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Palynology of Kamthi Formation from Ramagundam-Mantheni Area, Godavari Graben, Andhra Pradesh, India

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Palynological study of the Kamthi Formation from the Ramagundam-Mantheni area of Godavari Graben reveals that the palynoflora of Kamthi Formation is uniformly dominated by striate-disaccate (about 50%) and the subdominant groups differ. Thus Lower Member of the Kamthi Formation is characterised by the subdominance of nonstriate-disaccates while Middle Member is characterised by the subdominance of *Striasulcites* in the older part and *Densipollenites* in the younger part. The palynoflora is by and large comparable with the Raniganj palynoflora of Damodar Valley except a few differences. The palynoflora in the upper part of the cored Middle Member of Kamthi Formation exhibits close proximity towards Permian-Triassic (Panchet) transition. Obviously, only the Lower and partly Middle members of the Kamthi Formation are homotaxial with Raniganj Formation of Damodar Basin.

Key-words—Palynology, Striate-disaccates, Kamthi Formation, Godavari Graben (India).

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सारांश

आँध्र प्रदेश (भारत) में गोदावरी द्रोणिका के रामागुँडम्-मन्थेनी क्षेत्र से कामथी शैल-समूह का परागाणविक अध्ययन

दिनेश चन्द्र भारद्वाज, सुरेश चन्द्र श्रीवास्तव, बी वी रमनमूर्ति एवं नीरजा झा

गोदावरी द्रोणिका के रामागुँडम्-मन्थेनी क्षेत्र से कामथी शैल-समूह के परागाणविक अध्ययन से व्यक्त होता है कि कामथी शैल-समूह का परागाणुवनस्पतिजात रेखीय-द्विकोष्ठीय परागकणों (लगभग 50 प्रतिशत) से समान रूप से प्रभावी है तथा उपप्रभावी समूह भिन्नता प्रदर्शित करते हैं। अतएव कामथी शैल-समूह का अधरि सदस्य अरेखीय-द्विकोष्ठीयों के उपप्रभाव से लक्षणित है जबकि बीच का सदस्य पुराने भाग में स्ट्रिआसल्काइटिस तथा अल्पायु वाले भाग में डेन्सीपोलिनाइटिस के उपप्रभाव से अभिलक्षणित है। कुछ विभेदों को छोड़कर परागाणुवनस्पतिजात रानीगंज परागाणुवनस्पतिजात से बहुत कुछ तुलनीय है। कामथी शैल-समूह के मध्य-क्रोड़ सदस्य के ऊपरी भाग का परागाणुवनस्पतिजात परमी-त्रिसंधी (पचेत) परिवर्तन की ओर घनिष्ठ निकटता इंगित करता है। वस्तुतः कामथी शैल-समूह के केवल अधरि तथा आँशिक रूप से मध्य सदस्य तथा दामोदर द्रोणिका के रानीगंज शैल-समूह समकालक्रमी हैं।

LOWER Gondwana sediments representing Talchir, Barakar, Barren Measures and Kamthi formations are well developed in Godavari Graben (16° 38′ & 19° 32′; Longitude 79° 12′ & 81° 39′; Map 1). Amongst these the, Kamthi Formation has the maximum thickness. The rocks of Kamthi Formation are exposed extensively in Wardha-Godavari Valley in Maharashtra and Andhra Pradesh. However, the name Kamthi was given by Blanford, W. T. (1868) to these distinctive rocks after the erstwhile military station of Kamthi (20°10′ : 79°15′) close to Nagpur. The entire Gondwana sediments in Godavari Valley overlying the Barakar Formation and underlying the Maleri Formation were previously included within the Kamthi Formation by King (1881). But Sengupta (1970) for the first time identified Iron Stone Shale in Bheemaram area. Recently, Ramanamurty (1979) has reported the occurrence of 400 m thick sediments as Barren Measures Formation in Ramagundam area on the basis of lithological characteristics. Hence, the rocks overlying the Barren Measures Formation and underlying the Maleri

Formation are referred to here as Kamthi Formation.

The palynoflora of the Kamthi Formation has been hitherto unknown except a brief mention of few genera of pteridophytic spores and disaccate pollen by Ramanamurty (1979). Recently, occurrence of megaspores in the Kamthi Formation has been reported by Jha and Srivastava (1984) from Ramagundam-Mantheni and Chelpur areas of Godavari Graben. In the present paper the palynostratigraphy of the Kamthi Formation has been given in detail.

GEOLOGY

The oldest rocks in the area are the Archeans which are overlain by unfossiliferous Pakhal Limestone and shales and Sullavai Sandstone. Based on subsurface data, the stratigraphy and lithology of Lower Gondwana sediments of Ramagundam area (Ramanamurty, 1979) are as follows:

FORMATION	LITHOLOGY
Kamthi	Predominantly fine to medium-grained sandstone with subordinate shales and few shaly coal seams.
	Gradational Contact
Barren Measures	Predominantly medium to coarse-grained, greenish grey and greyish white felspathic sandstones with subordinate shales and clays.
	Gradational Contact
Barakar	Predominantly medium to gritty greyish white sandstones with shales and well developed coal seams
	Gradational contact
Talchir	Fine-grained greenish to greenish grey sand and siltstones and clays with few pebble beds

Lithology of Kamthi Formation

In the type area the rocks of Kamthi Formation consist of conglomerates of pebbles, grits, sandstone and shales. A typical member of the group is the fine, massive and homogeneous mudstone, yellow when fresh but becoming red on exposure. This member passes into red shales. Kamthi Formation of Godavari Graben (Map 2) has been subdivided into three units (Sengupta, 1970). The Lower Member consists of greyish white, calcareous sandstone and a few coal seams (Ramanamurty, 1979). The Middle Member consists of alternating sequence of medium grained grey-white sandstone and shale/variegated clays. The sandstone and shales exhibit a greenish tint at places. This member is remarkably devoid of any coaly horizon. The shales are characterised by nodules and concretions of calcareous material. The Upper Member comprises coarse-grained sandstone with bands of ferruginous sandstone and brick red bands of pebbles or conglomerate and have innumerable clasts of white, violet and yellow shales as well. Hard and compact violet claystone is associated with this member. The Kamthi Formation is succeeded by Upper Gondwana sediments progressively represented by the Maleri, Kota and Chikiala beds consisting of sandstones, intercalations of red and white clays, fine-grained grey sandstones and thin limestone beds.

Chikiala beds
Kota Formation
Maleri Formation

Kamthi Formation	Upper	Coarse-grained sandstone with bands of ferruginous sandstone and brick red siltstone
	Middle	Alternation of medium-grained grey white sandstone and shale, variegated clay, devoid of coal. Sandstone exhibit greenish tint at places
	Lower	Medium-grained greyish white calcareous sandstone and few coal seams

Barren Measures Formation Gradational contact.

