

BENCHMARK PERMIAN-TRIASSIC PALYNO-EVENTS IN PENINSULAR INDIA AND NORTHWEST TETHYS HIMALAYA

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ABSTRACT

This contribution provides a synthesis of the recent knowledge about Late Palaeozoic and Early Mesozoic palynological events, primarily in terrestrial sequences on peninsular India and their comparison with correlative Tethyan Himalaya sequences. A detailed evaluation of spore-pollen changes suggests that a continuous continental vegetation influence is represented in the marine domain. Interest in the two regions is aroused by the recognition of similar Palyno-events, and the identification of the *Striatopodocarpites-Crescentipollenites* (SC) and *Striatopodocarpites-Krem-pipollenites* (SK) palynozones, which are characteristic of the transition of Permian-Triassic boundary on Indian peninsula, and which have also been found in the Shal-Shal section of the Niti area, and the Lingti Hill section of Spiti area in Tethys Himalaya. This benchmark event confirms a pronounced encroachment of Indian Gondwana vegetation on to the southern region of Tethyan deposits during Late Palaeozoic-Early Mesozoic time. The Tethys Himalayan sequences which cross the Late Palaeozoic-Early Mesozoic transition, are significant for several sedimentary and tectonic cycles as well as other events, but this particular palynostratigraphic event is significant because of the ability to correlate it to terrestrial deposits.

INTRODUCTION

During of Late Permian and Early Triassic time span major changes in the earth's surficial features, climate and biota occurred (Hallam and Miller, 1988; Stanley, 1987; Vakhrameev, 1991; Benton, 1990; Tiwari and Vijaya, 1994). The rocks that record this fascinating temporal segment and the evolution of biota in the earth's history are found over almost all of the world. Although a precise stratigraphic time scale across the Permo-Triassic boundary has not yet been calibrated, it is well known that there has been a drastic change in the marine fauna and a gradual transformation in terrestrial flora across this boundary.

The stratigraphy of Permo-Triassic boundary beds has long been a matter of debate caused by incomplete sections, hiatuses, and undoubted provinciality of fossil occurrences. Fossil spores and pollen have nevertheless been used effectively to provide important biozonations at this boundary. On peninsular India various biotic aspects of Permo-Triassic systemic transition have been discussed (Ghose *et. al.*, 1988; Satsangi, 1988; Tiwari and Vijaya 1992) reflecting these problems.

Recently, attention has been drawn to the sequence of Palyno-events that occurred during the transition from Permian to Triassic (Tiwari and Vijaya, 1994). By using spores and pollen which are the only fossil tool for correlating between marine and nonmarine sequences, the objective of the present communication is to highlight some related patterns in the composition of the palynofloras, in two widely separated areas of Indian peninsula and Tethys Himalaya (fig. 1). Thus, the basic

trends of evolutionary morphology could be traced for common tagging in the Permo-Triassic sequences of the Central Tethys Himalaya, and those in the Damodar Basin of peninsular India, representing marine and non-marine deposits, respectively (fig. 9).

Similarities in the palynological assemblages recovered in Tethyan sequence (Pl. II, figs. 1-12; Pl. III, figs. 1-9) and the Indian peninsula (Pl. I, figs. 1-12) have been traced in the best sections. In the type area—Raniganj Coalfield, Damodar Basin, West Bengal, India, the Late Permian Raniganj Formation and Early Triassic Panchet Formation represent a nonmarine sequence with a interformational boundary which has also been established as the P/Tr boundary (Tiwari and Vijaya, 1992, 1994). Although macroplant fossils, and macrofauna could be used to develop a useful biostratigraphic scale over wide areas of India (Chandra and Chandara, 1988; Ghosh *et. al.*, 1988; Satsangi, 1988; Tiwari and Vijaya, 1992), correlation or tying to the



Fig. 1. Map of India, showing locations of Damodar Basin in India, and Niti and Spiti areas in Tethys Himalaya.

