OBSERVATION ON SOME PALYNOLOGICAL CONTRIBUTIONS TO INDIAN STRATIGRAPHY

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ABSTRACT

Important palynological contributions to Indian stratigraphy during the last two decades are reviewed.

The Vindhyan sediments as well as sediments met with in the sub-surface of Ganga valley are assigned a Pre-Tremadocian age.

The Talchir, Karharbari, Barakar and Barren measure and Raniganj sediments are distinguishable on palynofloras. A distinct floral break is observed at the Panchet Series which is here considered as an evidence of Middle Gondwanas. The Upper Gondwana palynofloras are well studied and can be differentiated from the Middle and Lower Gondwana palynofloras. Two distinct assemblages in the Upper Gondwanas are recognised besides a distinct Albian-assemblage known from the Dalmiapuram formation in the Cauvery basin.

Reworked Permian pollen encountered in Mesozoic sediments of Kutch, Cauvery and Godavari basins and Tertiary sediments of Assam and lignites of Cannanore are of significance in palaeogeographical considerations.

Lower Krol sediments from Nainital are assigned a Lower Triassic age.

On the basis of palynofloras the Supratrappean beds at Matanumadh, Kutch, and the Cherra formation, Assam, are assigned a Palaeocene age. Tertiary sediments of Himalayan foot hills are classified according to palynofloras.

INTRODUCTION

INTEREST in Palynology — a study of microfossils in sediments, was keenly aroused in India by Sahni's paper " On the prospects of Palynology in India " (1948). Though questionable affinities of the fossils recovered through acid digestion of sediments hampered active participation by several palaeobotanists and geologists in this study, their usefulness as stratigraphic markers and in coal seam correlation was realized by the vast number of publications, from United States and Europe (Raistrick, 1934; Schopf, Wilson & Bentall, 1944; and others) Palynological studies during the last two decades are mainly concerned with building up of palynological assemblages characteristic of different type sections and other well dated stratigraphical sections.

The present compilation attempts to review some of the important problems resolved by palynological methods in Indian stratigraphy.

THE VINDHYANS

The Vindhyan sediments which cover a large area in central India are seemingly unfossiliferous excepting *Fermoria* Chapman (1935) a disc-like fossil and Stromatolites which are of organic origin. Algal remains are recorded from Vindhyan sediments (Maithy, 1969; Misra, 1969; Salujha *et al.*, unpublished reports of ONGC; Sitholey *et al.*, 1953). Most of the fossils are identifiable with Leiosphaerids and Tasmanitids. It is also possible that the enigmatic *Fermoria* is a large form of *Tasmanites* Newton (1875). No authentic land plant spore has as yet been proved from these sediments. The records of trilete spores from Vindhyan sediments which undoubtedly prove the presence of land vegetation are not authentic, the evidences recorded by Ghosh *et al.* (1951), Ghosh and Bose (1950), Jacob *et al.* (1953) and Bose (1956) are not convincing. This point brings us to an important presumption that the land plants had not set foot on the landscape till about the Vindhyan times.

In a recent study of the Pre-Tertiary subsurface sediments in the Ganga Valley (Sastri & Venkatachala, 1968) an assemblage of sphaeromorphs without any structural pattern, *Spongiophyton*, a cyanophycean alga possibly comparable to *Nostoc* in association with well preserved trilete spores are recorded. The sphaeromorphs are classed with simple acritarchs and assigned to *Protoleiosphaeridium* Timofeev, and *Symplassosphaeridium* Timofeev. Similar acritarch remains are recorded from Ujhani sediments also from the subsurface of Ganga valley (Salujha *et al.*, 1967). Simple trilete spores with a distinct trilete mark and marked contact area are present in the material but are rare (only 4 specimen recovered). These differ from the earlier recorded ones in having a marked significant lip bordering the suture and a distinct contact area (*see* Sastri & Venkatachala, 1968; PL. 1, FIGS. 19 and 20). The morphology is simple and does not suggest a parentage or give evidence to the presence of pteridophytic parent plants; however, this type of mark is comparable with the spores recorded from Ordovician of Sahara (Combaz, 1967); Silurian of Spain (Cramer, 1967) and Tripoli, Libya (Hoffmeister, 1959).

Tremadocian fossils described from Sahara by Combaz (1967) include, trilete spores with distinct ornamentation and a prominent trilete mark associated with hystrichosphaerids, Leiosphaerids and Chitinozoa. This diverse hystrichosphaerid assemblage includes spinose types with distinct organization.

The Ganga Valley fossil assemblage (Salujha *et al.* and Sastri & Venkatachala *l.c.*) by comparison with the Tremadocian and Silurian assemblages discussed above, appear to be older. The acritarch fossils exhibit very simple organization without development of spines, hair-like growth or horns that are common in the Tremadocian assemblage. Thus it is suggested that the Tilhar as well as Ujhani sediments are Pre-Ordovician in age. The Vindhyan fossil assemblage discussed earlier also do not show any evidence of advanced fossil types and thus should be assigned an age older than Ordovician thereby allowing a contention that they are Cambrian or even Precambrian in age. This conclusion is also supported by the stromatolitic evidences (Valdiya, 1969). I am led to this conclusion looking at the simplicity of the assemblage and absence of any advanced spinose type of acritarchs which are common in the lower Ordovician sediments. It is suggested that further studies on filamentous and unicellular cyanophycean remains from the Vindhyan sediments would be of great significance.

