Palynostratigraphy of Lower Gondwana sediments in Godavari Graben, Andhra Pradesh, India

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The subsurface Lower Gondwana sediments in Ramagundam and Ramakrishnapuram areas of Godavari Graben, Andhra Pradesh comprise Talchir to Barren Measures formations present in two bore-holes, viz., GRK 1 and GGK-20. The distribution of palynofossils in time and space suggests the occurrence of six palynozones: Palynozone 1—marked by the dominance of radial monosaccates (chiefly *Parasaccites*) representing the Talchir mioflora; Palynozone 2—characterised by the incoming of *Callumispora* in addition to radial monosaccates representing Lower Karharbari mioflora; Palynozone 3—representing the Upper Karharbari mioflora marked by the dominance of radial monosaccates associated with low nonstriate-disaccates; Palynozone 4—nonstriate-disaccates (chiefly *Scheuringipollenites*) attaining overall dominance representing the Lower Barakar palynoflora and containing the productive coal seams of the area; Palynozone 5—striate-disaccate pollen (chiefly *Faunipollenites*) attaining overall dominance and representing the Upper Barakar palynoflora; Palynozone 6—characterised by the association of striate-disaccate pollen and *Densipollenites* representing the youngest assemblage in the present investigation. These assemblages have been compared with known palynofloras. The existence of Karharbari and Barren Measures formations in Ramagundam and Ramakrishnapuram areas has been established with palynological evidence.

Key-words—Palynostratigraphy, Karharbari Formation, Barren Measures Formation, Lower Gondwana, Permian (India).

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सारांश

आँध्र प्रदेश (भारत) में गोदावरी द्रोणिका के अधरि गोंडवाना अवसादों का परागाणुस्तरविन्यास

सुरेश चन्द्र श्रीवास्तव एवं नीरजा झा

गोदावरी द्रोणिका (आँध्र प्रदेश) के रामागुंडम् एवं रामकृष्णपुरम नामक क्षेत्रों में स्थित उपसतही अधरि गोंडवाना अवसादों में तलचीर से बैरन मेजर्स तक के शैल-समूह विद्यमान हैं ऐसा जी-आर-के० 1 एवं जी-जी-के० 20 नामक वेध-छिद्रों से ज्ञात हुआ है। परागकण-बीजाणुओं के वितरण से छः परागकण-मंडलों की उपस्थिति प्रस्तावित होती है: परागकण-मडल 1 में तलचीर सूक्ष्मवनस्पतिजात को निरूपित करने वाले अरीय एककोष्ठीयों (मुख्यतया **पैरासेक्काइटिस**) की बाहुल्यता है; परागकण-मडल 2 अधरि करहरबारी सूक्ष्मवनस्पतिजात के प्रतीक अरीय-एककोष्ठीयों के साथ-साथ **केल्यूमिस्पोरा** की शुरूआत से लक्षणित है; परागकण-मंडल 3 अधारीदार-द्विकोष्ठीयों से सहयुक्त अरीय-एककोष्ठीयों (उपरि करहरबारी सूक्ष्मवनस्पतिजात) से प्रभावी है; परागकण-मंडल 4 अधरि बराकार परागाणु-वनस्पतिजात को समग्र रूप से निरूपित करने वाले अधारीदार-द्विकोष्ठीयों (मुख्यतया **श्यौरिंगीपोलिनाइटिस**) से प्रभावी है तथा इसमें इस क्षेत्र की धारक कोयला-सीम विद्यमान हैं; परागकण-मंडल 5 उपरि बराकार परागाणु-वनस्पतिजात के द्योतक अधारीदार-द्विकोष्ठीयों (मुख्यतया **फॉनिपोलिनाइटिस**) से लक्षणित है; परागकण-मंडल 6 **डेन्सीपोलिनाइटिस** एवं अधारीदार-द्विकोष्ठीयों के साहचर्य से अभिलक्षणित है तथा यह मंडल अल्पतम आयु की समुच्चय का निरूपण करता है। इन सभी समुच्चयों की अन्य ज्ञात परागाणु-वनस्पतिजातों से भी तुलना की गई है। परागाणविक प्रमाणों के आधार पर रामागुंडम् एवं रामकृष्णपुरम नामक क्षेत्रों में करहरबारी एवं बैरन मेजर्स शैल-समूहों की उपस्थिति की पुष्टी की गई है।