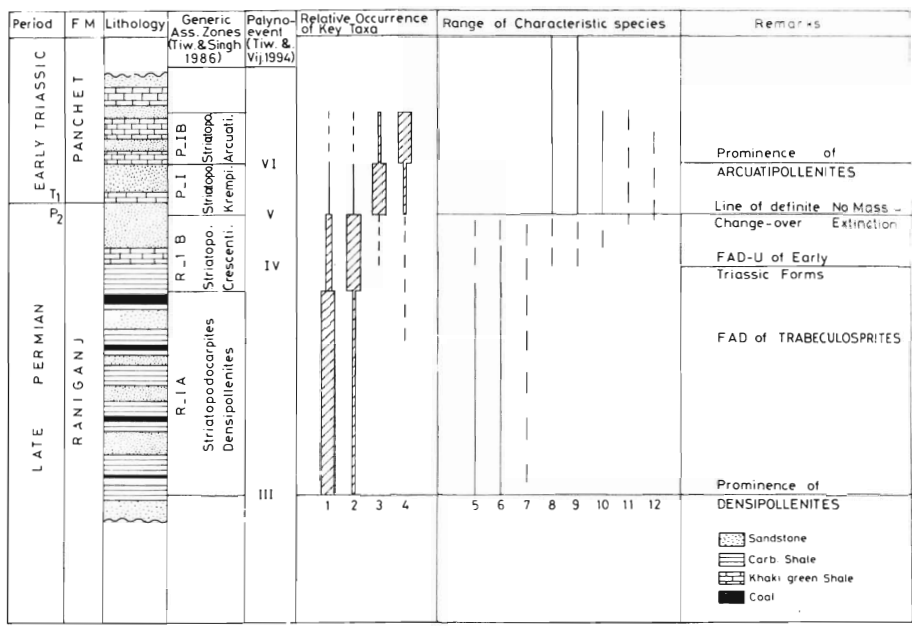


Fig. 2. Diagrammatic representation of lithosequence at the transitional passage-zone of Late Permian Raniganj Formation, and Early Triassic Panchet Formation in Raniganj Coalfield, Damodar Basin. Here, the relative position of Palyno-events is shown. Each Palyno-event reflects the relative prominence of Key-Taxa, and the FAD (inconsistent) as well as LAD of marker species through P/Tr boundary zone. (Modified after Tiwari and Vijaya, 1994). Numbers refer to following pollen-spore genera and species: 1. *Densipollenites*, 2. *Crescentipollenites*, 3. *Krempipollenites*, 4. *Arcuatipollenites*, 5. *Gondisporites raniganjensis*, 6. *Densipollenites magnicarpus*, 7. *Navalesporites spinosus*, 8. *Verrucosipollenites triassicus*, 9. *Playfordiaspora cancellosa*, 10. *Densoisporites playfordii*, 11. *Goubinispora indica*, 12. *Tethysispora tethysensis*.

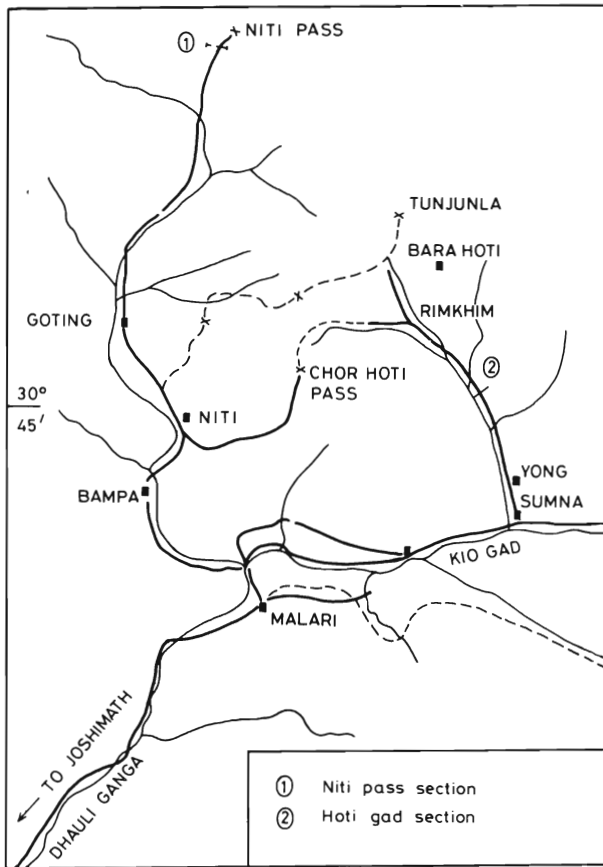


Fig. 3. Map of the Niti area in Tethys Himalaya showing locations of Hoti gad Section and Niti Pass Section (after Tiwari et al., 1996).

marine scale can only be achieved through palynofossils.