THE GONDWANAS

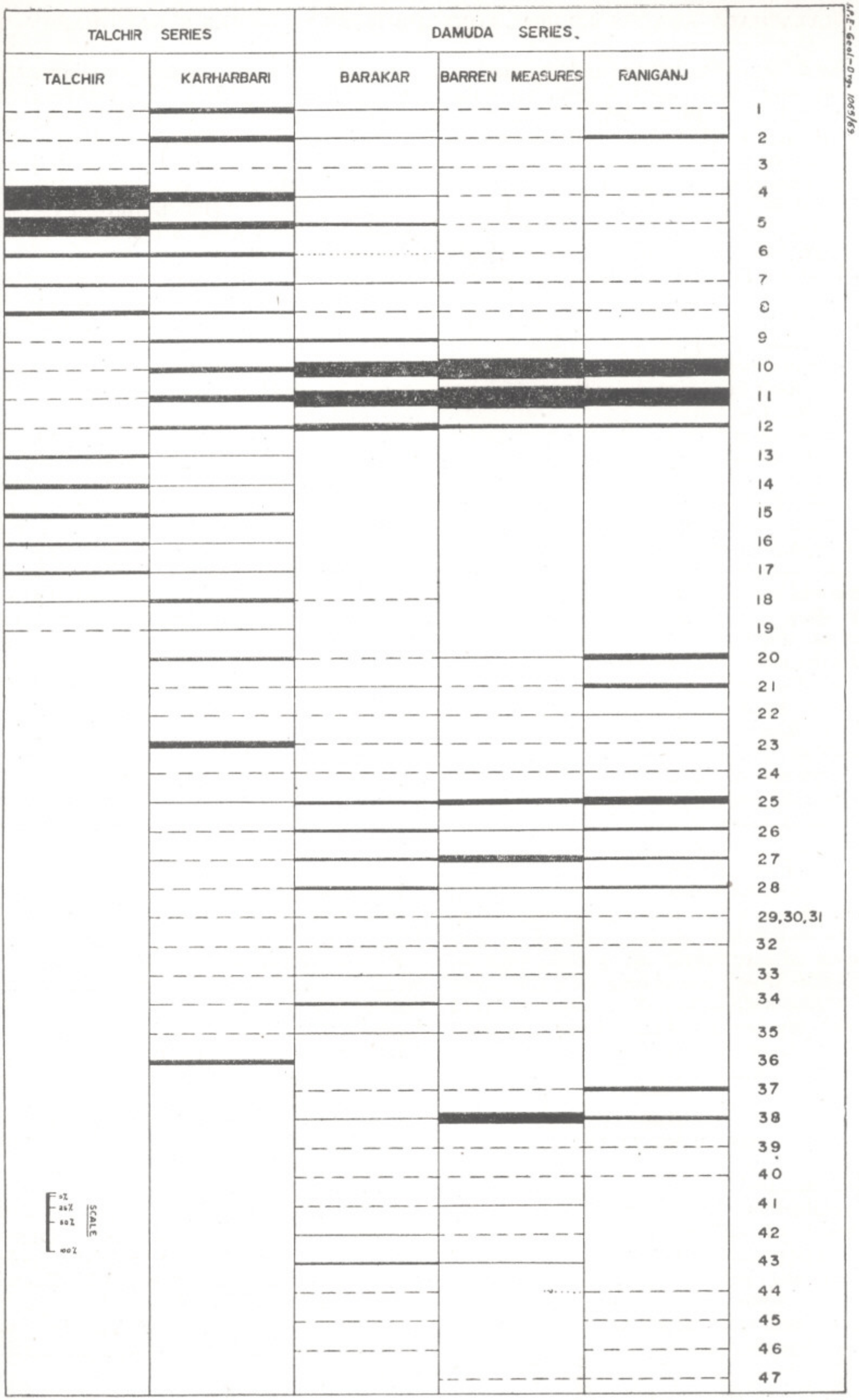
Conventional treatment of the Gondwana sediments have led us to believe that the sequence of sedimentation started with the Upper Carboniferous and concluded in the Lower Cretaceous times (Mehta, 1964). Thus the lower most stratigraphical unit is the Talchir Series considered as Upper Carboniferous in age.

Search for early remains of Glossopteris flora led Sahni (1945) and Virkki (1945) to study microremains from $1\frac{1}{2}$, $4\frac{1}{2}$ and 25 feet above the Talchir boulder bed at Kathwai in Salt range. Virkki (*l.c.*) also studied fossils from Warcha in the Salt Range and Bacchus Marsh, tillite in Victoria, Australia. This work is the first authentic palynological study from the Gondwana sediments of India. The Salt Range material was reexamined by Venkatachala and Kar (1968). The shales 25 ft. above the boulder bed yielded a well recognizable assemblage of Barakar age. The fossils from $1\frac{1}{2}$ and $4\frac{1}{2}$ ft. above the boulder bed also contain microfossils of Lower Permian age. The Talchir sediments mostly contain abundance of monosaccate pollen characterized by a central body without striations or grooves, disaccate grooved pollen are rare as well as other disaccate pollen. *Virkkipollenites* and *Parasaccites* dominate the assemblage while the other monosaccate pollen are well represented (*see* Text-figs 1 and 2 for distribution of Taxa). The dominant association of monosaccate pollen in the Talchir sediments shows an amphisaccate attachment which is characterised by *Virkkipollenites-Plicatipollenites-Parasaccites* plexus.

The Karharbari assemblage is essentially an extension of the Talchir one but shows advent of several new trends in bisaccate pollen, however, the amphisaccate pollen continue as an important group. Spores of *Varitrileti*, viz., *Lacinitriletes*, *Microbaculispora* and other such ones with a raised trilete mark and ornamentation restricted to distal side of the spore appear for the first time.

Spores grouped under *Zonotriletes* characterized by zonal appendages, viz., *Indotriradites*, also appear for the first time in the Karharbari sediments. The Karharbari assemblage can easily be recognized by the appearance of new types and continuation of amphisaccate pollen that were common in Talchir sediments (*see* Text-figs. 1 & 2).

The Barakar sediments are characterised by a diversity of saccate forms. The Striate-disaccate pollen as can be seen in Text-Figs. 1 & 2, increase both in number as well as in species and forms a dominant assemblage. Monosaccate astriate pollen that were abundant in the Talchir-Karharbari sediments reduce in number and importance in the assemblage. This tendency of depletion of this group can be further


TALCHIR SERIES
DAMUDA SERIES
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BARAKAR
BARREN MEASURES
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SCALE

TEXT-FIG. 1

seen in Barren measure and Ranigunj assemblage where they are almost negligible in the over all population. Several new genera appear for the first time and several others die out (*see* Text-fig. 1).