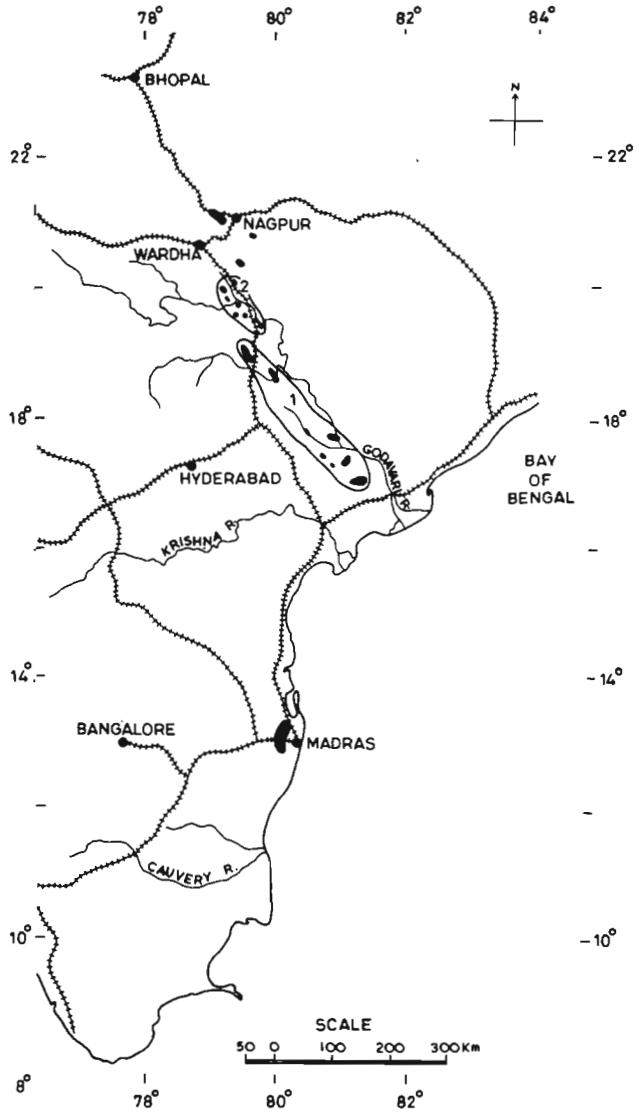
MATERIAL AND METHOD

The material has been obtained from bore-hole GGK-20 and GGK-27 in Ramagundam-Mantheni area of Godavari Graben. About 40 samples from these bore-holes representing Lower and Middle members of the Kamthi Formation were macerated. The samples containing silica were first treated with hydrochloric acid and hydrofluoric acid followed by nitric acid and KOH, if necessary. The samples have yielded a rich palynoflora. The details of the samples have been given in Tables 1 and 2. Location of the bore-holes has been shown in Map 2.

OBSERVATIONS

The sediments of Kamthi Formation have been studied from the subsurface of Ramagundam area where it attains maximum thickness in Godavari Graben. The sporae dispersae have been assigned to following 53 genera :

Laevigate trilete—*Callumispora.*
Apiculate trilete—*Lophotriletes, Horriditriletes, Osmundacidites, Verrucosisporites, Microbaculispora, Brevitriletes.*
Cingulate/Zonate trilete—*Gondisporites, Lundbladispora*
Monolete—*Laevigatosporites, Polypodiidites*
Alete monosaccate—*Densipollenites*
Radial monosaccate—*Parasaccites, Virkkipollenites,*



Map 1—Location map of Pranhita-Godavari Valley coalfields.

Cabeniasaccites, Potonieisporites, Striomonosaccites

Nonstriate-disaccate—*Platysaccus, Alisporites, Vitreisporites, Falcisporites, Vesicaspora, Paravesicaspora, Aurangapollenites, Ibisporites, Scheuringipollenites, Cuneatisporites*

Reticuloid disaccate—*Primuspollenites, Schizopollis*

Striate-disaccate—*Striatites, Circumstriatites, Lahirites, Faunipollenites, Striatopodocarpites, Crescentipollenites, Verticipollenites, Hindipollenites, Distriatites, Strotersporites*

Taeniate disaccate—*Lunatisporites, Corisaccites, Guttulapollenites, Hamiapollenites*

Colpate—*Weylandites, Striasulcites, Marsupipollenites, Praecolpatites, Pretricolpipollenites, Distriamonocolpites*

Alete—*Leiosphaeridia, Pilasporites, Inaperturopollenites, Singraulipollenites*

The qualitative and quantitative distribution of various palynotaxa have been evaluated and it has been found that *Densipollenites, Faunipollenites, Striatopodocarpites, Striasulcites, Scheuringipollenites, Alisporites, Falcisporites* and *Vesicaspora* show characteristic variation at various levels of the Kamthi Formation.

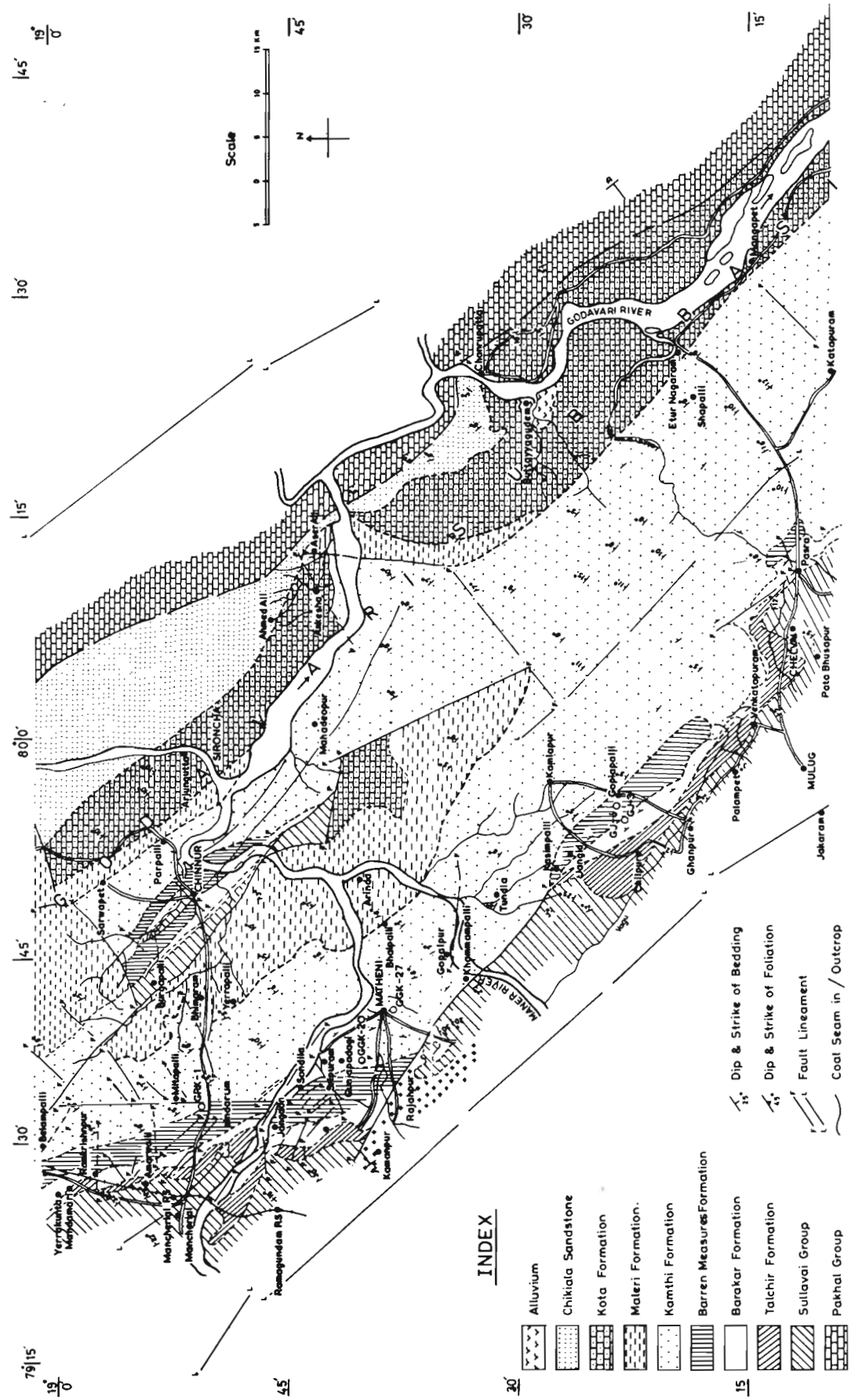
The trend of occurrence of palynofossils in two bore-holes studied has been given below. Out of the two bore-holes, GGK-27 has yielded more diversified palynoflora and has been described first.

