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PERMIAN PALYNOLOGY FROM INDIA AND AFRICA - A PHYTOGEOGRAPHICAL PARADIGM

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ABSTRACT

A comparison of Permian palynoflora of India and Africa has been attempted to interpret phytogeographic provincialism in Gondwana. Megafloral records from different Gondwana continents reflect a single large phytogeographic province during Permian time, wherein *Glossopteris* was the most characteristic element that dominated the vegetation. However, the analysis of palynological records from the Gondwana continents suggests that this floristic uniformity was more apparent than real. There are differences within the region. The palynological uniformity is much pronounced during the Early Permian, whereas the differences are more striking during the Late Permian.

A close similarity between India (Godavari and Satpura basins) and south-eastern half of Africa has been visualised during Late Permian on the basis of palynological records. Indian palynosequences are interestingly parallel to that of Africa rather than that of Australia. The *Guttulapollenites* palaeophytogeographic province has been recognised in central part of Gondwanaland extending from the Salt Range (Pakistan) in the north to the Amery Basin (Antarctica) in the south, Satpura–Godavari basins (India) in the east to Mid-Zambesi–Luangawa valley (Africa) in the west.

Key words: Gondwana, Palynology, Permian, India, Africa, Phytogeographic Provincialism

INTRODUCTION

Although India and Africa are now widely separated by Indian Ocean, for much of the Phanerozoic time they formed the heartland of the ancient supercontinent – Gondwana, which existed during Late Carboniferous to Early Cretaceous time, comprising the present-day South America, Africa, Malagasy, India including Sri Lanka, Antarctica and Australia.

During Permian time, India was flanked on its western margin by Africa along with Malagasy, while the eastern margin was juxtaposed with East Antarctica. The northern margin of India was bordered by Tethys sea and 40° - 60° south latitude included peninsular India, southeastern part of Africa (South Africa, Zimbabwe, Zambia, Tanzania) and Malagasy. The Gondwana continents were uniformly characterised by the presence of *Glossopteris* flora during the Permian. However, the palynological records gathered from India and Africa tend to show a differential distribution within the *Glossopteris* dominant vegetation of Gondwana. There is a compelling evidence that a number of morphologically distinctive form genera are restricted to parts of Gondwana rather than having a distribution that coincides with that of *Glossopteris* (Jha and Srivastava, 1996). High incidence of *Guttulapollenites* was first recorded from the Sakamena Group of the Morondava Basin in Malagasy (Goubin, 1965) and then in the Bijori Formation of the Satpura Basin, India by Bharadwaj *et al.* (1978). Later, when this assemblage was also recorded in Godavari Graben (Srivastava and Jha, 1990) its occurrence in adjacent Gondwana continents was analysed (Jha and Srivastava, 1996). A comparative analysis of Permian palynoassemblages of India and Africa was carried out in detail and *Guttulapollenites* phytogeographic province was recognized within *Glossopteris* dominated Gondwana floral province.

INDIA

Permian (Lower Gondwana) Lithostratigraphic sequence

In India, the Permian deposits occur in peninsular as well as extra-peninsular regions. In the peninsular part, these deposits occur in a triangular pattern distributed along four major river valleys, *viz.* Damodar, Son-Mahanadi, Wardha-Godavari and the Satpura Basin (Fig. 1). In the extra-peninsular region, the Permian sediments occur in Kashmir-Zanskar-Spiti of Jammu and Kashmir in the northwest (Western Himalava) and Darjeeling-Sikkim-Bhutan-Arunachal Pradesh, Assam and Meghalaya in the northeast India (Eastern Himalaya).

The Permian (Lower Gondwana) sediments mostly rest directly on the Archean basement rocks, although in some localities they overlie the Vindhyan Super Group (Proterozoic).

The generalised Lower Gondwana (Permian) stratigraphic sequence is given in Table 1. The oldest, and also the lowermost unit, in order of superposition, is the Talchir Formation, which is characterised by boulder bed, greenish sandstone, khaki green shale, varve and rhythmite of glacial origin. The overlying Karharbari and Barakar formations are the Lower Coal-bearing horizons of the Early Permian age, while the

Table1: Generalised Lower Gondwana (Permian) stratigraphic succession in India.

Age			Formation	
250 my	P	L A T E	RANIGANJ	Upper Coal Measures
	E R M		BARREN MEASURES/ KULTI	Non coal zone
	I	E A R L Y	BARAKAR	Lower Coal Measures
	A		KARHARBARI	
290 my	N		TALCHIR	Glacial

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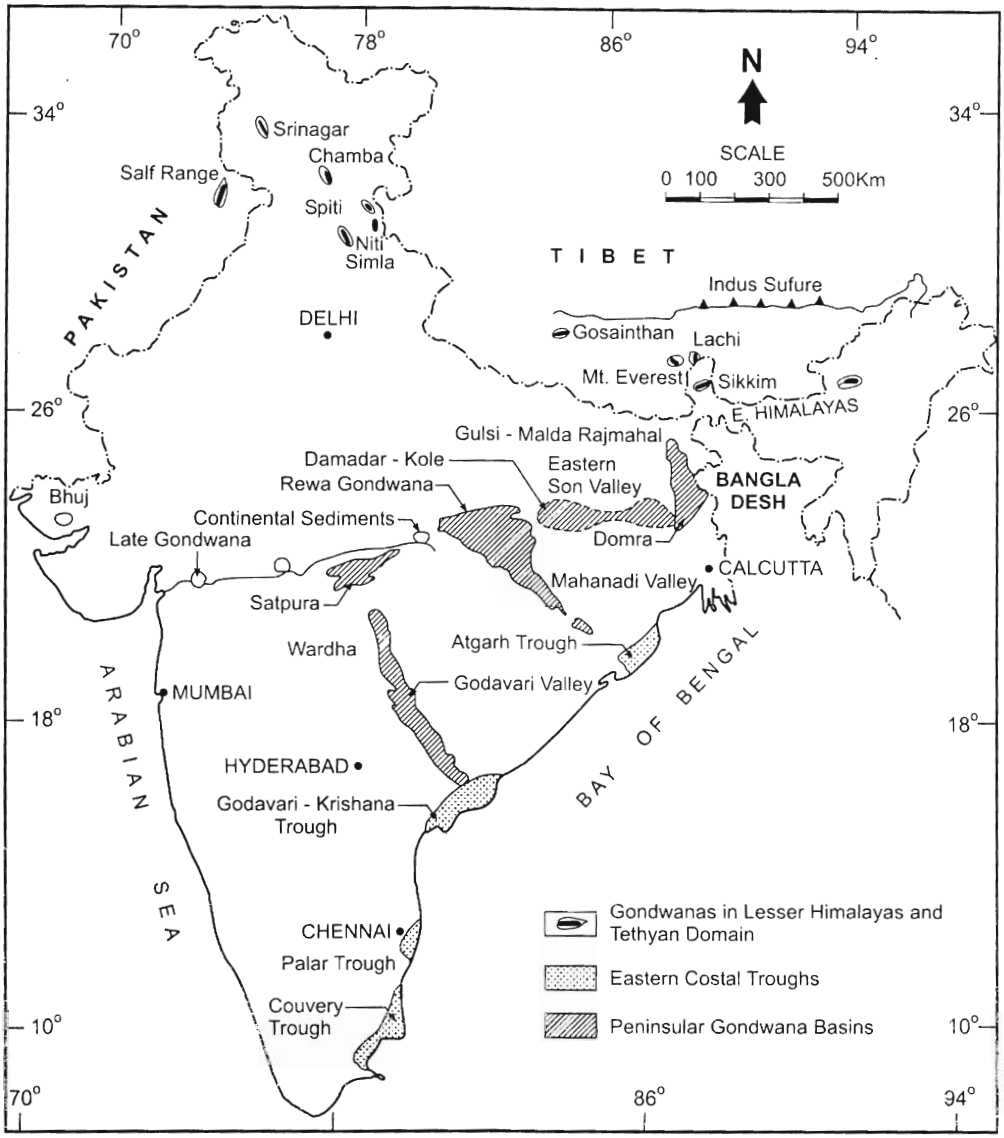