The assemblage of the Barren measure and the Ranigunj stages are characterised by the predominance of disaccate striate types and the appearance of a new group, i.e., the Alete saccate pollen. Both zonate and varitrilete spores deplete in the assemblage. The Upper Permian assemblages of the Damuda Series is so characteristic that it is easy to distinguish them from the assemblages of the Talchir Series (*see* Text-figs. 1 & 2).

It is clear, from a perusal of spore-pollen distribution in the Lower Gondwana sediments that the Talchir-Karharbari stage assemblages show closer affinity with each other than the Damuda-assemblages. The spore-pollen spectrum as seen in Text-fig. 2, where the assemblage is grouped into morphological grouping, show distinct trends allowing for distinction into different pollen zones. The Karharbari assemblage is an elaboration of the Talchir-stage assemblage while the Barakar stage shows an onset of new forms which continue into the younger Damuda sediments (Text-fig. 1, 36-43). Several genera that are common in Talchir Series (Text-fig. 1;13-19) do not continue into the Damuda sediments. An elaborate discussion is already made by Bharadwaj (1966). Other extensive studies include those of Bharadwaj and associates (1962, 1964, 1964a, 1965); Venkatachala and Kar (1968a, b, c); Maheshwari (1966, 1967); Tiwari (1965) and others. Bharadwaj and Tiwari (1964a) have attempted to use statistical approach in coal seam correlation. An important conclusion from the palynological succession studies done by Venkatachala and Kar (1968) in the Barakar sediments of Karanpura coalfield is that it is possible to recognize regular plant succession from one unit of deposition to the overlying sediments. They postulate a stage where monolete and trilete spores are abundant indicating a predominantly fern association associated with cycad and chlamydospermous plants (represented by polyplicate and monocolpate pollen) to start. This association lacks dominant upland elements like saccate conifer pollen, a zone

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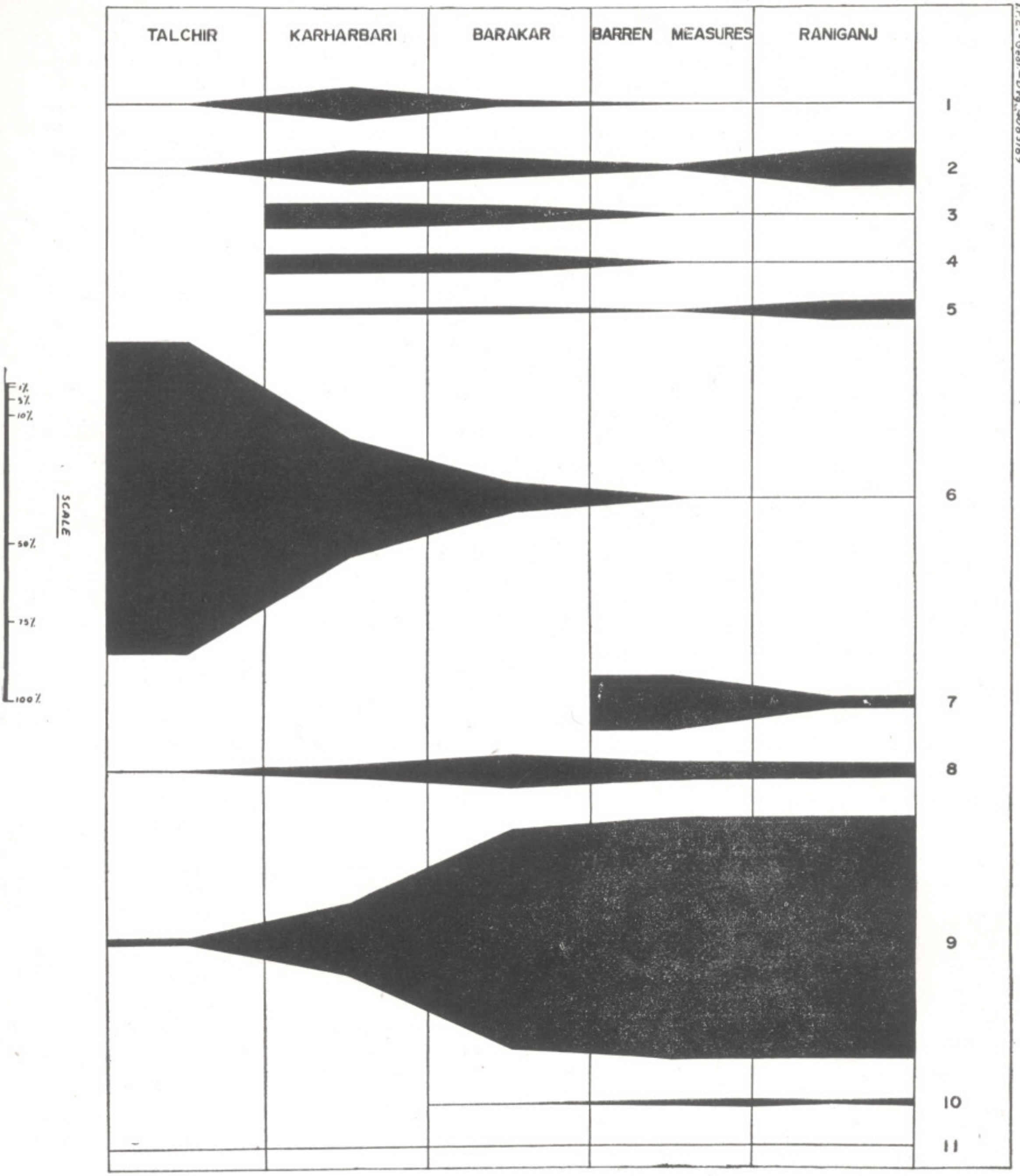
TEXT-FIG. 1 — Distribution of important Spore-pollen genera in the Lower Gondwana sediments. (Data modified from distribution pattern in the Karanpura Coal field, Venkatachala and Kar, 1968a and 1968b and Ghosh *et al*. MS.).

