SPOROLOGICAL CORRELATION OF COAL SEAMS IN SOME BLOCKS OF SOHAGPUR COALFIELD, M.P., INDIA

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ABSTRACT

The present paper includes a sporological study of 53 bore hole coal samples from Bhaskarpara, Kutkona and Batura blocks of Sohagpur Coalfield, M.P., India. The distribution of various palyno-taxa among the samples has suggested the occurrence of eight coal seams distinguished by eight spore assemblages. Miospore Assemblage G is characterized by the dominance of *Brevitriletes* and *Sulcatisporites*. The Assemblage F shows a dominance of *Brevitriletes* closely associated with *Microbaculispora* and *Indotriradites*. The last genus becomes dominant in Assemblage E_1 with the former two as subdominants. In Assemblage E, the subdominants are *Hennellysporites* and *Illinites*. *Brevitriletes* again ranks highest in Assemblage D and is associated with subdominant *Sulcatisporites*. In Assemblage C, *Brevitriletes* continues to be dominant but the association is marked by the subdominance of *Horriditriletes* and *Sulcatisporites* while in Assemblage B *Horriditriletes* becomes the most dominant genus and remains associated with *Brevitriletes* and *Sulcatisporites*. Assemblage A is characterized by the dominance of *Sulcatisporites* in association with *Striatopodocarpites* and *Striatites*.

The sporological succession is marked by three miofloral changes segregating four groups of assemblages. Chronostratigraphically, Assemblage G belongs to Lower Karharbari Stage, Assemblages F-E represent Lower Barakar Stage, Assemblages D-B represent Middle Barakar Stage and Assemblage A represents the Upper Barakar Stage.

INTRODUCTION

THE Sohagpur Coalfield extends over an area of about 1,200 square miles, and is bound by 83°0′ and 81°30′ east longitudes and 23°9′ and 23°40′ north latitudes. The rich deposit of coal measures are said to be of Barakar Stage but very little has been known in respect of their palynological contents. Navale and Tiwari (1967) have studied the palyno-petrological characters from Churcha block of Sohagpur Coalfield. Extensive survey of rich coal deposits has been done during the recent years and bore core samples of coal made available to us have been sporologically investigated to determine their correlation. The various details of the samples are given in Table 1. The study includes 53 overall coal samples from 33 bore holes obtained from Bhaskarpara, Kutkona and Batura blocks of Sohagpur Coalfield. The location of the bore holes in Bhaskarpara and Kutkona blocks is shown in Map 1 and that of Batura block is shown in Map 2.

METHODS

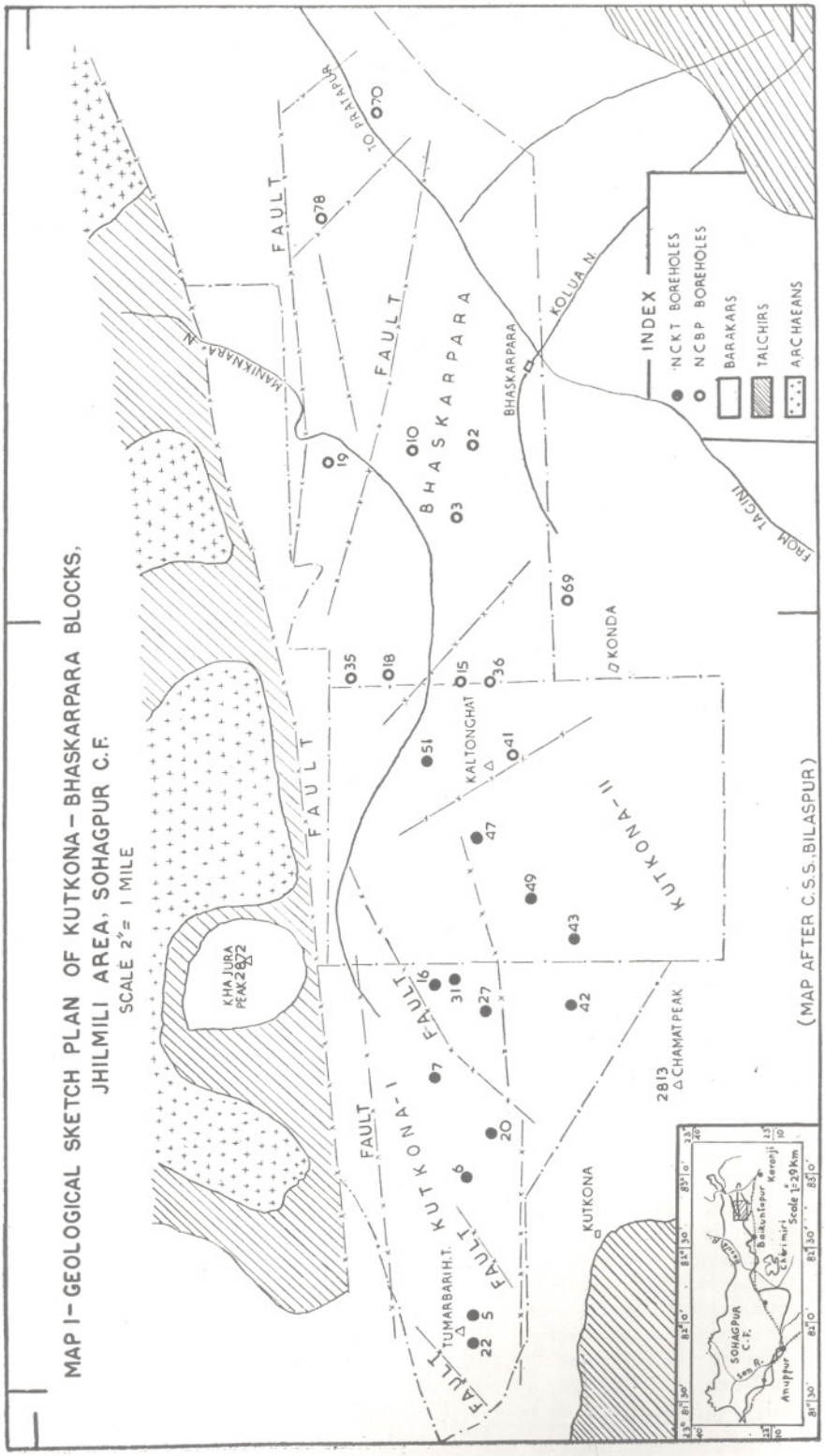
The coal samples were sent to us by the Regional Coal Survey Laboratory of Central Fuel Research Institute at Bilaspur, in powdered form in polythene packs to avoid contamination. All the samples were analysed separately and then the percentage frequency of miospores in each sample was calculated.

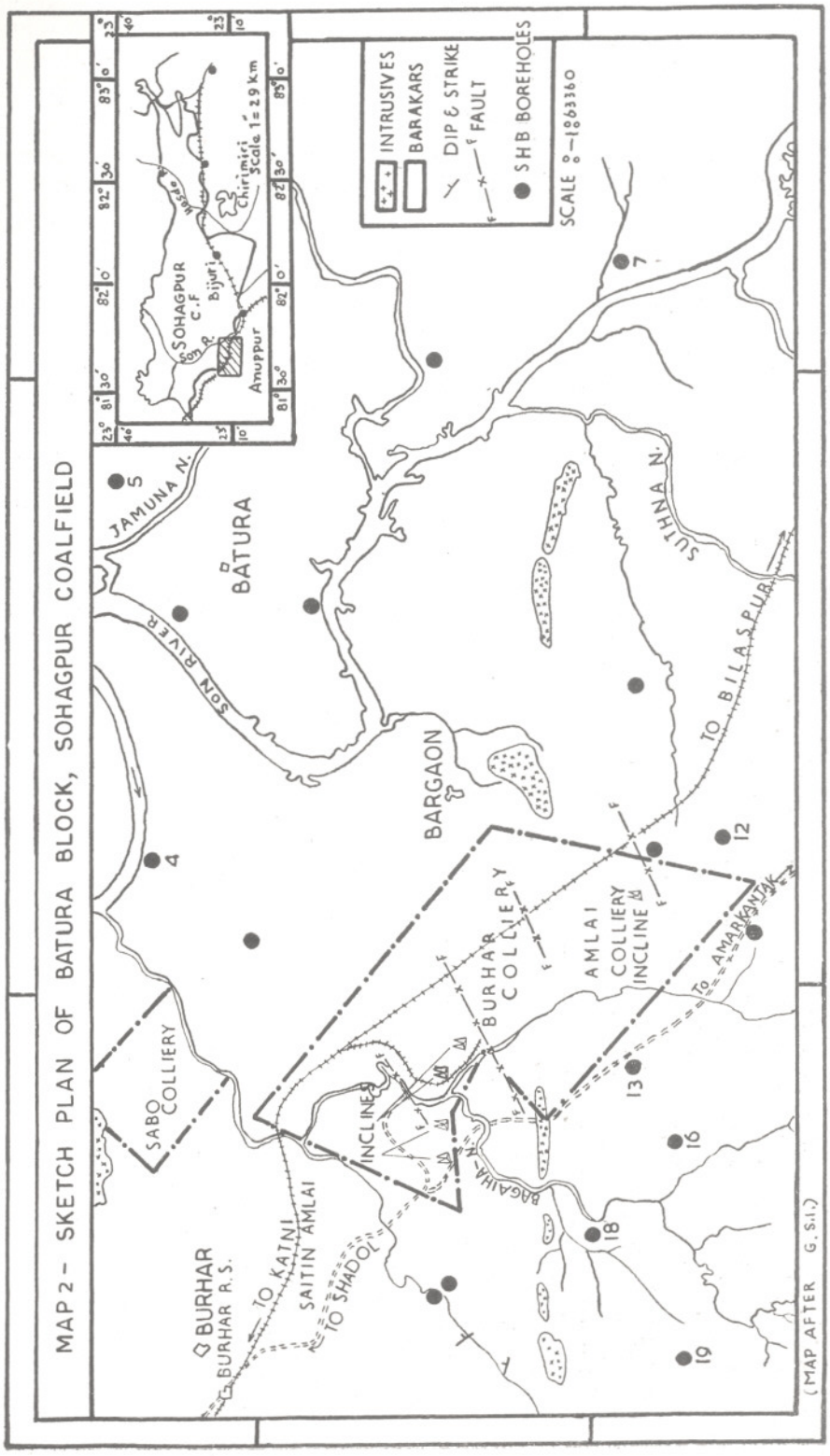
The samples were put to similar procedure of maceration and study, using commercial nitric acid and sodium hydroxide. Five grams of powdered material was treated with acid for three days followed by digestion with 10 per cent NaOH after thorough washing with water. The macerates were again thoroughly washed with water to remove alkali and were mounted in glycerine jelly. The slides and the " counting areas " were selected at random and 500 miospores were counted at generic level in each sample.

RESULTS

The interpretation of the data is based upon the qualitative association of miospores as well as their quantitative representation. Nearly similar quantitative association of spores designated as an assemblage and occurring in certain samples has been interpreted as indicative of the stratigraphic correlation of such samples. The succession of assemblages has been determined on the basis of differences in dominant and subdominant spores in them and their sequential position in such boreholes where from a number of successive samples have been available for study.

The *Sporae dispersae* of Sohagpur Coalfield have been assigned to 40 genera (sensu — BHARADWAJ, 1962; BHARADWAJ & SALUJHA,


MAP I- GEOLOGICAL SKETCH PLAN OF KUTKONA- BHASKARPARA BLOCKS, JHILMILI AREA, SOHAGPUR C.F.
SCALE 2"= 1 MILE
INDEX
NCKT BOREHOLES
NCBP BOREHOLES
BARAKARS
TALCHIRS
ARCHAEANS
FAULT
BHASKARPARA
KUTKONA-I
KUTKONA-II
KALTONGHAT
KONDA
KUTKONA
TUMARBARI H.T.
KHAJURA PEAK 2822
2813 CHAMAT PEAK
BHASKARPARA
KOLUAN
MANIKNARA-N
TO PRATAPUR
FROM TACHNI
(MAP AFTER C.S.S. BILASPUR)
SOHAGPUR C.F.
Scale 1:29Km


MAP 2 - SKETCH PLAN OF BATURA BLOCK, SOHAGPUR COALFIELD
INTRUSIVES
BARAKARS
DIP & STRIKE
FAULT
S H B BOREHOLES
SCALE 0—1863360
SOHAGPUR C.F
Bijuri
Anuppur
Chirimiri
Scale 1"= 2.9 km
JAMUNA N.
SON RIVER
BATURA
BARGAON
SUTHNA N.
TO BILASPUR
SABO COLLIERY
BURHAR COLLIERY
AMLAI COLLIERY
INCLINE
BAGAHA N.
TO AMARKANTAK
BURHAR
BURHAR R.S.
TO KATNI
SAITIN AMLAI
TO SHADOL
4
5
7
12
13
16
18
19
(MAP AFTER G.S.I.)