Fig. 1. Showing major river valleys in India during the Permian time.

Raniganj Formation includes the Upper Coal-bearing horizon of Late Permian age. In between these is the Kulti Formation (Barren Measures) characterised by ironstone shale and concretions and is devoid of workable coal seams.

Permian Palynosequences

The palynological succession in different basins of India during the Permian has been studied in detail and reviewed from time to time (Bharadwaj, 1970, 1971, 1975; Lele and Karim 1971; Srivastava, 1974, 1992; Lele and Srivastava, 1980; Tiwari and Ram Awatar, 1989; Srivastava *et al.*, 1989; Tiwari, 1974a; Tiwari *et al.*, 1991; Tiwari and Tripathi, 1992; Tripathi, 1993; Srivastava and Jha, 1989, 1990, 1992a and b; Jha and Srivastava, 1996). They have been summarised in Table 2, while the details of the Permian palynosequences of the Godavari Graben are presented in Table 3. The age connotation in the tables are tentative.

Inter-basinal comparison shows that palynofloral assemblages are more or less uniform during the Early Permian, whereas Late Permian ones exhibit differential distribution of a number of palynotaxa. Though, the Late Permian palynoassemblages show gross similarity in the dominance of striate disaccate pollen grains, yet differences exist such as the presence of some species in higher percentages. For example, the high incidence of *Guttulapollenites* in the Satpura and Godavari basins, the high percentage of *Striasulcites* in Godavari and Mahanadi basins, the recurrence of *Parasaccites* in high percentage during the Late Permian in Godavari and South Rewa basins. In addition, there is restricted presence of some species, viz. *Indospora* and *Dentatispora* in Damodar and their absence in Godavari, the presence of *Triquitrites, Iraquispora* in Late Permian sediments of Godavari and their absence in other basins. Thus, the differential distribution of these palynotaxa suggests that there was some variation in the vegetation growing in and around Damodar Valley and the Satpura-Wardha-Godavari valleys. A similar set of geophytological and palaeoenvironmental conditions during coalseam deposition in latter were suggested by Navale *et al.*, (1983) on the basis of petrological studies of coal and coal-bearing sediments of the Godavari Graben.

Table 2: Permian palynosequences in different basins of India.

AGE			FORMATION	ASSEMBLAGE	G	W	S	SR	M	D	R
PERMIAN	LATE	Lopingian	RANIGANJ	**14** *Striatopodocarpites+Corisaccites + Guttulapollenites*	*	*	*				
				13 *Striatopodocarpites + Crescentipollenites*	*	*	*		*	*	■
		Guadalupian		**12** Striate disaccates+ *Densipollenites*	*	*	*	*	*	*	
				11 Striate disaccates+ *Parasaccites*	*			*			
				10 *Faunipollenites+ Striasulcites*	*			*	*	♣	
				9 *Faunipollenites+ Striatopodocarpites*	*	*		*	*	*	*
		Roadian	BARREN MEASURES / KULTI	**8** Striate disaccates+ *Densipollenites*	*	*		*			*
	EARLY	Kungurian	BARAKAR	**7** Striate disaccates + *Scheuringipollenites*					*	*	
		Artinskian		**6** *Scheuringipollenites*+Striate disaccates	*	*	*	*	*	*	*
		Sakmarian		**5** Zonates+apiculate+monosaccates					*	*	
			KARHARBARI	**4** *Parasaccites+ Scheuringipollenites*	*	*	*	*		*	▲
				3 *Callumispora+Parasaccites*	*	*		*		*	
		Asselian	TALCHIR	**2** *Parasaccites+ Plicatipollenites*	*		*	*	*	*	
				1 Plicatipollenites+ *Parasaccites*	*	*	*	*			

■ indicates *Striatopodocarpites – Alisporites* Assemblage; ♣ indicates *Striatopodocarpites – Gondisporites* Assemblage; ▲ indicates *Potonieisporites- Scheuringipollenites* Assemblage, G - indicates Godavari Graben, W- Wardha Valley, S- Satpura Basin, SR- South Rewa Basin, M-Mahanadi Basin, D-Damodar Basin, R-Rajmahal Basin.

The Godavari Graben occupies a position that was almost parallel to Son-Mahanadi basins which in turn occupies a position at an angle with the general trend of the coalfields of the Damodar Basin. The Godavari Graben was separated from the Son-Mahanadi Basin by a SE highland, whereas the Son-Mahanadi and Damodar basins are separated by a highland called Fox Ridge (Bharadwaj, 1976). The differences in the palynofloras may be attributed to the presence of these physical barriers and also to latitudinal differences. The vegetation of a region is influenced by its geography, i.e. latitude, continentality and relief, all of which affect the climate.

AFRICA

Permian stratigraphic sequences

A simplified stratigraphy of important basins of southern Africa (after Visser, 1995) has been shown in Table 4. In the African continent, the Karoo System consists of an enormous thickness of both volcanic and freshwater sedimentary rocks, ranging in age from Carboniferous to Jurassic. Early Permian strata include the glacigene Dwyka Group (Late Carboniferous - Artinskian) as the lowermost unit of the Gondwana sequence, the coal-bearing Ecca Group (Artinskian-Roadian), and the arenaceous to argillaceous Lower Beaufort Group (Wordian to Permo-Triassic). The Lower Beaufort has been correlated with the Lower Kamthi (=Raniganj Formation of the Godavari Graben) by Kutty *et al.*(1988) on the basis of the *Endothiodon* and *Cistecephalus* fauna.

