

PALYNOLOGICAL DELIMITATION OF THE LOWER GONDWANAS IN THE NORTH KARANPURA SEDIMENTARY BASIN, INDIA*

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ABSTRACT

The Lower Gondwana outcrops exposed in the North Karanpura sedimentary basin comprise Talchir, Karharbari, Barakar, Barren Measures and Raniganj formations. A lot of surface and subsurface samples have been palynologically investigated from all these formations. It has been observed that in Talchir, the assemblage is dominated by monosaccates. The Lower Karharbari is dominated by triletes followed by monosaccates while in the Upper Karharbari monosaccates are dominant and bisaccates are next in abundance. In the Lower Barakar, the assemblage is dominated by striate bisaccates and monosaccates are found in small percentage. The next palynological zone in Barakar is dominated by triletes where there are thick coal seams. In the Upper Barakar, triletes dwindle down and striate bisaccates predominate. The Barren Measures is also dominated by striate bisaccates but presence of a monosaccate genus viz. *Densipollenites* in good percentage easily distinguishes this formation from the upper and lower ones. In the Raniganj, striate bisaccates are in abundance and where there are thick coal seams, triletes and monoletes are found in appreciable percentage. Eight palynological zones have been established.

It is observed that the various formations of the Lower Gondwanas in the North Karanpura sedimentary basin can be demarcated by means of palynological fossils. The relative dominance or paucity of triletes, monosaccates and bisaccates can be effectively used for demarcation of the various formations. It is observed that change in palynological assemblage from one formation to another is gradual and the palynological demarcation exactly between the uppermost and lowermost parts of the two successive formations based on lithology is rather difficult. After this transitional zone, the palynological assemblage gradually differs from one another and thus palynological boundary between the two formations can be marked satisfactorily.

INTRODUCTION

THE North Karanpura sedimentary basin covers an approximate area of 470 square miles lying between 84°50' to 80°30'E and 23°37'N in the state of Bihar, India. The basin was named by Hughes (1869) after the parganah (sub-district) of Karanpura and later workers maintained this name (Jowett, 1925;

Wadia, 1953; Krishnan, 1960; Pascoe, 1959; Ghosh and Basu, 1969 and others).

The Lower Gondwana outcrops exposed in this basin are found in the following order:

Damuda	{ Raniganj Barren Measures Barakar
Talchir	{ Karharbari Talchir —Unconformity —

The Talchir Formation occupies in this basin an area of about 9 square miles. Two comparatively larger outcrops are situated at the northern part of the basin. This formation, in the opinion of Ghosh and Mitra (1969), is characterized by its abraded, polished and stratified basement; presence of non-sorted and non-stratified tillites with striated and faceted pebbles and boulders and finally close association of tillites with glaciolacustrine rhytmites.

Besides, in their opinion, Talchir Formation has an interesting assemblage of rock types, though siltstones, mudstones and fine grained sandstones constitute its bulk. These show all gradations from unstratified boulder beds to partly or wholly stratified pebbly mudstones. There are also thick sequence of shales and siltstones which occasionally show varve-like alteration of dark and light coloured bands.

The Karharbari Formation, according to Ghosh and Basu (1969) is lithologically different both from underlying Talchir and overlying Barakar by its dominance of reworked Talchir material, the greywacke to subgreywacke composition of its sandstone and a characteristic heavy mineral assemblage dominated by zircon and rutile. It may, however, be stated here that though Blanford as early as 1878 recognized Karharbari as a formation, some geologists were inclined to place it

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in the Barakar as its basal unit while the former placed it as the upper limit of the Talchir Group. However, according to Ghosh and Basu (1969), the discovery of the marine bed lying unconformably over the Talchir in the Umaria coalfield proved to be the deciding factor for inclusion of Karharbari in the Damuda Group.

The Barakar Formation is very well developed in North Karanpura basin and possesses several productive coal seams. This formation is generally divided into 3 subformations on the basis of lithology. This can be summarized as follows: (see also Pareek, 1969).

Upper Barakar — mostly arenaceous sediments with argillaceous layers. Sandstone fine grained, Ferruginous beds common.

Middle Barakar — mostly arenaceous with argillaceous bands. Sandstone fine-coarse grained. Thick coal seams.

Lower Barakar — mostly arenaceous, sandstone coarse grained to gritty with quartz and felspar. Thick coal seams.

The Barren Measures Formation is mostly present in the northern and eastern regions of the basin. The shales of this formation is generally pale, more sandy and less carbonaceous. The ironstone shales also seem to be poor in iron.

The Raniganj Formation exposes as bands averaging some two to three miles in breadth, surrounding Panchets and Mahadevas in the central region of the basin. There are several coal seams in this formation but only a few are economically exploitable.

MATERIAL AND METHOD

The present material includes several surface exposures and bore cores from the various parts of the North Karanpura sedimentary basin. Palynological samples from four exposures near Badam were collected and studied (Venkatachala and Kar, 1968a). Three outcrops belonging to Barakar Formation were also investigated by Venkatachala and Kar (1968b) near Lungatoo, while Kar (1968) worked out Raniganj exposure from the same locality. Besides, Kar (1969a) studied subsurface palynology of the bore core no. K5 comprising Barakar, Barren Measures and Raniganj formations located at Raniganj-Kevendai area. Kar (1969b) also investigated bore core no. K2 from the same

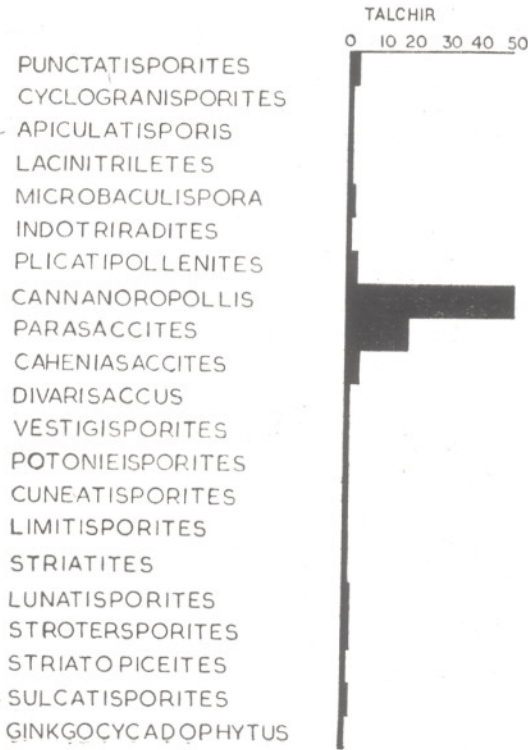
area consisting of Barren Measures and Raniganj formations. Recently, Kar has investigated two more bore cores from this basin. One (KMB 19) has Karharbari and Barakar formations while the other (KB 21) has Talchir, Karharbari, Barakar and Barren Measures formations. All these bore cores were kindly supplied by Shri P. K. Ghosh, the then Director, Coal Division, Geological Survey of India, Calcutta. The information gathered from the above materials has been utilized in preparing this paper.

Talchir assemblage — Only three samples of this formation yielded palynological fossils. Hence an exhaustive investigation of the palynological assemblage of this formation could not be made. It has, however, been observed that this assemblage is overwhelmingly dominated by monosaccates. In the Lower Talchir, they are found up to 92%, while in the upper one, their percentage may be dwindled down to 75%. Of the monosaccates, *Cannanoropollis* and *Parasaccites* are found in abundance. *Caheniasaccites* and *Plicatipollenites* are also occasionally found. Among the triletes, *Punctatisporites* is frequently met with while *Lunatisporites*, *Strotersporites* and *Sulcatisporites* are also common among the bisaccates. The following genera are found within the counted specimens: *Punctatisporites* (3%), *Cyclogranisporites* (1%), *Apiculatisporis* (1%), *Lacinitriletes* (1%), *Microbaculispora* (2%), *Indotriradites* (1%), *Plicatipollenites* (3%), *Cannanoropollis* (51%), *Parasaccites* (19%), *Caheniasaccites* (4%), *Divarisaccus* (1%), *Vestigisporites* (1%), *Potonieisporites* (1%), *Cuneatisporites* (1%), *Limitisporites* (1%), *Striatites* (1%), *Lunatisporites* (2%), *Strotersporites* (2%), *Striatopiceites* (1%), *Sulcatisporites* (2%), and *Ginkgocycadophytus* (1%) (Text-figs. 1a & 1b).