1964; BHARADWAJ & SRIVASTAVA, 1969; BHARADWAJ & TIWARI, 1964; TIWARI, 1964) which are listed below :

Leiotriletes, Callumispora, Hennellysporites, Cyclogranisporites, Verrucosisporites, Lophotriletes, Brevitriletes, Horriditriletes, Pseudoreticulatispora, Microbaculispora, Indotriradites, Latosporites, Densipollenites, Plicatipollenites, Virkkipollenites, Parasaccites, Divarisaccus, Caheniasaccites, Potonieisporites, Cuneatisporites, Platysaccus, Lueckisporites, Striatites, Primuspollenites, Rhizomaspora, Lahirites, Verticipollenites, Sriatopodocarpites, Lunatisporites, Striatopiceites, Illinites, Vesicaspora, Sulcatisporites, Ibisporites, Tiwariasporis, Decussatisporites, Ginkgocycadophytus, Pilasporites, Hemisphaerium and *Kagulubeites.*

The distribution of various palyno-taxa among the coal samples is given in Histograms 1-3. The quantitative, as well as, qualitative constitution reveals that the following genera are most characteristically present through all the palynological spectra and hence, form the dominant association of the coalfield:

Hennellysporites, Brevitriletes, Horriditriletes, Microbaculispora, Indotriradites, Sulcatisporites.

Apart from these, the following genera also are considered important here as they behave characteristically in a set of samples along with the dominant components:

Latosporites, Parasaccites, Striatites, Rhizomaspora, Lahirites, Striatopodocarpites, Striatopiceites, Illinites.

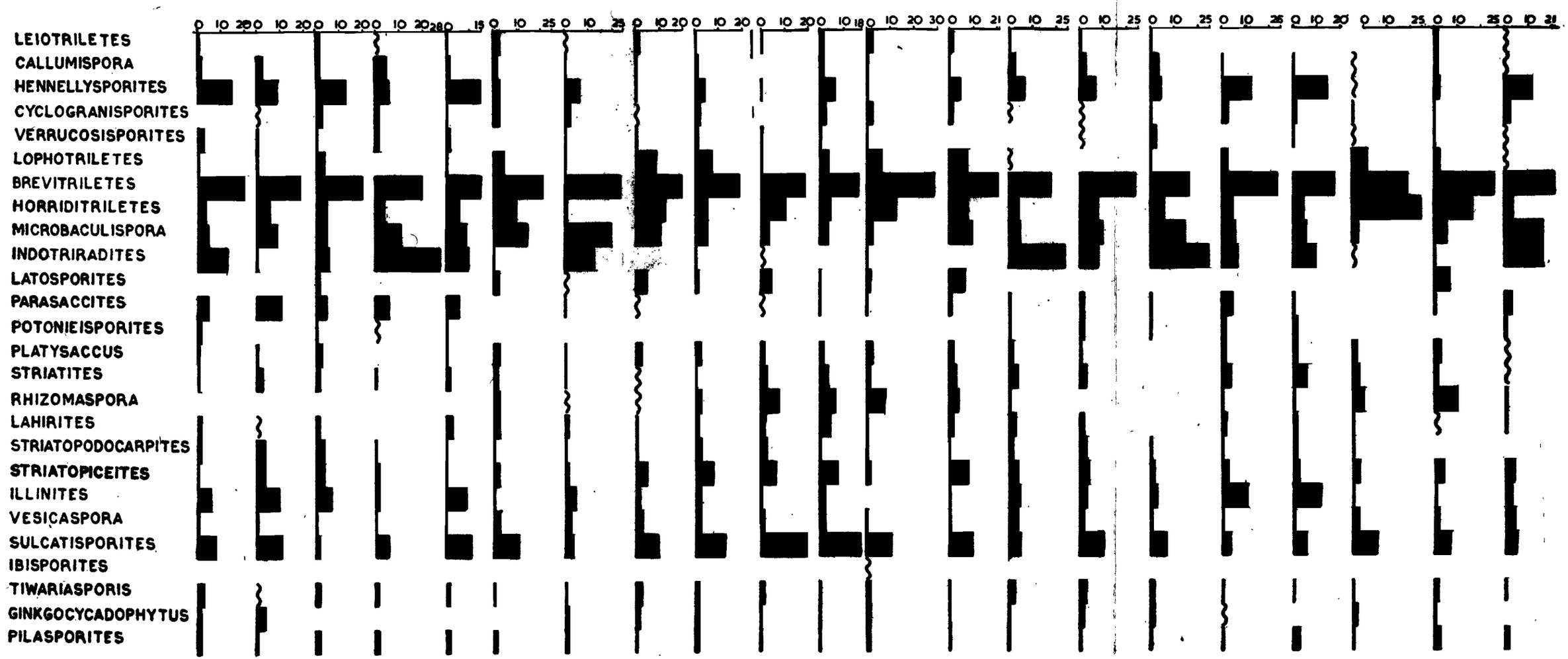
The nature of various palynological assemblages in each bore hole is discussed separately hereunder. The assemblages encountered in samples from Bhaskarpara block, have been alphabetically designated and similar assemblages in other blocks bear the same designations.

BHASKARPARA BLOCK — The behaviour of the dominant genera and their vertical variations among the samples of the same bore hole is shown in Histogram 1. A critical appraisal of the same reveals that the variations among the dominant constituents in several bore holes, where a succession of older to younger seam is available, are similar. Thus, in bore hole NCBP-41 (sample nos. BP 15-12) *Hennellysporites* increases in the middle while it decreases on either sides. *Brevitriletes* is high in sample BP-15 wherefrom it decreases in the younger BP 14, 13 but again increases in BP 12. *Microbaculispora* is present in the older seams only while in the younger ones it decreases appreciably. *Indotriradites* is dominant only in the second seam from below but decreases upwards. *Horriditriletes* remains at a low ebb in all the lower three seams while in the topmost seam it increases significantly. Similarly in the three samples of bore hole NCBP-78, sample BP 21 shows a dominance of *Indotriradites* which decreases in the younger ones later on. *Brevitriletes* increases in the middle. *Horriditriletes* remains low but becomes dominant in the topmost seam (sample BP 19). In the two samples of bore hole NCBP-15 *Brevitriletes* decreases from older to younger and so also *Microbaculispora* and *Hennellysporites. Horriditriletes* shows a slight increase in the upper seam and *Sulcatisporites* also varies similarly. In bore hole NCBP-3 *Indotriradites* decreases in the younger seam while *Brevitriletes* and *Hennellysporites* increase in it. *Parasaccites* and *Sulcatisporites* also decrease from older to younger seam. The two samples in bore hole NCBP-2 show a very close resemblance in respect of the dominant constituents which mark a slight increase parallely in the upper seam. Rest of the bore holes are represented by one sample each and hence, do not provide with any idea of the sporological succession occurring in their cores.

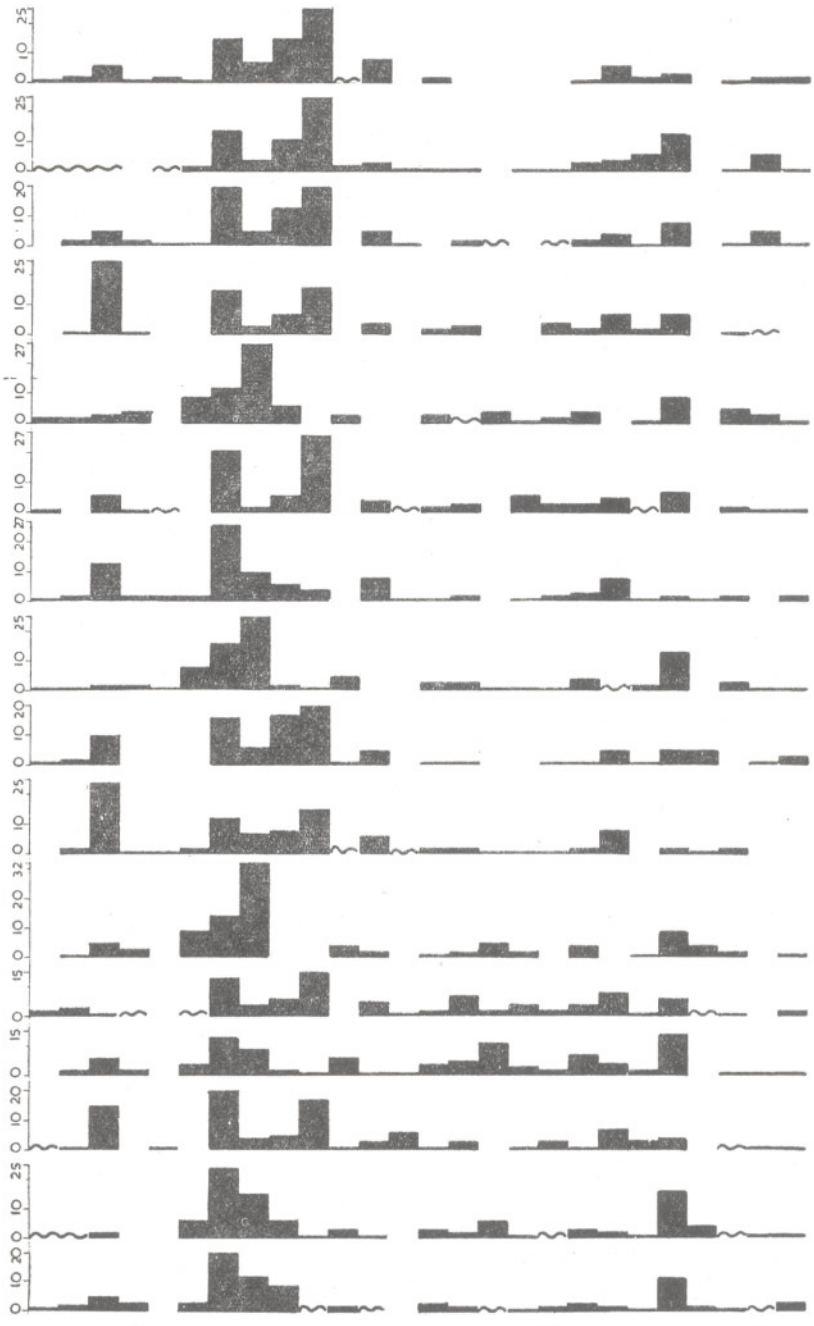
Considering the distinctive distribution of all the dominant constituents and their percentage frequency it has been possible to segregate the samples into seven sporological assemblages which are diagrammetically represented in Histogram 4.

Assemblage G — The oldest assemblage is characterized by the combined prominence of *Brevitriletes* (17%) and *Sulcatisporites* (19%). *Hennellysporites, Rhizomaspora* and *Illinites* (7%, 7%, 8%) are the other notable genera. This assemblage occurs in BP 11 of bore hole NCBP-36 only.