PALYNOZONATION AT PERMO-TRIASSIC TRANSITION

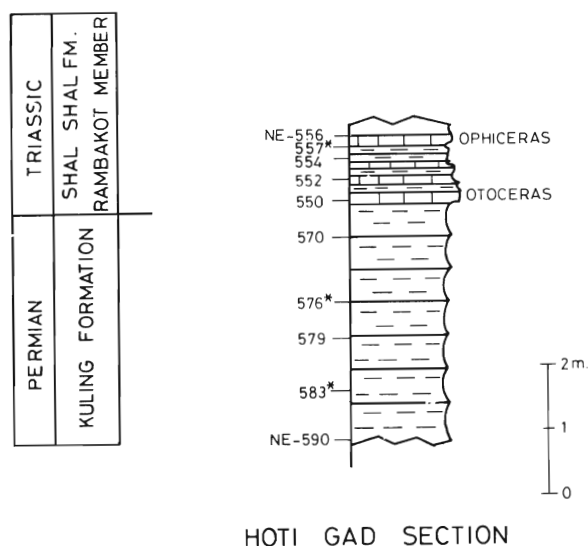
Since nineteen eighties, continuous progress has been made towards building a palynostratigraphic framework in the Tethyan sequence of Indian Himalaya, although the recovery of well preserved and ample palynological assemblages in this tectonically disturbed regime, makes it a difficult task.

The following sections in the two regions—are analysed.

1. Peninsular India : Raniganj Coalfield, Damodar Basin
2. Tethys Himalaya : Spiti Area, Niti Area

INDIAN PENINSULA

The continental facies with their contained palynological sequences are recognised in the Raniganj Coalfield, Damodar Basin, West Bengal (fig. 1). These facies have been identified both in out-crop and subsurface sequences and include the Raniganj-Panchet formational boundary and Permo-Triassic boundary (Vijaya and Tiwari, 1987; Tiwari and Vijaya, 1994; Tiwari et al., 1994). A well-defined palynostratigraphic sequence had



HOTI GAD SECTION

Fig. 4. Litho-column of Hoti gad Section showing the position of productive samples in the Permian-Triassic sequence (after Tiwari *et al.*, 1996).

been established which demonstrates a steady change-over in the pattern of spore-pollen genera and species, through this Permian-Triassic boundary zone (fig. 2).

Rock types that represent Raniganj-Panchet formational boundary are exposed in many sections, e.g., Nonia Nala and Machhkanda Jhor of the Raniganj Coalfield, Damodar Basin (Bharadwaj *et al.*, 1979). Extensive details have also been obtained from subsurface data in the eastern and western parts of the Raniganj Coalfield (Tiwari *et al.*, 1994). In the lithological column (fig. 2), thicknesses of various lithounits — coal, carbonaceous shale and sandstone represented in upper part of Raniganj Formation, and Khaki-green shale and sandstone comprising lower Panchet Formation have been assessed from a number of bore-cores. The interformational boundary had been identified on the top of the

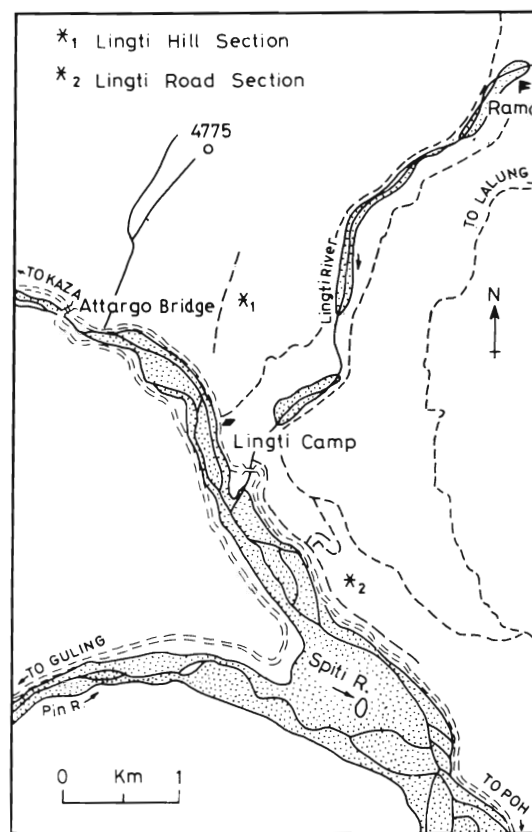


Fig. 6. Location of Lingti Hill Section and Lingti Road Section in Spiti area (after Singh *et al.*, 1996).

sandstone which overlies the top-most coal-bed of the Raniganj Formation (see Vijaya and Tiwari, 1987). Across the boundary, the palynological assemblage exhibits a marked change in the occurrence of Key-palynotaxa. As a result, the assemblages of the Upper Raniganj and the Lower Panchet can easily be distinguished.