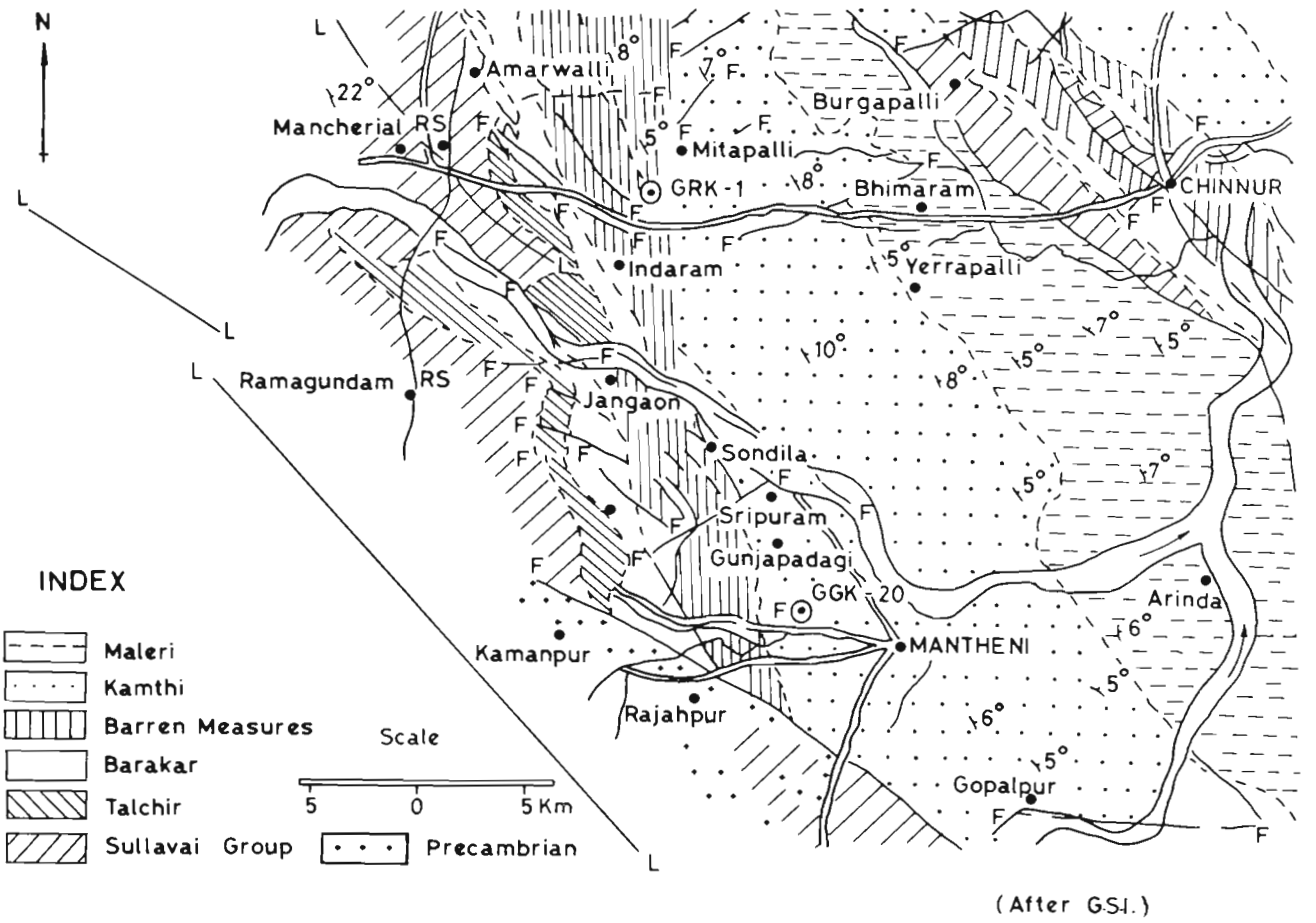
PALYNOLOGICAL studies of the Lower Gondwana sediments from many areas of the Peninsular India have been done during the last few years but in Godavari Valley coalfields it is rather meagre. Thiergart and Frantz (1962) mentioned few taxa from the working coals in Kothagudem area. Ghosh (1968) described the distribution of miospore genera in Salarjung and Ross seams of Tandur area.