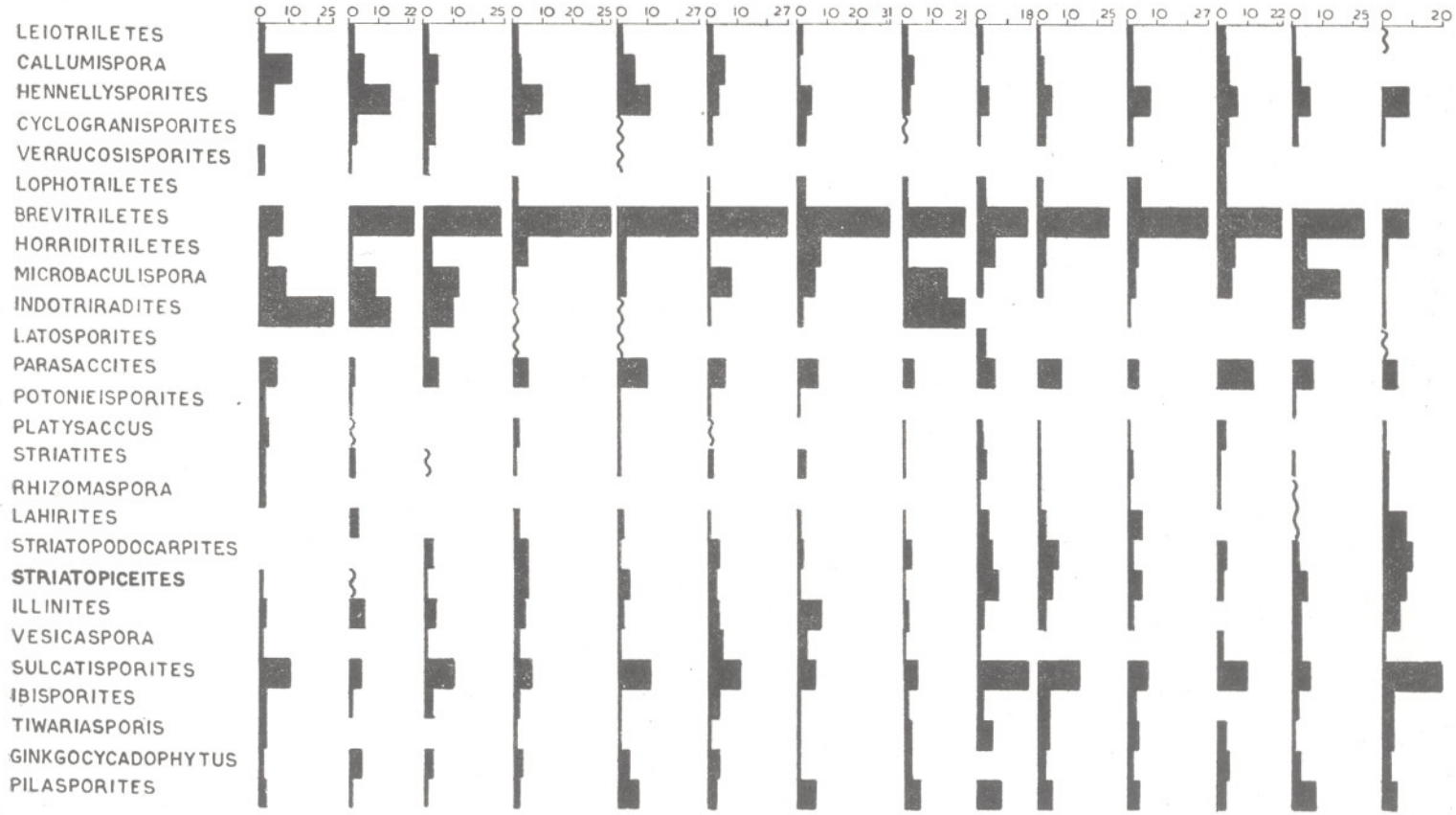
Assemblage F — Assemblage F is characterized by the dominance of *Brevitriletes* with an average frequency of 23 per cent and is closely associated with *Microbaculispora* (15%), *Hennellysporites* (9%), *Horriditriletes* (5%), *Indotriradites* (12%) and *Sulcatisporites* (6%). This assemblage is present in the lower most sample of the bore hole NCBP-15 (sample BP 7), NCBP-41 (sample BP 15). Between the two samples, BP 7 shows an older aspect in percentage of



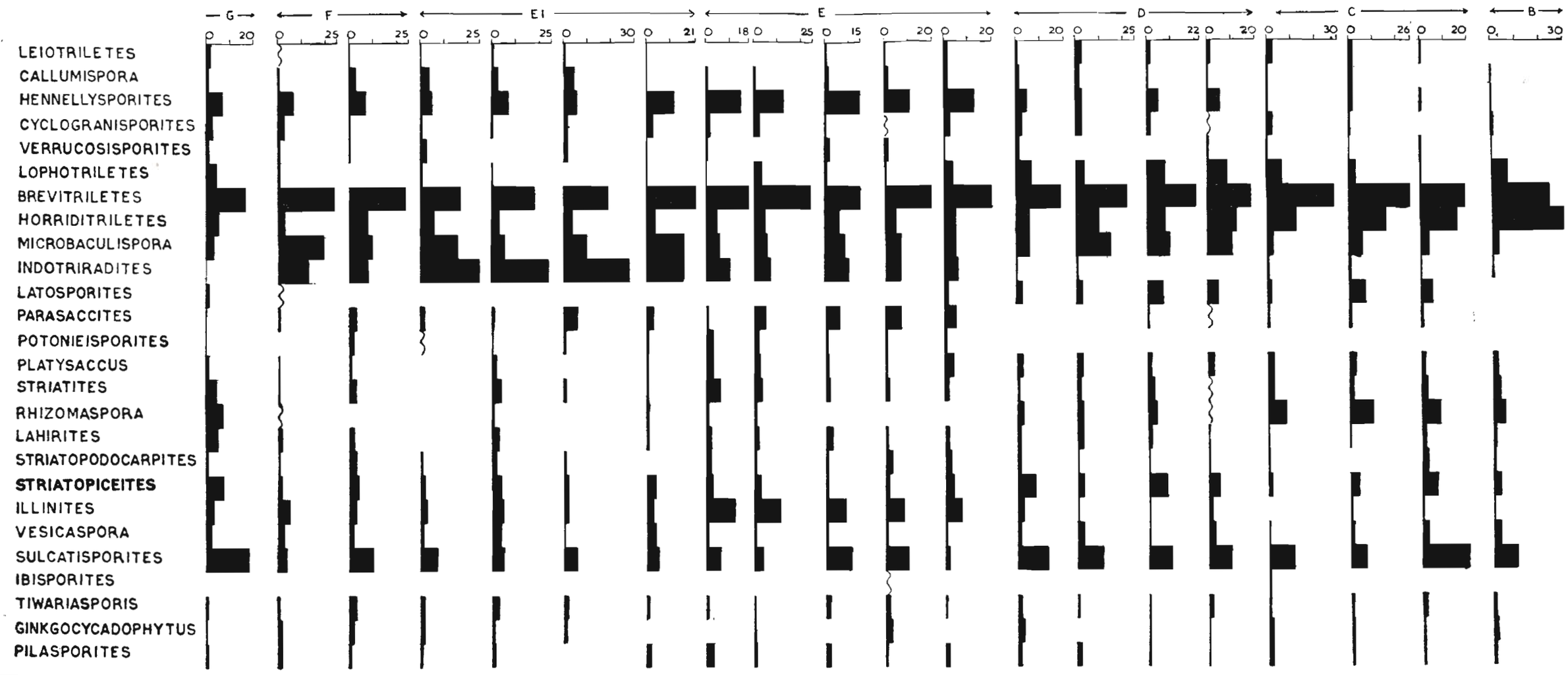
HISTOGRAM 1- SHOWING DISTRIBUTION OF MIOSPORES IN DIFFERENT BORE HOLES OF BHASKARPARA BLOCK, SOHAGPUR COALFIELD



HISTOGRAM 2 — SHOWING DISTRBUTION OF MIOSPORES IN DIFFERENT BORE HOLES OF KUTKONA BLOCK, SOHAGPUR COALFIELD



HISTOGRAM 3– SHOWING DISTRIBUTION OF MIOSPORES IN DIFFERENT BORE HOLES OF BATURA BLOCK SOHAGPUR COALFIELD



HISTOGRAM 4 – SHOWING THE PERCENTAGE FREQUENCY OF MIOSPORES IN DIFFERENT ASSEMBLAGES OF **BHASKARPARA** BLOCK SOHAGPUR COALFIELD

trilete miospores which averages up to 69 per cent and the bisaccate pollen grains range up to 23 per cent.

Assemblage E_1 — Assemblage E_1 is distributed in the lower most seam, BP 21 of the bore hole NCBP-78, BP 16 of NCBP-69, BP 4 of NCBP-3 and second seam from below, BP 14 of NCBP-41. All the four samples are coherent in the representation of their dominant components, except that *Indotriradites* is slightly reduced in BP 21. This assemblage is characterized by the general dominance of *Indotriradites* with an average of 26 per cent. *Brevitriletes*, a dominant genus of assemblage F, has become subdominant in this assemblage with an average of 18 per cent. *Microbaculispora*, which was subdominant in the former assemblage, has further decreased in the present assemblage. Trilete miospores range up to 73 per cent while bisaccate pollen average only 19 per cent.

Assemblage E — Samples BP 1, 2, 3, 4, 5, 17, 18 represent slightly different picture as compared to assemblage E_1. After analysing these samples critically the differences become more apparent than real. In the above mentioned samples, the dominant genus *Indotriradites* (8%) has decreased considerably while *Hennellysporites* (13%) and *Illinites* (10%) have increased. *Brevitriletes* (17%) occurs almost similar to assemblage E_1. If we compare the assemblage of these samples through that of the lower most seam of NCBP-78 (sample BP 21), it gives a picture almost in between BP 4, 14, 16 and BP 1+2, 3, 5, 17, 18 as it shows the decreasing tendency of *Indotriradites* but an increase in *Hennellysporites* though not in *Illinites*. In view of the above, it may be presumed that *Hennellysporites* has grown at the cost of *Indotriradites*. This replacement is all the more plausible because both these genera have lycopsid organization and hence, are presumably phylogenetically near to each other. Thus, a sequence of variation among the samples of this assemblage is represented in the manner BP 4, 14, 16 — BP 21 — BP 5, 1+2, 18, 17, 3. It is apparent that inspite of the differences encountered, the latter samples tend to cohere with assemblage E_1 and hence, they have been considered here as containing assemblage E.

Assemblage D — Assemblage D is marked by a combination of *Brevitriletes* (20%) and *Sulcatisporites* (11%). *Hennellysporites* (4%), *Horriditriletes* (8%), *Microbaculispora* (10%) and *Striatopiceites* (6%) remain subdominant in their representation. It comprises of 4 samples viz. BP 6, 8, 9, 13. If a critical analysis be made thereof, it becomes evident that higher percentage of *Microbaculispora* in BP 6, increase of *Latosporites* in BP 13 and higher representation of *Horriditriletes* togehther with the former two genera in BP 8 have ameliorated the pollen spectra appreciably and the occurrence of other representatives is similar to BP 9. One notable feature is the decrease in *Hennellysporites* as compared to Assemblage E. The total percentage of trilete miospores average up to 69 per cent and that of bisaccates up to 37 per cent.

Assemblage C — The pollen spectrum of assemblage C shows almost a homogeneous representation of their dominant components and is distributed in samples BP 10, 12, 20. This assemblage is marked by the dominance of *Brevitriletes* with an average representation of 23 per cent and is closely followed by *Horriditriletes* (15%), *Microbaculispora* (6%), *Rhizomaspora* (7%) and *Sulcatisporites* (12%). The sample BP 10 shows slightly a different picture in that *Sulcatisporites* is high, *Brevitriletes* is reduced considerably and so also *Lophotriletes* in comparison to other samples. *Horriditriletes* shows some rise in its frequency. However, the overall representation of the various components is very close to the rest of the samples of Assemblage C.

Assemblage B — Only one sample, viz. BP 19, contains assemblage B. *Horriditriletes*, which was a subdominant genus in assemblage C, becomes the most dominant genus in the present assemblage with an average frequency of 30 per cent. *Brevitriletes* (24%) reduces to subdominant status and is followed by *Lophotriletes* (7%) and *Sulcatisporites* (10%).

KUTKONA BLOCK — The variations among the dominant components and their behaviour among the samples of the same bore hole is shown in Histogram 2. It may be observed that the behaviour of the dominant genera is almost regular in each bore hole from below upwards. Thus, in bore hole NCKT-6 (samples KT 2, 3) *Indotriradites* decreases in the upper seam and so also *Hennellysporites*. *Brevitriletes*, *Horriditriletes*, *Lophotriletes* and *Sulcatisporites* are low in the lower seam but increase considerably in the upper seam. Bore hole NCKT-

7 (samples KT 4, 5) also shows a similar trend. *Hennellysporites* has increased in the upper seam in this bore hole. In bore hole NCKT-16A (samples KT 6, 7) *Hennellysporites, Brevitriletes, Microbaculispora, Indotriradites, Parasaccites* and *Illinites* decrease in the upper seam while *Lophotriletes, Horriditriletes, Latosporites, Rhizomaspora, Striatopiceites* and *Sulcatisportes* behave inversely.

The distribution of the dominant constituents, both qualitatively and quantitatively, has led to the distinction of four palynological assemblages which are represented in Histogram 5.