Permian Palynosequences of Africa and their comparison with India

A wealth of palynological information is available concerning the Permian of Africa, for example South Africa (Hart, 1960, 1965a,b, 1969; Anderson, 1977; Tiwari, 1974b; Macrae, 1988; Millsteed, 1994, 1997), Tanzania (Manum and Tien, 1973; Hankel, 1987; Maheshwari and Srivastava, 1984; Weiss in Wopfner and Kaaya, 1991; Weiss and Wopfner, 1997; Wescott *et al.*, 1991), Congo (Piérart, 1959; Hœg and Bose, 1960; Bose and Kar, 1966, 1967, 1976; Kar and Bose, 1967; Maheshwari and Bose, 1969; Bose and Maheshwari, 1966, 1968; Maheshwari, 1969), Zambia (Utting, 1976, 1978, 1979), Zimbabwe (Falcon, 1973, 1975; Chandra *et al.*, 1977), Kenya (Hankel, 1992) and Malagasy (Jekhowsky and Goubin, 1964; Goubin, 1964; Rakotoarivelo, 1971; Wright and Askin, 1987). The known palynoassemblages from southern part of the African continent are summarised in Table 5. While most of these contributions concern the Early Permian, some of them also contain detailed information about the Late Permian. Comparison of the palynoassemblages is easier where a similar taxonomic treatment has been used for different basins, but is difficult where the treatment is different.

SOUTH AFRICA

The four major palynofloristic zones proposed by Hart (1969) in South Africa are too generalised and much heterogenous for the purpose of correlation and they require revision.

Macrae (1988) has used concurrent range zones in South Africa whereas in the Indian literature assemblage zones have been used. Thus, when one tries to compare these biozones only a tentative correlation is possible. Tentatively, Biozone A with dominance of radial monosaccate pollen is comparable with the Talchir palynoassemblage of India. However, some of the Carboniferous taxa recorded in African Dwyka have never been recorded from the Indian Talchir palynoassemblages. A gradual change from monosaccate (*Parasaccites*) dominant assemblage to nonstriate and then striate dominant phase has been observed in Dwyka to Lower Beaufort assemblage of the Karoo Basin by Millsteed (1997) - a condition similar to Indian

Table 3: Palynocomposition of the Permian palynoassemblages in the Godavari Graben.

Palynoassemblage	Quantitatively Important taxa	Qualitatively significant taxa	Distribution in bore holes and mines	Palyno-zones	Age	
12. *Guttulapollenites* Assemblage	*Striatopodocarpites Guttulapollenites Corisaccites*	*Falcisporites, Ringosporites Osmundacidites, Triquitrites Iraquispora, Verrucosisporites Cyathidites, Concavissimisporites Playfordiaspora, Klausipollenites*	GAM-7; GRK-24, GRK-25; GJP-1; GM-4.	RARAKAR	LATE PERMIAN	LOPINGIAN
11.*Crescentipollenites* Assemblage	*Striatopodocarpites Crescentipollenites Columinisporites Faunipollenites*	*Lunatisporites, Falcisporites Densipollenites, Osmundacidites Kendosporites*	GBR-7 ; GAM-7			
10.*Densipollenites* Assemblage	*Striatopodocarpites Densipollenites Faunipollenites*	*Alisporites, Klausipollenites Falcisporites, Chordasporites Lunatisporites, Lundbladispora Vitreisporites Guttulapollenites* Leiosphaerids	GBR-7; GAM-7; GGK-27; GRK-24, GRK-25; GJP-11 ; GM4; S.C.Co. BORE CORE; BORE CORE 99; GS-4.			
9. *Parasaccites* Assemblage	*Striatopodocarpites Faunipollenites Parasaccites*	*Falcisporites, Vitreisporites Corisaccites Guttulapollenites*	GRK-25; GJ-6			
8. *Striasulcites* Assemblage	*Faunipollenites Striasulcites*	*Densipollenites, Weylandites Corisaccites Lundbladispora Falcisporites, Klausipollenites Vitreisporites, Guttulapollenites* Leiosphaerids	GGK-27; GM-3, GM-4, GM-5, GM-8; GSS-1, GS-1, GS-2,			GUADALUPIAN
7. *Faunipollenites Striatopodocarpites* Assemblage	*Faunipollenites Striatopodocarpites*	*Verticipollenites, Gondisporites Guttulapollenites, Falcisporites Hindipollenites Lundbladispora Crescentipollenites,Vitreisporites Lunatisporites, Hamiapollenites*	GBR-3; GAM-7; GRK-24; GGK-20, GGK-27; GM-3, GM-4, GM-8; GJ-3, GJ-6; GSS-1; GAG-1.			
6.Striate disaccates + *Densipollenites* Assemblage	*Faunipollenites Densipollenites Striatopodocarpites Scheuringipollenites*	------	GRK-1, GRK-24; GGK-20; GM-8, GM-3; GBR-5	Barren Measures	Roadian	
5. *Scheuringipollenites* Assemblage	*Scheuringipollenites Faunipollenites Striatopodocarpites*	*Primuspollenites, Brevitriletes Horriditriletes, Tiwariasporis Indotriradites, Rhizomaspora*	GBR-1, GBR-2 , GBR-3, GBR-5, GBR-6; ; GM-3GM-5, GM-8; TOP1 Seam-Kothagudam area; seam 1&2 Ramagundam area;Top seam-Belampalli area;GRK-1, GRK-24,GRK-25,GGK-20,GSS-1	BARAKAR	EARLY PERMIAN	ARTINSKIAN
4. *Parasaccites+ Scheuringipollenites* Assemblage	.*Parasaccites Scheuringipollenites*	*Brevitriletes, Jayantisporites Indotriradites, Callumispora Striatopodocarpites*	GBR-1, GBR-2, GBR-3; GBR-6; King Seam-Yellandu area; GGK-20; GRK-24; GAG-1.	UPPER Karharbari		
3. *Callumispora+ Parasaccites* Assemblage	*Callumispora Parasaccites*	*Scheuringipollenites Brevitriletes Indotriradites Faunipollenites Striatopodocarpites*	GBR-6; GRK-1; GRK-24; GAG-1	LOWER Karharbari		SAKMARIAN
2. *Parasaccites* Assemblage	*Parasaccites Plicatipollenites* Leiosphaerids	*Virkkipollenites, Caheniasaccites Divarisaccus, Potonieisporites Quadrisporites, Jayantisporites*	GBR-1; GBR-2; GRK-1; GM-8; GSS-1; GCH-4; GAG-1.	TALCHIR		ASSELIAN
1. *Plicatipollenites* Assemblage	*Plicatipollenites Parasaccites* Leiosphaerids	*Virkkipollenites*	GBR-1			

palynoassemblage zones of Talchir and Barakar formations.