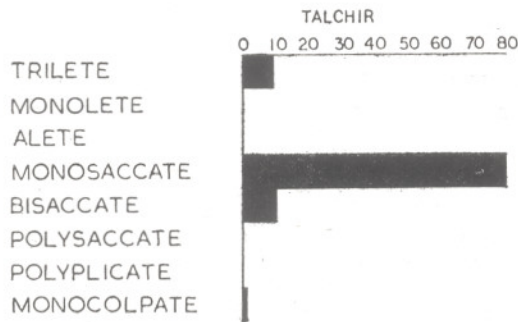
Karharbari assemblage — This assemblage is well represented in the present basin. It has been observed that the following 23 genera represent this assemblage: *Punctatisporites* (8%), *Cyclogranisporites* (7%), *Apiculatisporis* (2%), *Lacinitriletes* (3%), *Microbaculispora* (4%), *Indotriradites* (5%), *Tiwariasporis* (1%), *Plicatipollenites* (4%), *Cannanoropollis* (13%), *Katangaites* (1%), *Parasaccites* (10%), *Caheniasaccites* (2%), *Divarisaccus* (2%), *Vestigisporites* (2%), *Potonieisporites* (2%), *Cuneatisporites* (2%), *Limitisporites* (1%), *Striatites* (1%),

Lunatisporites (2%), *Strotersporites* (8%), *Striatopiceites* (9%) and *Sulcatisporites* (2%) (Text-figs. 2a & 2b).

It may be stated here that the above mentioned genera are not found in all the samples. In fact in Karharbari, there are two distinct palynological zones: the Lower Karharbari is dominated by triletes (50%)



TEXT-FIG. 1a—Showing the percentage of different genera present in Talchir Formation in North Karanpura sedimentary basin.

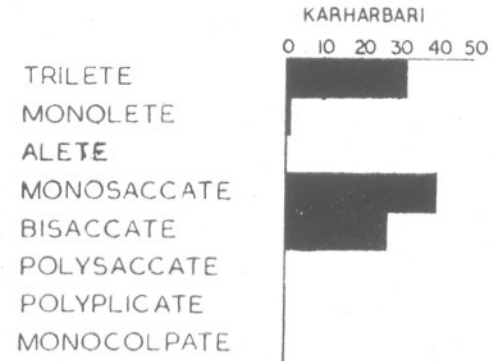


TEXT-FIG. 1b—Showing the percentage of different major groups present in Talchir Formation.

- PUNCTATISPORITES
- CYCLOGRANISPORITES
- APICULATISPORIS
- LACINITRILETES
- MICROBACULISPORIA
- INDOTRIRADITES
- TIWARIASPORIS
- PLICATIPOLLENITES
- CANNANOROPOLLIS
- KATANGAITES
- KIBAMBAITES
- PARASACCITES
- CAHENIASACCITES
- DIVARISACCUS
- VESTIGISPORITES
- POTONIEISPORITES
- CUNEATISPORITES
- LIMITISPORITES
- STRIATITES
- LUNATISPORITES
- STROTERSPORITES
- STRIATOPICEITES
- SULCATISPORITES

KARHARBARI.
0 10 20 30

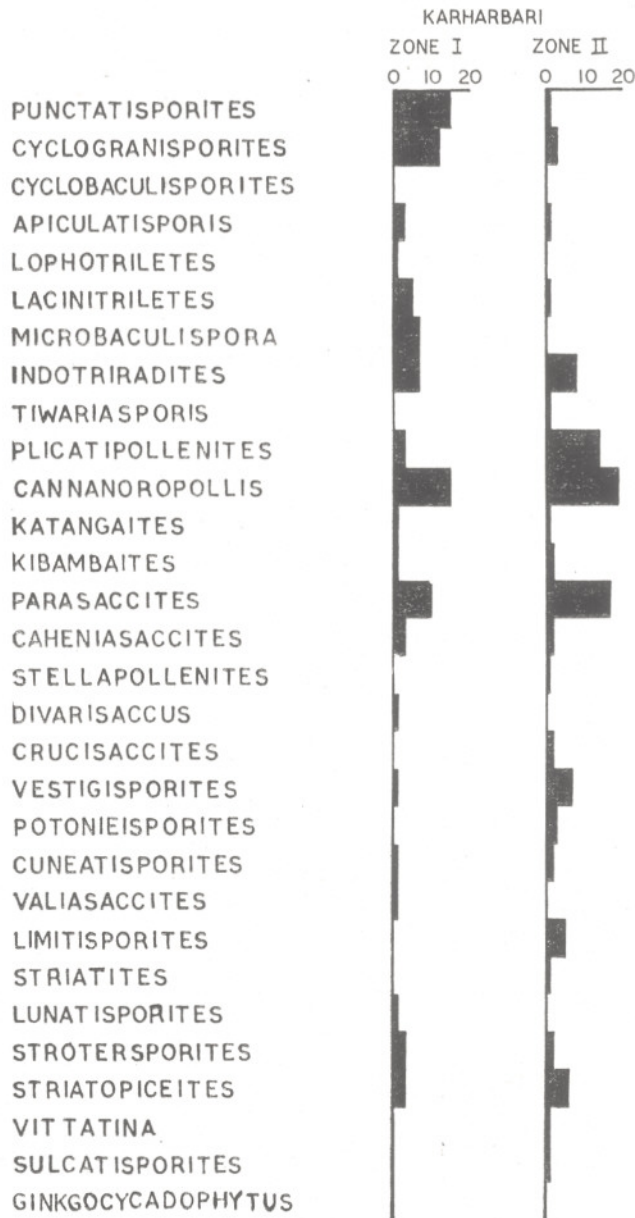
TEXT-FIG. 2a—Showing the percentage of different genera present in Karharbari Formation.



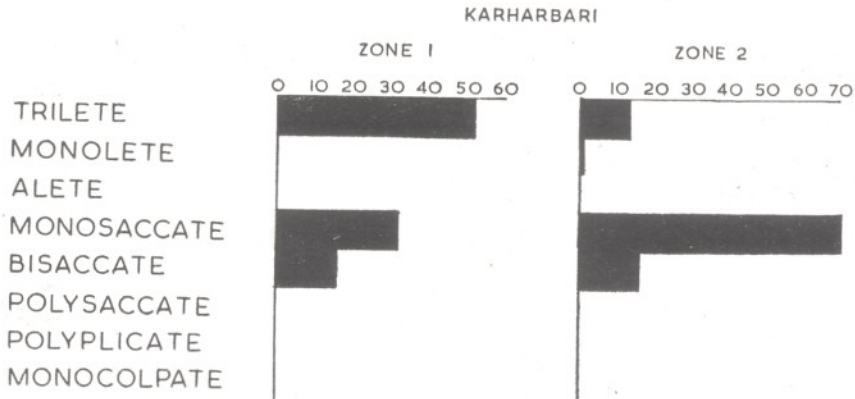
TEXT-FIG. 2b—Showing the percentage of different major groups present in Karharbari Formation.

and followed by monosaccates (32%) — while in the Upper Karharbari, monosaccates are dominant (60%) and bisaccates are next in abundance (25%). In the lower zone, among the triletes, *Punctatisporites*, *Indotriradites* and *Lacinitriletes* are very common. *Cannanoropollis*, *Parasac-*

cites, *Plicatipollenites* and *Caheniasaccites* mostly represent the monosaccates. In the upper zone monosaccate genera like *Cannanoropollis*, *Parasaccites*, *Plicatipollenites* and *Vestigisporites* are dominant. Of the bisaccates, *Strotersporites*, *Striatopiceites* and *Limitisporites* are frequently



TEXT-FIG. 3a — Showing the percentage of different genera in Zone 1 and Zone 2 present in Karharbari Formation.



TEXT-FIG. 3b— Showing the percentage of different major groups in Zone 1 and Zone 2 in Karharbari Formation.

met with. This zone resembles the Talchir assemblage but can be distinguished from the latter by its good percentage of striate bisaccate genera (Text-figs. 3a & 3b).