Bore-hole no. GGK-27, Ramagundam-Mantheni Area (Map 1, sample nos. 32-1, depth 841-54.0 m, Histogram 1)—This bore-hole was drilled near Mantheni Village south-east of Ramagundam Railway Station. It has penetrated through the Middle and Lower members of the Kamthi Formation and was closed at 851.15 m.

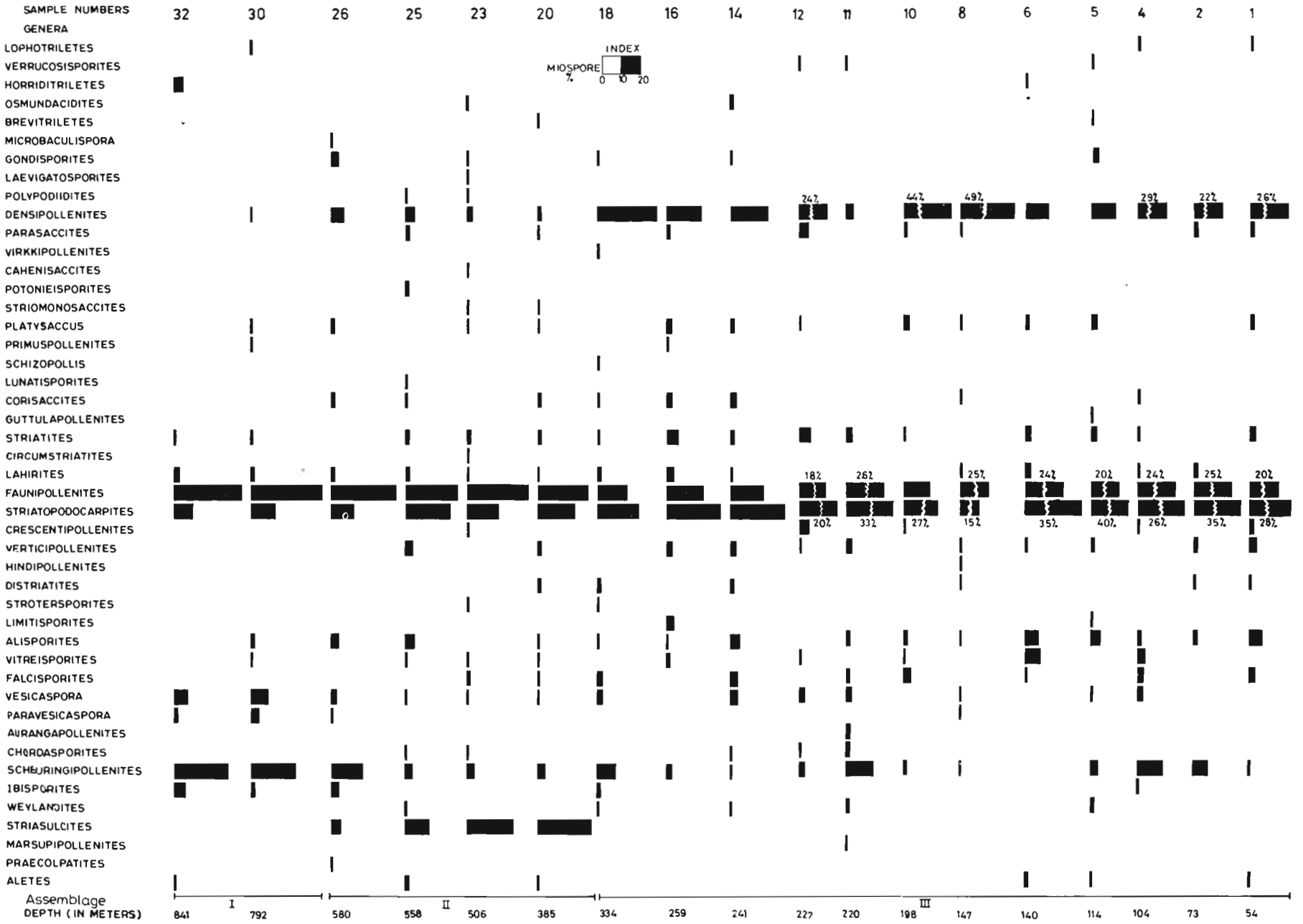
The Lower Member is coal-bearing containing the workable Sondila coal seam. Quantitatively, the older sediments (sample nos. 32, 30) are characterised by the abundance of striate-disaccates, chiefly *Faunipollenites* (36 to 38%). Nonstriate-disaccate *Scheuringipollenites* (24 to 29%) occurs next in order of dominance. *Striatopodocarpites* (10 to 13%) ranks next to the above and is followed by *Vesicaspora* (9-14%). Other disaccates represented are *Striatites* (1%), *Lahirites* (2-3%), *Vitreisporites* (1%), *Platysaccus* (1%) and *Primuspollenites* (1%). Triletes are quite low in percentage and are represented by *Horriditriletes* and *Lophotriletes*.

In comparatively younger sediments (sample nos. 26 to 1) representing the Middle Member of the Kamthi Formation, the overall dominance of striate-disaccates is maintained. *Striatopodocarpites* increases in the younger sequence and ultimately increases over *Faunipollenites*. *Scheuringipollenites* which was associated subdominantly in the Lower Member of the Kamthi Formation is reduced considerably in these sediments. *Striasulcites* on the other hand appears for the first time in sample no. 26 (5%) and increases to its maximum (29%) in sample no. 20 to represent the subdominant taxon next to *Faunipollenites*. In further younger samples *Striasulcites* disappears.

Densipollenites, already having made its appearance in sample no. 30, attains dominance in sample no. 18. The epibole of this genus with its maximum percentage (44-49%) lies in sample nos. 10 (198 m) and 8 (148 m). Though it shows a decline in younger sediments, still maintains subdominance. *Faunipollenites* on the other hand records a decline from sample no. 18 giving way to *Striatopodocarpites* which overrides ultimately in younger samples. The percentage frequencies of *Alisporites, Vitreisporites, Falcisporites, Vesicaspora, Paravesicaspora, Chordasporites, Gondisporites,*



Map 2—Geological map of Pranhita-Godavari Valley coalfields showing location of bore-holes GGK-20 and GGK-27.