Palynological succession of Witbank coalfield of South Africa shows dominance of monosaccates in Assemblage II as in Talchir Formation of India. Assemblages III, IV and V correspond with the Barakar palynoflora of India. Assemblage I having dominance of *Leiotriletes* and some elements of Upper Carboniferous has never been recorded in India (Tiwari 1974b).

ZIMBABWE

Falcon (1975) proposed four major assemblage zones and eight sub-zones in the Mid Zambesi basin.

Table 4: Permian stratigraphic sequences in important basins of Africa (after Visser, 1995) and comparable generalized Lower Gondwana (Permian) sequence of India.

<table>
<tr><td colspan="8">AFRICA</td><td>INDIA</td></tr>
<tr><td>KAROO</td><td colspan="3">CONGO</td><td colspan="2">ZAMBEZI</td><td colspan="2">ZAMBIA</td><td>MALAGASY</td><td colspan="2">AGE</td><td></td></tr>
<tr><td>Lower Beaufort Group</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3">Upper Lukuga beds</td><td rowspan="3">MADUMABISA MUDSTONE Upper Middle Lower</td><td rowspan="3"></td><td rowspan="3">MADUMABISA MUDSTONE Upper Lower</td><td rowspan="3"></td><td rowspan="4">Lower Sakamena Group</td><td rowspan="4">PERMIAN</td><td rowspan="3">LATE</td><td>RANIGANJ</td></tr>
<tr><td rowspan="3">ECCA Group (Including Coal Measures</td><td>BARREN MEASURES</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">Assise des schistes noirs de Lukuga</td><td rowspan="2">Lower Lukuga beds (Including Coal Measures)</td><td rowspan="2">Wankie Sandstone (Including Coal Measures)</td><td rowspan="2">Luwumbu Coal Formation</td><td rowspan="2">BARAKAR</td></tr>
<tr><td rowspan="2">EARLY</td></tr>
<tr><td>Dwyka Group (Glacial)</td><td colspan="2">Assise des schistes noirs de Walikale</td><td rowspan="2">Walikale Beds</td><td rowspan="2">Lubimbi Glacial</td><td rowspan="2">Mukumba Siltstone Member Musipizi Conglomerate Member</td><td rowspan="2">Sakoa Group</td><td>KARHARBARI</td></tr>
<tr><td colspan="2">Elia River (Glacial)</td><td colspan="2">Carboniferous</td><td>TALCHIR</td></tr>
</table>

Assemblage Zone-I (*Virkkipollenites-Plicatipollenites* Assemblage) from Dwyka, the Lower Wankie Sandstone and lowermost black shale and coal is dominated by radial monosaccate pollen and trilete spores. The sediments include glacigene/interglacial varves, siltstone, sandstone, conglomerate and carbonaceous shales. Among trilete spores *Callumispora (=Punctatisporites) gretensis* and *Calamospora* are in abundance. In India, the dominance of radial monosaccates and triletes, e.g. *Callumispora* have been observed in Talchir and Karhabari palynoassemblages. Thus, Assemblage Zone-I of Dwyka (Lower Wankie Sandstone and lowermost black shale and coal) compares with the Talchir and Lower Karharbari palynofloras.

Assemblage Zone-II shows a decrease of monosaccates and increase in disaccates. This zone corresponds to the Upper Karharbari / Lower Barakar palynofloras of India.

Assemblage Zone-III with its dominance of disaccates (nonstriate and striate) compares with the Upper Barakar palynoflora.

Assemblage Zone-IV shows dominance of striate disaccate pollen and corresponds to the Barren Measures and Raniganj palynofloras of India. Assemblage subzone H (*Taeniaesporites-Guttulapollenites* Assemblage) has dominance of striate disaccates. Abundant taxa include various species of *Faunipollenites, Striatopodocarpites, Guttulapollenites hannonicus, Sulcatisporites (=Scheuringipollenites) ovatus, S. splendens* and *S. potoniei*. This subzone H (Table 5) compares very well with the *Guttulapollenites* assemblage of the Godavari Graben in India (Srivastava and Jha, 1990, 1992a,b). The common taxa between the two include: *Striatopodocarpites, Faunipollenites, Guttulapollenites hannonicus, Platysaccus, Alisporites, Scheuringipollenites, Laevigatisporites colliensis, Polypodiidites (=Thymospora), Marsupipollenites triradiatus, M. striatus, Densipollenites indicus, Striomonosaccites, Vesicaspora, Lunatisporites (=Taeniaesporites noviaulensis* and *Lunatisporites*. Almost all the taxa reported are present in the Godavari Graben assemblages. Permian palynofloras from Zimbabwe comparable to the Talchir, Barakar and Raniganj palynoassemblages of India have been described by Chandra *et al.* (1977). Presence of *Kendosporites, Crescentipollenites, Hamiapollenites, Corisaccites, Strotersporites* in the assemblage from Zimbabwe and in Raniganj assemblage (=Lower Kamthi) of the Godavari Graben also shows similarity between the two.

Oesterian and Millsteed (1994) have recorded *Guttullapollenites hannonicus* in the Mkanga Formation from the western Cabora Basin, Lower Zambesi Valley, Zimbabwe and has been correlated with Assemblage subzone H of Falcon (1975).

ZAMBIA

Mid-Zambesi Basin

The palynozone from the Siankondoba Sandstone Formation dominated by *Plicatipollenites* and *Virkkipollenites* (Utting, 1978) compares with the Talchir palynoassemblages of India. The palynoassemblage from the Mamba Sandstone Member having triletes and monosaccates compares with the Lower Karharbari palynoflora, whereas palynoassemblage from the Main Coal Seam having triletes and disaccates corresponds to the Upper Karharbari/Lower Barakar palynofloras. Zone AV having *Vittatina africana* and *Gondisporites vrystaatensis* corresponds to the Raniganj palynoassemblage.