Assemblage E_1 — The assemblage E_1 is represented by the higher presence of *Indotriradites* (23%) while *Brevitriletes* (17%), *Microbaculispora* (12%) and *Sulcatisporites* (7%) are present subdominantly. Next to the subdominants follow *Hennellysporites* (5%), *Horriditriletes* (5%), *Parasaccites* (5%), *Illinites* (5%) and *Ginkgocycadophytus* (3%). This assemblage is distributed in samples KT 8, 11, 14, 15, 16. The total number of trilete miospores range up to 67 per cent while bisaccate pollen grains total up to 27 per cent. All the samples of this assemblage show a similar trend of variation.

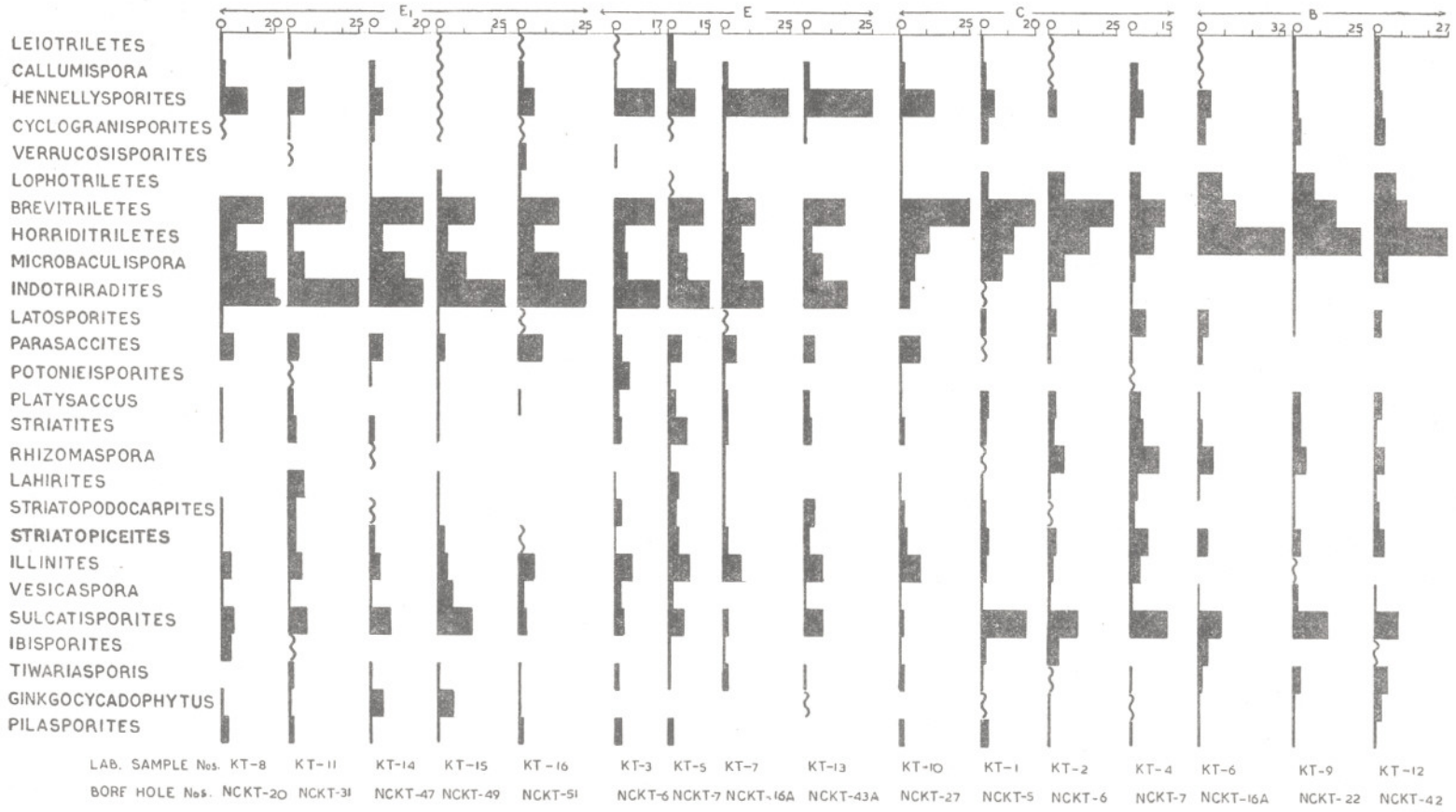
Assemblage E — Sample KT 3, 5, 7, 13 are characterized by the dominance of *Hennellysporites* with an average representation of 19 per cent. The subdominant genera are represented by *Indotriradites* (16%), *Brevitriletes* (16%) and *Illinites* (7%). *Microbaculispora* (7%), *Horriditriletes* (4%) and *Sulcatisporites* (4%) follow next to the subdominants. Thus, the representation of trilete miospores total up to 65 per cent while bisaccate pollen grains range up to 26 per cent. It is interesting to note here that the similarities, as discussed in Bhaskarpara block, between assemblages E_1 and E are more defined in Kutkona block and the conclusion that *Hennellysporites* has grown at the cost of *Indotriradites* is further substantiated. *Hennellysporites* is slightly reduced in KT 5 while *Indotriradites* behave inversely and thus shows a nearness to assemblage E_1. Samples KT 3, 5, 7, 13 represent assemblage E.

Assemblage C — Four samples, viz. KT 1, 2, 4, 10 represent the assemblage C showing the dominance of *Brevitriletes* with an average representation of 21 per cent. *Horriditriletes* (13%) and *Sulcatisporites* (12%) are present subdominantly while *Hennellysporites, Microbaculispora* (5%), *Rhizomaspora* (4%), *Striatopiceites* (4%) and *Illinites* (4%) closely follow the subdominants. The total value of triletes range up to 54 per cent and that of bisaccates 34 per cent. In sample KT 4 *Brevitriletes* has decreased appreciably while striated bisaccates and *Sulcatisporites* have taken an upper hand thus indicating a younger aspect. On the other hand, *Hennellysporites, Indotriradites, Parasaccites* and *Illinites* are present significantly in sample KT 10 and thus shows an older aspect.

Assemblage B — Assemblage B is represented by 3 samples viz. KT 6, 9, 12. This is dominated by *Horriditriletes* with an average of 28 per cent. *Brevitriletes* (14%), which dominates in assemblage C, reduces considerably. *Lophotriletes* (8%) and *Sulcatisporites* (10%) closely follow the subdominants. The next in order of occurrence are *Latosporites* (4%), *Rhizomaspora* (5%) and *Striatopiceites* (4%). The trilete miospores range up to 62 per cent while bisaccate pollen grains are represented up to 26 per cent only. All the three samples of this assemblage are consistent in the occurrence of the prominent constituents.

BATURA BLOCK — The behaviour of all the well represented components in sixteen coal samples from 8 bore holes and their vertical variation is represented in Histogram 3. In bore hole SHB-12 (samples BT 4-6) *Brevitriletes* is present in lesser amounts in the lower seam wherefrom it decreases upwards. Similar variation is also shown by *Hennellysporites*. On the other hand, *Microbaculispora, Parasaccites* and *Sulcatisporites* behave contrarily. The three samples in bore hole SHB-13 are very closely parted with each other. Samples BT 7 and 8 yielded very little spores therefore they have been combined with sample BT 9. In the bore hole SHB-18 (BT 11-15) *Brevitriletes* slightly increases in BT 13 as compared to BT 15, and finally decreases in BT 12, 11. *Microbaculispora* and *Indotriradites* decrease from below upwards. *Sulcatisporites* increases in BT 14, decreases in the overlying seam, again increases and becomes highest in the upper most seam. *Hennellysporites* and *Parasaccites* behave more or less similar to *Brevitriletes*. It is also evident that the upper two seams (samples BT 11, 12) are richer in striated pollen grains.

Variations in the dominant palyno-taxa suggest the segregation of the coal samples



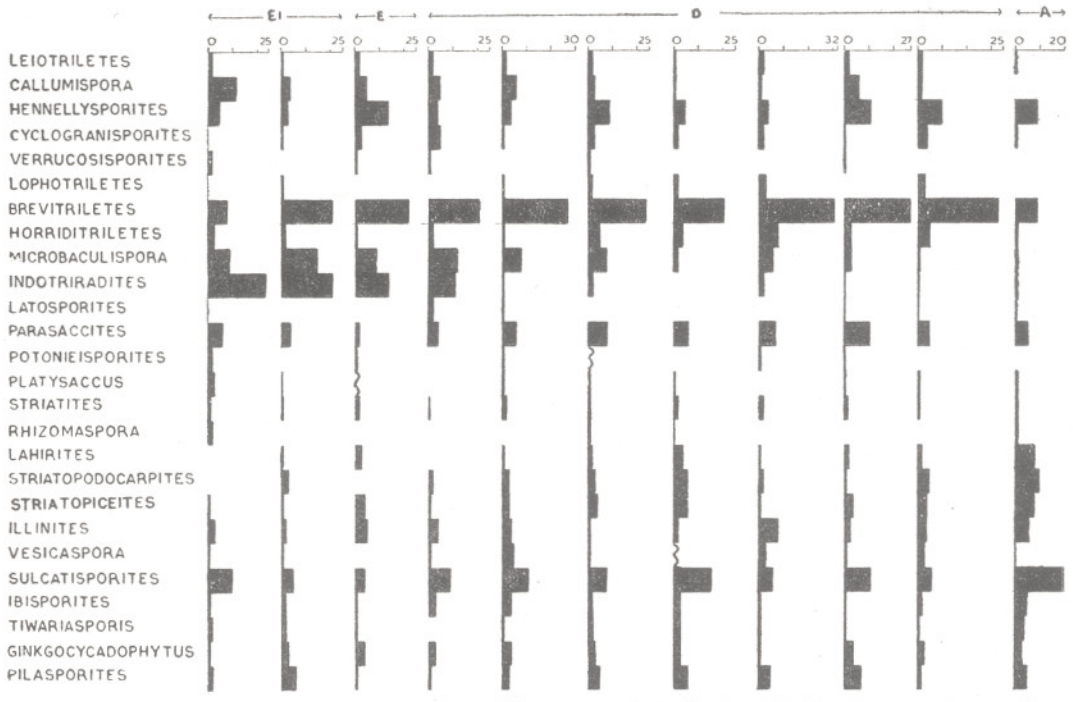
HISTOGRAM 5 – SHOWING PERCENTAGE FREQUENCY OF MIOSPORES IN VARIOUS ASSEMBLAGES OF KUTKONA BLOCK SOHAGPUR COALFIELD

into four palynological assemblages (Histogram 6).

Assemblage E_1 — As shown in the Histogram 6, assemblage E_1 is present in two samples viz. BT 1 and 10 which is characterized by the high incidence of *Indotriradites* with the average of 20 per cent. *Brevitriletes* (17%) closely follows while *Callumispora* (7%), *Hennellysporites* (7%), *Microbaculispora* (7%) and *Sulcatisporites* (6%) are present subdominantly. The total percentage of trilete miospores rises to 65 per cent whereas the gymnospermic pollen grains are present up to 19 per cent. A critical analysis of Histogram 6 reveals that the two samples represent two phases of the same assemblage. *Microbaculispora* is present in higher amounts in BT 10 but it is less in the other sample. *Brevitriletes* is more in BT 10 as compared to BT 1 and thus shows an older aspect. *Indotriradites* is present in higher percentage in BT 1. However, these variations do not distinguish the pollen spectrum significantly so as to give them a separate identity and hence, have been grouped together.

Assemblage E — Sample BT 2 represent almost a similar picture as has been described above. *Indotriradites* is considerably less in this sample but *Hennellysporites* (14%) is more. In this respect this sample compares very closely to BP 18 of Bhaskarpara Block and thus, is assigned to Assemblage E. The trilete miospores total up to 72 per cent while bisaccate pollen occur up to 24 per cent.