Histogram 1—Showing percentage frequency of miospores genera in bore-hole GGK-27.

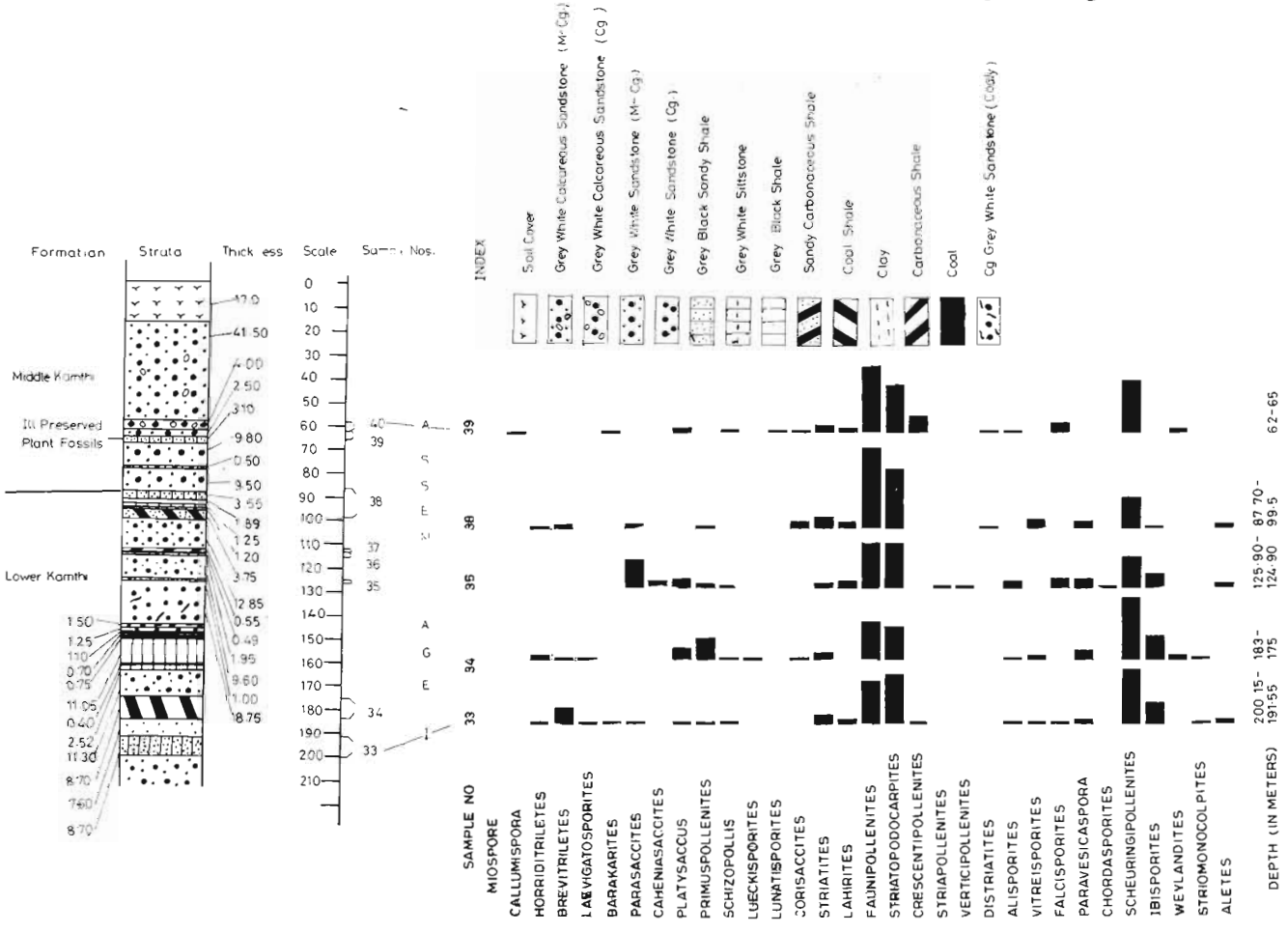
Polypodiidites, Osmundacidites, Crescentipollenites, Verticipollenites, Hindipollenites, Lunatisporites, Corisaccites and *Guttulapollenites* are quite low but these are persistent in occurrence, hence, significant. In general, the triletes are low in percentage.

Bore hole GGK-20, Ramagundam Area (Map 1, sample Nos. 33-40, depth 191-55-58.50 m, Histogram 2)—It was drilled north-west of the bore-hole GGK-27. This bore-hole also traversed the Lower and Middle members of the Kamthi Formation up to approximately 200 m. Further below, the sediments represent the Barren Measures Formation. In this sequence the sediments, appertaining lithologically to the Middle Member of the Kamthi Formation, show the continuation of Lower Kamthi palynoflora. Sample nos. 33 to 39 have yielded a palynoflora dominated by striate-disaccates. *Faunipollenites* (16-34%) and *Striatopodocarpites* (14-25%) together maintain the overall dominance although *Scheuringipollenites* records a higher percentage in sample nos. 33 and 34. *Primuspollenites* is present up to 9 per cent in sample no. 9 only and similarly *Parasaccites* is present up to 12 per cent in sample no. 35. Other notable genera, rare but persistent in occurrence, are *Lunatisporites* (0-1%), *Corisaccites* (1-3%), *Vitreisporites* (1-4%), *Falcisporites* (1-4%), *Crescentipollenites* (1-7%), *Chordasporites* (0-1%) and *Alisporites* (1-3%). Triletes are poorly represented.

