SPOROLOGICAL CORRELATION OF COAL SEAMS IN SAUNDA AND GIDI AREAS OF SOUTH KARANPURA COALFIELD, BIHAR, INDIA*

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ABSTRACT

Sixty seven coal samples out of six bore-holes in the Saunda and Gidi areas of South Karanpura Coalfield, Bihar, have been palynologically investigated. The various forms of dispersed spores and pollen grains are assigned to forty three genera. On the basis of generic percentage frequency and their distribution, nine miospore genera have been considered representing the dominant association. They are *Leiotriletes, Lophotriletes, Horriditriletes, Microbaculispora, Cyclobaculisporites, Striatopodocarpites, Faunipollenites, Vesicaspora* and *Sulcatisporites*. Along with them two rare genera — *Indotriradites* and *Dentatispora* are also included due to their characteristic distribution. On the basis of qualitative and quantitative miofloristic values, the samples fall in to 3 major coal seams out of which one is met with only in two bore-holes representing the youngest deposition, second is represented in all the bore-holes, and the seam occupying the position of oldest deposition is struck in five of the six bore-holes and is variously split. Apart from this, there are two samples which stand apart and are supposed to be of local importance.

INTRODUCTION

SOME times back on the basis of a detailed analysis of miospore assemblages represented in the coal seams of Korba Coalfield, Madhya Pradesh, a miofloristic correlation of different coal-seams in three sectors of the coalfield was suggested by us (BHARADWAJ & TIWARI 1964b). There the significant differences in the frequency of miospore genera in different assemblages could lead to a well defined and conclusive picture of correlation. However, it is not always so in palynological work that a few spore genera determine the nature of miospore complex in a basin and indicate a clear picture of correlation. So in cases where the distribution of a few genera is not very characteristic, an over all association of all the dominant genera, which exhibit a considerable amount of variation in their vertical distribution, also has to be considered. The correlation of coal seams in North Karanpura Coalfield has been suggested by us (BHARADWAJ & TIWARI, 1966) on the latter lines.

MATERIAL AND METHODS

Karanpura Coalfields lie in the upper part of the basin of Damodar River between latitudes 23°38′ and 23°56′ North, and longitudes 84°46′ and 85°28′ East. The present work is based upon the 67 coal samples from six bore-holes in the Saunda and Gidi areas of South Karanpura Coalfield. The material was collected by Central Fuel Research Institute of India and the samples were sent in powdered form in polythene bags to avoid contamination. Every sample was analysed separately and then the over all percentage frequency of each seam was calculated. Details of sampling data along with Lab. Sample Nos. are given in Table 1. Only the latter numbers are referred to in the discussion.

The maceration was done by the usual method, using commercial nitric acid and potassium hydroxide. Ten gms of powdered material was taken for each maceration and was kept covered under nitric acid. It took two to three days for the completion of acid reaction. After washing it free from all the traces of acid, it was treated with ten per cent KOH, which was heated upto the simmering stage. After allowing it to cool down at the room temperature, it was thoroughly washed to remove alkali. The slides were prepared in glycerine jelly.

During the preparation it has been kept in mind that all the samples received a more or less constant treatment. As far as possible equal amount of acid, alkali and glycerine jelly was taken in each case. The slides and the ' counting areas ' were sorted out at random. In each sample

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TABLE 1 — DATA OF SAMPLES UNDER STUDY FROM SOUTH KARANPURA COALFIELD

SAUNDA AREA

Lab. Sample No.	S. No.	Overall No.	Area	Depth from the surface	Band excluded	Thickness
			Bore-hole No. KSu 24 (17 Samples)			
1	1	1	Saunda	126′-136′	1	5″
	2	2	,,	136′-143′6″	3	10¼″
	3	3	,,	249′-256′	1	3″
	4	4	,,	256′-266′	2	1′7½″
2	5	5	,,	266′-276′	1	2″
	6	6	,,	276′-286′	2	4″
	7	7	,,	286′-294′	3	2′10″
	8	8	,,	393′6″-396′	1	3″
	9	9	,,	396′-406′	2	1′5¾″
3	10	10	,,	406′-414′	5	1′7¾″
	11	11	,,	414′-424′	1	4½″
	12	12	,,	481′-491′	4	3′7¼″
4	13	13	,,	491′-501′	3	1′8″
	14	14	,,	501′-506′	1	2″
			Bore-hole No. KSu 11 (17 samples)			
	15	1	Saunda	183′6″-186′	2	6″
	16	2	,,	186′-196′	3	1′2¾″
	17	3	,,	196′-206′	1	2″
	18	4	,,	206′-216′	5	1′2″
5	19	5	,,	216′-226′	1	8″
	20	6	,,	226′-236′	2	8¼″
	21	7	,,	236′-245′	—	—
	22	8	,,	245′-250′	1	2¼″
	23	9	,,	250′-251′	—	—
	24	10	,,	251′-255′9″	2	10″
	25	11	,,	328′6″-336′	2	1′10″
6	26	12	,,	336′-346′	1	11″
	27	13	,,	346′-356′	—	—
	28	14	,,	406′8″-414′2″	4	2′5″
	29	15	,,	414′2″-420′2″	—	—
7	30	16	,,	420′2″-426′	3	1′8″
	31	17	,,	426′-427′10″	1	4″
			Bore-hole No. KSu 21 (16 samples & M.Ch. Overall)			
8	32	1	,,	125′-130′	2	8½″
	33	2	,,	130′-132′2″	—	—
8A	34	M.Ch.Ov. 2	Saunda	162′4″-169′1″	2	3′4½″
	35	3	,,	208′5″-210′	2	8″
	36	4	,,	210′-220′	1	3″
	37	5	,,	220′-230′	—	—
9	38	6	,,	230′-240′	2	2′7½″
	39	7	,,	248′-250′	1	6″
	40	8	,,	250′-257′	1	4″
	41	9	,,	321′6″-330′	3	4′7″
10	42	10	,,	330′-336′	2	2′7½″
	43	11	,,	336′-346′	3	1′½″
	44	12	,,	346′-349′	—	—

TABLE 1 — DATA OF SAMPLES UNDER STUDY FROM SOUTH KARANPURA COALFIELD — *Contd.*

SAUNDA AREA

Bore-hole No. KSu 21 (16 samples & M.Ch. Overall)

Lab. Sample No.	S. No.	Overall No.	Area	Depth from the surface	Band excluded	Thickness
11	45	13	,,	406′-416′	5	4′0″
	46	14	,,	416′-418′2″	1	11″
12	47	15	,,	456′-462′	3	3′7½″
	48	16	,,	462′-471′	2	1′10″

Bore-hole No. KSu 1 (7 samples & M.Ch.Ov. 1, 2, 3, 6, 7, 8, 9)

A-13	49	M.Ch.Ov. 1	,,	60′8″-70′0″	—	—
B-13	50	M.Ch.Ov. 2	,,	98′9″-103′0″	1	3″
C-13	51	M.Ch.Ov. 3	,,	144′-153′0″	1	3½″
	52	1	Saunda	235′9″-240′	1	1′0″
13	53	2	,,	240′-251′	2	1′5″
	54	3	,,	251′-261′	1	1′8″
	55	4	,,	261′-271′9″	3	1′7″
	56	5	,,	319′-329′	5	5′1½″
14	57	6	,,	329′-338′	4	2′5½″
	58	7	,,	338′-344′	3	8½″
14-A	59	M.Ch.Ov. 6	,,	403′-416′	8	7′½″
14-B	60	M.Ch.Ov. 7	,,	451′0″-466′3″	6	3′1″
14-C	61	M.Ch.Ov. 8	,,	?	6	3′5½″
14-D	62	M.Ch.Ov. 9	,,	?	?	3′4½″

GIDI AREA

Bore-hole No. KG 29 (M.Ch.Ov. samples 1)

15	63	M.Ch.Ov. 1	Gidi	101′0″-164′6″	1-15	5′9″

Bore-hole No. KG 22 (M.Ch.Ov. samples I-IV)

16	64	M.Ch.Ov. 1	,,	137′11″-157′	1	6″
17	65	M.Ch.Ov. 2	,,	167′11″-185′2″	2, 3, 4. 5, 6,	1′6″
18	66	M.Ch.Ov. 3	,,	322′2″-137′0″	7, 8, 9, 10, 11, 12, 13, 14, 15, 16.	4′3½″
19	67	M.Ch.Ov. 4	,,	590′5″-674′2″	16-45	11′9½″

Note: Total No. of samples 67 (62 from Saunda area and 5 from Gidi area)

five hundred miospores were counted upto the generic level and the average frequency in the overall seam was determined by simple arithematical computation.