At the transition of Raniganj-Panchet formations, two major palynozones—1. *Striatopodocarpites - Crescentipollenites/Densipollenites* (R-I), and 2. *Striatopodocarpites - Krempipollenites (=Klausipollenites)* (P-I), have been identified (Tiwari and Singh, 1986). The important features recognized within these palynozones are the levels of increased or decreased frequencies of marker palynotaxa associated with First Appearances Datum (FAD) or Last Appearances Datum (LAD) of morphological characters. Cummulatively, such episodes are defined as Palyno-events (Tiwari and Vijaya, 1994).

1. *Striatopodocarpites-Crescentipollenites/Densipollenites* (SC) Palynozone (fig. 2)

This palynoassemblage is defined by the most prominent occurrence of the genus *Crescentipollenites*, together with abundant *Striatopodocarpites* (Palyno-

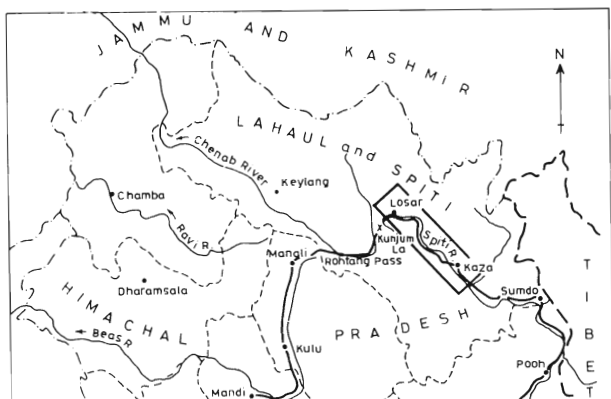


Fig. 5. Location of region in Spiti (after Singh *et al.*, 1996).

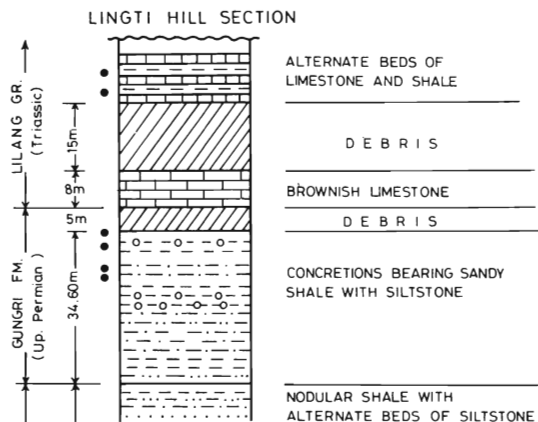


Fig. 7. Position of productive samples in Lingti Hill Section (after Singh et al., 1996).

event III in Tiwari and Vijaya, 1994). The genus *Densipollenites* continues from older horizons (Barakar, Kulti, Raniganj formations, Table 1) of the Permian but attains its prominence just below this (SC) level.

Table 1: The sequence of different formations in the Permian on Indian Peninsula.

Period	Formation
T1 L. Triassic	Panchet Formation
P2 U. Permian	Raniganj Formation
	Kulti Formation
	Barakar Formation
P1 L. Permian	Karharbari Formation
	Talchir Formation

Further, a state of diversification in *Densipollenites* species (*D. indicus*, *D. densus*, *D. magnicarpus*) characterizes the upper most part of the Raniganj Formation. As indicated in fig. 2, *Lundbladispora microconata*, *Playfordiaspora cancellosa*, *Densoisporites playfordii*, *Goubinispora indica*, *Krempipollenites* (=Klausipollenites) *indicus*, *Arcuatipollenites* (=Lunatisporites) *pellucidus*, (Pl. I) also

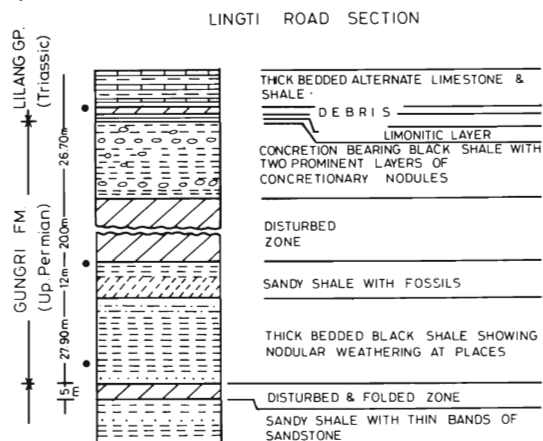


Fig. 8. Position of productive samples in the Lingti Road Section (after Singh et al., 1996).