The palynozone from the Siankondobo Sandstone rock unit from Mid Zambesi (Nyambe and Utting, 1997) compares with the Talchir flora of India, whereas palynozone from the Gwembe Coal Formation with *Brevitriletes* and *Scheuringipollenites* compares with the Barakar palynoflora of India. Palynomorph Zone of Madumabisa Mudstone For-

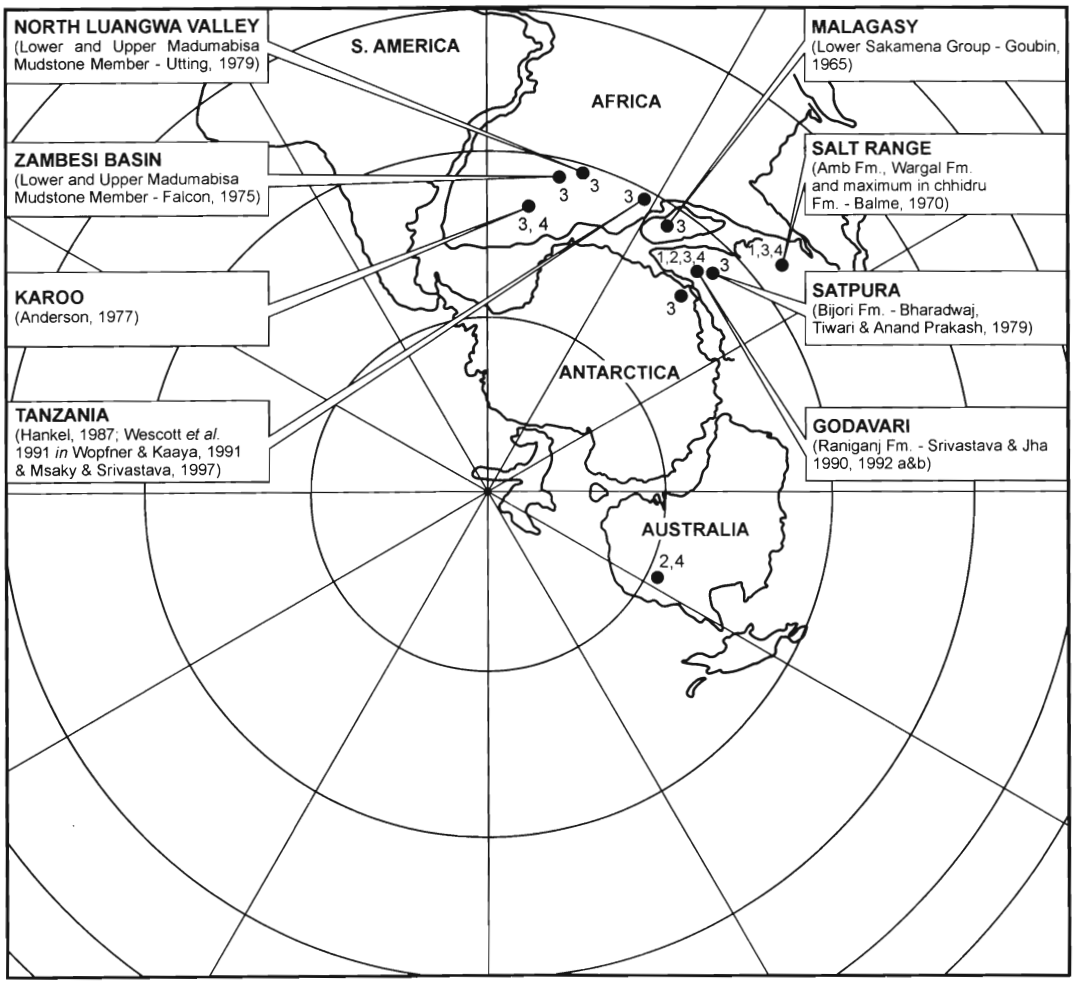

Fig. 2. Distribution of certain stratigraphically significant and geographically restricted taxa during Late Permian time showing *Guttulapollenites* palaeophytographic province in central part of Gondwana. 1. *Iraquispora,* 2. *Columinisporites,* 3. *Guttulapollenites,* 4. *Triquitrites.* (after Smith, Hurley and Briden, 1981).

mation corresponds to the Late Permian Raniganj palynoflora of India.

North Luangwa Valley

Among the two assemblages recorded from the Luwumbu Coal Formation of North Luangwa Valley, Zambia (Utting, 1976), the older one dominated by monosaccate taxa *Cananoropollis* (=*Virkkipollenites*) and *Plicatipollenites* corresponds to the Talchir palynoflora of India, and the younger assemblage having abundance of striate and nonstriate disaccates trilete spores and very few monosaccates corresponds to the Upper Karharbari/Lower Barakar palynoassemblages of India.

Abundance of *Guttulapollenites* has been recorded in the Lower and Upper Madumabisa Mudstone Member (Utting1979). The common taxa in the *Guttulapollenites* assemblage of North Luangwa Valley and the Godavari Graben are: *Weylandites* (=*Paravittatina*), *Guttulapollenites hannonicus, Lueckisporites virkkiae, Faunipollenites goraiensis, Striatopodocarpites rarus, S. cancellatus, Alisporites, Vesicaspora* and *Densipollenites indicus.*

TANZANIA

In Tanzania, Manum and Tien (1973) described two assemblage zones from Ketewaka Coalfield, the oldest of which - the *Cordaitina* Zone with dominance of monosaccates and common occurrence of *Callumispora (=Punctatisporites)*

EXPLANATION OF PLATE I

(All magnifications 500x)

1. ***Callumispora*** B.S.I.P. slide no. 12980,U-44.
2. ***Microbaculispora*** B.S.I.P. slide no. 12980, R-49/1.
3. ***Divarisaccus*** B.S.I.P. slide no. 12980, R50/3.
4. ***Caheniasaccites*** B.S.I.P. slide no. 12987, N-46/4.
5. ***Parasaccites*** B.S.I.P. slide no. 9481, L57/1.
6. ***Densipollenites densus*** B.S.I.P. slide no. 9333, N5/1.
7. ***D. invisus*** B.S.I.P. slide no. 9333, J66/3.
8. ***Faunipollenites*** B.S.I.P. slide no.9529, N68/4.
9. ***Crescentipollenites*** B.S.I.P. slide no. 9522, E48.
10. ***Barakarites*** B.S.I.P. slide no. 9529, R56/4.