Mioflora

A large number of dispersed spores and pollen grains have been found in the bore-hole coal samples under study. The *sporae dispersae* have been assigned to 43 miospore genera. (*Sensu* — Bharadwaj 1962, Bharadwaj & Tiwari 1964a, Tiwari 1964).

The following miospore genera are quantitatively important ones, either in being consistently well represented or in showing a characteristic distribution.

Leiotriletes (Naum.) Pot. & Kr.
Lophotriletes (Naum.) Pot. & Kr.
Horriditriletes Bharad. & Salujha.
Microbaculispora Bharad.
Cyclobaculisporites Bharad.

Indotriradites Tiwari
Dentatispora Tiwari
Latosporites Pot. & Kr.
Parasaccites Bharad. & Tiwari
Striatites (Pant) Bharad.
Rhizomaspora Wilson
Striatopodocarpites (Soritsch. & Sed.) Bharad.
Faunipollenites Bharad.
Vesicaspora (Schemel) Wils & Venk.
Sulcatisporites (Lesch.) Bharad.
Decussatisporites Lesch.

The genera listed below, though quantitatively irregular in occurrence and generally rare, are also present in the samples and are important when considered along with the whole association.

Punctatisporites (Ibr.) Pot. & Kr.
Hennellysporites Tiwari
Cyclogranisporites Pot. & Kr.
Verrucosisporites (Ibr.) Pot. & Kr.
Apiculatisporis (Ibr.) Pot. & Kr.
Microfoveolatispora Bharad.
Gondisporites Bharad.
Calamospora S. W. & B.
Thymospora Wilson & Venkatach.
Densipollenites Bharad.
Potonieisporites (Bharad.) Bharad.
Lahirites Bharad.
Cuneatisporites Lesch.
Lunatisporites (Lesch.) Bharad.
Gnetaceaepollenites Thiergart
Tiwariasporis Maheshw. & Kar.

The following genera are also present in this assemblage but their occurrence is mostly sporadic and the distribution is inconsistant.

Acanthotriletes (Naum.) Pot. & Kr.
Indospora Bharad.
Punctatosporites Ibr.
Barakarites Bharad. & Tiwari
Plicatipollenites Lele
Platysaccus Pot. & Kl.
Primuspollenites Tiwari
Verticipollenites Bharad.
Pityosporites (Seward) Pot.
Vittatina Luber
Ginkgocycadophytus Samoilovich
Maculatasporites Tiwari

Miofloristic Distribution

The qualitative as well as quantitative miofloristic composition of all the coal seams is given in Histogram I. A perusal of this histogram reveals that the following genera are most characteristic in the whole miofloral spectrum, in showing a fair to high percentage frequency, regularly in all the seams and hence are considered here to form the dominant association.

Leiotriletes
Lophotriletes
Horriditriletes
Microbaculispora
Cyclobaculisporites
Striatopodocarpites
Faunipollenites
Vesicaspora
Sulcatisporites

Along with them two genera, viz. *Indotriradites* and *Dentatispora* are also included. These two genera, although rare and inconsistant in their percentage frequency, behave characteristically in being quite significant in a set of samples and hence they are being considered along with other dominant genera.

Vertical Variation in the Distribution of Dominant Genera

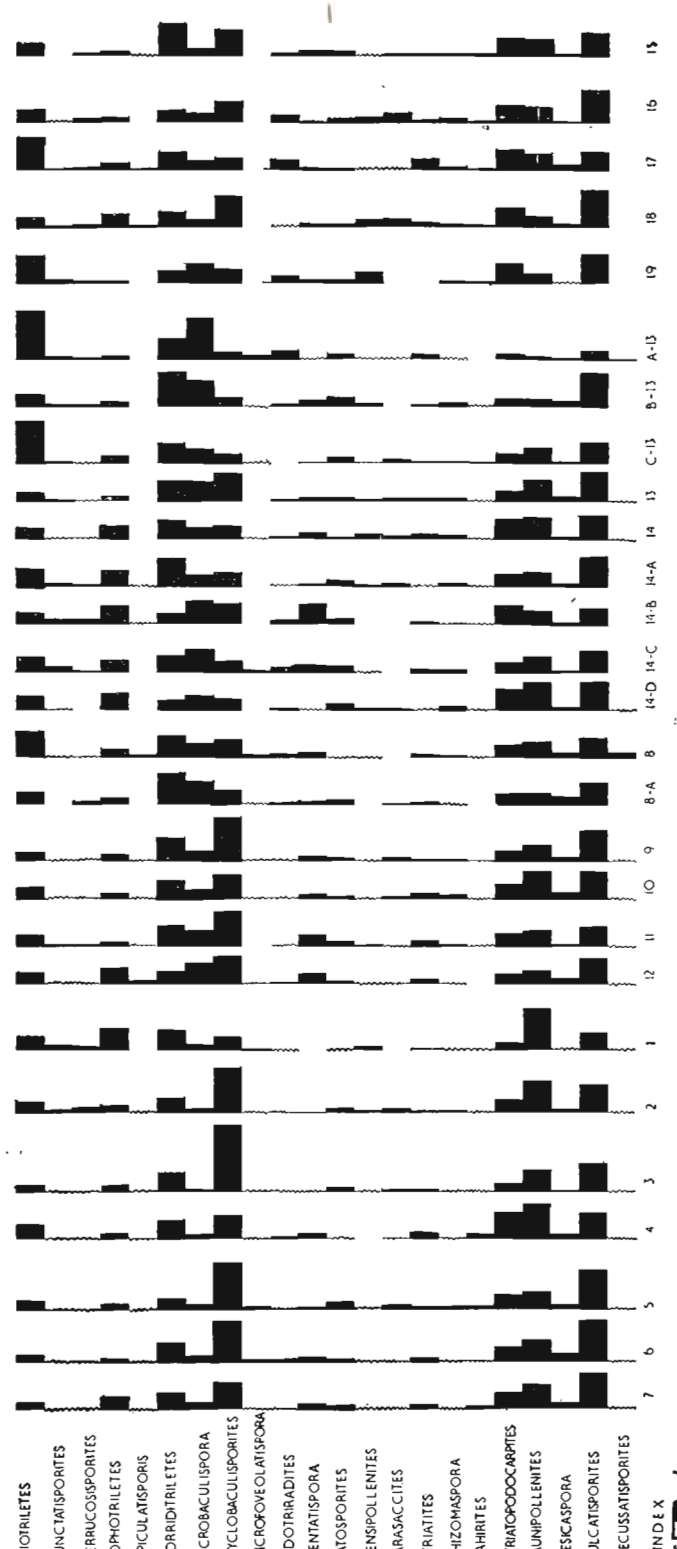
The distribution of quantitatively important miospore genera in time, is also depicted in the Histogram I, where miofloral composition in the seams of the same bore hole are plotted together. The tendency of vertical variation in the well-represented genera from older to younger seam in each bore-hole is as given below:

SAUNDA AREA

Bore-hole KSu-11 — (Seams represented by Lab. Sample Nos. 7, 6, 5).

In these three successive seams *Leiotriletes* consistently increases. *Lophotriletes* decreases and then increases a bit, *Horriditriletes* increases a little and then decreases, and *Microbaculispora* gradually decreases. The most dominating genus *Cyclobaculisporites* appreciably increases. *Indotriradites* increases and finally decreases but the genus *Dentatispora* consistently decreases. *Striatopodocarpites* is more or less constant but *Faunipollenites* shows a regular decrease. *Vesicaspora* increases a bit in the middle seam to decrease in the uppermost seam and so also is the trend of variation for the genus *Sulcatisporites*.

Bore-hole KSu-24 (Seams represented by Lab. Sample Nos. 4, 3, 2, 1).



HISTOGRAM I — Distribution of quantitatively important miospore genera in various bore-hole coal samples from Saunda and Gidi areas, South Karanpura Coalfield.