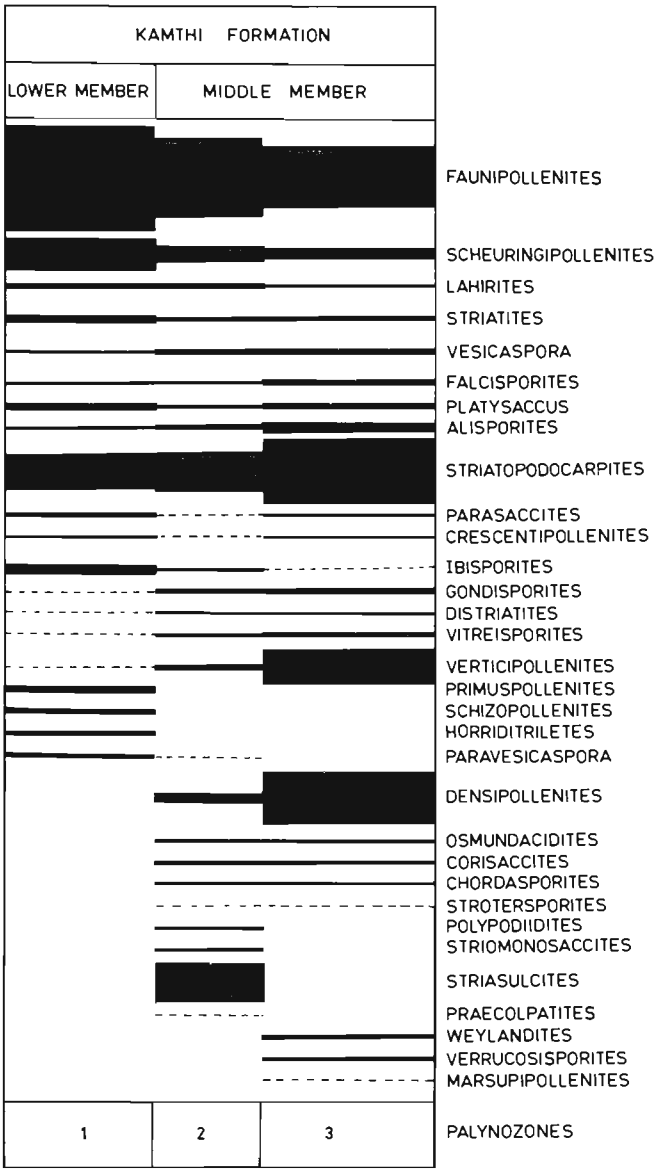
PALYNOASSEMBLAGES

The quantitative and qualitative distribution of palynotaxa as discussed here shows that the palynological succession within the Kamthi Formation has undergone two changes, one between the Lower and Middle Members and the other within the Middle Member. In this way the palynoflora is divisible into the following three assemblages (Text-fig. 1).

Assemblage I—It is characterised by the dominance of striate-disaccates chiefly *Faunipollenites* and *Striatopodocarpites; Scheuringipollenites* remains as subdominant element. *Densipollenites* is very low or virtually absent in this assemblage. An important feature of the assemblage is appearance of elements like *Alisporites, Falcisporites, Vitreisporites, Lunatisporites, Corisaccites, Chordasporites* and *Crescentipollenites.* These elements are rare but ± persistently present throughout the assemblage. Triletes are quite low in percentage.



Histogram 2—Showing percentage frequency of miospore genera in bore-hole GGK-20.



Text-figure 1—Showing average distribution of various taxa in Kamthi Formation, Ramagundam area, Godavari Graben.

In bore-core of hole GGK-27, Assemblage I has been encountered in samples 32 and 30 from the levels of 841 m and 792 m respectively. According to the stipulation of one of us (Ramanamurthy) Lower Member of the Kamthi Formation starts unlikely (or ends) at 776.70 m. In the bore-core of the hole GGK-20 the youngest productive sample containing Assemblage I comes from 62.00-65.00 m level out of a dark greenish grey, medium to coarse grained argillaceous sandstone and the oldest from 200.15 m level. This sequence of strata as well as about 50 m of micaceous and calcareous sandstone topping may be considered as the zone of Assemblage I. However, this does not conform with the lithological separation of top 87.97 m strata as Middle Member of the Kamthi Formation.

Assemblage II—This is also characterised by the dominance of striate-disaccates among which *Faunipollenites* is more than *Striatopodocarpites*. *Scheuringipollenites* being subdominant in the beginning loses place to *Striasulcites* which is restricted to this zone only. Although *Densipollenites* also appears simultaneously in this assemblage, it remains low in percentage. *Falcisporites, Vesicaspora, Paravesicaspora, Vitreisporites, Chordasporites, Gondisporites, Polypodiidites, Osmundacidites, Crescentipollenites, Verticipollenites* and *Lunatisporites* though low in percentage, are persistent in occurrence and hence significant. Triletes are low in percentage. Important feature of this assemblage is the presence of *Striasulcites* in high percentage and *Densipollenites* in low percentage.

In the hole GGK-27, the oldest evidence of Assemblage II is found at 580 m level; the three samples (29-27) from the underlying strata up to 776.60 m do not yield any palynoflora. The youngest occurrence of this assemblage is known from 385 m level. With the oldest occurrence of Assemblage III recorded from sample no. 18 at 334 m the upper limit of Assemblage II should lie between 385 and 334 m levels. At 366.70 m level there is a lithological change (Histogram 1) which could as well be the level of assemblage change.

Assemblage III—In this assemblage the general dominance of striate-disaccates remains unaltered but *Striatopodocarpites* mostly exceeds *Faunipollenites* presumably at the cost of the latter. *Densipollenites* increases to overall subdominance which is collated with the total exit of *Striasulcites*. Genera like *Alisporites, Vitreisporites, Falcisporites, Vesicaspora, Paravesicaspora, Chordasporites, Verticipollenites, Lunatisporites, Guttulapollenites* and *Hindipollenites* increase only slightly. These pollen grains are low in percentage but are persistent in occurrence. Trilete spores are also low in occurrence.

Assemblage III is observed in whole of the sequence overlying 366.70 m and up to 54 m depth from the surface. There is no lithological uniqueness in 43 m thick overlying strata. Hence, presumably the Assemblage Zone III continues right up to the surface soil cover.

COMPARISON

Assemblage I compares very well with the palynoflora of Jhingurdah Seam in Singrauli Coalfield (Tiwari & Srivastava, 1984) both having younger elements like *Falcisporites, Gondisporites, Lunatisporites* and *Corisaccites* besides dominant striate-disaccates and subdominant nonstriate-disaccates (excluding percentages of cryptogamic

Table 1—Showing details of samples, limits and characters of assemblages and biozones in bore hole GGK-27 (*Sample numbers with asterisk denotes yielding samples which could be counted).

Sample	Depth	Lithology	Lithological succession		Assem-blage	Characteristic forms	Remark	Biozones
1*	54	Green sandstone						
2*	73	Carb. shale						
3*	85	Carb. shale						
4*	104	Carb. Shale						
5*	114	Carb. shale						
6*	140	Carb. shale			III	*Striatopodocarpites, Faunipollenites, Densipollenites* (high), rare forms like *Alisporites, Falcisporites, Lunatisporites Chordasporites Guttulapollenites* etc.	*Densipollenites* Phase	Upper part of Middle Member
7	147	Greenish siltstone						
8*	156	Carb. shale						
9	188	Carb. shale						
10*	198	Carb. shale						
11*	220	Grey shale	KAMTHI FORMATION	MIDDLE MEMBER				
12*	222	Grey shale						
13	240	Grey shale slightly micaceous						
14*	241	Carb. shale slightly micaceous						
15	248	Grey shale						
16*	259	Grey shale			II	*Faunipollenites, Striatopodocarpites, Densipollenites* (low) *Striasulcites* + Rare forms like *Falcisporites, Vesicaspora, Chordasporites, Gondisporites Osmundacidites, Polypodiidites* etc.	*Striasulcites* Phase	Lower part of Middle Member
17	306	Greenish shale						
18*	334	Carb. shale						
19	357	Grey shale						
20*	385	Grey siltstone slightly micaceous						
21	420	Carb. shale						
22	450	Slightly greenish siltstone						
23*	506	Carb. shale						
24	525	Grey siltstone						
25*	558	Greenish siltstone						
26*	580	Carb. shale						
27	625	Grey siltstone						
28	650	Carb. shale		LOWER MEMBER	I	*Faunipollenites, Striatopodocarpites* + *Scheuringipollenites* + Rare forms like *Alisporites, Falcisporites, Chordasporites, Lunatisporites* etc.	Striate disaccate rich phase Appearance of rare forms	Lower Member
29	749	Carb. shale						
30*	792	Carb. shale						
31	793	Carb. shale						
32*	841	Carb. shale						

Table 2—Showing details of samples, limits and characters of assemblages and biozones in bore hole GGK-20 (*Sample numbers with asterisk denotes yielding samples which could be counted).