Fossil genera in text-fig. 1

1. *Punctatisporites* (Ibr.) Pot. & Kr. 1954.
2. *Cyclogranisporites* Pot. & Kr. 1954.
3. *Ginkgocycadophytus* Samoi., 1953.
4. *Virkkipollenites* Lele, 1964.
5. *Parasaccites* Bharad. & Tiw., 1964.
6. *Plicatipollenites* Lele, 1964.
7. *Potonieisporites* (Bhard.) Bharad., 1964.
8. *Divarisaccus* Venkat. & Kar., 1966.
9. *Cuneatisporites* Lesc., 1955.
10. *Strotersporites* (Wils.) Kl., 1963.
11. *Striatopiceites* (Zorich. & Sed., 1954) Sed., 1956.
12. *Sulcatisporites* (Lesc.) Bharad., 19162.
13. *Katangaites* Bose & Kar, 1967.
14. *Kibambaites* Bose & Kar, 1967.
15. *Caheniasaccites* Bose & Kar, 1966.
16. *Stellapollenites* Lele, 1965.
17. *Crucisaccites* Lele & Mait., 1964.
18. *Vestigisporites* Balme & Henn., 1955.
19. *Limitisporites* Lesc., 1956.
20. *Apiculatisporis* Pot. & Kr., 1956.
21. *Lophotriletes* (Naum.) Pot. & Kr., 1954.
22. *Cyclobaculisporites* Bharad., 1955.
23. *Lacinitriletes* Venkat. & Kar, 1965. & *Microbaculispora* Bhard., 1962.
24. *Vesicaspora* (Sch. 1951). Wils. & Venkat. 1953.
25. *Striatites* (Pant) Bhard., 1962.
26. *Verticipollenites* Bharad., 1962.
27. *Lahirites* Bharad., 1962.
28. *Hndipollenites* Bharad., 1962.
29. *Gnetaceaepollenites* Thierg., 1938.
30. *Welwitschiapites* Bolch., 1953.
31. *Ephedripites* Bolch., 1953.
32. *Hamiapollenktes* Wils., 1962.
33. *Laevigatosporites* (Ibr.) Sch., Wils. & Bent., 1944.
34. *Barakarites* Bharad. & Tiw., 1964.
35. *Rhizomaspora* Wils., 1962.
36. *Indotriradites* Tiw., 1964.
37. *Dentatispora* Tiw., 1964.
38. *Densipollenites* Bharad., 1962.
39. *Striomonosaccites* Bharad., 1962.
40. *Guttulapollenites* (Coup. 1965) Venkat., Coup. & Kar, 1967.
41. *Schizopollis* Venkat. & Kar, 1964.
42. *Corisaccites* Venkat. & Kar, 1966.
43. *Striasulcites* Venkat. & Kar, 1967.
44. *Vittatina* (Lub.) Wil., 1962.
45. *Neoraistrickia* Pot., 1956.
46. *Indospora* Bharad., 1962.
47. *Ghoshiasporites* Kar, 1969, *Venkatachalaites* Kar, 1969, *Bharadwajiapollis* Kar, 1969, and *Raniganjasaccites* Kar, 1969.



TEXT-FIG. 2 – Distribution of Spore-pollen groups in the Lower Gondwana sediments. (Compiled from Text-fig. 1).

Spore-pollen groups in Text-fig. 2 —

1. Azonotriletes — Laevigati.
2. Azonotriletes — Apiculati.
3. Azonotriletes — Varitrileti.
7. Zonotriletes.
5. Monoletes.
6. Monosaccites — Astriati.
7. Aletisaccites.
8. Disaccites — Astriati.
9. Disaccites — Striati.
10. Polyplicates.
11. Monocolpates.

reflecting luxurious coniferous gymnosperm vegetation, shown by the dominance of bisaccate pollen succeeds the earlier one. This is interpreted as due to shallowing through silting of the basin and invasion by coniferous vegetation from upland regions, which has overshadowed the fern representation in the pollen diagram (Venkatachala & Kar, 1968). Such plant succession, also recognized in other regions (Ghosh, Venkatachala & Kar, in press), prove that the Lower Gondwana coals were not entirely allocthonous but autocthonous coals are also present in several coal fields.

The Panchet sediments overlie the Raniganj with an unconformity in the Raniganj coalfield. The same is true in Karanpura and other regions. The Raniganj assemblage which is distinguished by striate saccate pollen, is replaced by a mixed assemblage of pteridophytic spores and gymnospermous pollen at the Panchet stage (*see* Text-fig. 3). Saccate striate pollen like *Densipollenites, Hindipollenites, Verticipollenites, Lahirites,* and trilete spores such as *Lacinitriletes, Microbaculispora, Indospora* and *Microfoveolatisporites* which dominate the Upper Permian Raniganj assemblage do not continue into the Triassic. *Taeniaesporites, Chordasporites,* and *Vitreisporites* which were not known in older sediments appear for the first time. This bisaccate assemblage associated with *Kraeuselisporites, Dictyophyllidites, Annulispora, Tigrisporites, Lundbladispora* and *Verrucosisporites morulae* all of which are pteridophytic spores, form the index assemblage of the Lower Triassic Panchet Stage. Some striate saccate pollen like *Striatopiceites, Strotersporites, Striatites,* and other nonstriate pollen such as *Platysaccus* and *Vesicaspora* do continue as stragglers in the Panchet but are not significant in the flora.

This sharp distinction in the assemblages does ring a note that there is a marked change in the edaphic factors influencing the vegetation or that there is a major climatic change bringing about extinction of the early vegetation, which is replaced by an entirely new one. The few survivors perhaps lingered on as stragglers.