In this bore-hole there are 4 successive seams. Genus *Leiotriletes* is highest represented in the lower most seam and then suddenly decreases to become lowest in the next younger seam but thereafter increases again. *Lophotriletes* shows a constant increase, thus, it is lowest in the oldest seam and highest in the youngest seam. *Horriditriletes* slightly increases, then decreases and again increases in the youngest seam of the bore-hole where it is represented by the highest percentage. *Microbaculispora* decreases in the second seam from below (Sample 3) and again increases consistently in the remaining seams. *Cyclobaculisporites* the most dominant genus, shows a peculiar behaviour in having low percentage in the oldest seam and highest (also highest among all the seams under study) in the subsequent younger one, then it continues to decrease sharply to reach its lowest in the upper most seam. *Indotriradites* as well as *Dentatispora* are relatively rare forms in these seams, showing maximum representation in the lower most seam and either represented in traces or not met with in the remaining seams. *Striatopodocarpites* is maximum in the lower most seam then decreases with a little increase in the seam immediately below the youngest seam. *Faunipollenites* decreases in the seam next to the oldest seam but thereafter consistently increases to reach its maximum in the upper most seam. *Vesicaspora* is highest in the oldest seam and decreases in the remaining seams. *Sulcatisporites* increases to attain its maximum in the seam next to the oldest and thereafter decreases to touch the minimum in the upper most seam.

Bore-hole KSu-21 (Seams represented by Lab. Sample Nos. 12, 11, 10, 9, 8A, 8).

In this bore-hole there are 6 successive seams. *Leiotriletes* increases and slightly decreases in the four successively older seams but sharply increases again in the fifth (Sample 8A) and the top most (Sample 8) seam reaching its maximum. *Lophotriletes* is highest in the lower most seam and then sharply declines in the next successive seam. It again increases slowly to decrease again in sample 8A only to reach its maximum in the top most seam. Genus *Horriditriletes* is lowest in the lower most seam; then it increases sharply in the next younger seam but declines a bit again in the next seam. Thereafter it increases to reach its maximum in the seam below the youngest to decline again in the youngest seam. *Microbaculispora* is a fairly well represented genus in this succession. It constantly decreases upto the second seam from the top where it sharply increases to reach its maximum. It decreases again in the top most seam. *Cyclobaculisporites* decreases and increases significantly in the alternate seams. *Indotriradites* decreases in the middle seams and increases again in the two seams at the top. *Dentatispora* increases in the second oldest seam to attain its maximum, then decreases consistently only to increase a bit in the top most seam. *Striatopodocarpites* does not show a significant variation and gradually increases in the lower 3 successive seams, then falls a bit in the 4th seam whereafter it again shows a slow increase.

Genus *Faunipollenites* increases upto the 3rd seam from bottom reaching its maximum and then decreases to increase again in the top most seam. *Vesicaspora* shows an alternate decrease and increase in the successive seams, and *Sulcatisporites* decreases in the second oldest seam but increases in the three successive seams and finally decreases in the top most seam.

Bore-hole KSu-1 (Seams represented by Lab. Sample Nos. 14-B, 14-A, 14, 13, C-13, B-13, A-13).

This bore-hole passes through the maximum number of seams i.e. seven seams. From older to younger seams *Leiotriletes* increases in 14-A, decreases in 14 and 13 and sharply increases in C-13. It declines again in sample B-13 and increases in the top most seam (A-13) where it reaches its maximum. *Lophotriletes* with its more or less constant behaviour in the lower most three successive seams declines thereafter gradually. *Horriditriletes* increases sharply in the next to the oldest seam then declines to show a constancy in the subsequent three seams but suddenly increases to reach its maximum in the 2nd seam from the top (B-13) and again declines sharply in the top most seam. *Microbaculispora* is a well represented genus in these seams. It sharply decreases in the seam next to the oldest seam, remains constant in the next seam but subsequently it sharply increases, to fall once again before increasing appreciably to reach its maximum in the top most seam. *Cyclobaculisporites* decreases to increase upto its maximum in the middle most seam (13) and again decreases to reach its minimum

in the top most seam. *Indotriradites*, although a relatively rarer form, after decreasing in the oldest-but-one seam again increases to show a more or less constant occurrence, but sharply increases in the top most seam to attain its maximum. *Dentatispora* is highest in the lower most seam. It decreases and increases significantly in the seam 3rd from the bottom seam but again decreases in two overlying seams. Finally it increases in the seam below the top seam to decline again in the top most seam. *Striatopodocarpites* first decreases then increases in the 3 successively lower seams and then regularly decreases to reach its minimum in the upper most seam of this bore-hole. *Faunipollenites* increasingly attains its maximum in the 3rd seam from the bottom seam then significantly declines upto its minimum in the top most seam. *Vesicaspora* increases upto the middle seam (13) where it is maximum and then alternately decreases and increases in the remaining successive seams. *Sulcatisporites* is noteworthy in its alternating increase and decrease in all the 7 seams.

GIDI AREA

Bore-hole KG-22 (Seams represented by Lab. Sample Nos. 19, 18, 17, 16).

In this bore-hole there are four successive seams. Genus *Leiotriletes* is markedly high and low in the successive seams from older to younger ones. *Lophotriletes* increases sharply in the second to the oldest seam and then decreases in the subsequent seams. *Horriditriletes* increases upto its maximum in the 3rd seam from below and finally decreases. *Microbaculispora* is highest in the lowest seam, decreases sharply in the seam next to it and then increases again. *Cyclobaculisporites* markedly increases in the seam next to the oldest then sharply declines to increase again in the remaining seam. *Indotriradites* declines in the second oldest seam but again resumes its high percentage in the remaining two seams. *Dentatispora* with a little declention maintains consistancy in the remaining seams. *Striatopodocarpites* shows a trend towards decrease and *Vesicaspora* virtually towards an increase. *Sulcatisporites* increases in the second from the bottom seam to attain its highest, sharply decreases and finally sharply increases.

Bore-hole KG-29: Only one seam (Sample 15) is represented in this bore-hole.

The Dominant Association

Table 2 gives the percentage frequency of the eleven, quantitatively well to richly represented genera.

The Total Dominant Percentages (T.D.P.) as given in Table 2 range from 73·5 per cent to 89·8 per cent. From this table it is also apparent that *Horriditriletes*, *Cyclobaculisporites*, *Faunipollenites* and *Sulcatisporites* contribute maximum individuality to the dominanace.

Extent of Variation in the Genera of Dominant Association

The variation exhibited by each of the 11 genera forming the dominant association is graphically represented in graph 1. This graph shows that the representation is quite variable between most of the seams in succession regarding the genera *Leiotriletes*, *Lophotriletes*, *Horriditriletes*, *Microbaculispora*, *Cyclobaculisporites*, *Faunipollenites* and *Sulcatisporites*. Genus *Striatopodocarpites* exhibits a lesser difference and *Vesicaspora*, *Indotriradites* and *Dentatispora* are the least variable. However, the last three genera are considered to show this tendency due to their over all low incidences in most of the seams but since they are characteristically well represented in a set of seams, they are considered along with the other genera of the dominant association.

A perusal of the Total Dominant Percentage (T.D.P.) given in Table 2 indicates that it behaves in a more or less regular manner in individual bore-holes in the seam from older to younger in succession. Thus, we have analysed this tendency of variation in the following manner.