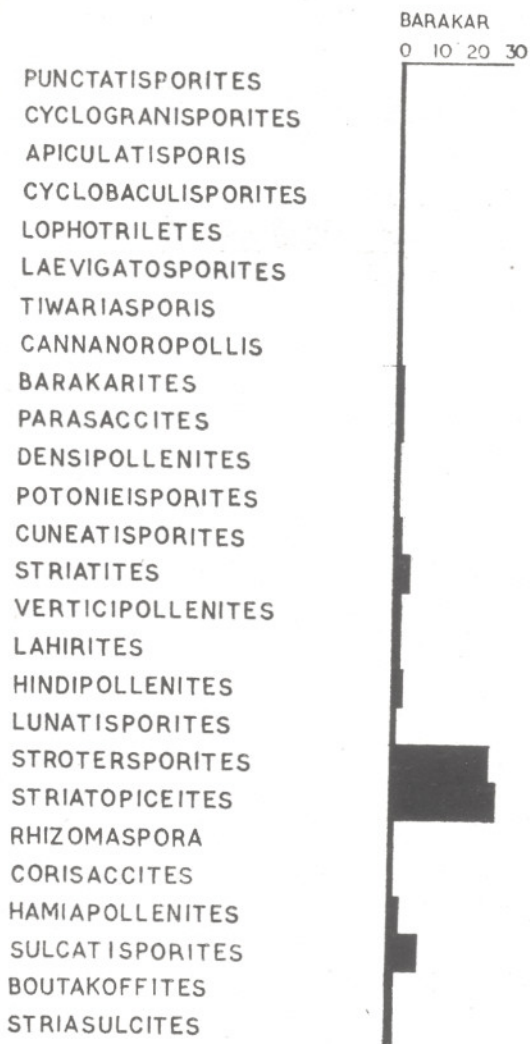
Barakar assemblage— The Barakar assemblage taking as a whole is characterized by its dominance of striate bisaccates. The following 26 genera are found within the count: *Punctatisporites* (1%), *Cyclogranisporites* (1%), *Apiculatisporis* (1%), *Cyclobaculisporites* (1%), *Lophotriletes* (1%), *Laevigatosporites* (1%), *Tiwariaspis* (1%), *Cannanoropollis* (1%), *Barakarites* (2%), *Parasaccites* (2%), *Densipollenites* (1%), *Potonieisporites* (1%), *Cuneatisporites* (2%), *Striatites* (4%), *Verticypollenites* (2%), *Lahirites* (2%), *Hindipollenites* (3%), *Lunatisporites* (1%), *Strotersporites* (26%), *Striatopiceites* (28%), *Rhizomaspora* (1%), *Corisaccites* (1%), *Hamiapollenites* (3%), *Sulcatisporites* (8%), *Boutakoffites* (2%), and *Striasulcites* (2%) (Text-figs. 4a & 4b).

In the lower part of the Barakar Formation, the striate genera like *Strotersporites*, *Striatopiceites* and *Striatites* dominate the assemblage. In association with these genera, some monosaccates like *Cannanoropollis*, *Barakarites*, *Parasaccites* and *Potonieisporites* are also found in small percentage. *Punctatisporites*, *Cyclogranisporites*, *Apiculatisporis* and *Microbaculispora* are found in meagre percentage. The next palynological zone is marked by the gradual increase of triletes which ultimately reach maximum in the assemblage. They are mostly represented by *Apiculatisporis*, *Lophotriletes*, *Altitriletes*, *Didecitriletes*, *Lacinitriletes* and

Microbaculispora. The striate bisaccates are next in abundance and are mostly represented by *Strotersporites*, *Striatopiceites* and *Striatites*. Monosaccate genera are hardly encountered in the assemblage. This palynological zone with the dominance of pteridophytic spores is, however, not found in all the bore cores. Where there are thick coal seams, the dominance of triletes is observed in the assemblage. In the Upper Barakar Formation, triletes again diminish in percentage and the striate bisaccate genera (*Strotersporites*, *Striatopiceites*, *Striatites* etc.) are predominating. *Densipollenites*, a monosaccate genus is also found in small percentage.

Barren Measures assemblage— This assemblage is mostly represented by following 13 genera: *Apiculatisporis* (1%), *Densipollenites* (20%), *Cuneatisporites* (1%), *Striatites* (4%), *Verticypollenites* (1%), *Lahirites* (3%), *Hindipollenites* (1%), *Strotersporites* (29%), *Striatopiceites* (35%), *Schizopollis* (1%), *Sulcatisporites* (4%), *Ephedripites* (1%) and *Striasulcites* (1%). Striate bisaccates mostly represented by *Strotersporites* and *Striatopiceites* dominate throughout the assemblage. This formation is, however, distinguished by its very good percentage of *Densipollenites*. This genus starts flourishing in Lower Barren Measures, attains its maximum development in middle (up to 40%) and then gradually dwindles down into the upper part (Text-figs. 5a & 5b).

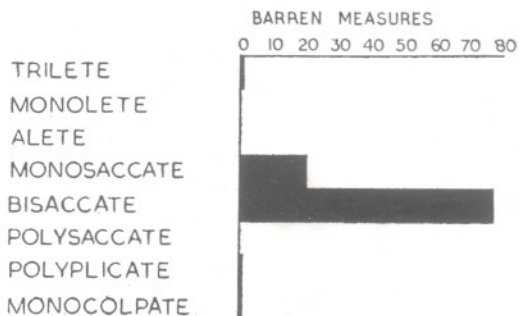
Raniganj assemblage— This formation is ushered in the appearance of triletes and monoletes in sizable percentage though



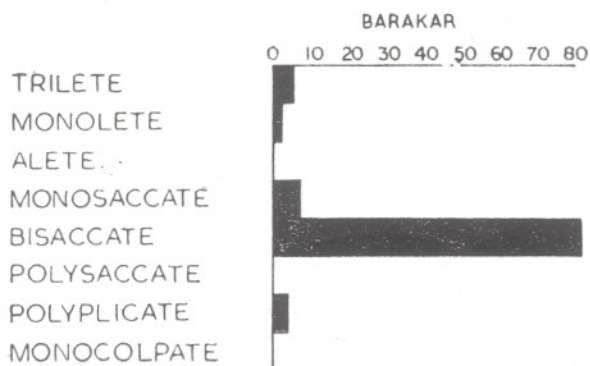
TEXT-FIG. 4a — Showing the percentage of different genera present in Barakar Formation.



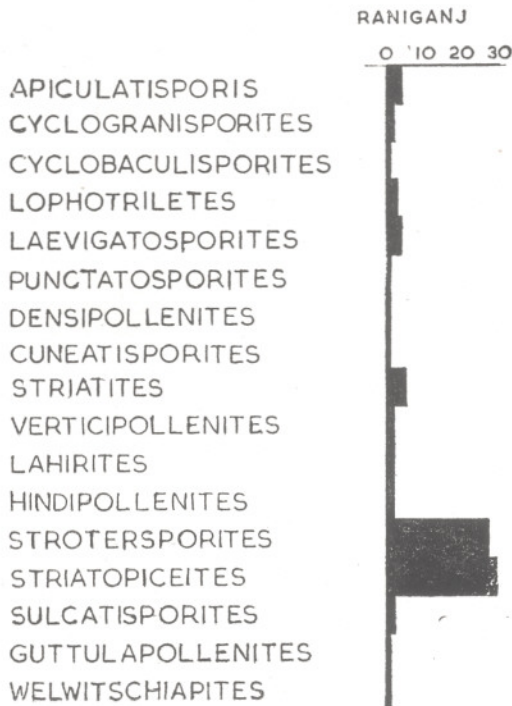
TEXT-FIG. 5a — Showing the percentage of different genera present in Barren Measures Formation.



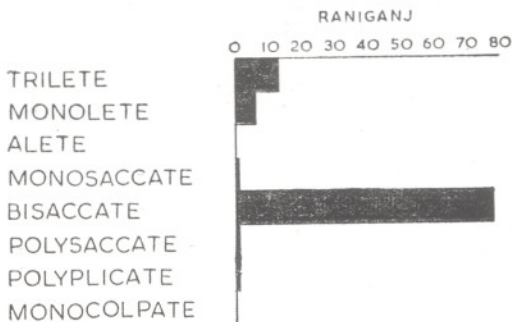
TEXT-FIG. 5b — Showing the percentage of different major groups present in Barren Measures Formation.



← TEXT-FIG. 4b — Showing the percentage of different major groups present in Barakar Formation.



TEXT-FIG. 6a—Showing the percentage of different genera present in Raniganj Formation.



TEXT-FIG. 6b—Showing the percentage of different major groups present in Raniganj Formation

striate bisaccates are dominant throughout. The following 17 genera are generally found within the count: *Apiculatisporis* (4%), *Cyclogranisporites* (2%), *Cyclobaculisporites* (1%), *Lophotriletes* (3%), *Laevigatosporites* (4%), *Punctatosporites* (1%), *Densipollenites* (1%), *Cuneatisporites* (1%), *Striatites* (5%), *Verticipollenites* (2%), *Lahirites* (2%), *Hindipollenites* (2%),

Sulcatissporites (2%), *Guttulapollenites* (1%) and *Welwitschiapites* (1%). The spore-pollen genera are more or less uniform in representation except where there is coal or coaly shale, the percentage of trilete and monoletes spores considerably goes up (Text-figs. 6a & 6b).