make their first appearance, although sporadic and very rare, within the carbonaceous shale and sandstone facies towards the top of the Raniganj Formation (Palyno-event IV in Tiwari and Vijaya, 1994). The top of this palynozone is also marked by the disappearance of the most significant species - *Gondisporites raniganjensis*, and *Densipollenites magnicarpus* (Palyno-event V) almost never continues into overlying strata. Thus, the *Striatopodocarpites-Crescentipollenites* / *Densipollenites* palynozone (R-I, top most Raniganj) records the following successive events :

- (i) Dominance of the genus *Crescentipollenites* / *Densipollenites* and the first appearance of *D. magnicarpus* (identify base line of Palynozone R-I B).
- (ii) Inconsistent FADs of many characteristic species of Early Triassic palynoflora in the uppermost carbonaceous-sandstone facies of the Raniganj Formation.
- (iii) Flabbiness of sexine in between the striations in striate bisaccate pollen genera, e.g., *Trabeculosporites*, *Arcuatipollenites*.
- (iv) LADs of *D. magnicarpus* and *Gondisporites raniganjensis* demarcating the top of this palynozone.

A Latest Permian (Greishbachian) age has been assigned to *Striatopodocarpites - Crescentipollenites* / *Densipollenites* (SC) palynozone (Tiwari and vijaya, 1994).

2. *Striatopodocarpites - Krempipollenites* (SK) Palynozone (fig. 2)

The base of the (P-I A) *Striatopodocarpites - Krempipollenites* (SK) palynozone of Tiwari and Singh (1986) in the early Panchet Formation is recognized by the following characteristics :

- (i) Prominence of *Krempipollenites* (=Klausipollenites, see Tiwari and Vijaya, 1995) *indicus*, and the absence of

Period	Palynoassemblages in peninsular India	Palyno-events and their characteristics	Palynoassemblages in Tethys Himalaya	
			Niti	Spiti
P/Tr	Early Triassic	VI		
	Late Permian	IV		

Fig. 9. Relative positions of the palynoassemblages recovered from Late Permian and Early Triassic sequences in Niti and Spiti area of Tethys Himalaya (see in Tiwari et al., 1996; Singh et al., 1996) and their correlation to palynosequence established by Tiwari and Vijaya, 1994, for continental sequences across the Permian-Triassic boundary.

Gondisporites raniganjensis and *Densipollenites magnicarpus* identify the Palyno-event V (in Tiwari and Vijaya, 1994).

- (ii) Frequent and consistent occurrences of — *Lundbladispota brevicula*, *L. microconata*, *Densosporites playfordii*, *Playfordiaspora cancellosa*, *Arcuatipollenites ovatus*, *A. pellucidus*; and *Goubinispora indica*, *Tethyispora tethyensis*, as inconsistent elements.
- (iii) Increased frequency of *Arcuatipollenites* (= *Lunatisporites*, see Tiwari and Vijaya, 1995) replacing *Krempipollenites* marks the top of SK palynozone, i.e., Palyno-event VI, in Tiwari and Vijaya, 1994.

Table 2 : Stratigraphic sequence in Niti area, Tethys Himalaya (after Tiwari *et al.*, 1996).

Age	Formation
Early Triassic	Shal-shal
Late Permian	Kuling Shale

An Induan age is assigned to Palynozone P-I (Lower most Panchet), based on a comparison of zonal assemblage with the equivalent ones in Australia (Helby *et al.*, 1987; Tiwari and Vijaya, 1994).

Table 3 : Sections in Niti area, which have yielded palynoassemblages from Permian and Triassic succession.

Section	Age	Formation
HOTIGAD SECTION:	Early Triassic	Shal Shal Formation
	Late Permian	Kuling Shale Formation
RAULIBAGAR SECTION:	Early Triassic	Shal Shal Formation
	Late Permian	Kuling Shale Formation

Table 4: Details of Late Permian-Early Triassic palynoassemblages, recovered in Hoti gad section, Niti Area (fig. 4).