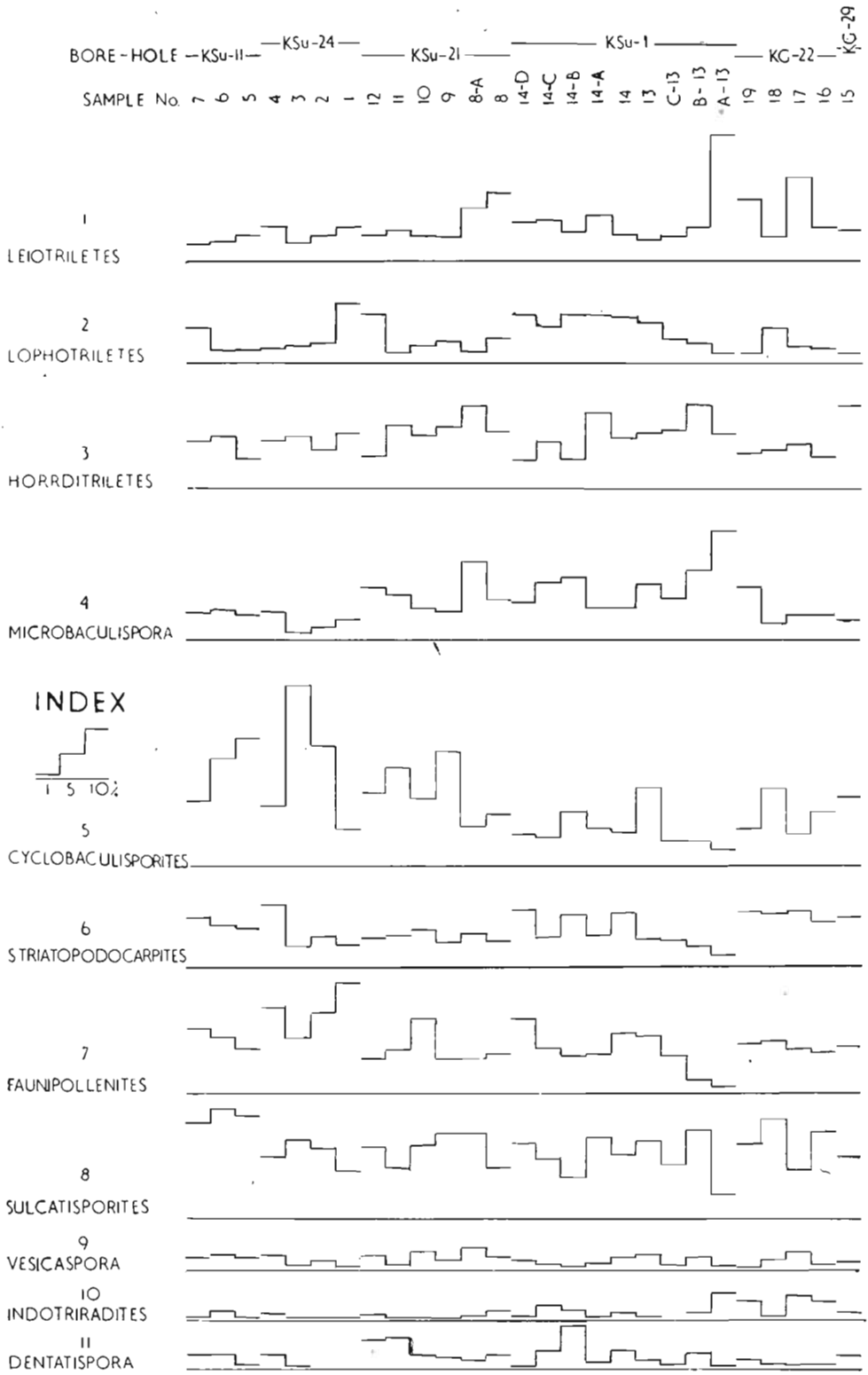
Bore-hole KSu-11 (Sample Nos. 7, 6, 5) — T.D.P. is 85·9 per cent in the lowest seam, increases in the middle seam (89·1 per cent) and again decreases (83·6 per cent) in the top seam.

Bore-hole KSu-24 (Sample Nos. 4, 3, 2, 1) — T.D.P. is 85·0 per cent in the lowest seam. It increases in the next seam (89·8 per cent) to decrease again in the remaining two seams (83·7, 79·7 per cent).

Bore-hole KSu-21 (Sample Nos. 12, 11, 10, 9, 8A, 8) — In the lowest seam the total

TABLE 2 — PERCENTAGE FREQUENCY OF THE IMPORTANT GENERA IN VARIOUS BORE-HOLE SAMPLES UNDER STUDY

Bore-hole No.	Lab. Sample Nos.	*Leiotri-letes*	*Lopho-triletes*	*Horridi-triletes*	*Microbacu-lispora*	*Cyclobacu-lisporites*	*Indotri-radites*	*Dentati-spora*	*Striatopo-docarpites*	*Faunipol-lenites*	*Vesica-spora*	*Sulcati-sporites*	Total Domi-nant Percen-tage (T.D.P.)
		%	%	%	%	%	%	%	%	%	%	%	
KSu-24	1	7·3	11·7	11·0	3·8	7·6	0·7	—	4·6	22·4	0·5	9·7	79·7
	2	5·3	3·9	7·8	2·4	24·0	0·7	—	6·6	16·3	2·2	14·4	83·7
	3	4·4	3·5	10·5	1·6	36·0	0·3	0·7	4·7	11·2	1·1	15·8	89·8
	4	7·6	3·2	9·6	2·9	12·1	1·3	3·7	12·7	17·4	3·0	12·5	85·0
KSu-11	5	5·1	2·7	6·0	2·6	25·3	0·42	1·0	7·96	9·29	2·44	20·73	83·6
	6	3·8	2·4	10·2	3·6	21·6	1·1	1·9	7·91	11·73	3·3	21·6	89·1
	7	3·7	7·2	9·35	3·15	13·7	0·85	2·3	9·93	13·45	3·12	18·9	85·9
KSu-21	8	14·0	5·0	12·0	7·75	10·25	2·0	3·25	7·05	8·25	3·0	10·45	82·8
	8A	10·5	2·0	16·5	13·0	8·0	1·0	2·0	5·5	6·5	4·5	17·0	86·5
	9	4·9	4·4	12·25	6·1	23·0	0·66	2·0	5·38	8·25	2·33	17·2	86·4
	10	5·5	3·37	10·37	6·5	13·62	0·37	2·37	7·5	15·2	3·9	15·0	83·8
	11	6·5	2·25	12·25	9·0	19·5	0·75	6·25	6·55	8·7	1·0	10·75	83·5
	12	5·5	9·4	6·5	10·9	14·82	1·4	5·6	6·05	7·0	3·2	14·25	84·6
KSu-1	A-13	25·5	2·0	11·5	22·0	3·5	5·5	0·5	2·5	1·5	1·0	5·0	80·5
	B-13	7·0	3·5	18·5	14·0	5·0	1·5	3·5	4·5	3·0	3·0	18·0	81·5
	C-13	22·5	4·5	11·5	8·5	5·0	0·5	1·5	5·5	7·5	1·0	11·0	79·0
	13	4·87	3·4	11·1	11·0	15·6	1·1	2·0	5·87	11·35	3·1	15·65	85·1
	14	5·83	7·50	10·0	6·5	6·8	1·8	4·0	11·3	12·3	2·7	13·0	81·8
	14-A	9·5	9·5	15·0	6·5	7·5	1·5	2·0	6·5	8·0	1·5	16·5	83·0
	14-B	6·0	9·5	6·0	12·5	11·0	2·0	10·5	10·5	7·5	1·0	8·5	84·0
	14-C	8·5	7·0	9·5	11·5	6·0	3·0	4·5	6·0	9·0	1·5	12·0	78·5
	14-D	8·0	9·5	5·5	7·5	6·5	1·5	0·5	11·5	15·0	2·0	15·0	82·5
KG-29	15	6·5	2·0	16·5	4·5	14·0	1·5	3·0	9·8	9·3	1·5	12·4	81·0
KG-22	16	7·0	3·0	6·5	5·0	11·0	4·0	1·0	9·0	8·5	1·0	17·5	73·5
	17	17·0	3·5	9·0	5·0	6·5	5·0	1·0	10·9	9·3	3·5	10·3	81·0
	18	5·0	7·0	7·5	3·5	15·5	0·5	1·0	10·5	5·7	2·0	19·8	78·0
	19	12·0	2·0	7·0	10·5	7·5	4·0	2·0	11·0	5·5	0·5	16·0	80·0



GRAPH 1 — Quantitative variation exhibited by miospore genera forming the dominant association.

dominant percentage is 84·6 per cent. It decreases in the two subsequent younger seams (83·5, 83·8 per cent) and again increases in the next two seams (86·4, 86·5 per cent). Finally it declines in the top most seam (82·8 per cent).

Bore-hole KSu-1 (Sample Nos. 14B, 14-A, 14, 13, C-13, B-13, A-13) — In the lower most seam the T.D.P. is 84 per cent. It decreases in the two subsequent younger seams (83·0, 81·8 per cent) and again increases in the middle seam (Sample 13) to reach its maximum (85·1 per cent). Then it shows a sharp fall (79 per cent) to increase a bit in the upper two seams (81·5, 80·5 per cent).

Bore-hole KG-22 (Sample Nos. 19, 18, 17, 16) — In the lowermost seam T.D.P. is 80 per cent; it decreases (78 per cent) and again increases (81 per cent) in the two next successive seams. Finally it decreases in the top most seam (73·5 per cent).

Bore-hole KG-29 (Sample No. 15) — The total Dominant Percentage in the only seam of the bore-hole is 81 per cent.

This reveals that in the major seams of the bore-holes there is a general trend for T.D.P. to increase in the middle seams and to decrease again in the upper ones.

TABLE 3 – GROUPING OF THE SAMPLES ON THE BASIS OF TOTAL DOMINANT PERCENTAGE (T.D.P.)

