37** : 81-84.

Srivastava SC, Anand-Prakash & Singh T 1988. Permian palynofossils from the eastern Himalaya and their genetic relationship. *Palaeobotanist* **36** : 326-338.

Srivastava SC & Dutta SK 1977. An note on the palynology of the Gondwana in Siang District, Arunachal Pradesh. *Geophytology* **7** : 281-283

Srivastava SC & Jha N 1987. Palynology of Kamthi Formation from Chelpur area, Godavari Graben, Andhra Pradesh, India. *Palaeobotanist* **35** . 342-346.

Srivastava SC & Jha N 1992a. Palynological dating of coal seams in Amavaram area, Khammam District, A.P., India. *Geophytology* **20** : 161.

Srivastava SC & Jha N 1992b. Palynostratigraphy of Permian sediments in Manuguru area, Godavari Graben, Andhra Pradesh. *Geophytology* **22** : 103-110.

Srivastava SC & Jha N 1993. Palynostratigraphy of Lower Gondwana sediments in Chintalpudi Sub-basin, Godavari Graben, Andhra Pradesh, India. *Geophytology* **23**(1): 93-98.

Srivastava SC & Sarate OS 1989. Palynostratigraphy of Lower Gondwana sediments from Shobhapur Block, Pathakhera Coalfield, Madhya Pradesh. *Palaeobotanist* **37** : 125-133.

Tappan H 1980. *The palaeobiology of plant Protists*. Freeman, Oxford.

Tiwari RS 1965. Miospore assemblage in some coals of Barakar Stage (Lower Gondwana) of India. *Palaeobotanist* **13** : 168-214.

Tiwari RS 1969. Sporological succession in Purewa Seam, Singrauli Coalfield (M.P.). *J. Sen Mem. Vol*: 93-100. Bot. Soc. Bengal, Calcutta.

Tiwari RS 1973. Palynological succession in the Barakar type area. *Geophytology* **3** : 166-194.

Tiwari RS & Moiz AA 1971 Palynological study of Lower Gondwana (Permian) coals from Godavari Basin, India-1. On some new miospore genera. *Palaeobotanist* **19** : 95-104.

Tiwari RS & Ram-Awatar 1986. Late Permian palynofossils from the Pali Formation, South Rewa Basin, Madhya Pradesh. *Bull. geol. Min. metall. Soc. India* **54** : 250-255.

Tiwari RS & Ram-Awatar 1987. Palynostratigraphic studies of sub-surface Supra-Barakar sediments from Korar Coalfield, Son Valley, Madhya Pradesh. *Geophytology* **17** : 256-264.

Tiwari RS & Ram-Awatar 1990. Palyno-dating of Nidpur beds, Son Graben, Madhya Pradesh. *Palaeobotanist* **38** : 105-121.

Tiwari RS & Rana Vijaya 1980. A Middle Triassic mioflora of India. *Biol.*

Mem. **5**(1) : 30-55.

Tiwari RS & Rana Vijaya 1981. Sporae dispersae of some Lower and Middle Triassic sediments from Damodar Basin, India. *Palaeobotanist* **27** : 190-220.

Tiwari RS & Srivastava SC 1984. Palynological dating of Jhingurdah Seam, Singrauli Coalfield : A reappraisal. *Palaeobotanist* **31** : 263-269.

Tiwari RS, Srivastava SC, Tripathi A & Singh Vijaya 1981. Palynostrati-graphy of Lower Gondwana sediments in Jharia Coalfield, Bihar *Geophytology* **11** : 220-237.

Tiwari RS, Tripathi A, Dutta AB & Mukhopadhyay A 1987. Palynological dating of olive-green shales underlying the Athgarh Sandstone in Mahanadi Basin. *Curr. Sci.* **56** : 1150- 1153.

Traverse A 1988. *Palaeopalynology.* Unwin Hyman Ltd., London.

Tripathi A 1993. Palynosequence in subsurface Permian sediments in Talcher Coalfield, Orissa, India. *Geophytology* **23** : 99-106.

Tripathi A, Tiwari RS & Kumar P 1990. Sporae dispersae and their distributional pattern in subsurface Mesozoic sediments of Rajmahal Basin, India. *Palaeobotanist* **37** : 367-388.

Venkatachala BS & Rawat MS 1973. Occurrence of Permian palynofossils in the Chingleput area, Palar Basin. *Bull Oil Natural Gas Commn* **10** : 105-108.

Venkatachala BS & Rawat MS 1984. Palynofossils from Bap Formation, Rajasthan, India. *Bull. Oil Natural Gas Commn* **21** : 61-68.

Venkatachala BS & Tiwari RS 1988. Lower Gondwana marine incursion periods and pathways. *Palaeobotanist* **36** : 24-29.

Vijaya & Tiwari RS 1992. Morpho-evolutionary biohorizon stratigraphy and cladistics in saccate pollen through Gondwana sequence of India. *Palaeobotanist* **40** : 157-193.

Wall D 1965. Microplankton, pollen and spores from the Lower Jurassic in Britain. *Micropalaeontology* **11** : 151- 190.

Wicander R & Playford G 1985. Acritarchs and spores from the Upper Devonian Lime Creek Formation, IOWA, U.S.A. *Micropalaeontology* **31**(2) : 97-138.

Wright RP & Meyers WC 1981 Organic-walled microplankton in the sub-surface Ordovician of north-eastern Kansas. *Kansas Geol. Surv. Subsurface Geol.* ser. **4** 1-32.