Bharadwaj and Srivastava (1969) describe an interesting Lower Triassic assemblage from Nidpur in Madhya Pradesh. *Dicroidium* and *Glossopteris* are also recorded from these carbonaceous shales. Many of the Raniganj genera such as, *Lunatisporites, Striatites* and *Faunipollenites* are present in the Nidpur assemblage; however pteridophytic spores that characterise the Raniganj assemblage such as *Leiotriletes, Cyclogranisporites, Horriditriletes, Cyclobaculisporites, Microfoveolatispora, Indospora, Thymospora* and *Eupunctisporites* are significantly absent. *Nidipollenites, Satsangisaccites, Alisporites* and *Weylandites* are new taxa appearing in this assemblage. Bharadwaj and Srivastava (*l.c.*) on a comparative study of this assemblage conclude that " this shale can be surmised to be in the Panchet Stage (Daigaon Stage — Lele, 1964)." This is the oldest Triassic palynoflora known from India.

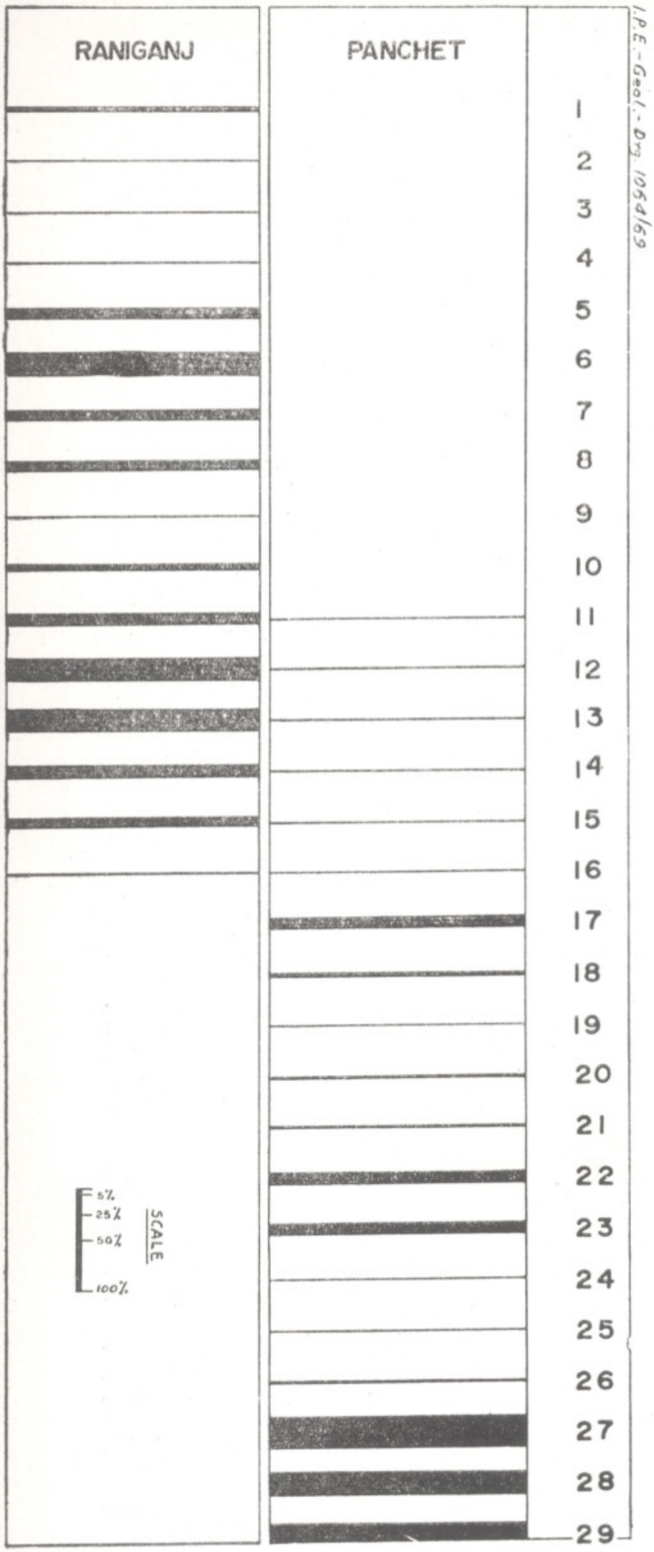
The Upper Gondwana Palynological assemblages are known from Rajmahal hills, Kutch, Jaisalmer, Dharangadhra, Jabalpur, Andhra Pradesh and Madras. The lowermost Jurassic assemblage recognised by Mathur and Mathur (in press) from Jaisalmer limestone in the subsurface is characterised by *Cosmosporites, Gliscopollis, Classopollis, Callialasporites, Araucariacites* and *Exesipollenites.* This is closely comparable to the Lower Jurassic assemblages recorded by Sah and Jain (1967) from the Variegated Shale Stage of Nammal Gorge in Salt Range of Pakistan and Leigh Creek Coal measures of South Australia described by Playford and Dettmann (1965).

A distinct Upper Jurassic assemblage is known from the Rajmahal hills (Sah & Jain, 1965) and Katrol sediments of Kutch (Venkatachala *et al.*, 1968), they are, however, characterized by the dominance of *Callialasporites, Podocarpidites,* and *Auracariacites* (Bharadwaj, 1969). The Chari sediments of Kutch have not as yet been well studied.

The Jurassic assemblage continues into the Lower Cretaceous sediments and the Jurassic-Lower Cretaceous boundary is hard to mark. Palynology of Neocomian-Aptian sediments from Kutch, Jabalpur, Dharangadhra and Rajasthan (Singh, 1966; Venkatachala *et al.* 1968 and Venkatachala and Rawat 1969) are well known. Lower Cretaceous subsurface sediments are also recognised on the basis of palynological evidences from the Cauvery and Godavari basins (Venkatachala & Jain, 1970 and unpublished work).