	B.H.No.	Sample No.	T.D.P.
	KSu-24	1	75·7
	KSu-24	2	83·7
Upper Group	KSu-11	5	83·6
(Low-T.D.P.)	KSu-21	8	82·8
	KSu-1	A-13	80·5
	KSu-1	B-13	81·5
	KSu-1	C-13	79·0
	KSu-24	3	89·8
	KSu-11	6	89·1
Middle Group	KSu-21	8A	86·4
(High-T.D.P.)	KSu-21	9	86·5
	KSu-1	13	85·1
	KSu-24	4	85·0
	KSu-11	7	85·9
	KSu-21	10	83·8
Lower Group	KSu-21	11	83·5
(Low-T.D.P.)	KSu-21	12	84·6
	KSu-1	14	81·8
	KSu-1	14-A	83·0
	KSu-1	14-B	84·0
	KSu-1	14-C	78·5
	KSu-1	14-D	82·5

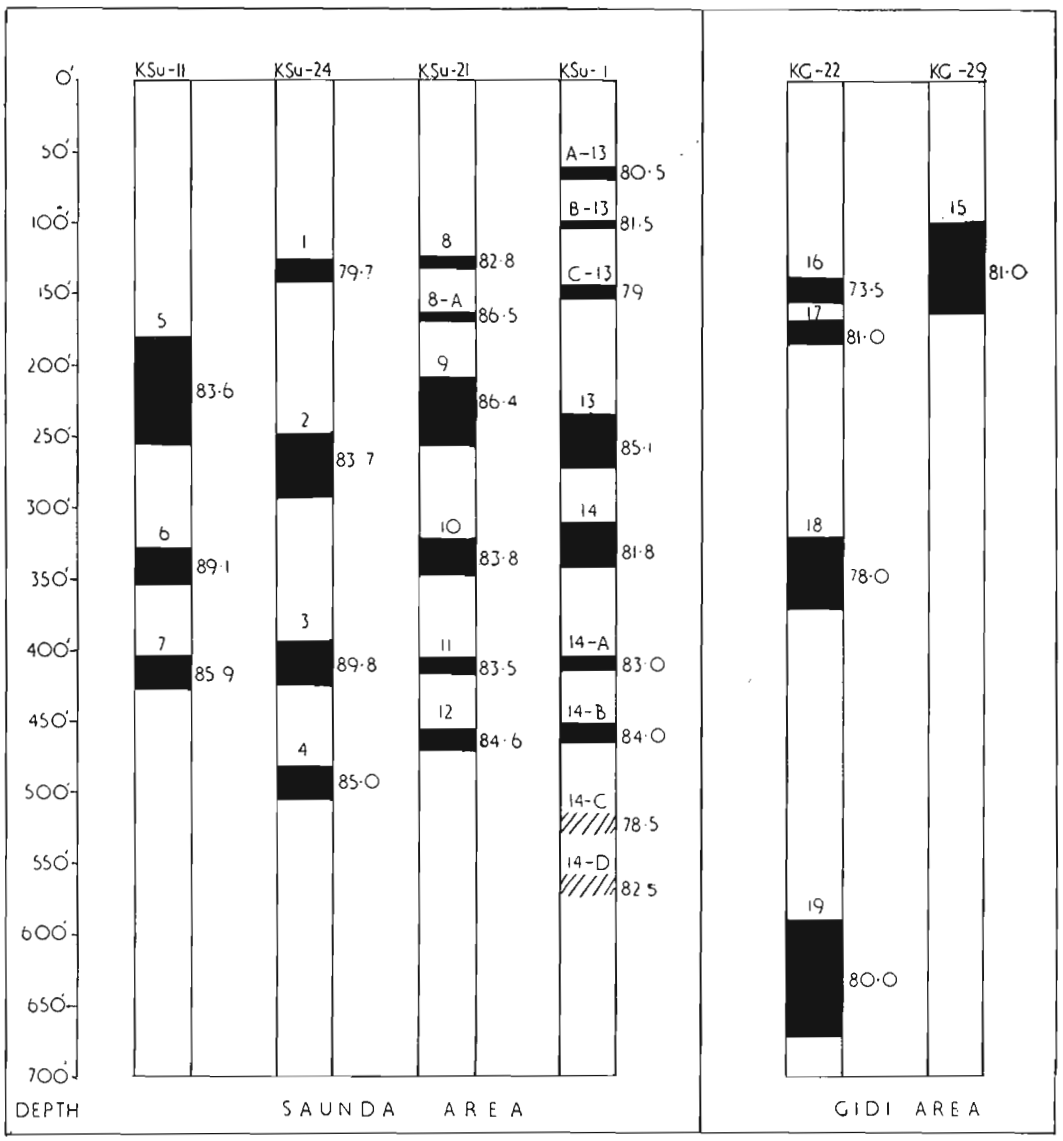
Correlation

Saunda Area — The vertical variation of T.D.P. as discussed above is given in Text-fig. 1. A look at this reveals that the major seams in the bore-holes can be divided into 3 groups on the basis of Total Dominant Percentage. Along with them the upper and the lower minor seams are also considered whose position will be ascertained later on, when the complete situation is analysed. Thus, the T.D.P. can be grouped into Lower, Middle and Upper groupes as given in Table 3.

Lower Group with Low T.D.P.— The seams of the lower groups show a first phase of low T.D.P. ranging from 78·5-85·9 per cent. As it is evident from Text-fig. 1, in every bore-hole there is a seam showing the maximum total dominant percentage and in the present group all the seams below this maximum point have been included. This has caused an apparent irregularity in the position of seams in the Upper, Middle and Lower groups given above (TABLE 3) — e.g. Sample No. 7 (T.D.P. 85·9 per cent) is included in the lower group with low T.D.P. while sample No. 13 having almost same T.D.P. (85·1 per cent) is included in the middle group of high T.D.P. What we have termed as ' an apparent irregularity ', is due to the fact that these two samples come from two different bore-holes in which the highest T.D.P. differ to a greater extent probably due to lateral miofloral variation. Thus, we see that in the bore-hole from which sample No. 7 comes, the highest T.D.P. is 89·1 and in the bore-hole of sample No. 13 the highest T.D.P. is 85·1 which is exhibited by the sample 13 itself. On this ground two samples showing similar T.D.P. have been separated in their grouping.

Thus, quantitatively the seams represented by the samples 7, 4, 10, 11, 12, 14, 14-A, 14-B, 14-C and 14-D form a coherent group.

Qualitative analysis, as depicted in the Histogram I, also suggests the homogeneous nature of these samples. Taking into account both qualitative as well as quantitative miospore analysis of these samples, it is apparent that sample 7 (B. H. KSu-11) is a correlative of sample 4 (B.H. KSu-24). These two samples are represented as samples 10, 11 and 12 in the bore-hole KSu-21 and as samples 14, 14-A, 14-B, 14-C and

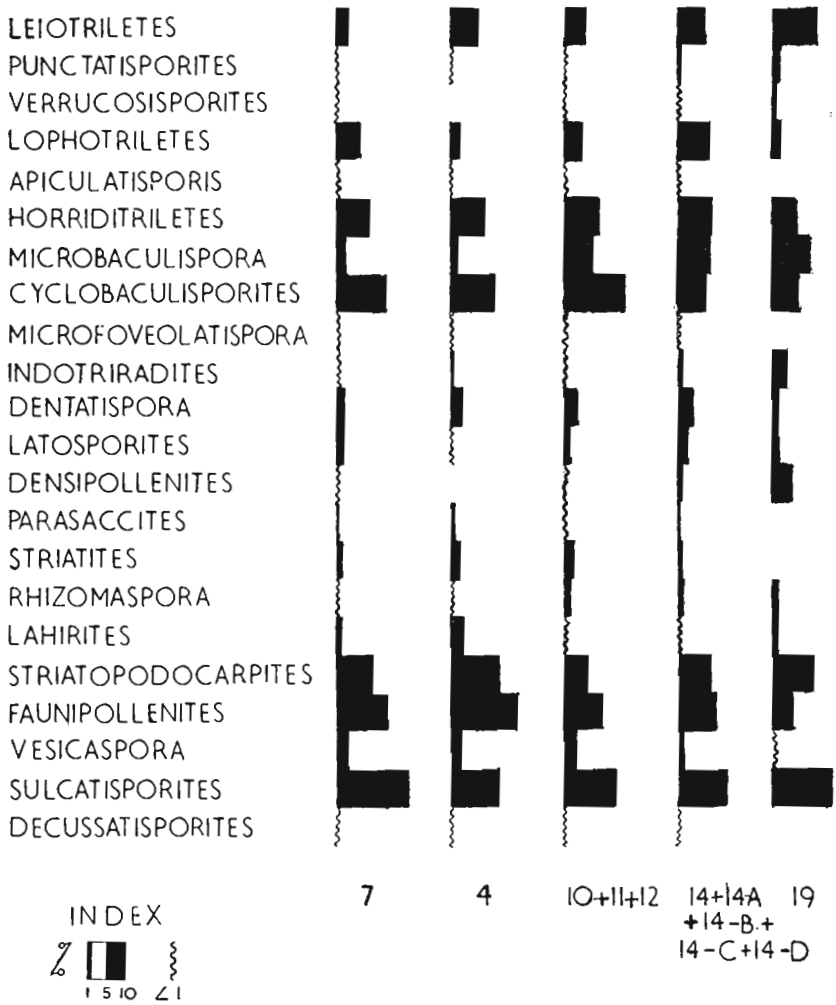


TEXT-FIG. 1 — Distribution of Total Dominant Percentage in various bore-hole samples from Saunda and Gidi areas.