Moiz and Ramana Rao (1968) have made a preliminary study of Ramagundam coals. Tiwari and Moiz (1971) again studied the working coals of Ramagundam area and described some new miospore genera. All these investigations available are incomplete as they are related to one or two coal seams only. Recently, Srivastava (1987) has described the sporae dispersae of working coal seams from a number of collieries in Godavari Valley and suggested their possible correlation on the basis of palynoflora. The present investigation has been carried out on subsurface sediments incorporating Talchir to Barren Measures formations from Ramagundam and Ramakrishnapuram areas in order to bring out the palynological succession hitherto unknown in these sediments. The bore-core samples (bore-hole GGK-20, GRK-1) investigated have been listed in Table 1 and 2 and the location of bore-holes has been shown in Map 1.

GEOLOGICAL DETAILS OF THE AREA

Ramagundam is situated in Karimnagar District of Andhra Pradesh (Map 1). The oldest rocks in the area are Archeans which are overlain by Pakhal limestone and shales and Sullavai sandstone. The Lower Gondwana sediments overlie these rocks unconformably at different places. The basalmost unit of the Lower Gondwana Sequence, i.e., Talchir Formation, has been encountered in bore-hole GRK 1 which was closed at 919.01 m and has cut through 29 m of the Talchir Formation which is characterised by coarse to medium-grained greenish sandstone with pebbles of quartzite and shales. This does not represent the complete thickness of the Talchir Formation as the bore-hole has not reached the basement metamorphics. Hence, the total thickness of Talchir Formation is not represented in this bore hole.

The two overlying formations, i.e., Barakar and Barren Measures, have been encountered in both the above bore-holes. On the basis of lithological attributes, the Barakar Formation has been divided into two members. The Lower Member is characterised by the presence of coarse-grained sandstone with lenses of conglomerates and is devoid of workable coal seams. The Upper Member consists of coarse-grained sandstone with



Map 1—Geological map of Godavari Graben showing location of bore holes.

subordinate shales and coal seams. In bore-hole GRK-1 the Barakar Formation has been delimited between 807.46-571.85 m while in bore-hole GGK-20 it has been delineated between 900.15-702.26 m.

A thick pile of sediments attributed to Barren Measures Formation has been marked above the Barakar Formation in bore-hole GGK-20 (700-200 m) and GRK-1 (571.85-105.30 m) which is lithologically characterised as medium-to coarse-grained, greenish grey and greyish white felspathic sandstone with grey to greyish-black shale and clay. The contact between the Barakar and Barren Measures is gradational and the latter is marked by the absence of coaly matter or coal seams. In both bore-holes Barren Measures Formation overlies the Barakar Formation through a gradational contact.

PALYNOLOGY

Out of a total of 68 samples macerated from bore-holes GRK-1 and GGK-20, only 29 samples have yielded a rich mioflora. The sporae dispersae distributed in the above sediments consists of 51 genera and 124 species which are listed below :

Indotriradites Tiwari 1964
- *I. korbaensis* Tiwari 1964
- *I. sparsus* Tiwari 1965
- *Indotriradites* sp.

Leiotriletes (Naumova) Potonié & Kremp 1954
- *Leiotriletes* sp.

Lophotriletes (Naumova) Potonié & Kremp 1954
- *L. rectus* Bharadwaj & Salujha 1967

Horriditriletes Bharadwaj & Salujha 1964
- *H. rampurensis* Tiwari 1968
- *H. ramosus* (Balme & Hennelly) Bharadwaj & Salujha 1964
- *H. concavus* Maheshwari 1969

Lobatisporites Tiwari & Moiz 1971
- *L. gondwanensis* Tiwari & Moiz 1971

Brevitriletes Bharadwaj & Srivastava emend. Tiwari & Singh 1981
- *B. triangularis* Kar & Bose 1976
- *B. unicus* (Tiwari 1965) emend. Bharadwaj & Srivastava 1969 emend. Tiwari & Singh 1981