General consideration and zonation—In the present samples, monosaccates dominate in Upper Talchir Formation, their behaviour in the basal most bed is, however, unfortunately not known. With the onset of Karharbari Formation, their number is decreased and the triletes take the lead. In Upper Karharbari Formation, the monosaccates again come into prominence. The percentage of monosaccates goes down in Barakar but increases again in Barren Measures for the last time. Triletes though common in Upper Talchir become dominant in Lower Karharbari, dwindle down in Upper Karharbari and are again in prominence in Middle Barakar. In Barren Measures, their position is precarious and in Raniganj they are again commonly met with. Striate bisaccates are in supremacy in Lower Barakar, they are partly eclipsed in Middle Barakar by triletes when there are thick coal seams, but again they are in prominence from Upper Barakar to Raniganj formations. Aletes, monoletes, polysaccates, polyplacates and monocolpates are not found in commanding position in any of the formations.

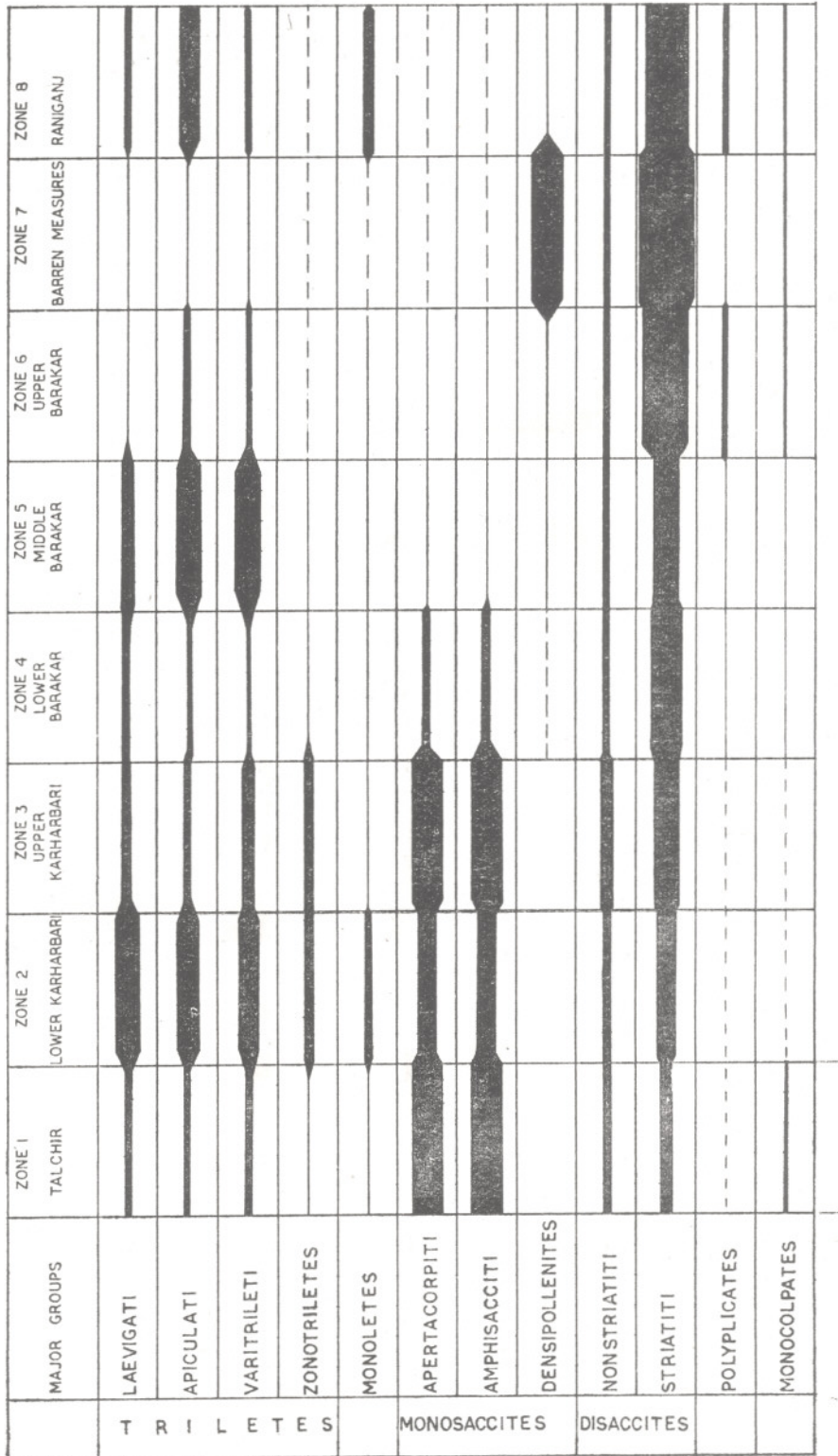
From the above mentioned data, on the dominance of different spore-pollen complexes, the following 8 palynological zones can be established (Text-fig. 7):

Zone 8 (Raniganj)—Striate bisaccates dominant, triletes and monoletes common, monosaccates rare. Dominant genera: *Striatopiceites*, *Strotersporites*, *Striatites*, *Apiculatisporis*, *Laevigatosporites* and *Lophotriletes*.

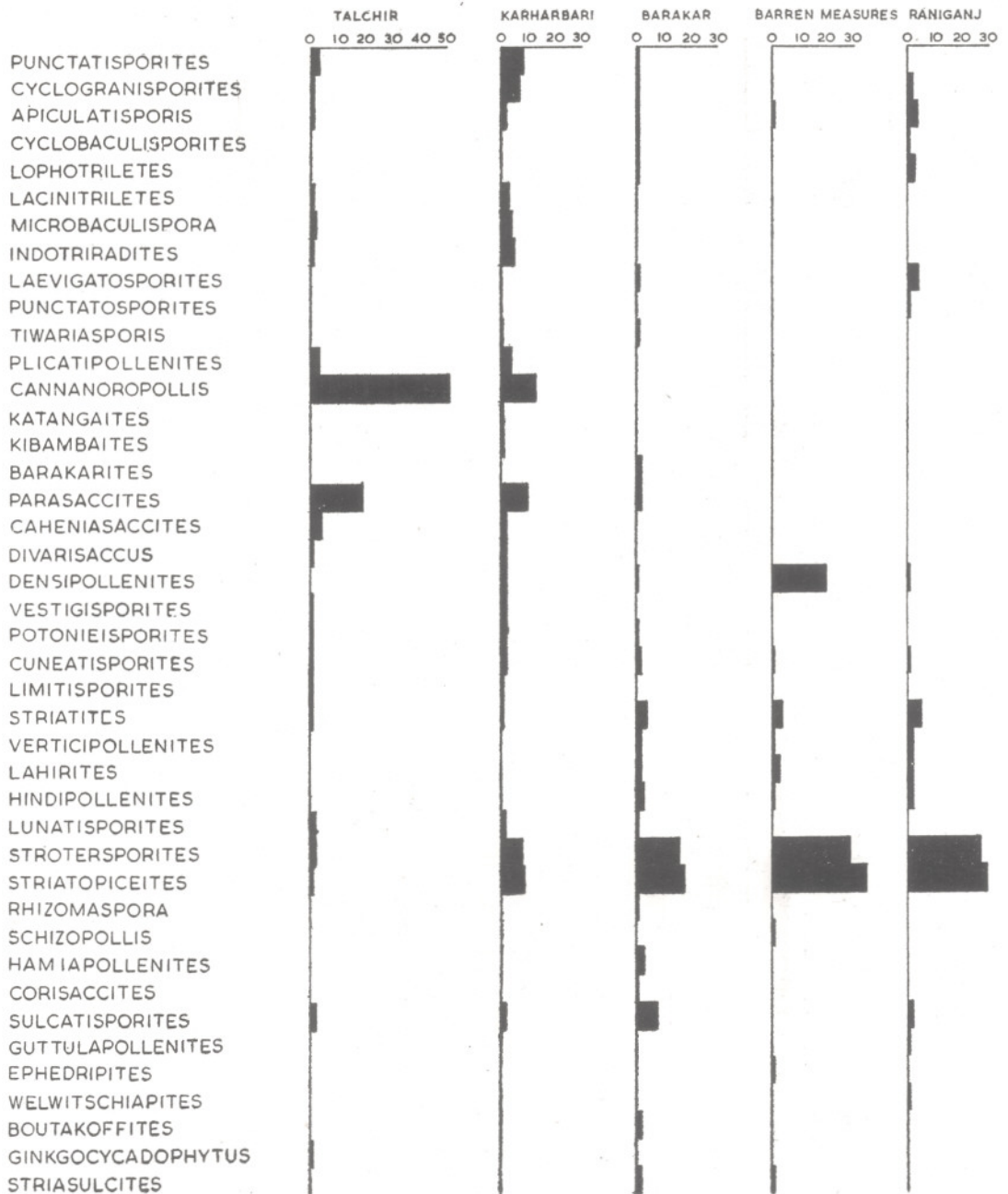
Zone 7 (Barren Measures)—Striate bisaccates dominant, monosaccates subdominant, triletes and monoletes rare. Dominant genera: *Striatopiceites*, *Strotersporites*, *Densipollenites*, *Striatites* and *Sulcatissporites*.