Assemblage D — The general dominance of *Brevitriletes* in all the 12 samples (viz. BT 3-9, 11-15) characterises the Assemblage D with an average frequency of 26 per cent. The next genus to follow it, is *Sulcatisporites* (10%). *Hennellysporites* (5%), *Horriditriletes* (4%), *Microbaculispora* (5%), *Parasaccites* (7%) range next to *Sulcatisporites*. Thus, the average total of trilete miospores ranges up to 53 per cent and that of bisaccate pollen grains totals up to 31 per cent. As is shown in Histogram 3, sample BT 3



HISTOGRAM 6 - SHOWING PERCENTAGE FREQUENCY OF MIOSPORES IN DIFFERENT ASSEMBLAGES OF BATURA BLOCK, SOHAGPUR COALFIELD

contains a significant amount of *Indotriradites* excluding which it compares very closely to BT 15. This character is also present in BT 6 of SHB-12. The three successive seams in bore hole SHB-12 (samples BT 4, 5, 6) show almost a similar pattern and indicate a closer relationship. Sample BT 6 contains *Microbaculispora* in higher percentages and thus indicates an older aspect. On the other hand, sample BT 4 contains the highest amount of *Brevitriletes* as compared to the lower two samples. In bore hole SHB-18 all the five seams are placed close to each other. Palynologically all the dominant constituents behave irregularly (Histogram 3) but after combining them into two groups they represent a similar picture as is shown in Histogram 6. This grouping appeared necessary so as to avoid the probable local variations among the closely parted seam. Thus, the compound histogram represented by samples BT 13+14+15 shows an older aspect in having a significant amount of *Microbaculispora* and *Parasaccites* and a little of *Indotriradites*. In this respect it resembles sample BT 6 of bore hole SHB-12. The pollen picture represented by BT 11+12 compares very closely to that represented by BT 7+8+9 of the bore hole SHB-13 in having *Brevitriletes, Horriditriletes, Microbaculispora, Parasaccites, Sulcatisporites* and *Pilasporites*. In this respect the two compound histograms represented by BT 7+8+9 and BT 11+12 together show a near resemblance to sample BT 5 of bore hole SHB-12.

Assemblage A — Assemblage A is represented by only one sample, viz. BT 16 and is marked by the general dominance of bisaccate pollen grains as compared to the earlier assemblages. *Sulcatisporites* becomes the dominant genus with an average occurrence of 20 per cent while *Striatopodocarpites* (10%) follows it. *Hennellysporites* (9%), *Brevitriletes* (9%), *Lahirites* (8%), *Striatopiceites* (8%), *Illinites* (6%) and *Ibisporites* (4%) are closely associated with the dominant components. Thus, the pollen spectrum is characterized by an abundance of bisaccate pollen grains (61%) whereas the trilete miospores have decreased considerably.

CORRELATION

The qualitative and quantitative variation of the dominant genera in all the coal samples of Sohagpur Coalfield have already been discussed. Their palynological correlations have been shown in Text-figs. 1-3.

BHASKARPARA BLOCK — A critical appraisal of Histogram 4 reveals that sample BP 13 represents the oldest coal seam containing assemblage G. Sample BP 7 comes very close to BP 15 in view of high *Brevitriletes* and *Microbaculispora*. These two samples represent the lower most seam of their respective bore holes and represent the second oldest coal seam (containing assemblage F) of Bhaskarpara block.

Samples BP 4, 14, 16, 21 (Assemblage E_1) are grouped together for having high *Indotriradites* followed by *Brevitriletes* and *Microbaculispora*. Samples BP 14 and 4 represent the second seam from below and lowest seam respectively in bore holes NCBP-41 and 3. They show correspondence in respect of their mioflora which is almost the same in BP 16 as well. Assemblage E_1 is contained by the third oldest seam in the Block.

Samples BP 1, 2, 3, 5, 17, 18 (Assemblage E) are correlated together to represent a seam closely younger to the third seam. Sample BP 21 shows a transition from assemblage E_1 to E as *Indotriradites* tend to decrease while *Hennellysporites* rises as a consequence. This tendency becomes distinct in the samples BP 1+2, 3, 5, 17, 18. The pollen flora of BP 1+2 compares very closely to BP 17, 18 as well as BP 5, 3. But for these variations, the dominating constituents show a near correspondence with the other samples and thus, all are placed together in Assemblage E, representing the fourth seam of the Block.

The fifth seam, containing assemblage D, is represented by samples BP 6 (NCBP-15), 8 (NCBP-18), 9 (NCBP-19) and 13 (NCBP-41). Sample BP 6 compares very closely to BP 13 and a similar miofloristic composition is also evident in BP 9. Thus, the upper seam of the bore hole NCBP-15 resembles the third seam from below in NCBP-41. Sample BP 8 also bears a closer relationship to the above samples except in having slightly high percentage of *Horriditriletes*.

The uppermost sample of bore hole NCBP-41 (sample BP 12) is correlated to the second seam from below in bore hole NCBP-78 (BP 20) as they possess similar palynological composition. The trend of variation of the dominant constituents in

sample BP 10 shows a close resemblance to BP 20 but for having a little higher *Microbaculispora* and *Sulcatisporites*. Thus, BP 10, 12 and 20 containing assemblage C represent the sixth seam from below in the Block.

The uppermost seam of the bore hole NCBP-78 (sample BP 21) is characterized by the dominance of *Horriditriletes*. This sample represents the youngest seam or seventh seam of Bhaskarpara Block.

The above analysis reveals that there are seven coal seams present in Bhaskarpara Block (*see* Text-fig. 1).

Coal seam	*Lab. Sample No.*	*Bore Hole No.*
1. Uppermost or seventh seam (Assemblage B)	BP 19	NCBP-78
2. Sixth seam from Bottom (Assemblage C)	BP 10	NCBP-35
	BP 12	NCBP-41
	BP 20	NCBP-78
3. Fifth seam from Bottom (Assemblage D)	BP 6	NCBP-15
	BP 8	NCBP-18
	BP 9	NCBP-19
	BP 13	NCBP-41
4. Fourth seam from Bottom (Assemblage E)	BP 1+2	NCBP-2
	BP 3	NCBP-3
	BP 5	NCBP-10
	BP 17	NCBP-70
	BP 18	NCBP-70
5. Third seam from Bottom (Assemblage E_1)	BP 4	NCBP-3
	BP 14	NCBP-4
	BP 16	NCBP-69
	BP 21	NCBP-78
6. Second seam from Bottom (Assemblage F)	BP 7	NCBP-15
	BP 15	NCBP-4
7. Bottom seam (Assemblage G)	BP 11	NCBP-36

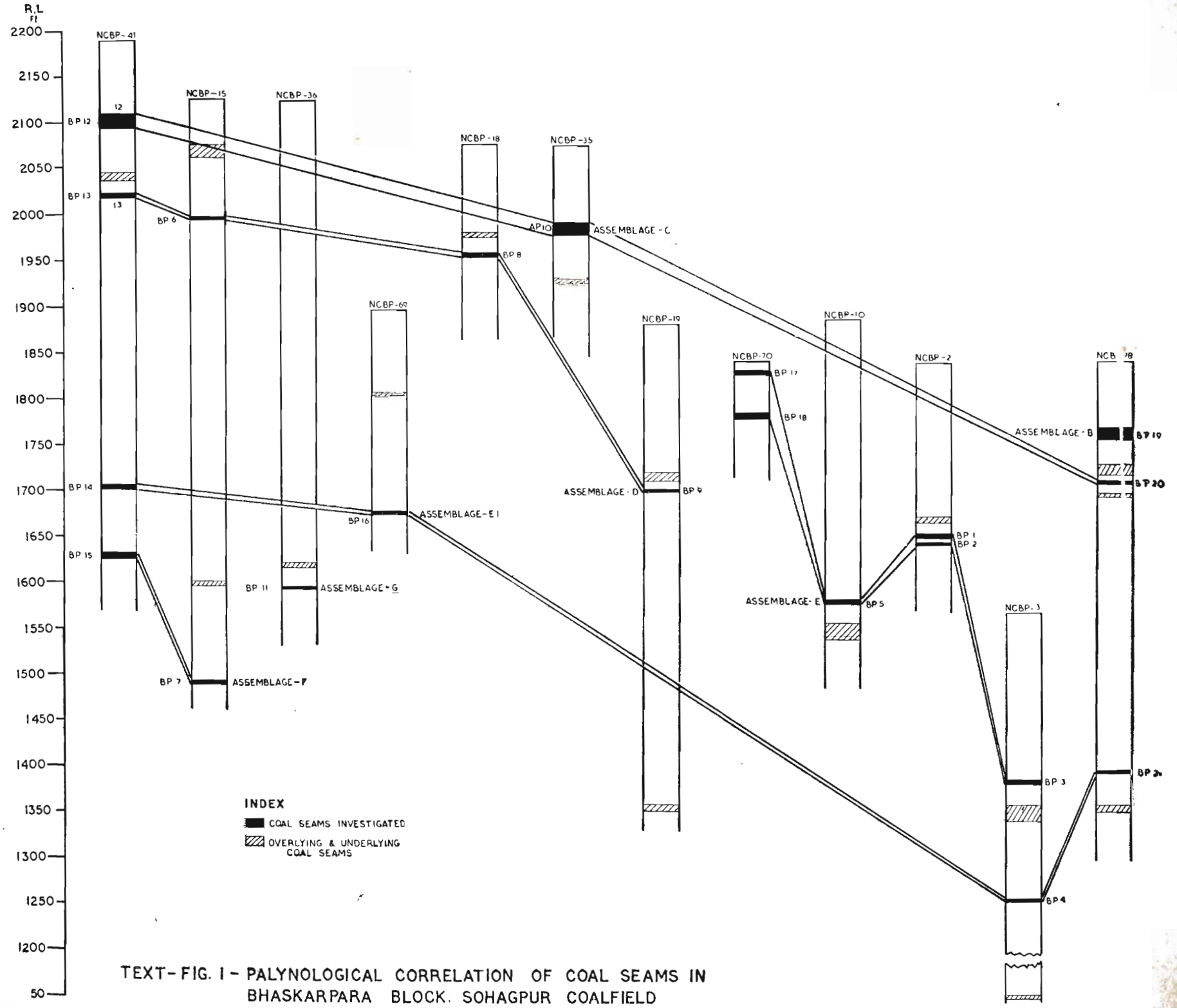
KUTKONA BLOCK — As shown in Histogram 5, the samples KT 8, 11, 14, 15, 16 (Assemblage E_1) compare very closely in representation of their dominant components. Although, *Microbaculispora* has slightly increased in KT 8 with low *Indotriradites*, the trend of variation is similar to the other ones. All the above samples are correlated together to represent one seam.

The lower seam of bore hole NCKT-6, 7 and 16A represented by samples KT 3, 5 and 7 show their palynological agreement with sample KT 13 in having high *Hennellysporites*, *Brevitriletes* and *Indotriradites* (Assemblage E).