Microfoveolatispora Bharadwaj 1962
- *M. foveolata* Tiwari 1965 emend. Tiwari & Singh 1981

Pseudoreticulatispora Bharadwaj & Srivastava 1969
- *P. barakarensis* Bharadwaj & Srivastava 1969

Verrucosisporites Ibrahim emend. Smith 1971
- *V. gondwanensis* Srivastava 1970
- *V. surangei* Maheshwari & Banerji 1975

Osmundacidites Couper 1953
- *O. senectus* Balme 1963

Laevigatosporites Ibrahim 1933
- *L. colliensis* Balme & Hennelly emend. Venkatachala & Kar 1968

Densipollenites Bharadwaj 1962
- *D. indicus* Bharadwaj 1962
- *D. invisus* Bharadwaj & Salujha 1964
- *D. densus* Bharadwaj & Srivastava 1969

Callumispora Bharadwaj & Srivastava 1969
- *C. barakarensis* Bharadwaj & Srivastava 1969
- *C. tenuis* Bharadwaj & Srivastava 1969
- *C. tenuis* var. *minor* Bharadwaj & Srivastava 1969

Hennellysporites Tiwari 1968
- *H. diversiformis* Balme & Hennelly emend. Tiwari 1968

Tiwariasporis Maheshwari & Kar 1967
- *T. simplex* Tiwari emend. Maheshwari & Kar 1967
- *T. gondwanensis* Tiwari emend. Maheshwari & Kar 1967

Weylandites Bharadwaj & Srivastava, 1969
- *W. magnus* Bose & Kar emend. Bharadwaj & Dwivedi 1981
- *W. indicus* Bharadwaj & Srivastava 1969
- *W. circularis* Bharadwaj & Srivastava 1969

Vesicaspora Schemel emend. Wilson & Venkatachala 1963
- *V. luteus* Salujha 1965

Divarisaccus Venkatachala & Kar 1966
- *Divarisaccus* sp.

Cahleniasaccites Bose & Kar 1966
- *C. ellipticus* Bose & Maheshwari 1968
- *C. elongatus* Bose & Kar 1966
- *C. ovatus* Bose & Kar 1966

Parasaccites Bharadwaj & Tiwari 1964
- *P. korbaensis* Bharadwaj & Tiwari 1964
- *P. obscurus* Tiwari 1965
- *P. distinctus* Tiwari 1965
- *P. diffusus* Tiwari 1965
- *P. bilateralis* Tiwari 1965
- *P. perfectus* Bose & Maheshwari 1968
- *P. densicorpus* Lele 1975
- *P. talchirensis* Lele & Makada 1972
- *P. longus* Kar & Bose 1967

Plicatipollenites Lele 1964
- *P. indicus* Lele 1964
- *P. gondwanensis* Balme & Hennelly emend. Lele 1964
- *P. diffusus* Lele 1964
- *P. ganjrensis* Saxena 1971

Virkkipollenites Lele 1964
- *V. orientalis* Tiwari 1968

Trochosporites Wilson 1962
- *Trochosporites* sp.

Striomonosaccites Bharadwaj 1962
- *S. ovatus* Bharadwaj 1962

Leuckisporites Potonié & Klaus emend. Bharadwaj 1974
- *L. microgranulatus* Klaus 1963
- *L. crassus* Sinha 1972

Crucisaccites Lele & Maithy 1964
- *C. indicus* Srivastava 1970
- *C. monoletus* Maithy 1965
- *C. medius* Lele & Maithy 1969

Lunatisporites Leschik emend. Bharadwaj 1974
- *L. pellucidus* Goubin 1965 emend. Maheshwari & Banerjee 1975
- *L. ovatus* (Goubin 1965) Meheshwari & Banerjee 1975

Corisaccites Venkatachala & Kar 1966
- *C. alutus* Venkatachala & Kar 1968
- *C. distinctus* Venkatachala & Kar 1968

Hamiapollenites Wilson emend. Tschudy & Kosanke 1966
- *Hamiapollenites* sp.