Zone 6 (Upper Barakar)—Striate bisaccates dominant, monosaccates rare, triletes and monoletes few. Dominant genera: *Striatopiceites*, *Strotersporites*, *Striatites* and *Sulcatissporites*.

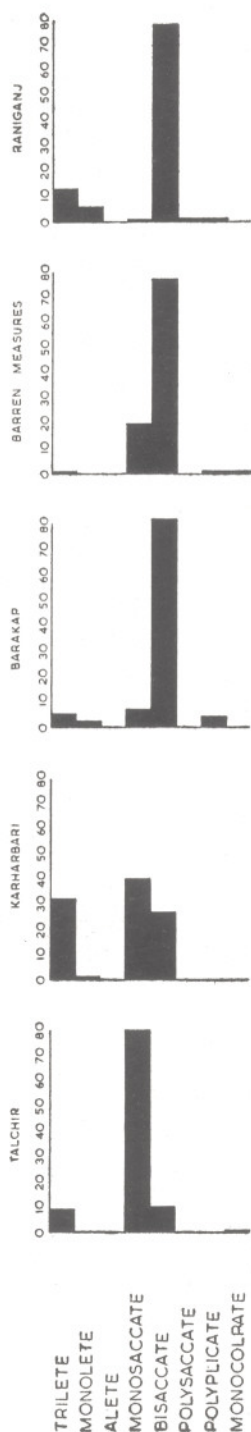
Zone 5 (Middle Barakar)—Triletes dominant, striate bisaccates subdominant monoletes common, monosaccates rare,



TEXT-FIG. 7 — Showing the percentage of different groups present in 8 palynological zones in North Karanpura sedimentary basin.



TEXT-FIG. 8a — Showing the percentage of different genera present in Talchir, Karharbari, Barakar, Barren Measures and Raniganj formations in North Karanpura sedimentary basin.



TEXT-FIG. 8b — Showing the percentage of different major groups present in Talchir, Karharbari, Barakar Barren Measures and Raniganj formations.

Strotersporites (27%), *Striatopiceites* (29%), Dominant genera: *Lophotriletes*, *Lacinitriletes*, *Microbaculispora*, *Didecitriletes*, *Apiculatisporis*, *Strotersporites*, *Striatites* and *Striatopiceites*. This zone might be, a localized one as has been found here in association with thick coal seams. Palynological assemblage of the older seam worked out by Bharadwaj and Tiwari (1966) from Bachra area, North Karanpura coalfield comes close to this zone.

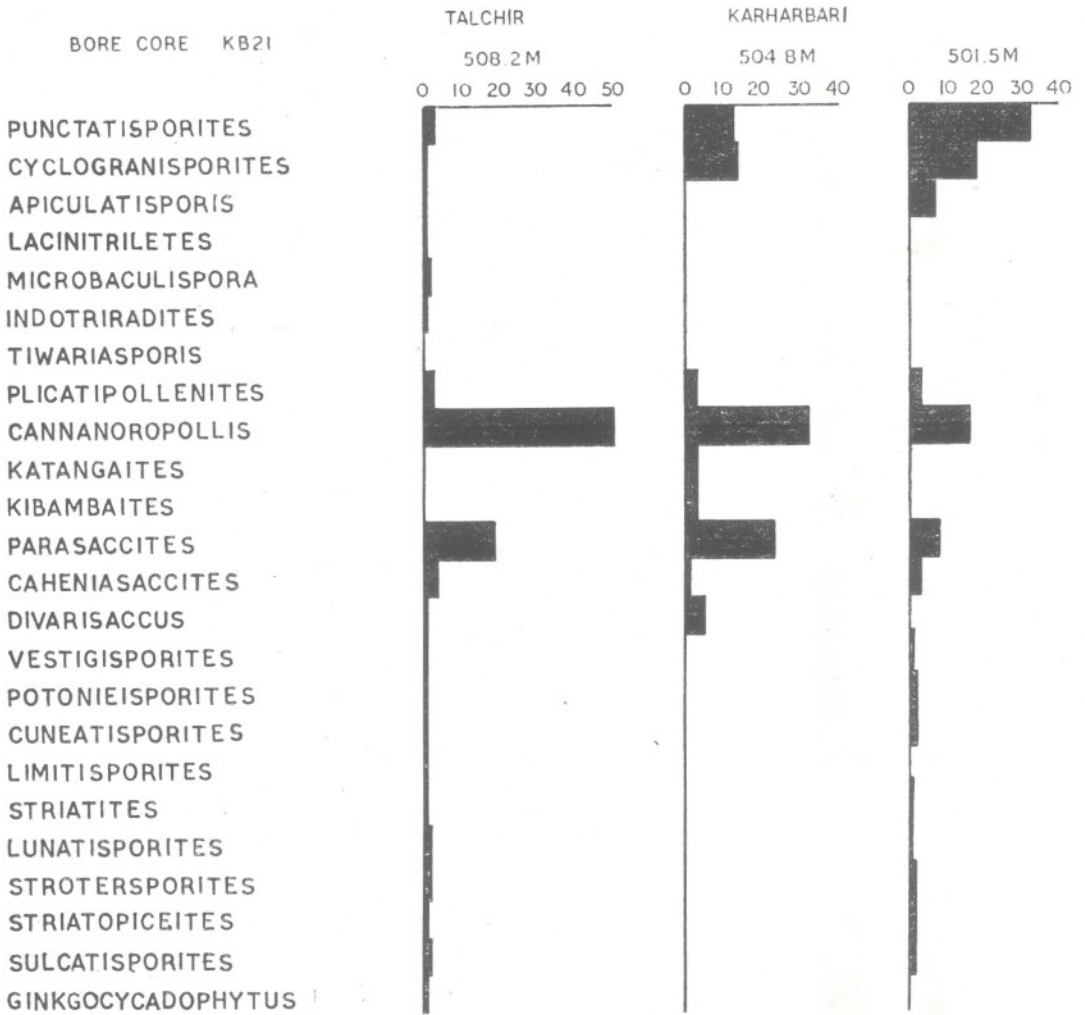
Zone 4 (Lower Barakar) — Striate bisaccates dominant, monosaccates and triletes common. Dominant genera: *Strotersporites*, *Striatopiceites*, *Striatites*, *Cannanoropollis*, *Barakarites*, *Parasaccites* and *Punctatisporites*.

Zone 3 (Upper Karharbari) — Monosaccates dominant, striate bisaccates subdominant, triletes common. Dominant genera: *Cannanoropollis*, *Parasaccites*, *Plicatipollenites*, *Vestigisporites*, *Strotersporites*, *Striatopiceites* and *Limitisporites*.

Zone 2 (Lower Karharbari) — Triletes dominant, monosaccates subdominant, striate bisaccates rare-common. Dominant genera: *Punctatisporites*, *Cyclogranisporites*, *Microbaculispora*, *Indotriradites*, *Lacinitriletes*, *Cannanoropollis*, *Parasaccites*, *Plicatipollenites* and *Caheniasaccites*.

Zone 1 (Talchir) — Monosaccates dominant, triletes common, striate bisaccates not common. Dominant genera: *Cannanoropollis*, *Parasaccites*, *Caheniasaccites*, *Plicatipollenites*, *Punctatisporites* and *Microbaculispora* (Text-figs. 8a & 8b).

Palynological boundaries — It is evident from the above 8 zones that the different formations of the Lower Gondwanas in the North Karanpura sedimentary basin can be demarcated by means of palynological fossils. It is also observed that the mere presence or absence of spores-pollen genera is not much helpful in delimitation of the different formations. The relative dominance or paucity of major groups particularly of triletes, monosaccates and bisaccates can be effectively used for the demarcation of the boundaries in this sedimentary basin. The change in palynological assemblage from one formation to other is gradual. Hence the palynological demarcation exactly between the uppermost and the lowermost parts of the two successive formations based on lithology is rather difficult for the lack of distinctive assemblages. After this transitional zone,