Sample no.	Depth	Lithology	Lithological succession		Assem-blage	Characteristic forms	Remark	Biozone
40	62.50-58.50	Coarse grained grey white Calc. sst.	KAMTHI FORMATION	MIDDLE				
39*	65-62	Dark greenish grey micaceous arg. sst.						
38*	99.5-87.70	Grey Carb. shale				*Faunipollenites* +	Absence of Middle Member	
36	112-113	Coal				*Stripatopodocarpites* +	*Densipollenites*	
37	113-115	Shale				*Scheuringipollenites*		
35*	124.90-125.90	Grey shale		LOWER		+ Rare forms like *Falcisporites, Vitrei-*		
34*	175-183	Coal fine grained micaceous sst. with Coal lenticles.				*sporites, Lunatisporites, Corisaccites*		
33*	191.55-200.15	Grey black, Coaly & Sandy shale				*Chordasporites* & *Crescentipollenites*		

spores in Jhingurdah Seam). *Densipollenites* is characteristically almost absent in both.

Assemblage I can also be compared with the Raniganj palynoflora of Auranga Coalfield (Lele & Srivastava, 1979), Assemblage I of bore-hole RAD-2 (Singh & Tiwari, 1982), Assemblage 2 of bore-hole RNM-3 (Rana & Tiwari, 1980) and Assemblage II of bore-hole RNM-2 (Tiwari & Rana, 1984) from East Raniganj Coalfield in having dominant striate-disaccates. However, some younger forms which appear in Lower Kamthi Member of Godavari Valley are absent. Besides, *Densipollenites* is positively better represented in Assemblage-2 of RNM-3 and Assemblage II of RNM-2 in East Raniganj Coalfield.

The association of *Striasulcites* (Assemblage II) with dominant striate-disaccates has not been reported so far from any other coalfield excepting the Hutar Coalfield (Shukla, 1983). But therein *Striasulcites* is associated with the dominance of *Scheuringipollenites* and it has been recovered from upper part of Barakar Formation. The positive presence of *Densipollenites* in this assemblage is very significant.

Assemblage III, i.e. *Densipollenites* rich phase of Kamthi Formation in Godavari Graben bears a close correspondence with Assemblage 3 of bore-hole RNM-3 (Rana & Tiwari, 1980), with Assemblage III of bore-hole RAD-2 (Singh & Tiwari, 1982), with Group I of bore-hole RAD-5, with Group A of bore-hole RAD-4 (Tiwari & Singh, 1983) and Assemblage III of bore-hole RNM-2 (Tiwari & Rana, 1984) in East Raniganj Coalfield in having dominant striate-disaccates, high percentage of *Densipollenites* and presence of younger forms such as *Lunatisporites, Chordasporites, Klausipollenites, Alisporites, etc.* *Densipollenites* rich palynoflora of Upper Raniganj is also known from Nonia Nala (Banerji & Maheshwari, 1974), Noniakhal and Machkanda Jhore in Raniganj Coalfield (Bharadwaj, Tiwari & Anand-Prakash, 1979) and from Gopad River (Maheshwari, 1967). Thus, *Densipollenites* appears as one of the significant elements of palynoflora during the Middle Member of Kamthi Formation in Godavari Graben as is also known from upper part of Raniganj Formation of Damodar Basin. But the genera having younger aspect are relatively better represented in Godavari Graben than in other known *Densipollenites* rich assemblages in Damodar Basin—a condition similar to that in Bijori Formation of Satpura Gondwana Basin (Bharadwaj, Tiwari & Anand-Prakash, 1978). The present palynoflora also shows paucity of trilete spores while in Damodar Valley triletes are comparatively higher in representation in the Raniganj Formation.

COMPARISON OF PALYNODATA WITH LITHODATA

Bore-hole GGK-20—Lithologically, the Lower Member of Kamthi Formation in bore-hole GGK-20 has been marked between 200.15 to 87.90 m levels and Middle Member above this level (Histogram 2). But the palynoflora shows no change in the sequence and thus palynologically the whole sedimentary sequence in bore-hole GGK-20 above 200.15 m belongs to Lower Member of the Kamthi Formation. Lithologically also, the beds above 87.90 m level do not exhibit appreciable difference but for lack of coaly facies. However, the occurrence of plant fossils at 68.10 m level suggests that carbonaceous nature continued well above the coaly facies.

PLATE 1

(All photomicrographs magnified × 500)

→

1. *Guttulapollenites hannonicus*, negative no. 32/9, slide no. BSIP 9324; Coordinates 104 × 12.6
2. *Hamiapollenites* sp., negative no. 26/14, slide no. BSIP 9325; Coordinates 7.6 × 108.3
3. *Lueckisporites* sp., negative no. 32/14, slide no. BSIP 9334; Coordinates 89.5 × 17.5
4. *Chordasporites australiensis*, negative no. 21/20, slide no. BSIP 9330; Coordinates 3.4 × 103.0
5. *Paravesicaspora nilssoni*, negative no. 37/6, slide no. BSIP 9336; Coordinates 12.6 × 90.0
6. *Falcisporites nuthallensis*, negative no. 28/21, slide no. BSIP 9329; Coordinates 19.2 × 96.4
7. *Crescentipollenites densus*, negative no. 27/28, slide no. BSIP 9331; Coordinates 106 × 13.3
8. *Lunatisporites ovatus*, negative no. 22/10, slide no. BSIP 9332; Coordinates 113.9 × 11.5
9. *Striasulcites ovatus*, negative no. 37/3, slide no. BSIP 9338; Coordinates 3.0 × 82.7
10. *Lueckisporites microgranulatus*, negative no. 23/7, slide no. BSIP 9327; Coordinates 10.7 × 84.8
11. *Strotersporites* sp., negative no. 37/11, slide no. BSIP 9339; Coordinates 13.7 × 93.9
12. *Strotersporites crassiletus*, negative no. 37/1, slide no. BSIP 9340; Coordinates 13.3 × 83.2
13. *Densipollenites kamthiensis*, negative no. 24A/7, slide no. BSIP 9324; Coordinates 10.3 × 100.0
14. *Verticipollenites debilis*, negative no. 35/3, slide no. BSIP 9328; Coordinates 2.8 × 91.0
15. *Vitreisporites pallidus*, negative no. 28/35, slide no. BSIP 9324; Coordinates 19.8 × 95.7
16. *Striatopodocarpites multistriatus*, negative no. 20B/8, slide no. BSIP 9329; Coordinates 19.0 × 98.7