Striatites Pant emend. Bharadwaj 1962
- *S. rhombicus* Bharadwaj & Salujha 1964
- *S. tentulus* Tiwari 1965
- *S. naditoliensis* Bharadwaj & Dwivedi 1981
- *S. obliquus* Srivastava 1979
- *Striatites* sp. cf. *S. parvus* Tiwari 1965

Labirites Bharadwaj 1962
- *L. rarus* Bharadwaj & Salujha 1964
- *L. parvus* Bharadwaj & Salujha 1964
- *L. karanpuraensis* Bharadwaj & Dwivedi 1981
- *L. parvus* Bharadwaj & Salujha 1964
- *L. fractus* Tiwari 1965
- *L. rhombicus* Maithy 1965

Verticipollenites Bharadwaj 1962
- *V. secretus* Bharadwaj 1962
- *V gibbosus* Bharadwaj 1962
- *V debilis* Venkatachala & Kar 1968
- *V crassus* Bharadwaj & Salujha 1964

Hindipollenites Bharadwaj 1962
- *H. indicus* Bharadwaj 1962
- *H. gibbosus* Kar 1968
- *Hindipollenites* sp. cf. *H. rajmahalensis* Maheshwari 1967

Striatopodocarpites Soritch. & Sedova emend. Bharadwaj 1962
- *S. brevis* Sinha, 1972
- *S. rotundus* Maheshwari emend. Bharadwaj & Dwivedi 1981
- *S. decorus* Bharadwaj & Salujha 1964
- *S. labrus* Tiwari 1965
- *S. subcircularis* Sinha 1972

Faunipollenites Bharadwaj 1962
- *F. goraiensis* Potonié & Lele emend. Maithy 1965
- *F. copiosus* Bharadwaj & Salujha 1965
- *F. varius* Bharadwaj 1962
- *F. bharaduajii* Maheshwari 1967
- *F singrauliensis* Singh 1972
- *F. gopadensis* Bharadwaj & Srivastava 1969

Strotersporites Wilson 1962
- *Strotersporites* sp.

Striapollenites Bharadwaj 1962
- *S. saccatus* Bharadwaj 1962

Distriatites Bharadwaj 1962
- *D. insolitus* Bharadwaj & Salujha 1964
- *D. distinctus* Sinha 1972

Rhizomaspora Wilson 1962
- *R. indica* Tiwari 1965
- *R. monosulcata* Tiwari 1968

Primuspollenites Tiwari 1964
- *P levis* Tiwari 1964

Crescentipollenites Bharadwaj, Tiwari & Kar 1974
- *C. talchirensis* Lele 1975

Circumstriatites Lele & Makada 1972
- *C. obscurus* Lele & Makada 1972
- *C. ovatus* Lele & Makada 1972

Marsupipollenites Balme & Hennelly emend. Pocock & Jansonius 1969
- *M. fasciolatus* Balme & Hennelly 1956

Potonieisporites Bhardwaj emend. Bharadwaj 1964
- *P neglectus* Potonié & Lele 1961
- *P barrelis* Tiwari 1965
- *P concinnus* Tiwari 1965
- *P lelei* Maheshwari 1967
- *P jayantiensis* Lele & Karim 1971
- *P distinctus* Lele & Makada 1972

Scheuringipollenites Tiwari 1973
- *S. maximus* Hart emend. Tiwari 1973
- *S. minutus* Sinha 1972
- *S. barakarensis* Tiwari 1965
- *S. tentulus* (Tiwari) Tiwari 1973