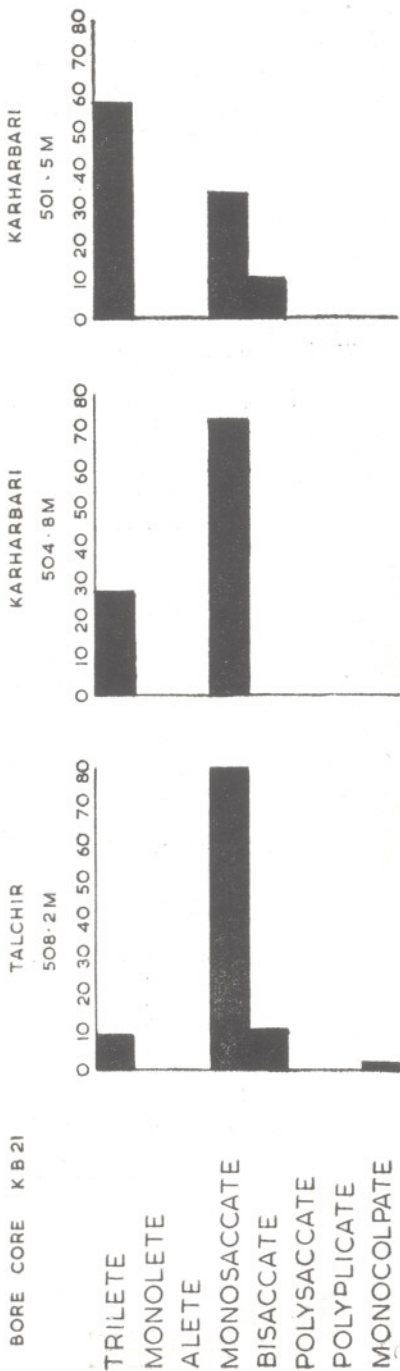
TEXT-FIG. 9A — Showing the percentage of different genera present in Upper Talchir and Lower Karharbari in the bore core No. KB 21.

the palynological assemblage starts to differ from one another and thus the boundary between the two formations can be marked with confidence (Text-figs. 9a & 9b).

Talchir-Karharbari boundary — The Upper Talchir is dominated by monosaccates though triletes are also frequently met with. In the lowermost beds of Karharbari, this tendency also persists though the triletes become fairly common. In the succeeding beds, triletes become more and more prominent ultimately to dominate the assemblage.

The top of Talchir Formation has been marked at 508.2 m. level in the bore core

no. KB21. *Cannanoropollis* (51%) and *Parasaccites* (19%) are dominant in the assemblage at the top. Among the triletes, *Punctatisporites* and *Microbaculispora* contribute 3 and 2% respectively while *Cyclogranisporites*, *Apiculatisporis*, *Lacinitriletes* and *Indotriradites* share 1% each to the assemblage. The assemblage from carbonaceous shale belonging to Karharbari at 504.8 m. level also shows the dominance of *Cannanorobollis* (33%) and *Parasaccites* (24%). *Cyclogranisporites* (14%) and *Punctatisporites* (13%) are most common genera among the triletes. At 501.5 m. level, *Punctatisporites* (32%) is most common



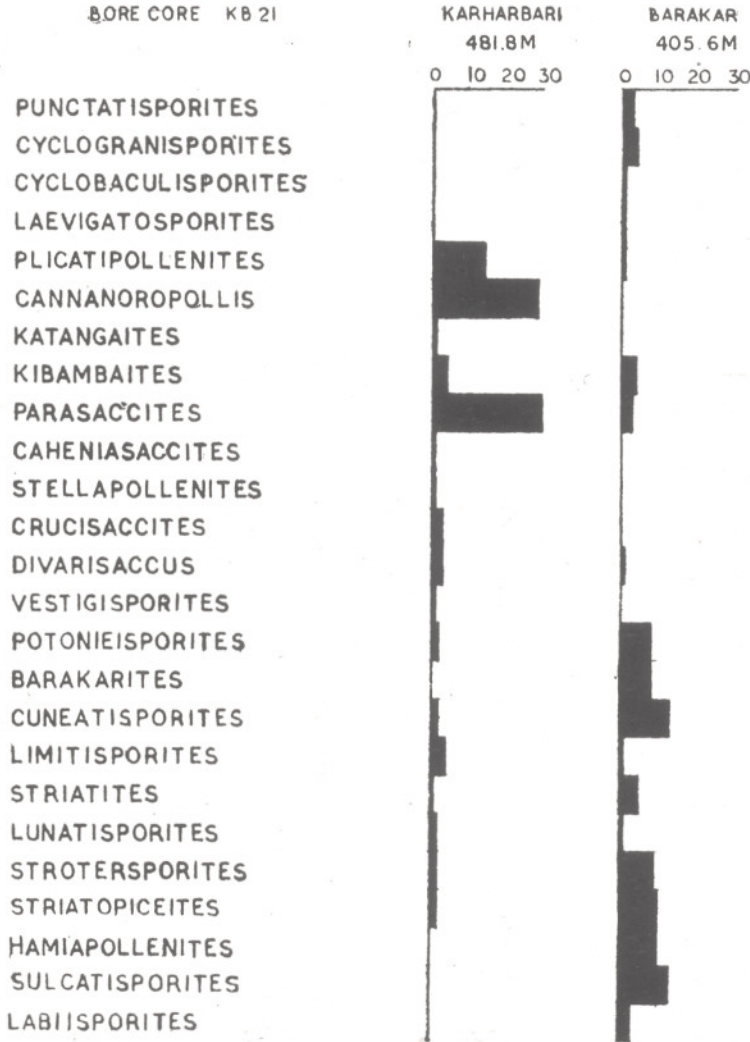
TEXT-FIG. 9B — Showing the percentage of different major groups present in Upper Talchir and Lower Karharbari in the bore core No. KB 21.

followed by *Cyclogranisporites* (18%). Triletes as a group contribute 57% of the total assemblage. Monosaccates in this sample appear as subdominant and mostly represented by *Cannanoropollis* (16%) and *Parasaccites* (8%).

Karharbari-Barakar boundary — The Upper Karharbari assemblage is overwhelmingly dominated by monosaccates. Bisaccates come next while triletes rank third. Among the monosaccates, *Cannanoropollis* and *Parasaccites* are abundant. In the uppermost Karharbari, the dominance of monosaccates is replaced by bisaccates like *Strotersporites* and *Striatopiceites*. In the lowermost Barakar beds, percentage of these forms increases and that of monosaccates goes down. Gradually, triletes also become fairly common (Text-figs. 10a & 10b).

In the bore core no. KB21, the top of Karharbari Formation has been marked at 444 m. level. The sample from 481.8 m. depth yielded an assemblage very much dominated by monosaccates: *Parasaccites* (29%), *Cannanoropollis* (28%), *Plicatipollenites* (14%) and *Kibambaites* (4%). Bisaccate genera present within the counted specimens are: *Limitisporites* (4%), and *Cuneatisporites*, *Lunatisporites*, *Strotersporites* and *Striatopiceites* 2% each. The next productive sample at the level of 405.6 m. belongs to Barakar. It shows the dominance of bisaccates: *Cuneatisporites* (13%), *Sulcatisporites* (13%), *Striatopiceites* (10%), *Hamiapollenites* (10%), *Strotersporites* (9%), *Potonicisporites* (8%) and *Barakarites* (8%) are most common among the monosaccates. Among the triletes, *Cyclogranisporites* (4%) and *Punctatisporites* (3%) are common (Text-figs. 11a & 11b). The next productive sample at 393 m. level shows more dominance of striate bisaccates.

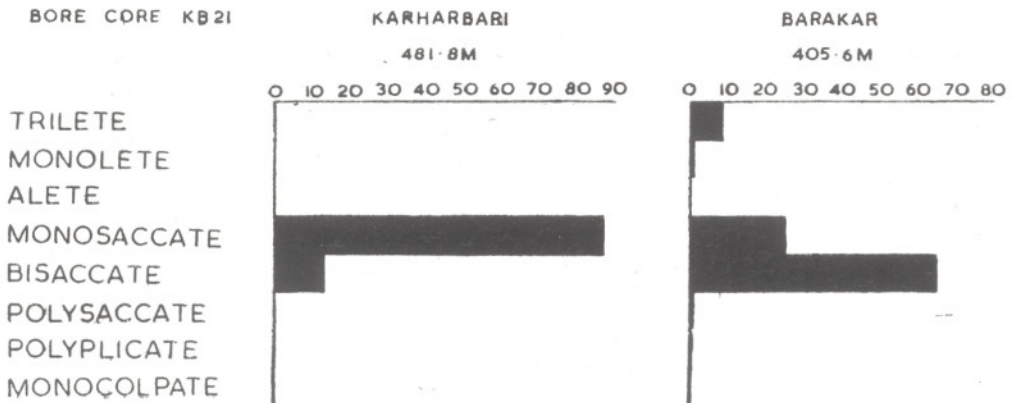
In the bore core no. KBM19, the top of Karharbari Formation has been marked at 71.2 m. The sample at 83.7 m. shows the dominance of striate bisaccate genera like *Striatopiceites* (26%) and *Strotersporites* (15%). Monosaccates are subdominant and mostly represented by *Parasaccites* (7%), *Cannanoropollis* (5%), *Barakarites* (3%) and *Vestigisporites* (3%). At 71.5 m. level, the percentage of striate bisaccate genera increases and monosaccates decreases. Trilete genera are also more common than the previous sample. The next productive sample is from Barakar at 48 m. level. In