14-D in B.H. KSu-1. Samples 10-12 and 14-14D are in succession in the bore-hole nos. KSu-21 and KSu-1 respectively, and they are closely comparable among themselves, both qualitatively as well as quantitatively. This reveals that they are the split of the same seam. Histogram II shows the combined percentage frequency of samples 10 to 12 and 14 to 14-D along with the samples 7 and 4. This composite histogram reveals the qualitative correspondence of these samples all the more.

Thus it is concluded that the samples 7, 4, 10+11+12, 14+14A+14B+14C+14D in various bore-holes of Saunda Area constitute the lower most seam.

Middle Group with High T.D.P.— The samples of this group (6, 3, 8A, 9 and 13) show the Total Dominant Percentage ranging from 85·1 to 89·9 per cent. The two



HISTOGRAM II — Composit histogram showing the percentage frequency of miospore genera in the samples of bottom Seam.

successive seams in this group are represented by samples 8A and 9 in the B.H. KSu-21, which show their T.D.P. as 86·5 and 86·4 per cent respectively, which strongly indicates their relationship.

Qualitatively as well, the samples 6, 3, 9 and 13 are quite comparable with each other as seen in the Histogram I. However, relatively the genus *Microbaculispora* is more, and *Cyclobaculisporites* is less represented in the sample 13. Other significant genera behave in a more or less constant manner in all the four samples. Sample 8-A, quantitatively comparable to sample 9, differs in the higher percentage of *Microbaculispora* and lower percentage of *Cyclobaculisporites* (HISTOGRAM I). But since the two samples in question are similar in their T.D.P., lie in succession in the same bore-hole and show a qualitative similarity to some extent, their palynological affiliations are evident. For this reason percentage frequency of the genera found in them, have been merged (HISTOGRAM III, 8-A+9) for the sake of comparison.

Upper Group with Low T.D.P.— The T.D.P. in this group range from 79·0 to 83·7 per cent. Thus quantitatively, the

samples of this group (1, 2, 5, 8, A-13, B-13, C-13) are fairly well coherent, but the qualitative histograms (HISTOGRAM I) indicate wide range of variation. This gives rise to a problem that on what basis the correlation of such samples should be determined? Because, in the basins — as is the present one — having a gradually changing miospore assemblages from older to younger depositions, delimitations of miofloral zones alone on the basis of qualitative or quantitative analysis of the few genera is quite difficult.

In the present case similar hurdle arises. In such cases we consider that both qualitative as well as quantitative values of the miofloral analysis should be taken into account. Both these values may not coincide at times, due to one reason or the other, but the conclusions should be drawn on the overall picture. Thus, in the present case a number of samples fall into a group termed as upper group of low Total Dominant Percentage, showing a coherent T.D.P. values but at the same time, it is not so when the percentage histograms are compared. The T.D.P. values have helped us to bring these samples together but the qualitative histogram patterns will ultimately decide their position.

Samples 5 and 2 are quite comparable with each other as well as with sample 8-A and C-13. But since the sample 8-A is quite comparable to the sample No. 9 (both fall in Middle group of high T.D.P.), it is presumed that the seam represented by sample 5, 2, 8-A and C-13 is palynologically affiliated with immediately older seam represented by sample 6, 3, 9 and 13 of the middle group of high T.D.P. Physically they are two separate seams but palynologically they are very much related to each other. A combined histogram of these two successive seams reveals (HISTOGRAM III) that most of the genera are comparable in their percentage frequency. However, genera *Microbaculispora* and *Leiotriletes* show an increasing trend in the combined samples 8-A+9 and C-13+13, while *Cyclobaculisporites* decreases considerably. In spite of these trends of variations the seams under discussion are quite comparable among themselves qualitatively as well quantitatively (in T.D.P.) and hence considered here as palynologically allied.

Now, the seams represented by sample 8 (B.H. KSu-21), A-13 and B-13 (B.H. KSu-1) show comparable T.D.P. (82·8, 80·5 and 81·5 per cent respectively). The latter two samples are in succession and hence they are supposed to represent the split of the same seam. Qualitatively as well, sample 8 and A-13+B-13 are very near to each other as shown in Histogram IV except that the genus *Microbaculispora* increases and *Leiotriletes* and *Cyclobaculisporites* decreases in the combined sample A-13+B-13 of bore-hole KSu-1. This trend of variation has already been noted in the case of combined samples C-13 and 13 belonging to the same bore-hole. Beside this, the percentage of the other remaining genera as well as the Total Dominant Percentage of these three samples under discussion are so affiliated with each other that their correlation can not be doubted.

The remaining sample of the Upper group with a Low T.D.P. (79·7) is sample No. 1. This is appreciably a low T.D.P. value even among the samples of Upper group showing low T.D.P. Moreover, qualitatively as well this sample stands apart and hence considered here as representing a local deposition.

Thus the preceding analysis suggests that in Saunda area there are 5 seams.

1. The Lower most Seam represented by

Sample	*Bore-hole No.*
7	KSu-11
4	KSu-24
10, 11, 12	KSu-21
14, 14-A, 14-B 14-C, 14-D	KSu-1

2. Second seam from the Bottom represented by

6	KSu-11
3	KSu-24
9	KSu-21
13	KSu-1

3. Third seam from the Bottom represented by

5	KSu-11
2	KSu-24
8-A	KSu-21
C-13	KSu-1

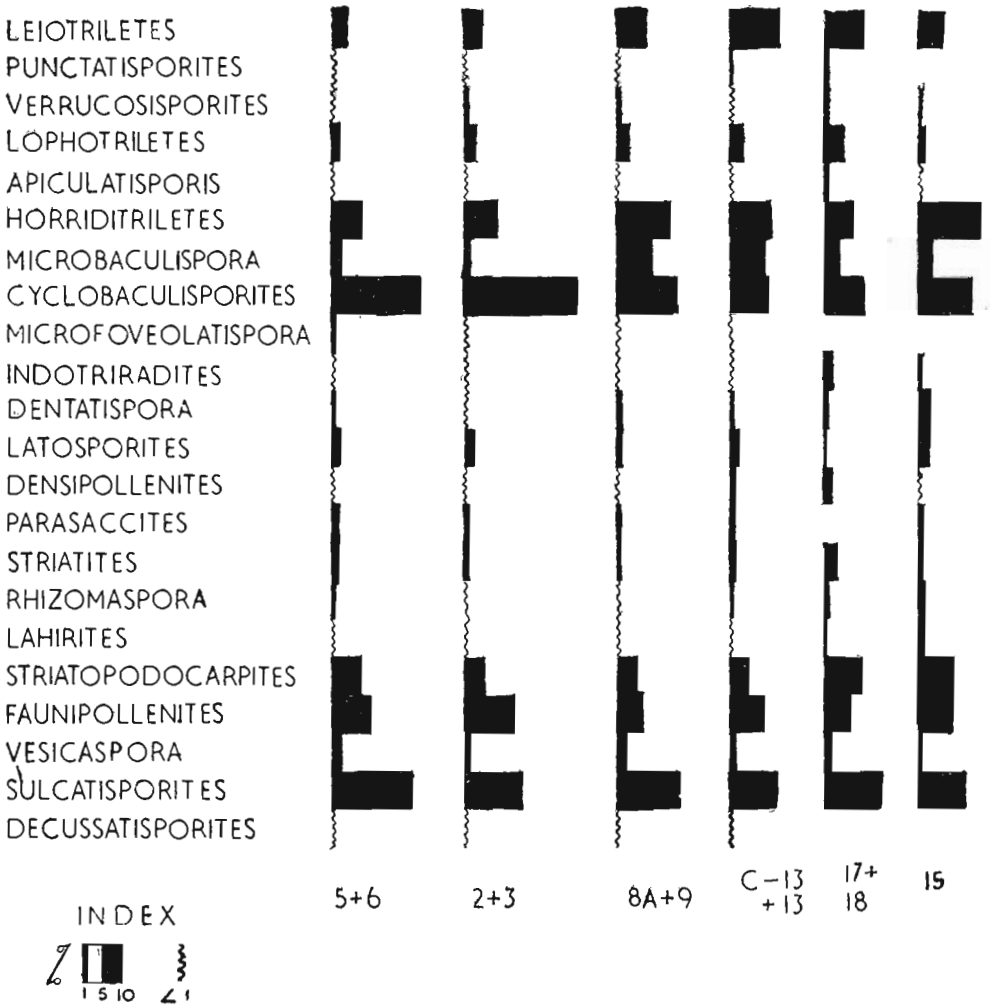
4. Fourth seam from the Bottom represented by