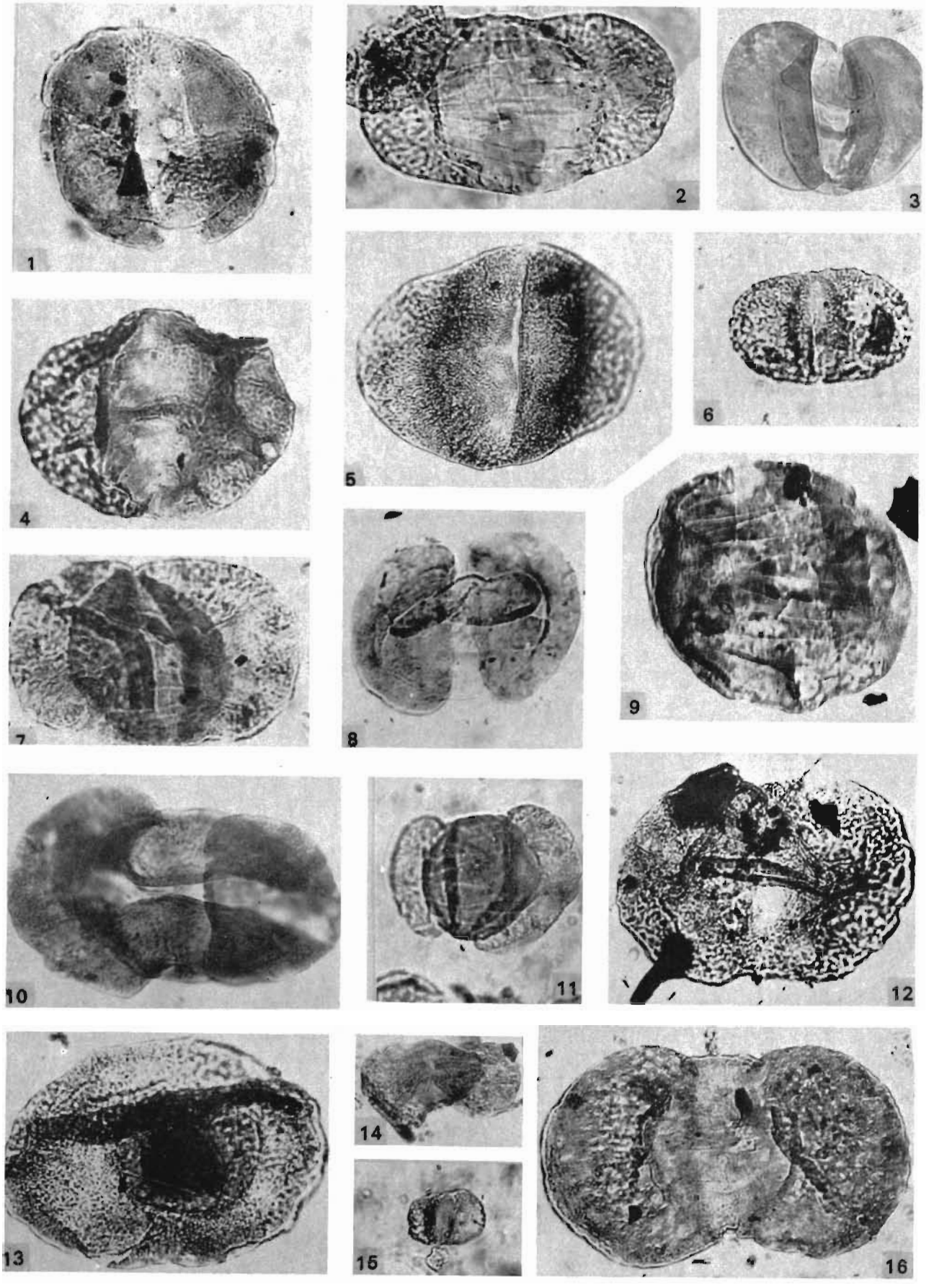


PLATE 1

Bore-hole GGK-27—The samples of bore-hole GGK-27 lithologically belong to Kamthi Formation. The boundary between the Lower and Upper members of the Kamthi Formation has been marked at 776.70 m in bore-hole GGK-27. But Lower Kamthi palynoflora has been observed up to 792 m. The actual upper limits of the palynoflora is not known but could well have extended to 776.70 m level as lithologically stipulated. Thus, the palynodata corresponds with the lithodata. Assemblages II and III represent palynoflora of Middle Member of the Kamthi Formation. Assemblage II represents lower part while Assemblage III represents upper part of Middle Member in bore-hole GGK-27.

DISCUSSION

The Kamthi Formation of Wardha-Godavari Valley coalfields has been correlated with the Raniganj Formation of Damodar Basin on the basis of plant fossils. Hughes (1877) considered them to represent a time equivalent of the upper part of Damuda Series and a part of Panchet Formation of Damodar Basin. This contention has been corroborated by the present palynological investigation.

The palynological investigations carried out in the bebehhhhhhhhRamagundam area show a close resemblance with the palynoflora of the Raniganj Formation of Damodar Valley. The entire sequence shows the dominance of striate-disaccate pollen grains. The Lower Member of the Kamthi Formation which contains a workable coal seam, has been lithologically identified between 851.15 to 776.70 m in the bore-hole GGK-27 and between 87.90 to 200.15 m from the surface in the bore-hole GGK-20. With the beginning of the Middle Member of the Kamthi Formation the carbonaceous sediments disappear and an uninterrupted sequence of alternating medium to coarse-grained grey-white sandstone, shales and clays predominates. Palynologically, the lower part of Middle Member (between 776.70-366.70 m in bore-hole GGK-27) is characterised by association of high *Striasulcites* + striate-disaccates + low *Densipollenites*. In the overlying sequence *Striasulcites* vanishes and *Densipollenites* attains dominance. This youngest assemblage is known to occur between 54-334 m and palynologically corresponds with the upper part of Raniganj Formation in the Damodar basin.

At specific level it has been found that the palynoflora of Middle Member of the Kamthi Formation is much more diversified than that of Lower Member. Few species of *Densipollenites* are present only in Middle Member, viz., *D. magnicorpus, D. brevis, D. kamthiensis* and *D. marginalis* (Srivastava & Jha, MS). Besides, *Striasulcites ovatus, S. tectus* and *Strotersporites crasseletus* (Srivastava & Jha, MS) are restricted to Middle Member of the Kamthi Formation only. The distribution of different species is as follows :

SPECIES	LOWER KAMTHI	MIDDLE KAMTHI
Lophotriletes rectus	+	+
Gondisporites sp.		+
Verrucosisporites surangei Maheshwari & Banerji 1970		+
Horriditriletes ramosus (Balme & Hennelly) Bharadwaj & Salujha 1964	+	+
H. rampurensis Tiwari 1968	+	+
Microbaculispora tentula Tiwari 1965	+	+
Brevitriletes communis Bharadwaj & Srivastava emend. Tiwari & Singh 1981	+	+
B. unicus (Tiwari) Bharadwaj & Srivastava emend. Tiwari & Singh 1981	+	+
Osmundacidites senectus Balme 1963		+
O. pilatus Tiwari & Rana 1981		+
Laevigatosporites colliensis (Balme & Hennelly) Venkatachala & Kar 1968	+	+
Polypodiidites perverrucatus Couper 1953		+
Praecolpatites sinuosus (Balme & Hennelly) Bharadwaj & Srivastava 1969		+
Callumispora tenuis Srivastava 1969	+	+
Densipollenites indicus, Bharadwaj 1962		+
D. invisus Bharadwaj & Salujha, 1964		+
D. densus Bharadwaj & Srivastava 1969		+
D. minimus Venkatachala & Kar 1968		+
D. brevis Lele & Srivastava 1977		+
D. sp. cf. *D. brevis* Lele & Srivastava 1977		+
D. magnicorpus Tiwari & Rana 1981		+
D. sp. cf. *D. magnicorpus* Tiwari & Rana 1981		+
D. kamthiensis Srivastava & Jha (MS)		+
D. marginalis Srivastava & Jha (MS)		+
Densipollenites sp.		+
Tiwarisporis novus Bharadwaj & Dwivedi 1981		+
Weylandites minutus Bharadwaj & Srivastava 1969	+	+
W. circularis Bharadwaj & Srivastava 1969	+	+
W. obscurus (Tiwari) Bharadwaj & Dwivedi 1981	+	+
Vesicaspora luteus Salujha 1965		+
Parasaccites korbaensis Bharadwaj & Tiwari 1964	+	+
P. obscurus Tiwari 1965	+	+
P. distinctus Tiwari 1965	+	+
P. diffusus Tiwari 1965	+	+
P. bilateralis Tiwari 1965	+	+
P. densus Maheshwari 1967	+	+
P. talchirensis Lele & Makada 1972	+	+
Virkkipollenites orientalis Tiwari 1968		+
Lueckisporites sp.		+
Guttulapollenites hannonicus Goubin 1965		+
Lunatisporites diffusus Bharadwaj & Tiwari 1977		+
Lunatisporites sp.		+
Corisaccites alutus Venkatachala & Kar, 1966	+	+
C. distinctus Venkatachala & Kar 1968	+	+
Hamiapollenites sp.		+
Striatites communis Bharadwaj & Salujha 1964	+	+
S. solitus Bharadwaj & Salujha 1964	+	+
S. tentulus Tiwari 1965	+	+
Striatites sp.	+	+