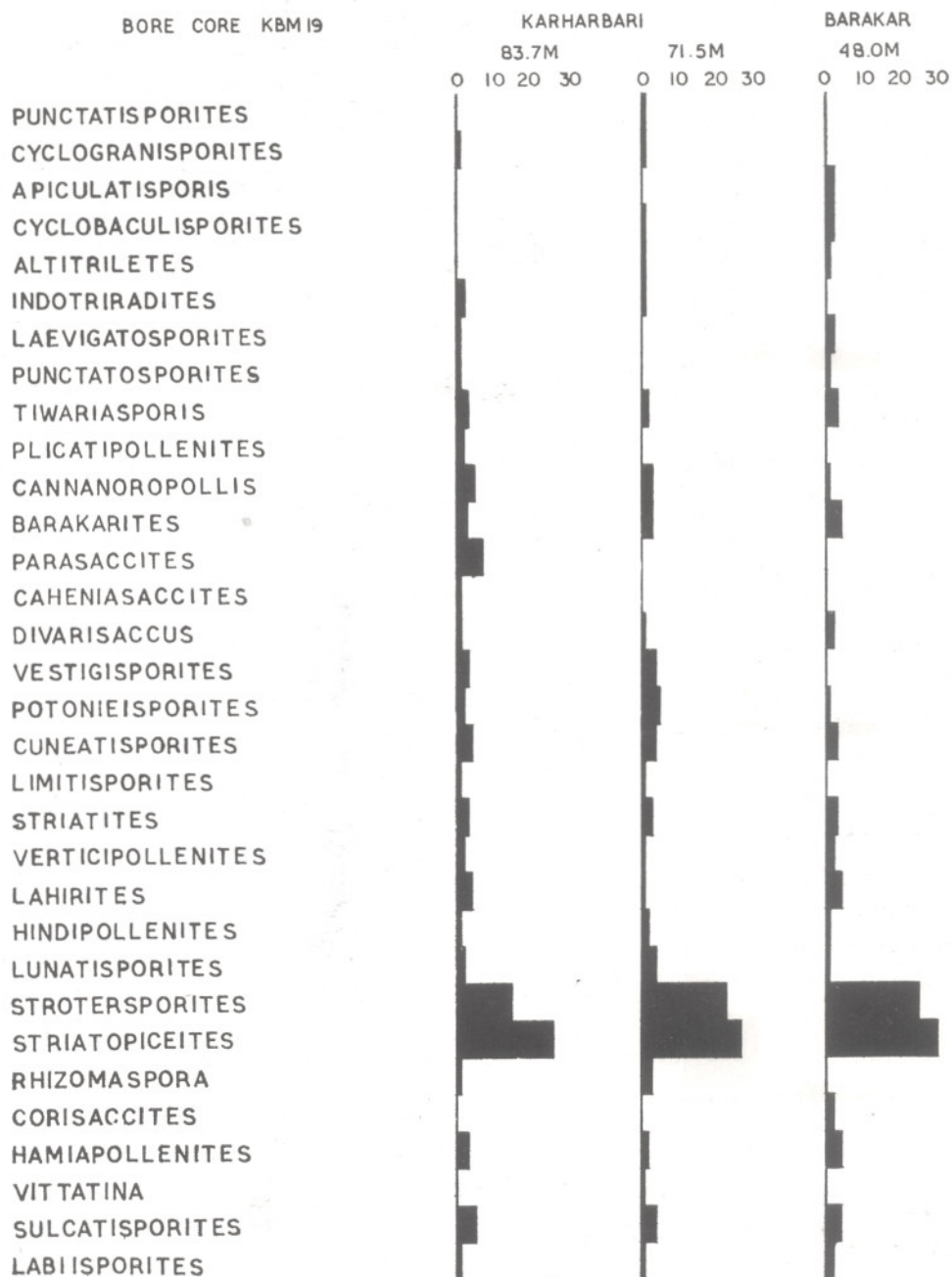


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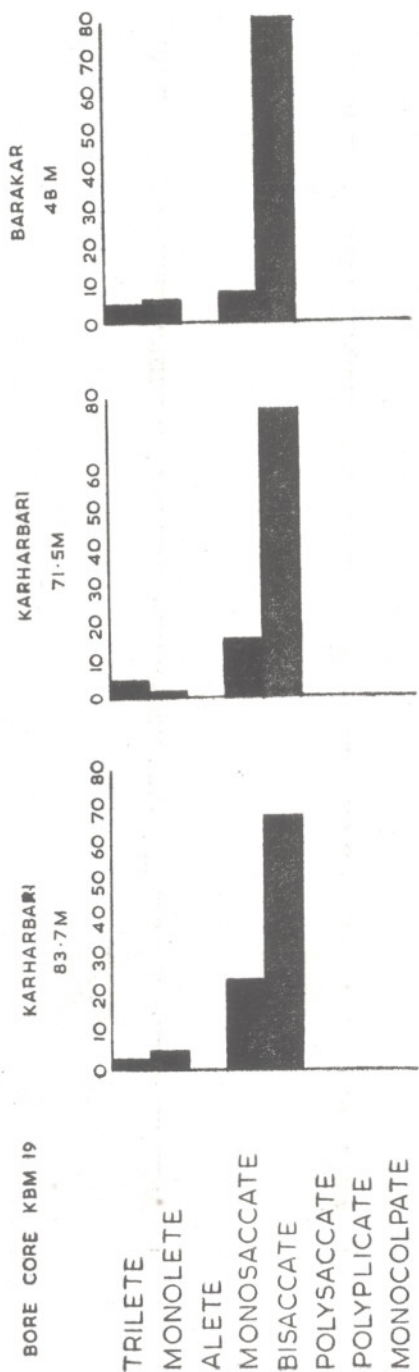
TEXT-FIG. 10A — Showing the percentage of different genera present in Upper Karharbari and Lower Barakar in bore core No. KB 21.

TEXT-FIG. 10B — Showing the percentage of different major groups present in Upper Karharbari and Lower Barakar in bore core No. KB 21.





TEXT-FIG. 11A — Showing the percentage of different genera present in Upper Karharbari and Lower Barakar in the bore core No. KBM 19.



TEXT-FIG. 11B — Showing the percentage of different major groups present in Upper Karharbari and Lower Barakar in the bore core No. KBM 19.

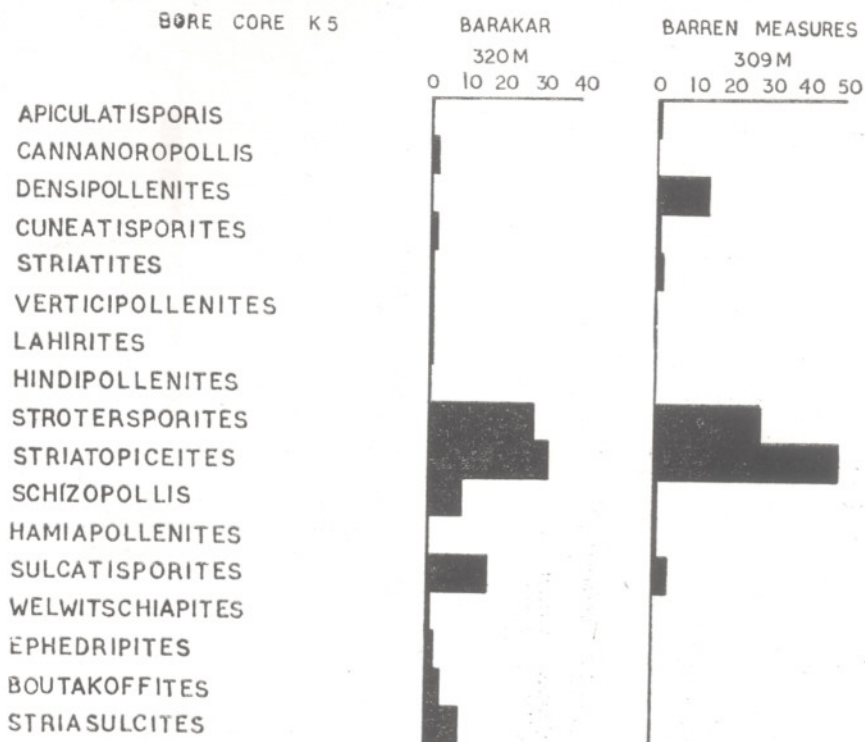
this assemblage *Striatopiceites* contributes maximum (30%) followed by *Strotersporites* (25%). *Lahirites*, *Hamiapollenites* and *Sulcatisporites* each share 4% in the assemblage. Among the monosaccates, *Barakarites* contributes 4% and *Divarisaccus* (2%). Pteridophytic spores are common and represented by *Tiwariasporis* (3%), *Apiculatisporis* (2%), *Cyclobaculisporites* (2%) and *Laevigatosporites* (2%).