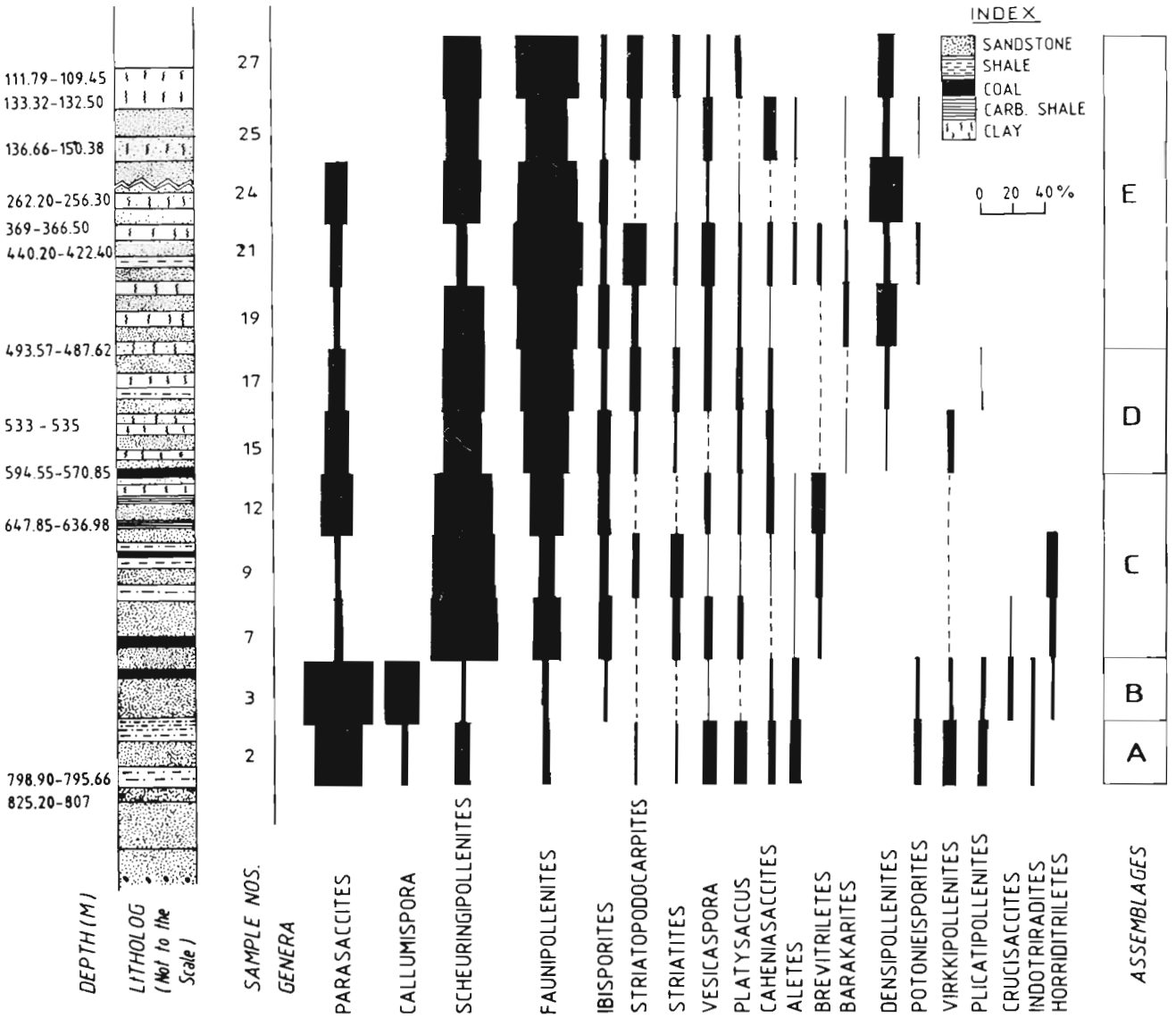
Ibisporites Tiwari 1968
- *I. diplosaccus* Tiwari 1968
- *I. jhingurdahiensis* Sinha 1972

Platysaccus Naumova emend. Potonié & Klaus 1954
- *P. papilionis* Potonié & Klaus 1954
- *P plicatus* Bharadwaj & Dwivedi 1981
- *P. leschiki* Hart 1960
- *P densicorpus* Anand-Prakash 1972

Paravesicaspora Klaus 1963
- *P. obliqua* Singh emend. Bharadwaj & Dwivedi 1981

Aurangapollenites Srivastava 1977
- *A. gurturiensis* Srivastava 1977

Barakarites Bharadwaj & Tiwari 1964
- *B. densicorpus* Tiwari 1965
- *B. crassus* Tiwari 1965
- *B. implicatus* Tiwari 1965
- *B. decorus* Tiwari 1965
- *B. rotatus* Balme & Hennelly emend. Bharadwaj & Tiwari 1964



Text-figure 1—Showing percentage frequency of palynotaxa in bore-hole GRK-1.