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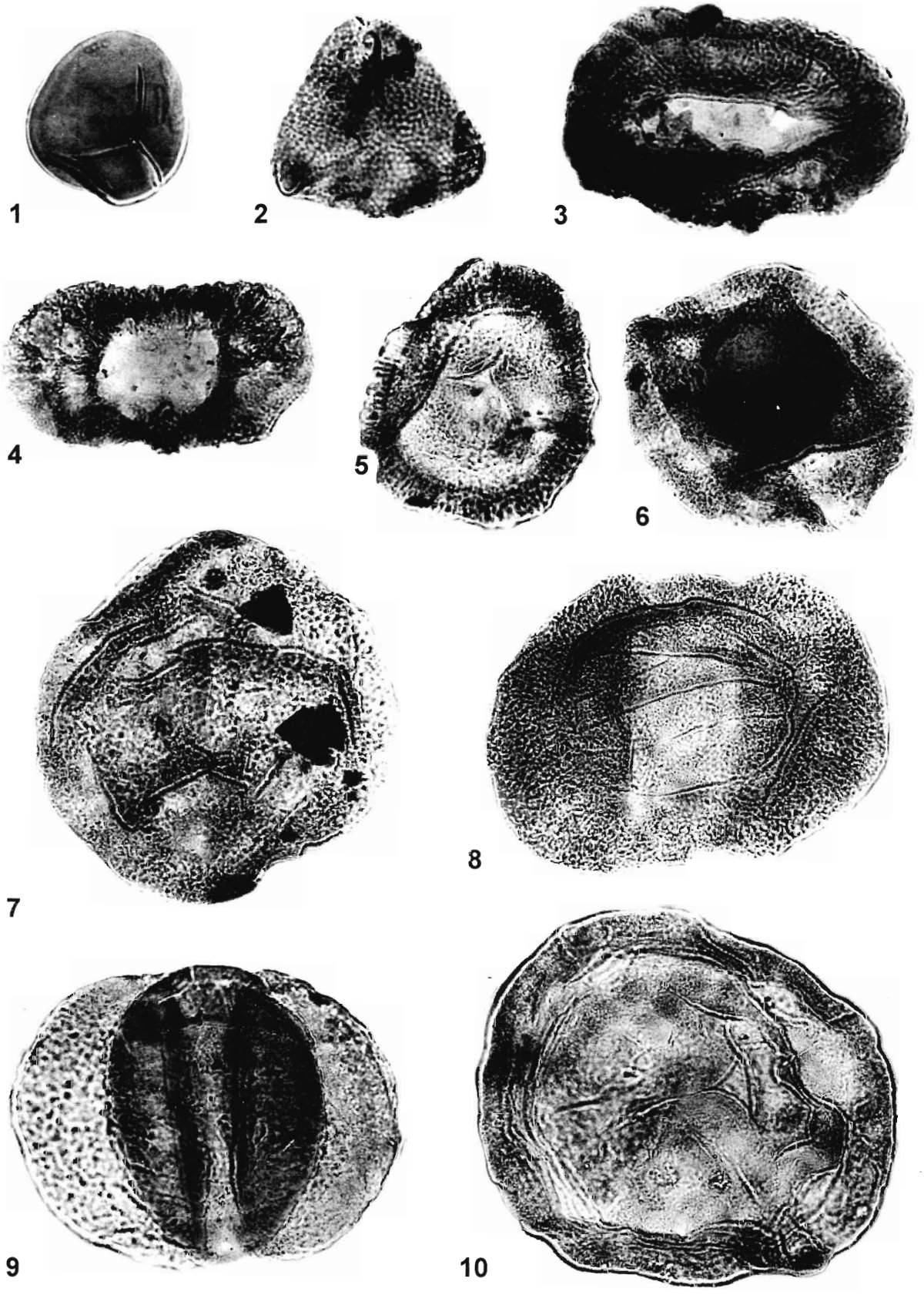
Plate I



gretensis-compares with the Talchir and Karharbari palynoassemblages; the *Vesicaspora* zone having dominance of disaccates and frequent triletes corresponds to the Barakar palynoflora of India. The palynoflora recovered from the Sumbadzi Member in the Luwega Basin is characterised by the abundance of *Guttulapollenites* (Hankel, 1987). A similar palynoflora has been reported by Weiss from the Pangani Member of the Selous Basin (*in* Wopfner and Kaaya, 1991), Karoo sediments of the Rukwa Basin by Wescott *et al.* (1991) and from Steigler Gorge in Tanzania by Msaky and Srivastava (1997). This compares well with the *Guttulapollenites* assemblage of Satpura, Godavari Valley Coalfields.

Scheuringipollenites-dominant palynoassemblage equivalent to the Barakar palynoflora of India is reported from Namwele- Mkomolo and Moze Coalfields in Tanzania (Semkiwa *et al.*, 1998).

MALAGASY

A Late Permian palynoflora (Zone IsC) from the upper part of the Lower Sakamena Group in Malagasy described by Goubin (1965), Jekhowsky and Goubin (1964) and Wright and Askin (1987) compares with the Late Raniganj palynoflora (*Guttulapollenites* palynoassemblage) of the Godavari Graben in view of the common occurrence of *Guttulapollenites hannonicus, G. gondwanensis, Weylandites* (=*Paravittatina*), *Vitreisporites pallidus,* and *Lunatisporites* (=*Taeniaesporites*) *noviauliensis*.

Thus, a close similarity has been observed between India and the southern part of Africa during the Permian. Indian palynoassemblages resemble those of Africa rather than those of Australia. For example, *Dulhuntyispora* - a stratigraphically important taxa in the Australian Late Permian - has not been observed in the Indian and African palynoassemblages and appears to be confined to the Australian deposits only, although there is a report of rare occurrence in South Africa (Anderson, 1977). Venkatachala and Kar (1990) recorded its presence from the Tertiary sediments of Assam (India) as reworked taxa and there is no record of its presence in the Permian sediments of India. *Guttulapollenites*-another stratigraphically important taxa, has been recorded in significant percentage in Satpura-Godavari, Madagascar, Tanzania, Zimbabwe, etc. The genus *Columinisporites* has been recorded initially from Carboniferous coals of Europe but its presence in the Late Permian of Gabon (Jardine, 1974), South Africa (Anderson, 1977), India (Srivastava and Jha 1990) and Australia (Foster, 1979) is noteworthy.

Different communities of vegetation could have occupied different latitudinal belts. This resemblance in palynological data from peninsular India, particularly Godavari-Satpura basins and Africa may be due to this fact. During the Late Permian time, India and southeastern half of Africa including Kenya, Tanzania, Zimbabwe and South Africa occupied the same latitudinal position between 40° and 60°south (Bharadwaj, 1976a). The Godavari Graben was separated from Son Valley by southeast trending highland which in turn was separated from the Damodar Basin by the Fox Ridge. These physical barriers may have caused variations in the palynoflora of the Damodar and Godavari basins. The continuity of the Amery Basin into Mahanadi/Godavari during Permian-Triassic time was suggested by Stagg (1985). The possibility of land connections between India and Africa or existence of Indo-African continent has been suggested by earlier workers (*in* Medlicot and Blanford 1880). It was proposed that the palaeohigh was in Antarctica and the palaeocurrent direction might have been from Antarctica (Amery Basin) to Godavari-Satpura through Narmada to South Africa through Malagasy.

A close connection between southern Africa and peninsular India during the Late Permian has also been suggested by Satsangi (1988) on the basis of faunal evidence. *Endothiodont* and *Cistecephalus* have been recorded in the Godavari Graben (Kutty *et al.*, 1988) and in the Karoo beds of South Africa (Kitching, 1972, *in* Anderson, 1977).