Barakar-Barren Measures boundary — In Upper Barakar, striate bisaccate genera mainly *Striatopiceites* and *Strotersporites* dominate the assemblage. Monosaccates are rare and a few triletes are observed. In some samples polylicates and monocolpates are fairly common but in others they are rare. In shale samples from Lower Barren Measures, *Striatopiceites* and *Strotersporites* are more dominant, triletes, polylicates and monocolpates are rare. Monosaccates represented mostly by *Densipollenites* contribute more and more to the assemblage (Text-figs. 12a & 12b).

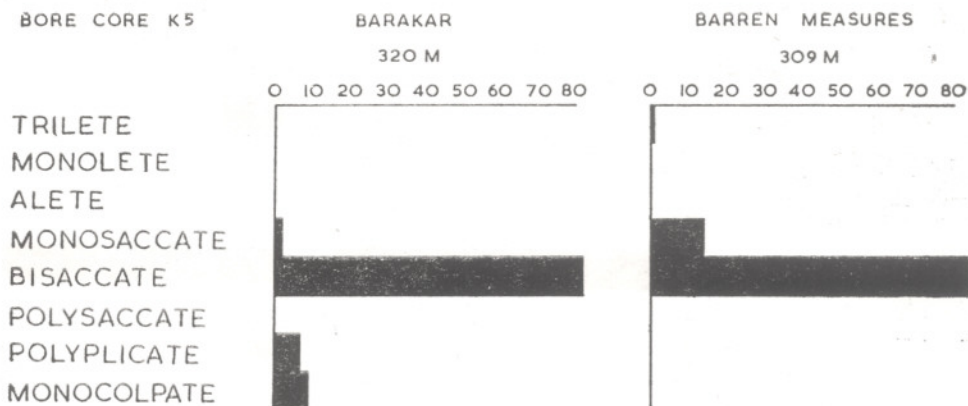
In the bore core no. K5, the top of Barakar has been marked at 326.7 m. The sample at a depth of 320 m. yielded an assemblage which is very rich in striate bisaccates. *Striatopiceites* shares 32% while *Strotersporites* contributes 28%, *Sulcatisporites* and *Schizopollis* represent 16 and 9% respectively. A striate monocolpate genus viz. *Striasulcites* also contributes 9% while *Boutakoffites* is found in 4%. The sample from 309 m. level yielded not a very diversified assemblage. *Striatopiceites* represents 49% while *Strotersporites* contributes 28%. *Densipollenites* (14%) is fairly common and *Sulcatisporites* shares 4%. The percentage of *Densipollenites* in the succeeding samples increases providing a basis for differentiating the two formations (Kar, 1969a).

In the bore core no. K2, the top of Barren Measures has been marked at the depth of 352.97 m. It has been observed that up to the depth of 259 m. (assigned as Raniganj) *Densipollenites* is quite common. Triletes, polylicates and monocolpates are also rare (Kar, 1969b). Moreover, up to this level there is no coal and the lithology comprises sandstones alternating with green, sandy shale. So the uppermost limit of Barren Measures in this bore core seems to be upto 259 m (Text-figs. 13a & 13b).

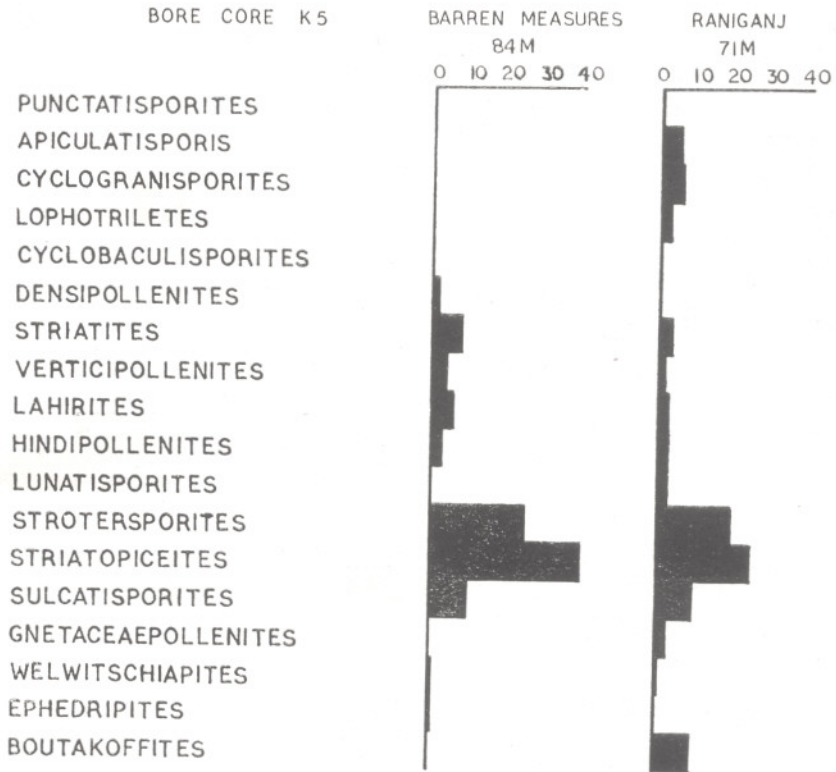
Barren Measures — Raniganj boundary — The Upper Barren Measures assemblage is



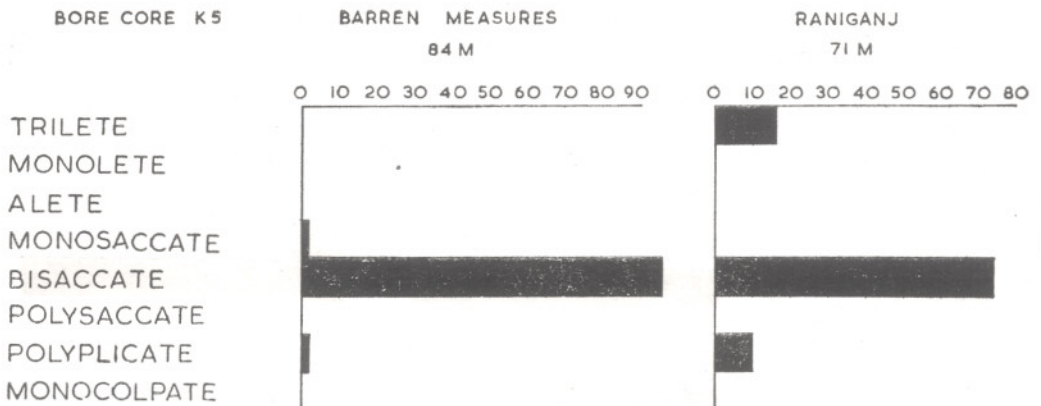
TEXT-FIG. 12A — Showing the percentage of different genera present in Upper Barakar and Lower Barren Measures in the bore core No. K 5.



TEXT-FIG. 12B — Showing the percentage of different major groups present in Upper Barakar and Lower Barren Measures in the bore core No. K 5.



TEXT-FIG. 13A — Showing the percentage of different genera present in Upper Barren Measures and Lower Raniganj in the bore core No. K 5.



TEXT-FIG. 13B — Showing the percentage of different major groups present in Upper Barren Measures and Lower Raniganj in the bore core No. K 5.

predominated by striate bisaccates. *Striatopiceites* and *Strotersporites* are very common. Triletes, polyplacates and monocolpates are rare. Monosaccates are meagrely represented by *Densipollenites*. In the Lower Raniganj assemblage also, striate bisaccates are dominant, but triletes are fairly common. Some of the polyplacates are also frequently met with and the percentage of *Densipollenites* decreases.

In the bore core no. K5, the top of Barren Measures has been marked at 63.15 m. The sample at the depth of 84 m. is very much dominated by *Striatopiceites* (40%) and *Strotersporites* (25%). Other bisaccate genera fairly common in the assemblage are: *Sulcatisporites* (10%), *Striatites* (8%) and *Lahirites* (6%). No trilete genera are found within the percentage count. *Densipollenites* represents 2% while *Ephedripites* and *Welwitschiapites* share 1% each. The sample at the depth of 71 m. assigned as Barren Measures is also dominated by striate bisaccates: *Striatopiceites* (25%) and

Strotersporites (20%). *Sulcatisporites* (10%) is also quite common.

Trilete genera like *Apiculatisporis* (6%) and *Lophotriletes* (3%) are well represented. In the succeeding samples, triletes are also well represented though the striate bisaccate genera viz. *Striatopiceites* and *Strotersporites* dominate. So the sample at 71 m. level seems to belong to the Lower Raniganj Formation.

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