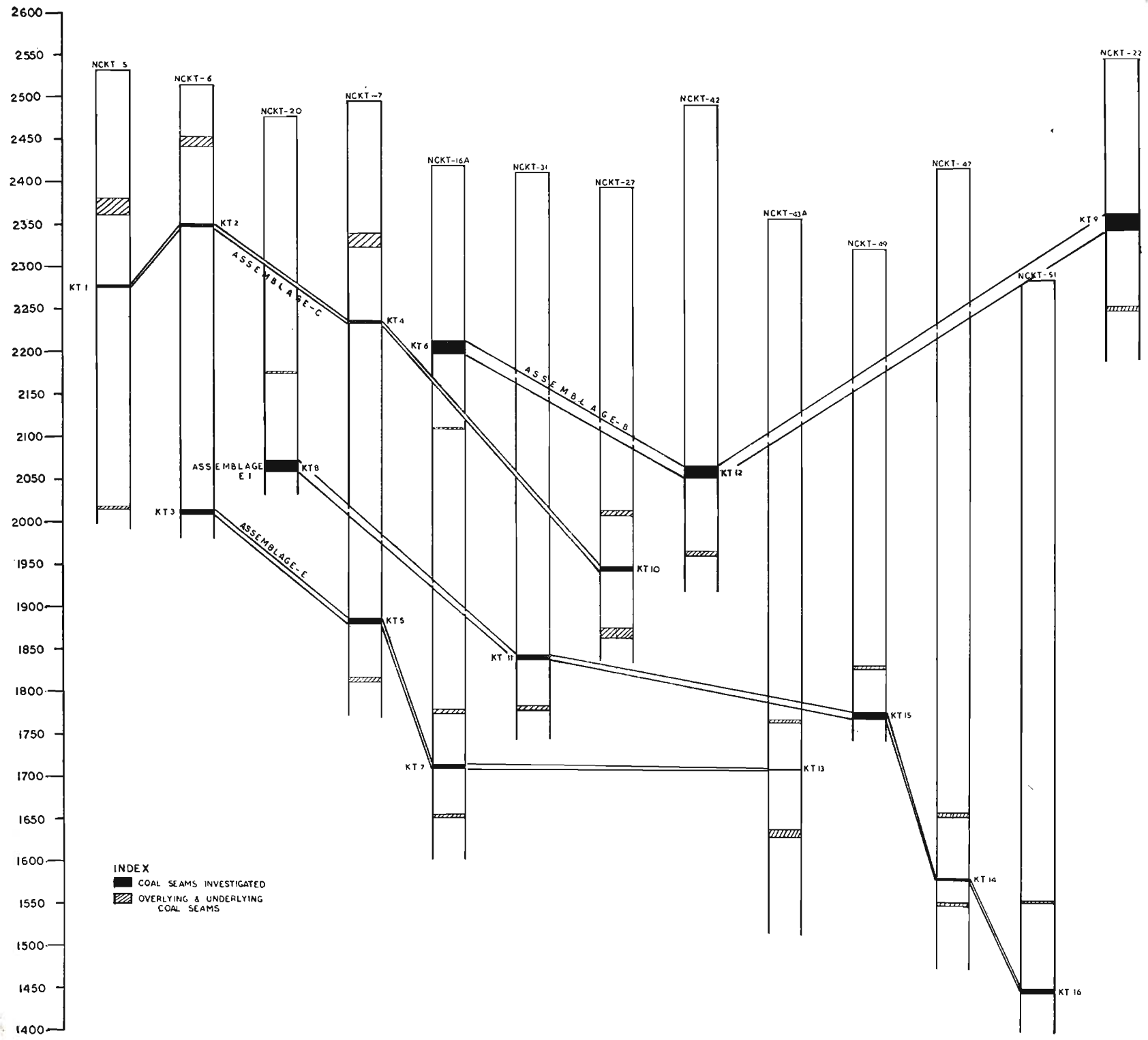
Assemblage C occurs in the upper seam of the bore holes NCKT-6 and 7 and the samples KT 1 and 10. The assemblage in all these samples shows the coherence in having a combination of *Brevitriletes*, *Horriditriletes* and *Microbaculispora*.

The upper seam of the bore hole NCKT-16A is equivalent to samples KT 9, 12 in having the dominance of *Horriditriletes* (Assemblage B). These samples represent the youngest seam. Thus, there are four seams present among the samples investigated from Kutkona Block (*see* Text-fig. 2).

Coal seam	*Lab. Sample No.*	*Bore Hole No.*
1. Uppermost seam (Assemblage B)	KT 6	NCKT-16A
	KT 9	NCKT-22
	KT 12	NCKT-42
2. Seam (Assemblage C)	KT 1	NCKT-5
	KT 2	NCKT-6
	KT 4	NCKT-7
	KT 10	NCKT-27
3. Seam (Assemblage E)	KT 3	NCKT-6
	KT 5	NCKT-7
	KT 7	NCKT-16A
	KT 13	NCKT-43A
4. Seam (Assemblage E_1)	KT 8	NCKT-20
	KT 11	NCKT-31
	KT 14	NCKT-47
	KT 15	NCKT-49
	KT 16	NCKT-51



TEXT-FIG. 1 - PALYNOLOGICAL CORRELATION OF COAL SEAMS IN BHASKARPARA BLOCK, SOHAGPUR COALFIELD



TEXT-FIG. 2 - PALYNOLOGICAL CORRELATION OF COAL SEAMS IN KUTKONA BLOCK SOHAGPUR COALFIELD

BATURA BLOCK — Samples BT 10, 1 are correlated together to represent as one seam being characterized by the higher representation of *Indotriradites* and *Brevitriletes* (Assemblage E_1). The two samples show slight variation yet they indicate a close relationship.

Sample BT 2 although represents a seam almost similar to that represented by samples BT 1, 10 yet differs in having higher amounts of *Hennellysporites* and *Illinites* thus, representing Assemblage E.

The three successive seams in bore hole SHB-12 (samples BT 4-6) and SHB-13 (samples BT 7-9) compare very closely to the five seams in bore hole SHB-18 (samples BT 11-15) in their miofloral characteristics. Since the seams are in close succession in their respective bore holes representing a similar mioflora (Assemblage D) they are supposed to represent partings of one and the same seam. Sample BT 3 shows its equivalence to sample BT 15.

Sample BT 16 stands apart containing the youngest miospore Assemblage A and thus represents the youngest coal seam of Batura Block.

Thus, there are four coal seams present in this area (*see* Text-fig. 3).

Coal seam	*Lab. Sample No.*	*Bore Hole No.*
1. Top seam (Assemblage A)	BT 16	SHB-19
2. Seam (Assemblage D)	BT 3	SHB-7
	BT 4	SHB-12
	BT 5	SHB-12
	BT 6	SHB-12
	BT 7	SHB-13
	BT 8	SHB-13
	BT 9	SHB-13
	BT 11	SHB-18
	BT 12	SHB-18
	BT 13	SHB-18
	BT 14	SHB-18
	BT 15	SHB-18
3. Seam (Assemblage E)	BT 2	SHB-5
4. Seam (Assemblage E_1)	BT 1	SHB-4
	BT 10	SHB-16

DISCUSSION

Inter-block correlation of coal seams

The lower most seam in Bhaskarpara block is represented by sample BP 11, characterized by an assemblage containing prominently *Brevitriletes* and *Sulcatisporites*. From Kutkona and Batura Blocks, none of the samples investigated contain Assemblage G.

The next younger seam accosted in several bore holes of Bhaskarpara Block and signified by the presence of Assemblage F in its samples, is also not present in Batura and Kutkona Blocks.

The next younger seam containing Assemblage E_1 is represented in all the three Blocks and so is the seam containing Assemblage E.

The seam represented by Assemblage D has been detected by us to be present in Bhaskarpara and Batura Blocks and those represented by Assemblages C and B are present in Bhaskarpara and Kutkona Blocks. Whether Assemblage D is really absent in Kutkona Block or Assemblages C and B are equally so in Batura Block, is not certain because we have investigated only parts of the sequences in the bore holes as supplied to us. The youngest seam of Sohagpur Coalfield as palynologically determined by us, occurs in Batura Block.

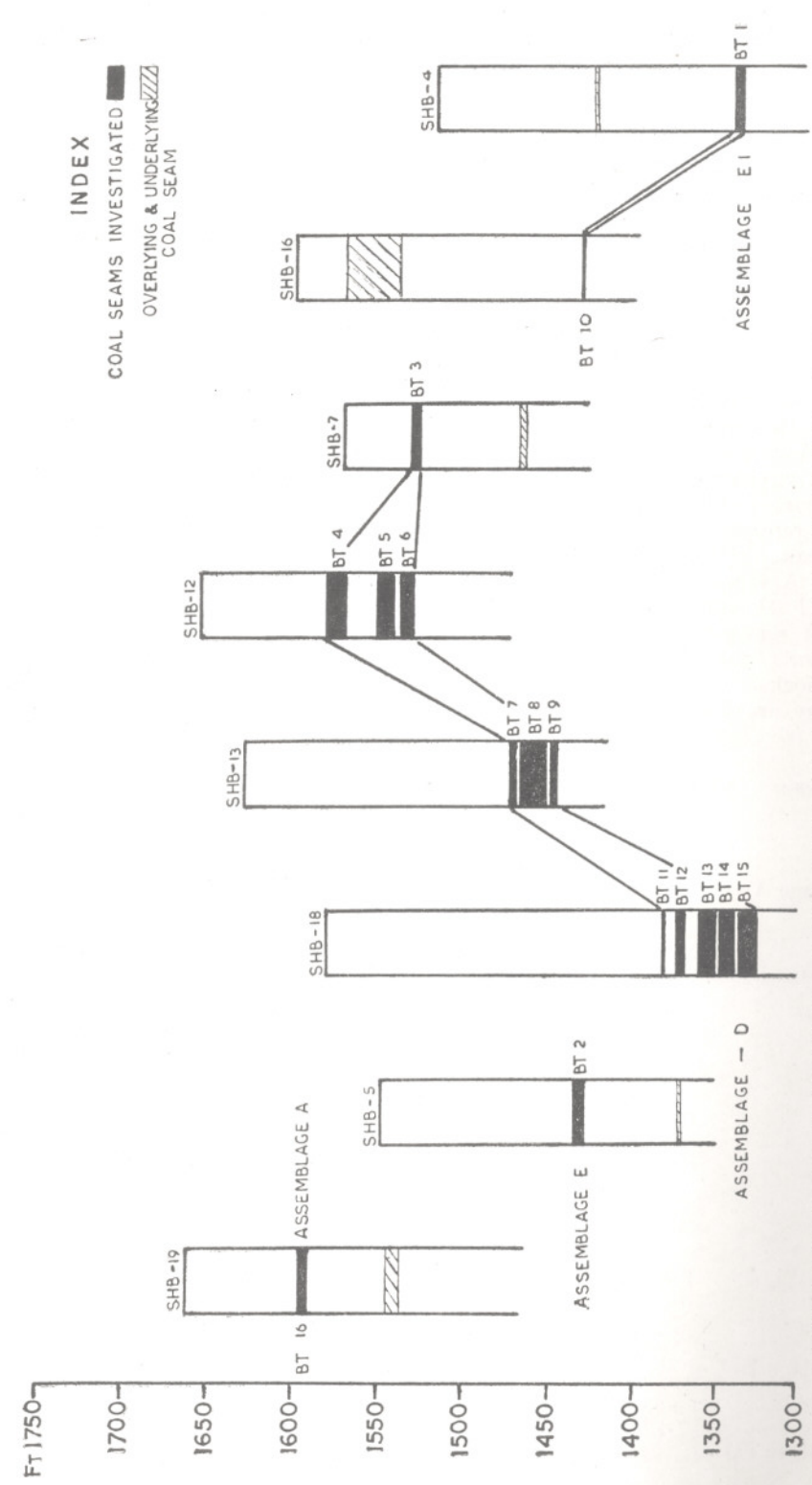
The inter-block correlation of Sohagpur Coalfield is summarized below and is diagrammetically represented in Text-fig. 4.

1. Bottom Seam : Represented by Sample BP 11 (NCBP-36) of Bhaskarpara Block (Assemblage G).

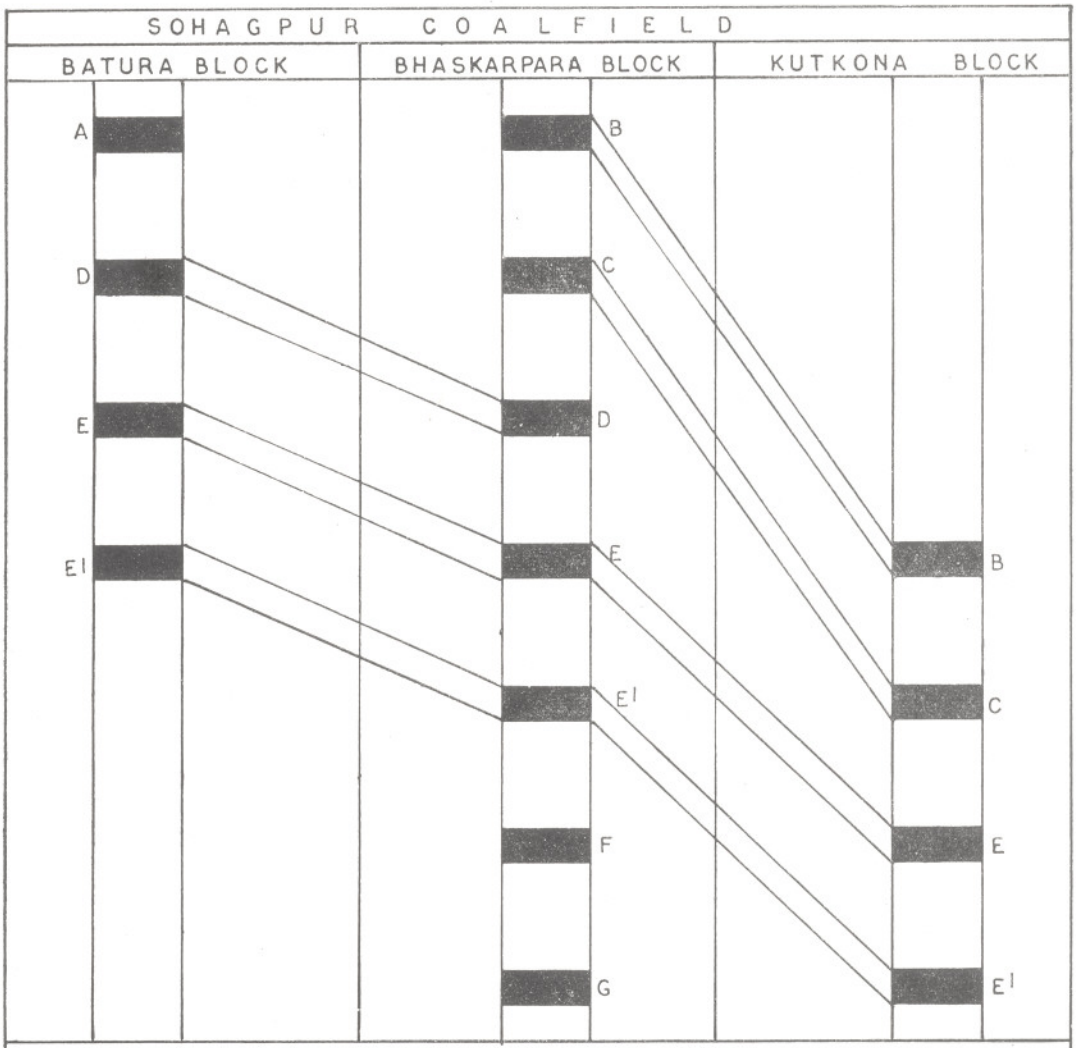
2. Seam II from below : Represented by samples BP 7 (NCBP-15), BP 15 (NCBP-41) in Bhaskarpara Block (Assemblage F).