Age	Formation	Generic Palyno-assemblage	Reasons for tagging	Relativity with Palyno-events in Damodar Basin
Early Triassic	Shal Shal Formation Rambakot Member	<i>Striatopodocarpites</i> , <i>Krempipollenites</i> / <i>Arcuatipollenites</i> (SK palynozone)-	Significant occurrence of these two taxa, and consistent occurrence of Early Triassic forms, — <i>Densosporites playfordii</i> , <i>Lundbladispota brevicula</i> , <i>Verrucosporites triassicus</i> , <i>Playfordiaspora cancellosa</i> , <i>Goubinispora indica</i> , <i>Arcuatipollenites pellucidus</i> , <i>A. ovatus</i>	Palyno-event V
Late Permian	Kuling Shale Formation	<i>Striatopodocarpites</i> , <i>Crescentipollenites</i> (SC palynozone)	Significant occurrence of <i>Crescentipollenites</i> , and FAD-(uncertain) of Early Triassic elements <i>Krempipollenites indicus</i> , <i>Arcuatipollenites pellucidus</i> , <i>Lundbladispota microconata</i> , <i>Playfordiaspora cancellosa</i>	Palyno-event IV

TETHYS HIMALAYA

Recently, palynological studies have been made on the Late Palaeozoic and Mesozoic Tethyan sequence of Indian Himalaya (fig. 1) in Niti and Spiti areas (Tiwari *et al.*, 1996; Singh *et al.*, 1996). To date the Benchmark Palyno-events, identified at the Permo-Triassic boundary in nonmarine sequence in Damodar Basin, India, the palynological data recorded through Permian-Triassic sequences in Niti, and Spiti areas of Tethys Himalaya, is evaluated.

Niti Area

The Niti area shown in figs. 1,3, is located in the Central Himalayas. The Tethyan sequence exposed there are extensively studied for their faunas (Kumar *et al.*, 1977; Jai-Krishna *et al.*, 1982; Mehrotra *et al.*, 1983). As yet palynologic data on the Late Palaeozoic and Mesozoic formations is scanty. Recently, Tiwari *et al.* (1996) has studied the palyno-sequence in about eight sections and has found Late Permian, Early Triassic, and Late Jurassic sequences. Amongst these, those most suited for the present comparison, across the Permian-Triassic boundary (fig. 4), are mentioned in Table 3.

Spiti area

The Spiti Valley is part of the Spiti Zaskar Basin in Central Himalayas (fig. 5), where eight sections representing Permian and Early Triassic sequences have been studied by palynology (Singh *et al.*, 1996). Here the Permian-Triassic transition is found in the Lingti Hill and Lingti Road sections (fig. 6). In this area, the Late Permian sequence is represented by the Gungri Formation, and the thickest exposure of Triassic is assigned to the Lilang Group (Table 5, figs. 7-8).

Table 5 : Stratigraphic sequence in Spiti Basin (in Singh *et al.*, 1996).

Age	Group	Formation
Triassic	Lilang	Alaror
		Nimaloska
		Hanse
Permian	Kuling	Tamba Kurkur
		Gungri
		Gechang
		Ganmachidam

Table 6 : Sections in Spiti area from where the palynological data of Permian-Triassic transition is on record (figs. 7,8).

Section	Age	Formation
GANMACHIDAM HILL SECTION :		
	Early Triassic	Lilang Formation
	Late Permian	Gungri Formation
LINGTI HILL SECTION :		
	Early Triassic	Lilang Formation
	Late Permian	Gungri Formation
LINGTI ROAD SECTION :		
	Early Triassic	Lilang Formation
	Late Permian	Gungri Formation

Table 7 : Details of palynoassemblages recovered in Late Permian and Early Triassic sequences in Spiti area.

Age	Formation	Generic Palyno-assemblage	Reasons for tagging	Equation with Palyno-events in Damodar Basin
Early Triassic	Lilang	<i>Striatopodocarpites</i> , <i>Krempipollenites</i> (SK palynozone)	Prominence of <i>Krempipollenites</i> , steady occurrences of Triassic forms— <i>Lundbladispora brevicula</i> , <i>Densoisporites playfordii</i> , <i>Playfordiaspora cancellosa</i> , <i>Goubinispora indica</i> , <i>Satsangisaccites nidpurensis</i> , <i>Arcuatipollenites ovatus</i> .	Palyno-event V
Late Permian	Gungri	<i>Striatopodocarpites</i> , <i>Crescentipollenites</i> (SC palynozone)	Prominence of striate taxa and un-steady FAD of Early Triassic forms— <i>Arcuatipollenites pellucidus</i> , <i>Lundbladispora microconata</i> , <i>Playfordiaspora cancellosa</i> , <i>Krempipollenites indicus</i> , <i>Kamthisaccites kamthiensis</i> .	Palyno-event IV

CONCLUDING REMARKS

Palynological assemblages at the transition of Permian-Triassic boundary in Tethyan sequence of Indian Himalayas, can be closely compared to the Palyno-events recognised in Raniganj Coalfield, Damodar Basin, West Bengal, India (fig. 9) in the following ways:

1. Prominence of *Striatopodocarpites* and *Crescentipollenites* in Late Permian Kuling Shale Formation in Niti area, and Gungri Formation of Spiti area is similar to Palyno-event III on the peninsula as defined by Tiwari and Vijaya (1994).
2. First Appearance Datum (FAD) of Early Triassic marker genera in SC palynozone of Late Permian compares with Palyno-event IV of Damodar Basin.
3. Abundance of *Krempipollenites* (= *Klausipollenites*) along with the genus *Striatopodocarpites* in Early Triassic Shal-Shal Formation in Niti area, and Lilang Formation of Spiti area is equatable with Palyno-event V of Damodar Basin.
4. Similarly, no record of *Densipollenites magnicarpus* and *Gondisporites raniganjensis* in Early Triassic sequence of Tethys Himalaya has yet been noted.

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EXPLANATION OF PLATES

Plate I

(Characteristic spore - pollen found to occur in Late Permian - Early Triassic passage zone on Indian peninsula. All x750).

1. *Densipollenites magnicarpus*, x500
2. *Crescentipollenites gondwanensis*
3. *Densoisporites playfordii*
4. *Gondisporites raniganjensis*
5. *Playfordiaspora cancellosa*
6. *Tethyispora tethyensis*
7. *Kamthisaccites kamthiensis*
8. *Krempipollenites indicus*
9. *Satsangisaccites nidpurensis*
10. *Callumispora gretensis*
11. *Arcuatipollenites ovatus*
12. *Goubinispora indica* x300

Plate II

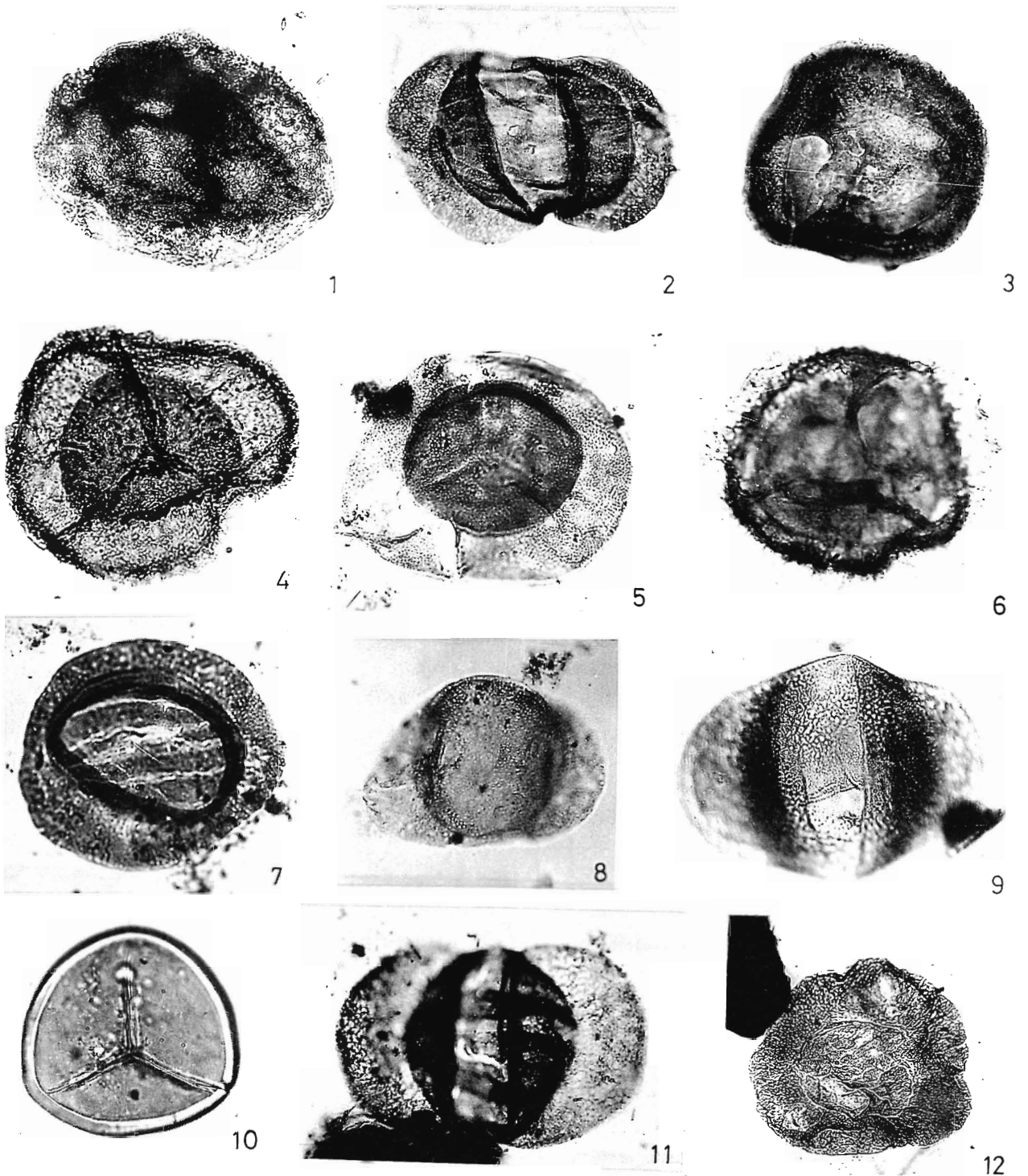
(Characteristic spore - pollen recovered in Late Permian - Early Triassic sequence of Niti area, Tethys Himalaya. All x500).