Guttulapollenites Palaeophytogeographic Province

Plant communities in response to varying climatic conditions in different latitudinal belts reflect provincialism. In the Gondwana supercontinent, *Guttulapollenites* which has been recorded from India, Salt Range, Malagasy, Africa and Antarctica, constitutes a distinct phytogeographic province. The genus *Guttulapollenites* instituted by Goubin (1965) and later emended by Venkatachala *et al.* (1967) is characterised by subcircular to circular shape, tetrasaccate condition, subcircular to circular, central body completely covered by sacci on all sides. Two sacci are found on either side of central body, those on each side face each other but mutually reverse the attachment zone from one set to other. Proximal attachment of sacci to central body is equatorial and distal attachment is bilateral. The two species of the genus *Guttulapollenites*, i.e *G. hannonicus* and *G. gondwanensis* described by Goubin (1965) from Malagasy are recorded in the Godavari Graben and also Salt Range. In the Salt Range, Pakistan, it appears in the Amb Formation (Early Permian) and attains maximum proliferation in the lower part of the Chhidru Formation (Balme, 1970). In India, this taxon shows maximum development during the Late Permian in the Satpura (Bijori Formation, Bharadwaj *et al.*, 1978), Godavari (Raniganj Formation, Jha and Srivastava, 1996) and Wardha (Bhattacharyya, 2004) basins. Other than these three basins, it occurs in the Late Permian of the Kamptee, Rajasthan and Damodar basins but in very low percentage. Further south, it has been reported in the Amery Basin

EXPLANATION OF PLATE II

(All magnifications 500x)

1. ***Scheuringipollenites*** B.S.I.P. slide no. 9481, R43/1.
2. ***Striatopodocarpites*** B.S.I.P. slide no. 9483, G59/4.
3. ***Striasulcites*** B.S.I.P. slide no. 9338, R57/3.
4. ***Hamiapollenites*** B.S.I.P. slide no. 9529, M32/4.
5. ***Guttulapollenites*** B.S.I.P. slide no. 10003, S43/4.
6. ***Polypodiidites*** B.S.I.P. slide no. 10015, J62/1.
7. ***Corisaccites*** B.S.I.P. slide no. 9481, V60/2.
8. ***Strotersporites*** B.S.I.P. slide no. 9525, H56.
9. ***Guttulapollenites*** B.S.I.P. slide no. 10008, K49.
10. ***Striasulcites*** B.S.I.P. slide no. 9338, F36/3.
11. ***Columinisporites*** B.S.I.P. slide no. 10009, T57.
12. ***Guttulapollenites*** B.S.I.P. slide no. 10010, P45.
13. ***Lunatisporites*** B.S.I.P. slide no. 9481, R73/4.
14. ***Kendosporites*** B.S.I.P. slide no. 10010, U52/1.

Plate II

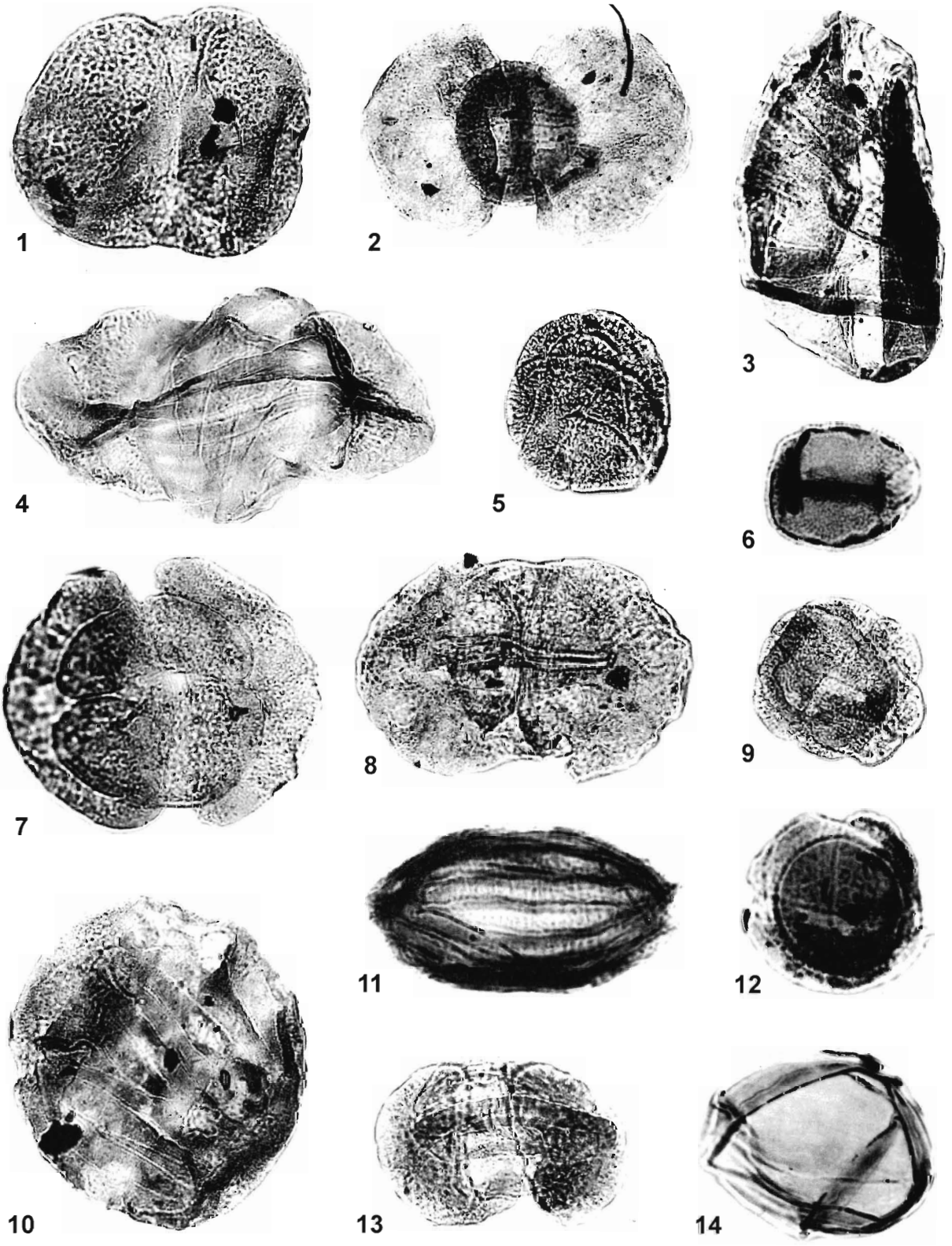


Table 5: Permian palynoassemblages in different basins of Africa and comparable generalized Lower Gondwana stratigraphic sequence (Permian) of India.