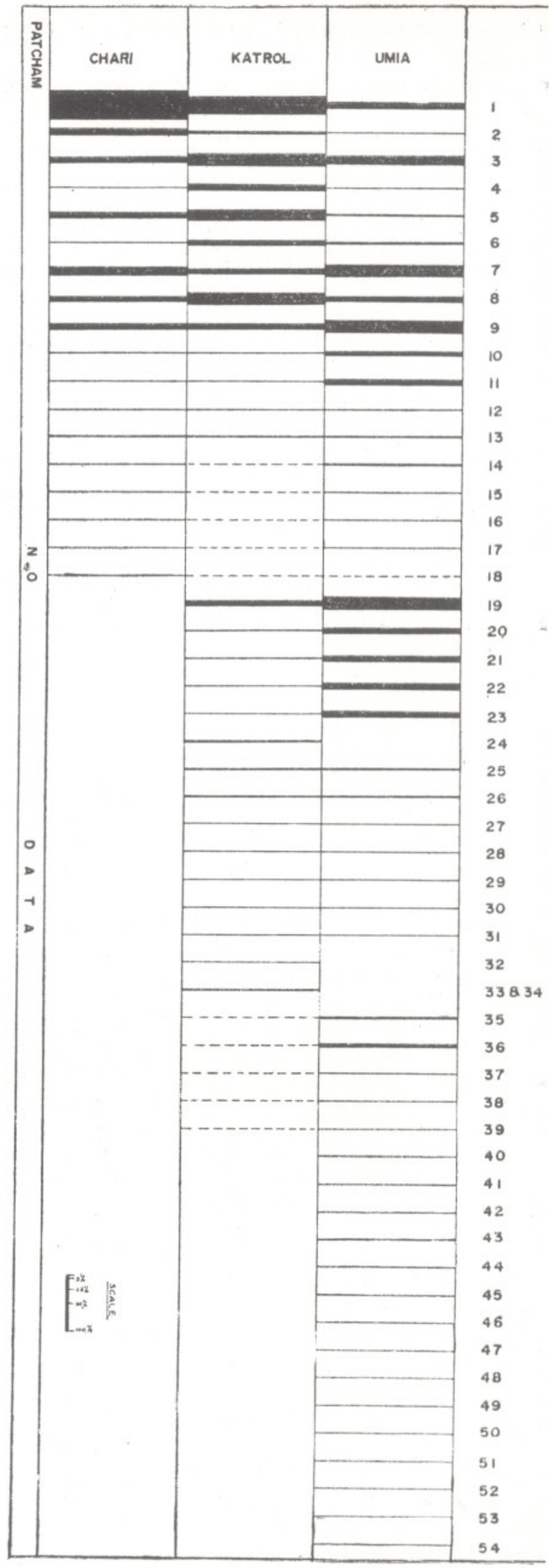
The distinct index assemblage that marks the Neocomian-Aptian sediments is:

Palycingulatisporites, Staplinisporites, Ischyosporites, Klukisporites, Coptospora,



TEXT-FIG. 3

TEXT-FIG. 4 ⟶



Aequitriradites, *Microcachryidites*, *Sestresporites*, *Coronatispora*, associated with Jurassic pollen mentioned above (*see* Text-fig. 4). The Jurassic-Cretaceous boundary in Kutch (Venkatachala & Kar, 1970) is marked on the basis of the above index fossils and distribution of several species within the circumscription of broad genera. They recognize a transition zone between Katrol and Bhuj series. The transition zone is marked by a gradual change in the vegetation.

The age of the topmost Gondwana sediments in Kutch is assigned Neocomin-Aptian age on the basis of palynological evidences. Most of the Lower Cretaceous sediments are known to contain *Hystrichosphaerids* and *Dinoflagellates* which indicate a shallow marine depositional environment in association with continental representatives

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TEXT-FIG. 3 — Distribution of important Spore pollen genera in the Raniganj and Panchet sediments (Data based on distribution in Purnea Well drilled in Bihar by Oil and Natural Gas Commission).

Fossil genera in Text-fig. 3 —

1. *Neoraistrickia* Pot. 1956.
2. *Lacinitriletes* Venkat. & Kar, 1965.
3. *Microbaculispora* Bharad., 1962.
4. *Microfoveolatisporites* (Knox) Bharad., 1962.
5. *Indospora* Bharad., 1962.
6. *Densipollenites* Bharad., 1962.
7. *Hindipollenites* Bharad., 1962.
8. *Verticipollenites* Bharad., 1962.
9. *Lahirites* Bharad,. 1962.
10. *Sulcatisporites* (Lesch.) Bharad., 1962.
11. *Vesicaspora* (Sch. 1961) Wils. & Venkat., 1963.
12. *Striatopiceites* (Zorich. & Sed., 1954), Sed., 1956.
13. *Strotersporites* Wils., 1962.
14. *Striatites* (Pant) Bharad., 1962.
15. *Platysaccus* (Naum.) Pot. & Kl., 1954.
16. *Crustaesporites* (Lesch., 1956), Jans., 1962.
17. *Retusotriletes* Naum., 1953.
18. *Verrucosisporites* (Ibr.) Pot. & Kr., 1954.
19. *Cyathidites* Coup., 1953.
20. *Dictyophyllidites* Coup., 1958.
21. *Annulispora* de Jer., 1962.
22. *Tigrisporites* Kl., 1960.
23. *Thymospora* Wil. & Venkat., 1963.
24. *Cycadopites* Wil. & Webs., 1956.
25. *Chordasporites* Kl., 1960.
26. *Vitraeisporites* (Lesch.) Jans., 1962.
27. *Taeniaesporites* (Lesch.) Jans., 1962.
28. *Lundbladispora* Balme, 1963.
29. *Kraeuselisporites* (Lesch.) Jans., 1962.

TEXT-FIG. 4 — Distribution of important Spore-pollen genera in the Upper Gondwana sediments (Data modified from Venkatachala and Kar, 1970).