3. Seam III from below : Represented by samples BP 4 (NCBP-3), BP 14 (NCBP-41), BP 16 (NCBP-69), BP 21 (NCBP-78) in Bhaskarpara Block; samples KT 8 (NCKT-20), KT 11 (NCKT-31), KT 14 (NCKT-47), KT 15 (NCKT-49), KT 16 (NCKT-51) in Kutkona Block and BT 1 (SHB-4), BT 10 (SHB-16) in Batura Block (Assemblage E_1).

4. Seam IV from below : Represented by samples BP 1-2 (NCBP-2), BP 3 (NCBP-3), BP 5 (NCBP-10), BP 17-18 (NCBP-70) in Bhaskarpara Block; samples KT 3 (NCKT-6), KT 5 (NCKT-7), KT 7 (NCKT-16A), KT 13 (NCKT-43A) in Kutkona Block and sample BT 2 (SHB-5) in Batura Block (Assemblage E).



TEXT-FIG. 3 – PALYNOLOGICAL CORRELATION OF COAL SEAMS IN BATURA BLOCK, SOHAGPUR COALFIELD



TEXT-FIG. 4 – SHOWING INTER-BLOCK CORRELATION IN SOHAGPUR COALFIELD

5. Seam V from below : Represented by samples BP 6 (NCBP-15), BP 8 (NCBP-18), BP 9 (NCBP-19), BP 13 (NCBP-41) in Bhaskarpara block and samples BT 3 (SHB-7), BT 4-6 (SHB-12), BT 7-9 (SHB-13), BT 11-15 (SHB-18) in Batura block (Assemblage D).

6. Seam VI from below : Represented by samples BP 10 (NCBP-35), BP 12 (NCBP-41), BP 20 (NCBP-78) in Bhaskarpara Block and samples KT 1 (NCKT-5), KT 2 (NCKT-6), KT 4 (NCKT-7), KT 10 (NCKT-27) in Kutkona Block (Assemblage C).

7. Seam VII from below : Represented by sample BP 19 (NCBP-78) in Bhaskarpara Block and samples KT 6 (NCKT-16A), KT 9 (NCKT-22), KT 12 (NCKT-42) in Kutkona Block (Assemblage B).

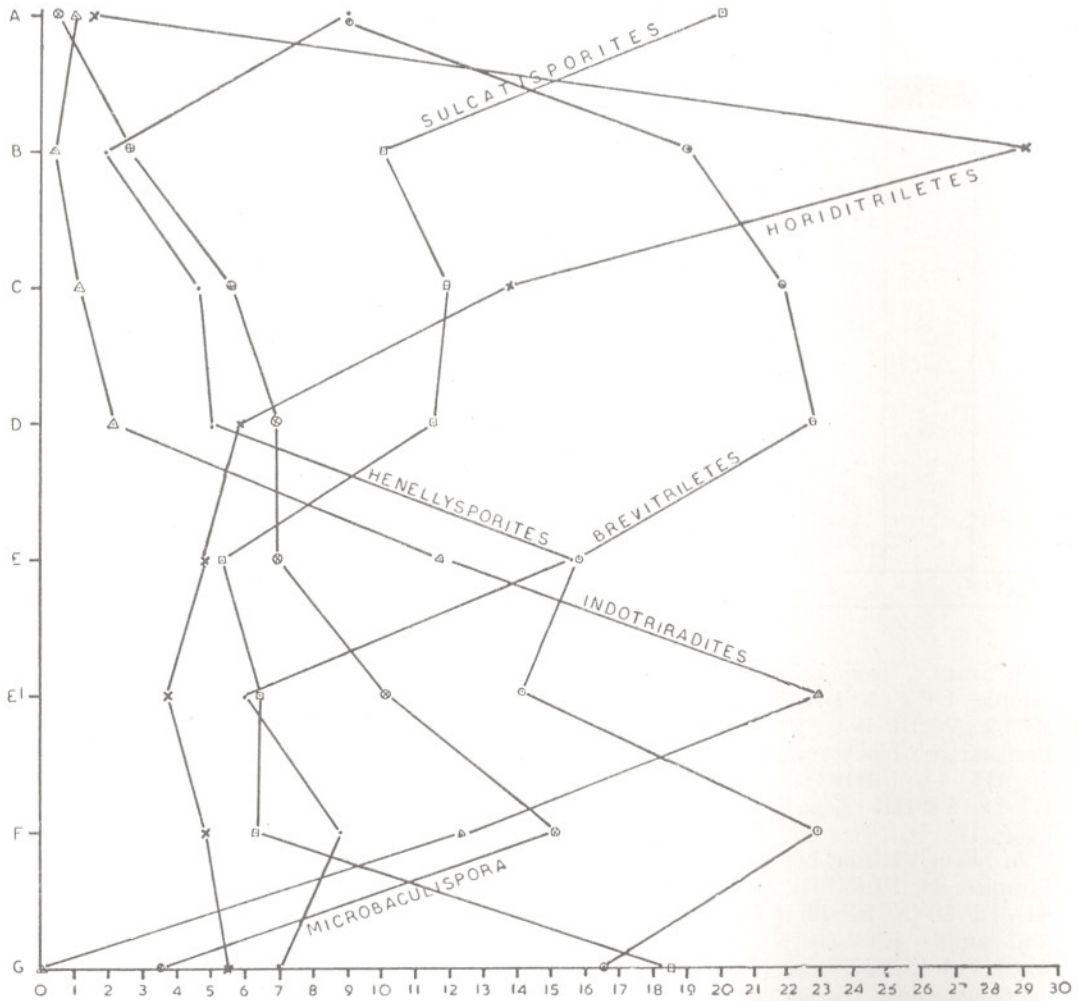
8. Seam VIII from below (Top Seam) : Represented by sample BT 16 (SHB-19) in Batura Block (Assemblage A).

Palynological succession and age

As a result of palynological investigations eight miospore assemblages (Histogram 7) have been discovered representing equal number of coal seams. The percentages of the various important miospora genera among the different assemblages in suc-

cession have been graphically represented in Graph 1. It may be observed that all the dominant components possess considerable dynamism in their behaviour from one assemblage to another. *Microbaculispora* starts low in Assemblage G to attain its maximum in assemblage F but therefrom it declines gradually. Similarly *Indotriradites* which is absent in Assemblage G, successively increases to reach its maximum in assemblage E_1. *Hennellysporites* reaches maximum in assemblage E and thence declines steadily. *Horriditriletes* is low in Assemblages G-D, increases through Assemblage C to reach maximum in Assemblage B and thence declines sharply to reach its lowest in Assemblage A. The behaviour of *Brevitriletes* is slightly different. It is present in significant amounts in Assemblage G, reaches the maximum in Assemblage F, decreases in Assemblage E_1 and E but again attains its maximum in Assemblage D and decreases gradually in the younger assemblages. Like *Brevitriletes*, *Sulcatisporites* also shows two maxima. It is very high in Assemblage G then it decreases in Assemblages F-B and becomes dominant again in Assemblage A.

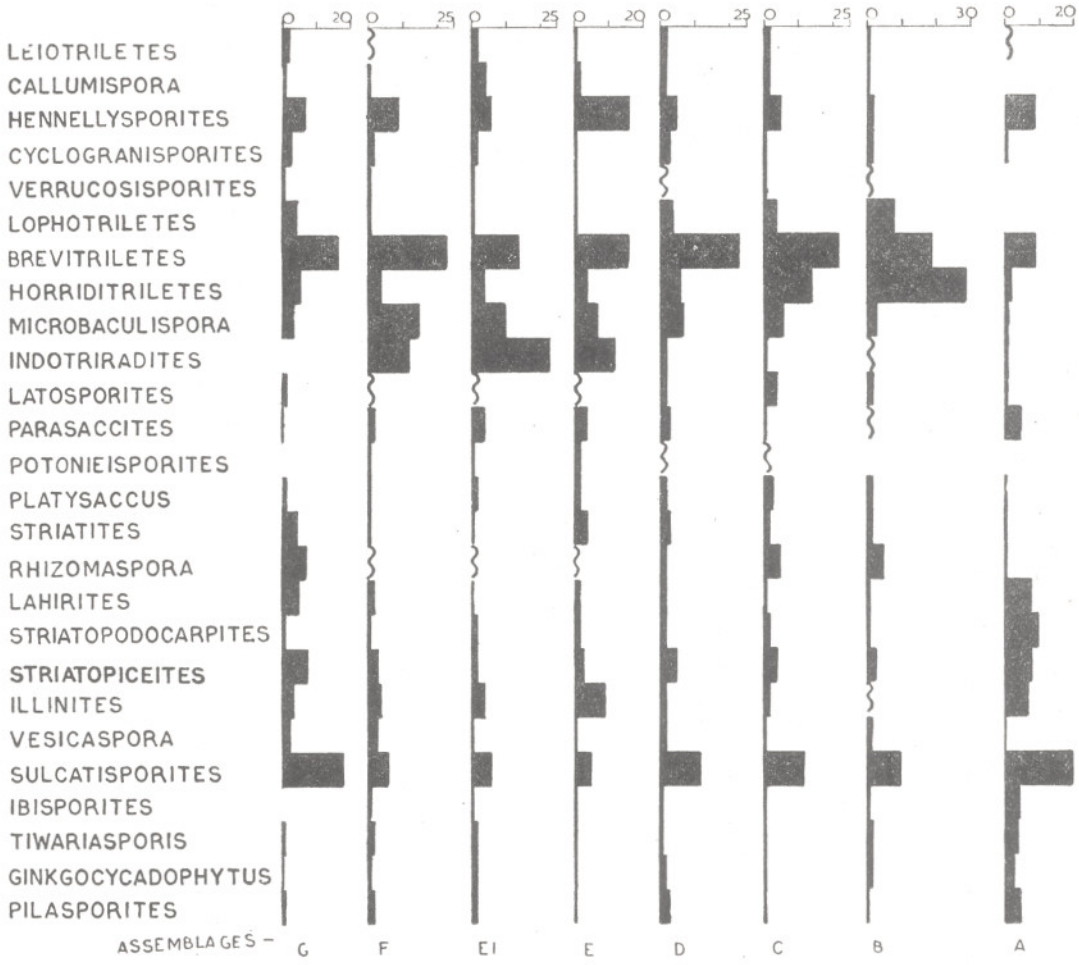
In Table 2, the various spore assemblages of Sohagpur Coalfield have been represented,