8	KSu-21
A-13, B-13	KSu-1

5. Upper most Seam represented by

1	KSu-24

Gidi area — There are two bore-holes KG-29 and KG-22. The samples of these



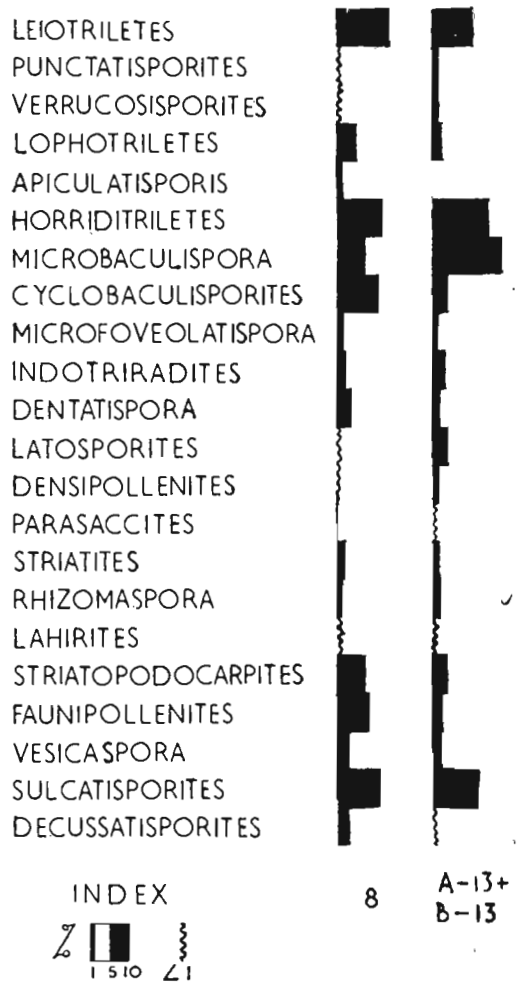
HISTOGRAM III — Composit histogram showing the percentage frequency of miospore genera in various samples of middle seam.

bore-holes (15-19) show a wide range of T.D.P. from 73·5-81 per cent. Moreover, the T.D.P. as shown in Text-fig. 1, do not seggregate into groups as regularly as is the case in Saunda area. Therefore, a qualitative comparison is given primary importance in this case. On comparison of histograms of these samples (HISTOGRAM I) it becomes quite evident that palynologically, sample 15 (B.H. KG-29) comes very near to the sample 18 B.H. KG-22). So also, sample 17 and 18 are quite comparable with each other. Since the latter two samples are in succession in the same bore-holes, they are supposed to be indicative of only one seam. Remaining samples (16,19) stand apart as evident from the Histogram I.

Thus, it can be concluded that in Gidi area there are following seams.

1. *Bottom Seam* — Represented by sample 19 in bore-hole KG-22.
2. *Second from the bottom* — Represented by samples 17 and 18 in bore-hole KG-22 and 15 in bore-hole KG-29.
3. *Top most seam* — Represented by sample 16 in bore-hole KG-22.

Inter Area Correlation — Histogram II shows the qualitative and quantitative



HISTOGRAM IV — Composit histogram showing the percentage frequency of miospore genera in the samples of top seam.

composition of the lower most seam in Saunda area, in all the bore-holes. In bore-hole KSu-1 samples 14-14D represent this seam. When compared with this seam, the histogram of sample 19, bore-hole KG-22 (Gidi area) reveals a palynological similarity to a great extent (HISTOGRAM II). The prominance of *Leiotriletes, Microbaculispora, Striatopodocarpites* and *Sulcatisporites* prevails in the sample 19, very much similar to combined samples 14-14D, and 10-12. However, samples 7 and 4 are more close to each other than to the remaining three samples (i.e. 19, 14-14D, 10-12) in the lesser percentage of *Microbaculispora* and a little higher percentage of *Striatopodocarpites* and *Sulcatisporites*, but, as discussed earlier, this seems to be a trend of variation during the lateral extention of the seam as is clear by its very coherent T.D.P. values. In the light of these observations the qualitative affiliation of these samples constituting the lower most seam in Saunda area (Samples — 7, 4, 10-12, 14-14D) and Gidi area (Sample 19) in spite of some trend of variation is quite understandable (HISTOGRAM II).

Coming to the position of the seam represented by sample 15 (Gidi area), we see that in the Total Dominant Percentage, it comes very near to the samples 17 and 19 in bore-hole KG-22; but on the other hand qualitative histograms suggest its closest alliance with the sample No. 18. The histograms of these two samples (HISTOGRAM III) are so closely comparable that their palynological relationship cannot be doubted.

Sample 16 (Gidi area) stands apart from all the other samples in having a very low T.D.P. value (73·5 per cent). Samples 17 and 18 (Gidi area) are the successive samples of bore-hole KG-22 and are quite comparable in their T.D.P. values (81 and 78 per cent respectively), as well as they exhibit a close relationship in the general pattern of the qualitative histogram (HISTOGRAM I). Their composite miospore frequency, when compared with the miospore frequency in the seams of Saunda area, shows greater relationship with the seam 2nd and 3rd from below. And as stated above it is also comparable to the sample 15 of Gidi area. In Histogram III, the combined percentage frequency of samples 5+6, 2+3, 8A-9, C13+13, 17+18 and 15 are given. The patterns exhibited by the latter four samples are very much uniform than the former two. This is a complete picture of the trend met with in these seams. Genera *Leiotriletes, Horriditriletes* and *Microbaculispora* increase and *Cyclobaculisporites* decreases in the last 4 samples. Inspite of this all the samples under discussion stand apaprt from other samples and are qualitatively and/or quantitatively affiliated with each other.

The inter area correlation is suggested as give below:

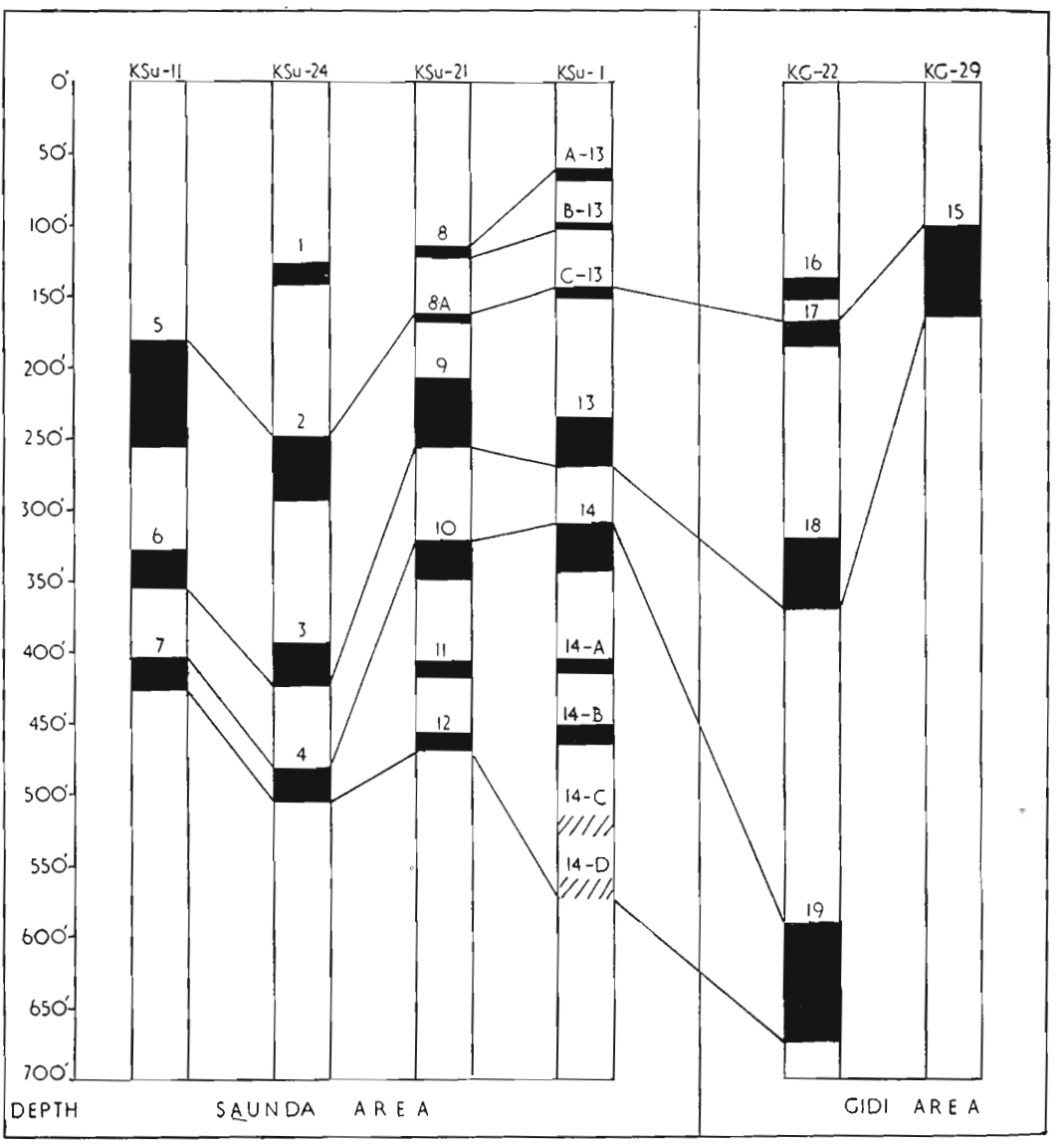
1. *Bottom Seam*: Represented by samples 7 (B.H. KSu-11), 4 (B.H. KSu-24), 10+11+