Fossil genera in text-fig. 4 —

1. *Araucariacites* Cook, 1947.
2. *Gleicheniidites* (Ross.), Delc. & Sprum., 1955.
3. *Callialasporites* Dev 1961.
4. *Classopollis* (Pf.) Poc. & Jans., 1961.
5. *Podocarpidites* (Cook.) Pot., 1958.
6. *Vitreisporites* (Lesch.) Jans., 1962.
7. *Alisporites* (Daguh., 1941) Nils., 1958.
8. *Contignisporites* Dettm., 1963.
9. *Podosporites* Rao, 1943.
10. *Cicatricosisporites* Pot. & Gell., 1933.
11. *Lycopodiumsporites* Thierg. ex Delc. & Sprum., 1955.
12. *Osmundacidites* Coup., 1953.
13. *Matonisporites* (Coup.) Dettm., 1963).
14. *Stereisporites* Pf., 1953.
15. *Neoraistrickia* Pot., 1956.
16. *Ceratosporites* Cook. & Dettm., 1958.
17. *Ginkgocycadophytus* Samo., 1953.
18. *Polypodiisporites* Pot., 1934.
19. *Microcachryidites* Cook. ex Coup., 1953.
20. *Impardecispora* (Coup.) Venkat. *et al.*, 1969.
21. *Bhujiasporites* Venkat. *et al.*, 1969.
22. *Psilospora* Venkat. & Kar, 1968.
23. *Murospora* Som., 1952.
24. *Boseisporites* (Dev) Singh *et al.*, 1964.
25. *Coptospora* Dettm., 1963.
26. *Concavissimisporites* (Delc. & Spru.) Delc. Dettm. & Hug., 1963.
27. *Klukisporites* Coup., 1958.
28. *Pilosisporites* Delc. & Sprum., 1957.
29. *Lycopodiacidites* (Coup.) Pot. 1956.
30. *Biretisporites* (Delc. & Sprum.) Delc. Dettm. & Hug., 1963.
31. *Cycadopites* (Wod.) ex Wils. & Webs., 1946.
32. *Foveotriletes* V.d. Ham. ex Pot., 1956.
33. *Katrolaites* Venkat. & Kar, 1967.
34. *Exesipollenites* Balme, 1957.
35. *Platysaccus* (Naum., 1937) ex Pot. & Kl., 1954.
36. *Densoisporites* (Weyl. & Krieg.) Dettm., 1963.
37. *Deltoidospora* Min. 1953 emend. Pot., 1966.
38. *Equisetisporites* (Daugh.) Singh, 1964.
39. *Cingulatisporites* Thoms. (In Thom. & Pf., 1935) Pot., 1956.
40. *Trilobosporites* Pant ex Pot., 1956.
41. *Annulispora* de Jer., 1962.
42. *Polycingulatisporites* Simo. & Ked., 1962.
43. *Staplinisporites* Poc., 1962.
44. *Leptolepidites* Coup., 1953.
45. *Ischyosporites* Balme, 1957.
46. *Concavisporites* Pf. in Thom. & Pf., 1963.
47. *Laevigatosporites* Ibr., 1933.
48. *Aequitriradites* (Delc. & Spru.) Cook. & Dettm., 1961.
49. *Foraminisporis* Krutz., 1959.
50. *Appendicisporites* Weyl. & Kr., 1953.
51. *Baculatisporites* Thom. & Pf., 1953.
52. *Foveosporites* Balme, 1957.
53. *Sestrosporites* Dettm., 1963.
54. *Coronatispora* Dettm., 1963.

such as spores and pollen. The Gondwana sediments are considered as sub-aerial, fluviatile or lacustrine deposits since th eoriginal definition by Medlicott (1869), doubts arise as to the validity of the term Upper Gondwanas to describe the sediments of Lower Cretaceous age in Kutch, Jaisalmer, Cauvery and Godavari basins. The term may, therefore, prove useful in geographical connotation rather than of a stratigraphical one as presently used in this country.

Floristically the Upper Jurassic – Lower Cretaceous sediments do fall into a single floristic zone, several taxa that appear at the beginning of the Upper Jurassic continue into the Lower Cretaceous sediments. Minor differences mark the boundary (*see* Text-fig. 4).

The start of the Albian, the world over marks the advent of a angiospermous vegetation. Authentic Pre-Albian angiospermous records are rare. Albian palynoflora is not well known so far from India. Aptian Lower Albian subsurface sediments of Cauvery Basin as well as exposed sediments at Dalmiapuram quarry No. 2 (Subbaraman, 1968) do not contain any angiospermic remains. The grey shales of Pre-Uttatur age recorded by Subbaraman (*l.c.*) is of Aptian Albian age both on palynological and palaeontological evidences. The absence of Angiosperms here cannot be taken as evidence of Pre-Albian age as deduced by Jain and Subbaraman (1969). The shales contain spores and pollen besides a large number of hystrichosphaerids and dinoflagellates indicating a shallow marine depositional environment. The continental-land plant spores are also not well preserved indicating that they have been considerably washed from long distances before deposition. *Appendicisporites* spp. and *Rouseisporites* recorded are good markers of Albian age. *Rouseisporites* is abundant in Albian-Cenomanian sediments of Vridhachalam area in the Cauvery basin. (For a detailed discussion on the Lower Cretaceous of Cauvery and Godavari basins *see* Rao and Venkatachala, 1970).

It is clear that three main floral divisions are possible in the Gondwana sediments. The first representing the Lower Gondwana sediments from Talchir-Raniganj stages, characterized by a striate saccate-*Virkkipollenites-Stroter sporites-Lahirites-Varitrilete*-assemblage; the second, Panchet assemblage mainly showing a new flora with *Lundbladispora - Kraeuselisp orites - Taeniaesporites* assemblage and a distinct Jurassic-Lower Cretaceous assemblage marked with the appearance of *Classopollis-Callialasporites-Microcachryidites-Cicatricosisporites-Contignisporites* assemblage.

Does this mean that the classification of the Gondwanas be a two-fold one or a three-fold one? The distinct palynological break at the beginning of Panchet is of importance and the Triassic sediments be recognized as representing the Middle Gondwanas. The Upper Gondwanas, of course, is a distinct palynological unit. This contention is also supported by palaeobotanical evidences put forward by Lele (1964).