GRAPH I — SHOWING THE OCCURRENCE OF DOMINANT GENERA IN DIFFERENT ASSEMBLAGES OF SOHAGPUR COALFIELD

TABLE 1 – STATEMENT SHOWING PARTICULARS OF COAL SAMPLES UNDER STUDY FROM SOHAGPUR COALFIELD

Sl. No.	Borehole No.	Reduced level of surface	Particulars of the overall samples				Overlying seam Depth from surface		Underlying seam Depth from surface	
			C.F.R.I. sample No.	Depth from surface From	To	Nature of roof	Nature of Floor	From	To	From	To
				BHASKARPARA BLOCK							
				CACI-NS							
BP-1	NCBP-2	1837·90 ft.	2050B(C_1-C_3)E	185′5″	191′4″	Sandstone	Shale/Sand-stone	167′1″	174′6″	194′6½″	197′7″
BP-2	NCBP-2	1837·90 ft.	2050B(C^4)	194′6½″	197′7″	Shale/Sand-stone	Sandy shale	185′5″	191′4″	—	
BP-3	NCBP-3	1566·91 ft.	2051(A)	181′8″	188′7″	—	—	—		210′0″	229′0″
BP-4	NCBP-3	1566·91 ft.	2051(D)	312′10″	315′½″	Sandstone	Shale/Sand-stone	210′0″	229′0″	516′10″	519′3″
BP-5	NCBP-10	1885·66 ft.	2060(A)	306′2″	312′4″	Sandstone	Shale/Sand-stone	—		330′0″	349′10″
BP-6	NCBP-15	2125·62 ft.	2067B(C_1)	128′3″	132′10″	Sandstone	Sandstone	49′0″	63′3″	525′0″	530′6″
BP-7	NCBP-15	2125·62 ft.	2067(D)	632′0″	636′6″	—	Shale/Sand-stone	525′0″	530′6″	—	
BP-8	NCBP-18	2075·97 ft.	2069(C)	116′9″	122′7″	Sandstone	Shale/Sand-stone	97′10½″	103′7″	—	
BP-9	NCBP-19	1882·55 ft.	2080B(C_5)	183′0″	186′4″	Sandstone	Sandstone	165′10½″	175′0″	525′2½″	533′2″
BP-10	NCBP-35	2076·67 ft.	2120A(C_1-C_7)E	87′0″	100′8″	—	Shale/Sand-stone	—		146′2½″	152′2″
BP-11	NCBP-36	2123·60 ft.	2127(F)	529′3″	531′2″	Carb. shale	Shale/Sand-stone	503′9″	510′5″	—	
BP-12	NCBP-41	2190·34 ft.	2150A(C_1-C_9)E	81′6½″	98′0″	Sandstone	Shale/Sand-stone	—		143′0″	152′1″
BP-13	NCBP-41	2190·34 ft.	2150(C)	161′0″	167′3½″	Shale	Carb. shale	143′0″	152′1″	483′0″	488′0″
BP-14	NCBP-41	2190·34 ft.	2150(D)	483′0″	488′0″	—	Sandstone	161′0″	167′3½″	559′5″	566′0″
BP-15	NCBP-41	2190·34 ft.	2150(E)	559′4″	566′0″	Sandstone	—	483′0″	488′0″	—	
BP-16	NCBP-69	1896·17 ft.	2297(B)	211′3″	214′7½″	Sandstone	Sandstone	89′3″	93′10″	—	
BP-17	NCBP-70		2298A(C_3)	60′7½″	64′1″	Sandy shale	Sandy shale	—		107′6″	114′0″
BP-18	NCBP-70		2298B(C_2-C_1)E	107′6″	114′0″	Shale	—	60′7½″	64′1″	—	
BP-19	NCBP-78		2330A(C_1-C_9)E	122′6″	135′4″	Carb. shale	Shale/Sand-stone	—		162′9″	173′0″
BP-20	NCBP-78		2330(C)	181′4″	184′2″	Sandstone	Shale/Sand-stone	162′9″	173′0″	195′3½″	187′4″
BP-21	NCBP-78		2330(E)	495′0″	497′11″	Sandstone	Sandstone	195′3½″	197′4″	535′0″	542′4″
				KUTKONA BLOCK							
KT-1	NCKT-5	2532·12 ft.	1973(B)	259′5″	262′5½″	Sandstone	Sandy shale	153′10″	172′7″	614′3″	618′½″
KT-2	NCKT-6	2514·47 ft.	1978(B)	162′0″	165′0″	Sandstone	Sandstone	62′1″	76′3″	499′10″	505′1″
KT-3	NCKT-6	2514·47 ft.	1978(C)	499′10″	505′1″	Sandstone	Sandy shale	162′0″	165′0″	—	
KT-4	NCKT-7	2493·65 ft.	1966B(C_2)	257′6″	260′7″	Sandstone	Carb. shale	156′0″	172′6″	608′0″	615′10″
KT-5	NCKT-7	2493·65 ft.	1988(C)	608′0″	615′10″	Sandstone	Sandy shale	257′6″	260′7″	677′8″	683′6½″
KT-6	NCKT-16A	2417·70 ft.	2019(C_1-C_{15})E	205′6″	221′6″	Sandstone	Sandy shale	—		308′0″	310′0″
KT-7	NCKT-16A	2417·70 ft.	2019(D)	704′9″	709′11″	Sandstone	Sandstone	641′4″	647′0″	758′2″	763′9″
KT-8	NCKT-20	2471·55 ft.	2024D(C_1-C_5)	400′8″	414′6″	Sandstone	Sandstone	306′2″	308′2″	—	
KT-9	NCKT-22	2471·55 ft.	2045A(C_1-C_{12})E	182′4½″	202′9″	Carb. shale	Sandy shale	—		291′11″	296′11″
KT-10	NCKT-27	2392·47 ft.	2078B(C_1)	447′10″	453′2″	Shale/Sand-stone	Shale	380′4″	386′5″	508′9″	521′9″
KT-11	NCKT-31	2409·55 ft.	2110B(C_1-C_2)E	566′9″	572′6″	Sandstone	Sandstone	—		627′7″	633′7″
KT-12	NCKT-42	2488·44 ft.	2172A(C_1-C_9)E	425′0″	439′0″	Sandstone	Shale/Sand-stone	—		524′3″	529′4″
KT-13	NCKT-43A	2456·42 ft.	2232(D)	748′1″	749′7″	Sandstone	Sandstone	690′7″	694′2″	820′3″	830′9½″
KT-14	NCKT-47	2411·33 ft.	2288(E)	833′4″	834′10″	Sandstone	Sandstone	756′0″	763′2″	861′1″	865′6″
KT-15	NCKT-49	2317·12 ft.	2315(D)	543′10″	550′6″	Sandstone	Sandstone	490′2″	494′2″	—	
KT-16	NCKT-51	2280·70 ft.	2342(F)	833′5″	836′7″	Carb. shale	Sandy shale	729′1″	730′11″	—	
				BATURA BLOCK							
				CACI-BH							
BT-1	SHB-4	1516·35 ft.	32(C)	176′2″	181′4″	Sandstone	Sandstone	85′0″	97′3″	—	
BT-2	SHB-5	1518·48 ft.	33(A)	113′3″	116′1″	Sandstone	Sandstone	—		176′5″	177′4″
BT-3	SHB-7	1570·46 ft.	34(A)	89′1″	95′7″	Sandstone	Sandstone	—		103′9″	107′25″
BT-4	SHB-12	1653·77 ft.	88A(C_9)	74′2″	86′4″	Carb. shale	Shale/Sand-stone	—		100′3″	110′8″
BT-5	SHB-12		88B(C_1)	100′3″	110′8″	Sandstone	Shale coal	74′2″	86′4″	113′3″	121′4″
BT-6	SHB-12		88B(C_1-C_6)I	113′1″	121′4″	Shaly coal	Sandstone	100′3″	110′8″	—	
BT-7	SHB-13	1638·99 ft.	122A(C-1)	166′9″	170′6″	Sandstone	Carb. shale	—		171′2″	188′4″
BT-8	SHB-13		122A(C_2-C_3)I	171′2″	188′4″	Carb. shale	Shale coal	166′9″	170′6″	189′2″ ×	194′0″
BT-9	SHB-13		122A(C_1-C_6)I	189′2″	194′0″	Shaly coal	Carb. shale	171′2″	188′4″	—	
BT-10	SHB-16	1598·40 ft.	151(B)	163′3″	170′9″	Carb. shale	Carb. shale	129′3″	161′5″	—	
BT-11	SHB-18	1580·08 ft.	152A(C_1-C_2)I	197′6″	200′0″	Carb. shale	Carb. shale	—		206′9″	212′8″
BT-12	SHB-18		152(B)	206′9″	212′8″	Carb. shale	—	197′6″	200′6″	223′7″	255′7″
BT-13	SHB-18		152C(C-1)	223′7″	233′6″	Carb. shale	Coal	206′9″	212′8″	—	
BT-14	SHB-18		152C(C-3)	233′6″	242′2″	Coal	Shale coal	206′9″	212′8″	—	
BT-15	SHB-18		152C(C_1-C_6)I	243′2″	255′7″	Shaly coal	Shaly sand-stone	206′9″	212′8″	—	
BT-16	SHB-19	1661·67 ft.	153(A)	65′3″	72′2″	Sandstone	Sandtsone	—		118′4″	126′0″



HISTOGRAM 7– SHOWING VARIOUS TYPES OF MIOSPORE ASSEMBLAGES OCCURRING IN SOHAGPUR COALFIELD

condensed on the basis of the presumed affinities of the genera into broader groups such as Zonate triletes (*Indotriradites* + *Hennellysporites* etc.), Varitriletes (*Microbaculispora* etc.), Apiculate triletes (*Lophotriletes* + *Brevitriletes* + *Horriditriletes* etc.), Striated bisaccates (*Striatopiceites* + *Striatopodocarpites* + *Lahirites*) and Nonstriated bisaccates (*Sulcatisporites* + *Vesicaspora*). This condensed synthesis of the principle spore kinds reveals that the palynological sequence was influenced by three miofloral changes during the course of deposition of the coal measures in Sohagpur Coalfield. Thus, the oldest change occurred after the deposition of the bottom seam containing Assemblage G; the next change occurred after the deposition of the seam containing Assemblage F and the last change took place after the seam containing Assemblage B was deposited.

With regard to the chronostratigraphic age of the various coal depositions in Sohagpur Coalfield, Assemblage G corresponds with the one found in Argada 'S' seam of South Karanpura Coalfield (Bharadwaj & Anand-Prakash, MS), and that of Mohpani Coalfield (Bharadwaj & Anand-Prakash, MS). The latter two have been dated by these authors as of Lower Karharbari Stage. The remaining three, younger groups of Assembalges correspond with the three zones in Barakar Stage, distinguished by Venkatachala and Kar (1968) in North Karanpura Coalfield. Evidently,

TABLE 2 – SPORE PERCENTAGE IN SOHAGPUR COALFIELD

Assemblages	Zonate Triletes Indo.+ Hennelly.	Varitriletes Micro-bacul.	Apiculate triletes Lopho.+ Brevi.+ Horridi.	Striated saccates Striato-pic.+ Striato-podo.	Non-striated saccates Sulcati.+ Illinites		
A	1+9	1	0+9+2	8+10	20	Upper	Barakar
B	0+2	3	8+19+29	3+1	10	Middle	
C	1+5	6	4+22+14	2+4	12		
D	2+5	7	4+23+6	3+5	12		
E	12+16	7	1+16+4	2+3	5	Lower	
E_1	23+6	10	1+14+4	2+2	6		
F	12+9	15	1+23+5	1+3	6		
G	0+7	4	4+17+5	1+8	19	Lower	Karharbari

the Assemblages F-A in Sohagpur Coalfield are of Barakar Stage. But, while the two older zones of Barakar Stage are fully represented, the youngest zone with only one coal seam appears to be only partially represented.

In view of our findings here, the dating and correlation of Churcha seam investigated by Navale and Tiwari (1967), is now possible more precisely. In this connection the most distinguishing features are the appreciable percentages of *Hennellysporites* (*Retusotriletes*) and *Illinites*. Such percentages of these genera are present only in Assemblage E here and thus, Churcha seam is the topmost of Lower Barakar Stage.

CONCLUSION

In all, eight coal seams occur among the 55 bore hole samples investigated palynologically. Their distribution in various blocks is graphically represented in Text-fig. 4. The qualitative and quantitative compositions of miospore contents of the samples have been analysed and used for their correlation. While most of the samples are palynologically very much allied within the same or different bore holes when the qualitative and quantitative values of miospore assemblage are taken into account, some samples show certain variations, yet they agree with others in the overall representation of the dominant constituents and thus are correlated to them.

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