Labirites rarus Bharadwaj & Salujha 1964	+	+
L. singularis Bharadwaj & Dwivedi 1981	+	+
L. karanpuraensis Bharadwaj & Dwivedi 1981	+	+
L. levicorpus Tiwari 1968		+
L. rhombicus Maithy 1965		+
Verticipollenites gibbosus Bharadwaj 1962	+	+
V. debilis Venkatachala & Kar 1968		+
V. finitimus Bharadwaj & Salujha 1964		+
V. crassus Bharadwaj & Salujha 1964	+	+
Verticipollenites sp.		+
Hindipollenites indicus Bharadwaj 1962		+
H. globosus Kar 1968a		+
H. sp. cf. *H. rajmahalensis*		+
Striatopodocarpites tiwari Bharadwaj & Dwivedi 1981	+	+
S. globosus (Maheshwari) Bharadwaj & Dwivedi 1981	+	+
S. brevis Sinha 1972	+	
S. diffusus Bharadwaj & Salujha 1964	+	+
S. rotundus (Maheshwari) Bharadwaj & Dwivedi 1981	+	+
S. decorus Bharadwaj & Salujha 1964	+	+
S. labrus Tiwari 1965	+	+
S. subcircularis Sinha 1972	+	+
Striatopodocarpites sp.	+	+
Faunipollenites parvus Tiwari 1965	+	+
F. goraiensis (Potonié) Lele & Maithy 1965	+	+
F. copiosus Bharadwaj & Salujha 1965	+	+
F. varius Bharadwaj, 1962	+	+
F. bharadwajii Maheshwari 1967	+	+
F. singrauliensis Sinha 1972	+	+
F. gopadensis Bharadwaj & Srivastava 1969	+	
Faunipollenites sp.		+
Strotersporites crassiletus sp. nov. Srivastava & Jha (MS)		+
Strotersporites sp.		+
Striapollenites monosaccoides Tiwari & Rana 1981		+
Distriatites insolitus Bharadwaj & Salujha 1964	+	+
D. distinctus Sinha 1972	+	+
Distriatites sp.		+
Rhizomaspora indica Tiwari 1965		+
R. monosulcata Tiwari 1968	+	
Primuspollenites levis Tiwari 1964	+	+
Schizopollis extremus Venkatachala & Kar 1964		+
Striasulcites tectus Venkatachala & Kar 1968		+
S. ovatus Venkatachala & Kar 1968		+
Distriamonocolpites circularis Sinha 1972		+
Crescentipollenites barakarensis (Sinha) comb. nov.		+
C. fusus (Bharadwaj) Bharadwaj, Tiwari & Kar 1974	+	+
C. gondwanensis (Maheshwari) Bharadwaj, Tiwari & Kar 1974	+	+
C. talchirensis (Lele) comb. nov.		+
C. densus Srivastava & Jha (MS)		+
Circumstriatites ovatus Lele & Makada 1972	+	
C. obscurus Lele & Makada 1972	+	
Marsupipollenites fasciolatus Balme & Hennelly 1956		+
Pretricolpipollenites bharadwajii Balme 1970		+
Potonieisporites neglectus Potonié & Lele 1961		+
Scheuringipollenites maximus (Hart) Tiwari 1973	+	+
S. minutus (Sinha) Bharadwaj & Dwivedi 1981		+
S. barakarensis (Tiwari) 1973	+	+
S. tentulus (Tiwari) Tiwari 1973	+	+
Ibisporites jhingurdahiensis Sinha 1972	+	+
Alisporites indarraensis Segroves 1969	+	+
A. landianus Balme 1970	+	+
Chordasporites australiensis de Jersey 1962	+	+
Cuneatisporites royaliensis Saxena 1971		+
Falcisporites nuthallensis (Clark) Balme 1970	+	+
Paravesicaspora ovata (Balme & Hennelly) Bharadwaj & Dwivedi 1981	+	+
P. brevis (Sinha) Bharadwaj & Dwivedi 1981		+
Aurangapollenites gurturiensis Srivastava 1977		+
Vitreisporites pallidus (Reissinger) Balme 1970	+	+
Pilasporites sp.	+	+
Inaperturopollenites nebulosus Balme 1970	+	+
Singraulipollenites indicus Sinha 1972	+	+
S. finitimus Sinha 1969	+	+

Lithologically, both the sequences are devoid of coal-bearing sediments and present a monotonous sequence of sandstone, shale and clay. However, the sandstones of the Middle Member of the Kamthi Formation show a greenish tint more frequently in the upper part of the sequence. It is also interesting to note that the upper part of the Middle Member in GGK-27 shows a declining trend in the genus *Densipollenites*. Further, the presence of *Verrucosisporites, Osmundacidites, Polypodiidites, Vitreisporites* and *Falcisporites* becomes more frequent in this zone and thus heralds the incoming of the younger, the Panchet, elements. It is probable that the Permian Period comes to a close somewhere not much above this palynozone of the Middle Member of the Kamthi Formation. If this presumption holds good the equivalent of Panchet Formation may be expected close to the present level of Assemblage III in Middle Member studied from the bore-hole GGK-27 in Ramagundam-Mantheni area of Godavari Graben.

CONCLUSION

The palynological investigations of the Kamthi Formation in Ramagundam-Mantheni area brought to light for the first time that the Lower and Middle members are characterised by three palynological assemblages with two breaks separating one assemblage restricted to Lower Member, one to older part of Middle Member and the third in the upper part of latter. Palynostratigraphically, these assemblages indicate a close resemblance with the Raniganj Formation of Damodar Basin except certain variations which are restricted to Godavari Graben. Further, it is reasonable to presume that the younger

part of Middle Member and Upper Member of Kamthi Formation is homotaxial with the Panchet Formation of Damodar Basin in part or whole.

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