12 (B.H. KSu-21), 14-14D (KSu-1) in Saunda area and sample 19 (B.H. KG-22) in Gidi area.

2. *Seam II from the bottom*: Represented by samples 6 (KSu-11), 3 (KSu-24), 9 (KSu-21), 13 (KSu-1) from Saunda area and samples 18 (KG-22), and 15 bottom (KG-29) from Gidi area.

3. *Seam III from the bottom*: Represented by sample 5 (KSu-11), 2 (KSu-24), 8-A (KSu-21), C-13 (KSu-1) from Saunda area and sample 17 (KG-22) and 15-top (KG-29) from Gidi area.

4. *Seam IV from the bottom*: Represented by Sample 8 (KSu-21), A-13+B-13 (KSu-1) of Saunda area.



TEXT-FIG. 2 — Representation of the sporological correlation of coal seams in Saunda and Gidi areas.

5. *Solitary sample A*: Represented by sample 1 (KSu-24) in Saunda area.

6. *Solitary sample B*: Represented by sample 16 (KG-22) in Gidi area.

Further Considerations — The conclusions so far arrived at, are based upon the qualitative and quantitative values of various miospore genera, separately as well as totally. Some points of interest still remain to be analysed and explained. We see that sample 1 (Bore-hole KSu-24) stands apart having a low T.D.P. in the upper group of Saunda area. Qualitatively also, it does not show a greater resemblance with the other samples of low T.D.P. in general. The relatively high percentage frequency of *Lophotriletes*, *Horriditriletes*, and *Faunipollenites* and low percentage frequency of *Cyclobaculisporites* keep this sample apart from other samples, members of low T.D.P. Group (HISTOGRAM I).

Similarly, the solitary sample 16 in Gidi area does not find its correlative seam. Apparently sample 1 of Saunda area and sample 16 of Gidi area are affiliated with each other by virtue of their low T.D.P. (79·7 and 73·5 per cent respectively). But this situation is not really so when their histograms are compared (HISTOGRAM I). Sample 16 differs from sample 1 in having lesser percentage of *Lophotriletes*, *Horriditriletes* and *Faunipollenites* and higher percentage frequency of *Sulcatisporites*. Apart from this the most important point for their being palynologically unrelated is the presence of certain genera such as *Indotriradites*, *Dentatispora*, and *Latosporites* in sample 16 in fairly high percentages, but only in traces in sample 1. Thus, it becomes quite evident that samples 1 and 16 represent a single seam each and are of local importance.

It has been discussed in detail that the second seam from below (Samples 6, 3, 9, 13, 15, 18) and the third seam from below (Samples 5, 2, 8-A, C-13, 17) are palynologically very much allied when the qualitative and quantitative values of miospore assemblage are taken in to account. This relationship gets more strength when we see that the successive samples in individual bore-holes are either comparable by virtue of their T.D.P. values or qualitative patterns. Thus in all the bore-holes under study (except one) these two seams are in succession. In the exceptional bore-hole (KG-29), the solitary sample 15 represents the second seam from below (i.e. samples 6, 3, 9, 13, 18, 15). But we have already seen that sample 18 shows affiliation with sample 17 (its successive younger seam, i.e. seam III from bottom) on one hand and with sample 15 on the other and thus a probability that sample 15 represents the union of two seams represented by sample 17 and 18 can not be ruled out. This probability becomes all the more a belief in view of the facts that along the whole lateral extent, the respective samples from each bore-hole representing these two seams resemble each other palynologically. The similar T.D.P. of samples 8-A and 9, and the qualitative relationships between samples 5 and 6, 2 and 3, C-13 and 13, and 17 and 18 suggested that these two seams are parts of one and the same seam palynologically, which is evident in sample 15.

Bottom seam (represented by samples 7, 4, 10-12, 14-14D and 19) is a more compact unit qualitatively as well as quantitatively. This seam splits in to 3 seams in bore-hole KSu-21 and in to 5 seams in bore-hole KSu-1. The minor lower splits in bore-hole KSu-1 can as well be of local importance only, but palynologically it is not possible to separate them away from the bottom seam.

CONCLUSION

In the preceding account the qualitative as well as quantitative values of miospore assemblage found in the various seams of Saunda area and Gidi area of South Karanpura Coalfield, have been analysed and used in establishing the correlation. The results are shown in Text-fig. 2. In brief, there are the following seams in both the areas:

1. *Bottom Seam*

Sample	*Bore-hole*
7	KSu-11
4	KSu-24
10, 11, 12	KSu-21
14, 14A, 14B, 14C, 14D	KSu-1
19	KG-22

2. *Middle Seam* (in the preceding discussion, seams termed as II from bottom and III from bottom)

5, 6	KSu-11
2, 3	KSu-24
8A, 9	KSu-21
C-13, 13	KSu-1
17, 18	KG-22
15	KG-29

3. *Top Seam*

8	KSu-21
A-13, B-13	KSu-1

4. *'Local Seam' A, Top*

1	KSu-24

5. *'Local Seam' B, Top*

16	KG-22

The application of palynology in correlation of coal seems, is relatively a recent approach. Very little work has been done on these lines on the Lower Gondwana coal basins. Some workers (GHOSH & SEN 1948, SEN 1953, SURANGE, SRIVASTAVA & SINGH 1953) have suggested the correlation of coal seams on the basis of palynology but no principles could be derived from these works. Extensive and intensive studies carried out by us and our colleagues (BHARADWAJ, 1962, BHARADWAJ & SALUJHA, 1965, BHARADWAJ & TIWARI, 1964, 1966) in this direction, during the last ten years, have provided us with valuable experiences and very encouraging results. We (BHARADWAJ & TIWARI, 1964) suggested the correlation of coal seams in Ghordewa, Korba and Rajgamar Sectors of the Korba Coalfield, Madhya Pradesh. In this basin the whole mioflora falls into five distinct assemblages which can easily be distinguished from each other suggesting thereof that the floristic change from one phase of deposition to another was substantial and the percentage frequency of various miospore genera alone was enough to define the nature of each individual assemblage representing one phase of deposition.

In later work of ours (BHARADWAJ & TIWARI, 1966), the histogram patterns alone could not suggest the separation or probable palynological affiliations of the bore-hole samples. To overcome this difficulty, the genera forming the dominant association were sorted out and the Total Dominant Percentage (T.D.P.) was calculated in each sample. This could give us more balanced and logical results and thus a new principle for palynological correlation was derived.

In the present work we faced a still greater difficulty. The samples show neither qualitative nor quantitative harmony on which the results could be based. But when both qualitative as well as quantitative values of mioflora were analysed, and employed in determining the position of individual bore-hole samples, we could arrive at a plausible picture. This indicated yet another approach in palynological correlation of coalseams.

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