Reworked Lower Gondwana spores and pollen are commonly encountered in the Mesozoic sediments of Kutch, Cauvery and Godavari basins and Tertiary sediments of Assam and lignites of Cannanore. On the basis of this study Venkatachala (1969) suggested that the Lower Gondwana sedimentation was extensive throughout the country and have been subsequently eroded to be only preserved in present day positions.

Lower Krols from Brewery, Nainital yielded an assemblage on the basis of which a Lower Triassic age is assigned (Sah *et al.*, 1968). Ghosh and Srivastava (1962) have also assigned a Triassic age to Krol A and D from Mussoorie.

THE DECCAN TRAPS

Palynology has provided only indirect evidence on this problem by fossil finds from Infra, Inter or Supratrappean beds. Investigations on the Palynology of Frog beds at Bombay, and Infra and Intertrappeans at Rajahmundry and Dudukuru have not been fruitful.

Mathur (1966) in a detailed palynological study of the Supratrappean beds at Matanumadh identified a rich assemblage consisting of the following important taxa:

Proteacidites palisadus
Engelhardtioidites sp.
Schizaeoisporites sp.
Alsophilidites sp.
Smilacipites sp.
Polycolpites spp.
Ilexpollenites sp.
Casuarinapollenites sp.
Palmaepollenites
Potomogeton pollen
Nymphaepollenites

This assemblage is dated as Palaeocene in age comparable to the other Palaeocene assemblages in the sub-surface of Rajasthan and Cauvery basins (unpublished work of Mathur and Venkatachala from ONGC records). This is the first evidence regarding the age of Supratrappeans in Kutch which indirectly help us to date the trap activity as belonging to pre-Paleocene age in this region. It is now clear from this study that the trap activities started as early as Upper Cretaceous and continued into the Eocene and younger times.

THE CHERRA FORMATION, ASSAM

Age and stratigraphical position of the Cherra Sandstone Stage in Assam has been controversial. Since the studies of Medlicott (1869) and Palmer (1923) they were considered as Upper Cretaceous in age (for a full discussion *see* Sah & Dutta, 1966). Based on faunal records the Nummulitic Sylhet limestone overlying the Cherra Formation is dated as Eocene while the underlying Langpar Stage is considered as Danian in age. It is a matter of opinion whether the Cherra Formation is of Lower Tertiary age or it forms a part of the Upper Cretaceous.

Sah and Dutta (1966) record an interesting assemblage consisting of the following taxa:

Biretisporites sp.
Palmaepollenites sp.
Schizosporis sp.
Retialetes sp.
Polycolpites spp.
Rhoipites
Polygalacidites
Engelhardtioidites
Triorites
Couperipollenites (*Monocolpites*)
Nyssapollenites
Myrtaceidites

This assemblage in general closely compares with the Lower Tertiary ones described earlier (for a detailed discussion *see* Sah & Dutta *l.c.*); the Supratrappean assemblage from Kutch Mathur (1966) is also closely comparable. Apart from showing similarities with Lower Tertiary assemblages, fossil pollen of Onagraceae, Polygalaceae, Eubiaceae, Nyssaceae and Berberidaceae are not as yet known from the Upper Cretaceous sediments. This evidence substantiated the contention of Ghosh (1940) that the Cherra Stage is infact, the basal member of the Sylhet Limestone Stage and equivalent to the Ranikot Stage of western India. Palynological evidence from the Supratrappean of Kutch are also substantiative.

TERTIARY SEDIMENTS OF HIMALAYAN FOOT HILLS

Mathur and Mathur (1970) carried out studies on the Tertiary sequence of the Himalayan foot hill belt extending through Jammu and Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh and Nepal.

The Subathu sediments deposited predominantly in shallow marine environment are considered Palaeocene-Eocene in age (Mathur and Mathur *l.c.* & Salujha *et al.*, 1969). Micropalaeontological evidences also corroborate these findings (Datta *et al.*, 1965).

The Subathu assemblage is characterised by the presence of algal remains such as *Baltisphaeridium*, *Hystrichosphaeridium*, and *Pediastrum* and pollen of *Anacolosia*, *Couperipollis* Venkatachala and Kar, *Triletisporites* Ramanujam, *Triorites* Cookson, *Tricolporites* Couper, *Retitricolpites* Mathur, *Favitricolporites* Sah and *Pinuspollenites* Raatz in association with pollen of Palmae.

The Lower Dharamsala sediments of Eocene age are both marine and continental.

They are palynologically distinguishable from older Subathu sediments by the occurrence of pollen grains of Chenopodiaceae, Tiliaceae, *Lindsaya* and those referable to *Ephedripites* Maljawkina, *Striainaperturites* Pierce, *Scabratriporites* V. der Hammen, *Pinuspollenites* Raatz and *Tetracolporites* Couper.

The Upper Dharamsala sediments are considered as Oligocene-Lower Miocene in age (personal communication V. Raiverman) deposited under predominantly fluviatile conditions. This association is characterized by a large number of pteridophytic spores belonging to Schizeaceae, Hymenophyllaceae and Polypodiaceae associated with pollen of Chenopodiaceae and saccate pine pollen.

The Lower Siwalik sediments of Miocene age are characterized by pollen of Palmae and Graminae associated with *Quercoidites* (Potoniè) Thomson and Thiergart; *Haloragacidites* Couper, *Cupuliferoipollenites* Potoniè, *Saptaceoidaepollenites* Potoniè and *Araceopollenites* Mathur.

The Middle Siwalik sediments are associated with more of gymnospermous vegetation heralding the onset of cooler climate. Angiospermous pollen are comparatively less represented. The assemblage contains pollen of Malvaceae, Betulaceae, Anacardiaceae, Pinaceae and spores of Polypodiaceae. Both the Siwalik assemblages represent fresh water deposition.

Palynological assemblages detailed above from the Tertiary sediments of the Himalayan foot hills, prove that palynological studies can be effectively employed in solving stratigraphical problems in Pre-Siwalik — Siwalik sequence (for detailed discussion on this problem *see* Mathur and Mathur, 1969).

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