INDIA	SOUTH AFRICA			TANZANIA			RHODESIA		ZAMBIA		MALAGASY	CONGO	
				Ketewaka-Mchuchuma		Steigler gorge	Mid-Zambesi Valley		N. Luangawa Valley Utting (1976, 1979)	Mid-Zambesi Valley Utting , 1978	Morondava Basin Goubin (1965)	Bose & Maheshwari (1966, 1968)	Bose & Kar (1966) Kar & Bose (1967)
	Hart (1974)	Tiwari (1974)	Anderson (1977)	Hart (1960, 1965a&b)	Manum & Tien (1973)	Msaky & Sinha (1997)	Falcon 1975 Zone	Subzone					
Raniganj	Striatiti		Zone 7 Zone 6 Zone 5			Abundance of *Guttulapollenites*	Dominance of disaccates chiefly striates (Lower & Middle Madumabisa Mudstone)	H *Guttula pollenites* Assemblage	Abundance of *Guttulapollenites* (Lower & Upper Madumabisa Mudstone)	*Vittatina*+ *Gondi sporites*	Abundance of *Guttulapollenites* (Upper Lower Sakamena Group)		
Barren Measures	Zonati		E Zone 4 d c b					G					
Barakar	Cingulati	Assemblage V AssemblageIV Assemblage III	A Zone 3	K2 e2	*Vesicaspora* Zone		Disaccates	F	Disaccates+few Monosaccates			Apiculate Zonate, Triletes, *Sulcatispo-rites* (Lake Tanga nayika)	Disaccates (Walikale, Kindu-Kalima) Trilete+Monosaccates+Bisaccates (Lukuge)
				K2 e1	*Cordaitina* Zone		Triletes+Disaccates+ Monosaccates	E D		Triletes + Mono-saccates			
Karharbari	Cavati/ Camarati	Assemblage II	Zone 2	K2 d			*Virkkipollenites Plicatipollenites* Assembalge (Triletes + Monosaccates)	C B A	*Virkkipollenites Plicatipollenites*	*Plicati pollenites* + *Virkki pollenites*		*Plicatipolle-nites* + *Virk-kipollenites* (Epulu River)	*Virkkipollenites* + *Parasaccites* (Elila River)
Talchir		Assemblage I	Zone 1	K2 c									

(Bainmedart Coal Measures - Late Permian; Balme and Playford, 1967). It occurs in the upper part of the Lower Sakamena Group (Late Permian) in high percentages and continues into the Triassic of Malagasy (Goubin, 1965). Towards west in the African continent, *Guttulapollenites* occurs in upper part of the Karoo sequence of Late Permian age (Anderson, 1977), Late Permian of Tanzania (Hankel, 1987, Msaky and Srivastava 1997, Wescott *et al.*, 1991, Weiss *in* Wopfner and Kaaya 1991), Zimbabwe (Falcon, 1975; Osterian and Millstead, 1994), Zambia (Utting, 1979). So, the *Guttulapollenites* palaeophytogeographic province is very characteristic during the Late Permian from the Salt Range in the north to the Amery Basin in the south, Godavari-Satpura basins in the east to eastern half of Africa including the Mid-Zambesi Basin and Luangwa Valley in the west. Rare presence of *Guttulapollenites* in the Late Permian sediments of Australia (Foster, 1979), South America (Menendez, 1979) requires reinvestigation in view of their isolated occurrences. The appearance of *Guttulapollenites* in Early Triassic of the Netherlands (Visscher, 1966) could be through migration via southern Tethys coast into the Europe as explained by Bharadwaj (1976a). The western half of Africa possibly has American or Northern Hemisphere's effect as the Gabon palynoassemblage shows dominance of *Lueckisporites* during the Late Permian. *Dulhuntyispora* is a significant Late Permian taxon of Australian Permian palynosequences. It has been reported from Tertiary sediments of Antarctic peninsula (Askin and Elliot, 1982) and northeast India (Venkatachala and Kar, 1990) as reworked Permian pollen and the possible explanation of such stray occurrences is discussed by Playford (1989). Venkatachala and Kar (1990) suggested that it is possible that tubidity currents were responsible for bringing reworked Permian sediments from Australia to northeastern India. Such instances of long distance transport by turbidty currents are known (Sclater *et al.*, 1974 *in* Venkatachala and Kar, 1990). From the Karoo sediments of South Africa, this genus was recorded by Hart (1971) and Anderson (1977). Its probable migration from western Australia to India along the northeastern coast and from eastern Australia to Africa along western and southern Antarctic coast cannot be disregarded. The occurrence of the *Guttulapollenites* in significant percentage in the Bijori Formation of the Satpura Basin, and in the Raniganj Formation of the Godavari Graben, as compared to its poor representation in the Late Permian of the Damodar Basin, shows an increasing trend from south to north in India with still better representation in the Late Permian of Malagasy, Zimbabwe and Tanzania, which were then located quite closer to the Satpura area towards the north juxtaposed with Malabar Coast of India (Bharadwaj, 1976a).

Truswell (1980) suggested two phytogeographical provinces – African or West Gondwanaland and Australian or East Gondwanaland. The generally accepted reassembly of Gondwana Supercontinent also comprises two segments - the West Gondwanaland comprising Africa and South America and East Gondwanaland consisting of Antarctica, Australia and India. However, on the basis of the present palynological study, it is suggested that instead of two there were three palaeophytogeographic provinces: 1. East Gondwana floral province comprising Australia, part of Antarctica, northeastern part of India (Arunachal Pradesh), etc.; 2.West Gondwana floral province consisting of South America and western half of Africa; and 3.Central Gondwana floral province including part of Antarctica, southeastern part of Africa (i.e. from Kenya to South Africa), Malagasy, India and Pakistan (Salt Range) (Fig.2).

CONCLUSION

1. A degree of closer similarity between India and eastern half of Africa, Tanzania, Zambia, Zimbabwe, Malagasy and the Salt Range (Pakistan) can be drawn during the Late Permian from the above comparison.
2. Indian palynosequences resemble those from Africa rather than Australian palynoassemblages.
3. *Guttulapollenites* phytogeographic province in central part of Gondwana was very characteristic during the Late Permian time from the Salt Range in the north to the Amery Basin in the south, Godavari-Satpura basins (India) in the east to Mid-Zambesi–North Luangwa Valley in the west. It supports the concept of Central Gondwanaland in between the east and west Gondwanaland.
4. This province shows the nearness of Malagasy and Tanzania and supports northern fit of Malagasy with Tanzania-Somalia-Kenya coast as visualised by Du Toit (1937).

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