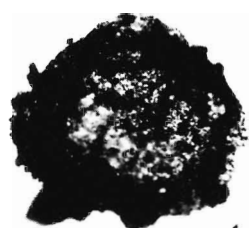
1. *Lundbladlisporea brevicula*
2. *Densoisporites playfordii*
3. *Cyathidites* sp.
4. *Playfordiaspora cancellosa*
5. *Krempipollenites indicus*
6. *Striatopodocarpites magnificus*
7. *Arcuatipollenites ovatus*
8. *Arcuatipollenites rhombicus*
9. *Goubinispora indica*
10. *Crescentipollenites fuscus*
11. *Brachysaccus ovalis*
12. *Satsangisaccites nidpurensis*

Plate III

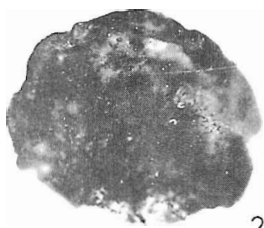
(Characteristic spore - pollen recovered in Late Permian - Early Triassic sequence of Spiti area, Tethys Himalaya. All x500).

1. *Crescentipollenites fuscus*
2. *Striatopodocarpites magnificus*
3. *Lundbladlisporea* sp.
4. *Verrucosisporites triassicus*
5. *Densoisporites playfordii*
6. *Kamthisaccites kamthiensis*
7. *Densipollenites magnicarpus*
8. *Densipollenites indicus*
9. *Arcuatipollenites ovatus*

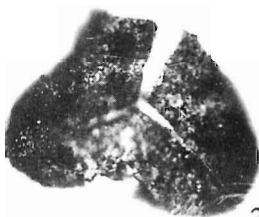




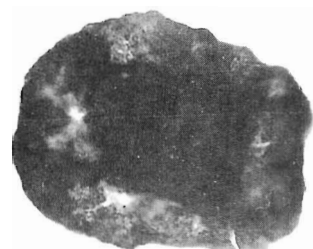
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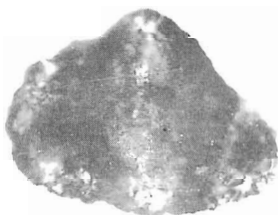
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3



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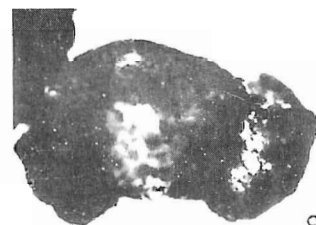
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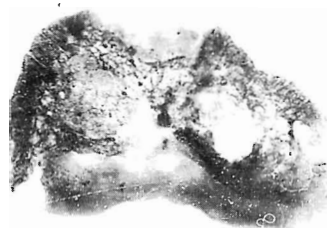
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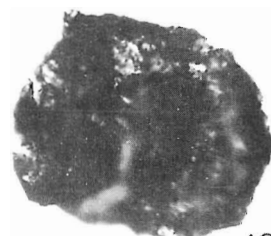
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8



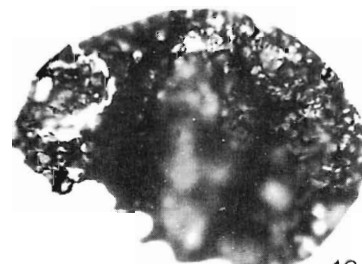
9



10



11



12