B. triquetrus Tiwari 1965

Parastriopollenites sp. cf. *P. triangularis* Maheshwari 1967

P. rajmahalensis Maheshwari 1967

The quantitative analysis of the palynoflora is based on a count of 200 spores in each sample at generic level. The criteria for marking the quantitative abundance of various miospore genera is comparative and the categories are dominant, subdominant, common and rare.

A critical appraisal of the vertical distribution of spore genera in the two bore-core samples (GGK-20, Text-fig. 2 & GRK-1, Text-fig. 1) of Ramagundam and Ramakrishnapuram areas, respectively has revealed *Callumispora, Parasaccites, Densipollenites, Faunipollenites, Scheuringipollenites* as the most important components.

These genera constitute the association of dominants and subdominants and have made possible to recognise the following six distinct palynozones distributed at various levels of the bore holes.

BORE-HOLE GRK-1

Assemblage A

Assemblage A is present in the bore-hole GRK-1 at the depth of 825-807 m (Text-fig. 1) lithologically represented by a shale/sandstone intercalation. The dominant component of this assemblage is *Parasaccites* (Text-fig. 1). Nonstriate and striate-disaccates in this assemblage are present in low amounts. The palynofloral assemblage on the whole is dominated by radial monosaccates (55%).

Assemblage B

Assemblage B is present between 798.90-795.6 m (sample no. 3) which is again a shale/sandstone intercalation. It consists of monosaccates, chiefly *Parasaccites* as a dominant element alongwith subdominant *Callumispora*. Striate and nonstriate-disaccate pollen are quite low in percentage. The palynoflora in this assemblage is also dominated by radial monosaccate pollen (60%) similar to Assemblage A but the association of *Callumispora* (22%) distinguishes it from the latter.

Assemblage C

Assemblage C is present in bore-hole GRK-1 at 647.85-533 m, the dominant element being *Scheuringipollenites*. *Faunipollenites* among the striate-disaccates pollen is the subdominant genus. In the younger part of this palynozone *Parasaccites* rises suddenly to become almost equal to *Faunipollenites*. However, the nonstriate-disaccate pollen attain overall dominance (59.5%) in this zone while monosaccates decline to become common. Striate-disaccate pollen also rise to attain subdominance.

Assemblage D

This assemblage, having striate-disaccate pollen, chiefly *Faunipollenites* (32-36%) as the dominant component, is present in GRK-1 between 493.57-422.40 m. *Scheuringipollenites* reduces to be subdominant (24-27%). *Parasaccites* is slightly reduced to 15-10 per cent and continues to reduce in further younger samples. *Densipollenites* appears for the first time in this assemblage although in rare amounts. Thus the dominant percentage is shared by striate-disaccate pollen grains closely followed by nonstriate-disaccate pollen.

Assemblage E

Assemblage E of the bore-hole GRK-1, present between 399-109.45 m, is characterised by the dominance of striate disaccates, chiefly *Faunipollenites*. *Scheuringipollenites* remains as a subdominant element of the assemblage. The important feature of the assemblage is that it shows the epibole of *Densipollenites*, i.e., in the beginning the percentage of *Densipollenites* is low (2-11%), in the middle it increases up to 19 per cent and at the end it declines to 4-9 per cent again. *Parasaccites* although present between 2-12 per cent behaves irregularly. The bulk of the percentage is shared by striate-disaccate pollen (48.5%) and the subdominance is maintained by non-striate disaccate genera (30%). Monosaccate pollen including *Densipollenites*, however, increase to 18.4 per cent.

BORE-HOLE GGK-20

Assemblage 1

Assemblage 1 has been differentiated between 854-827.25 m in bore-hole GGK-20 (Text-fig. 2). The dominant element in this assemblage is *Parasaccites* (42.5%). The other monosaccate pollen occur between 2-5 per cent. The nonstriate-disaccate genera like *Scheuringipollenites*, *Primuspollenites*, *Platysaccus* and *Ibisporites* remain as subdominant elements. Among the striate-disaccates pollen *Faunipollenites* occurs between 8-17 per cent. The striate-disaccates are common. The monosaccate pollen total up to 48.5 per cent, striate-disaccate 21 5 per cent and nonstriate-disaccate average up to 28.5 per cent.

Assemblage 2

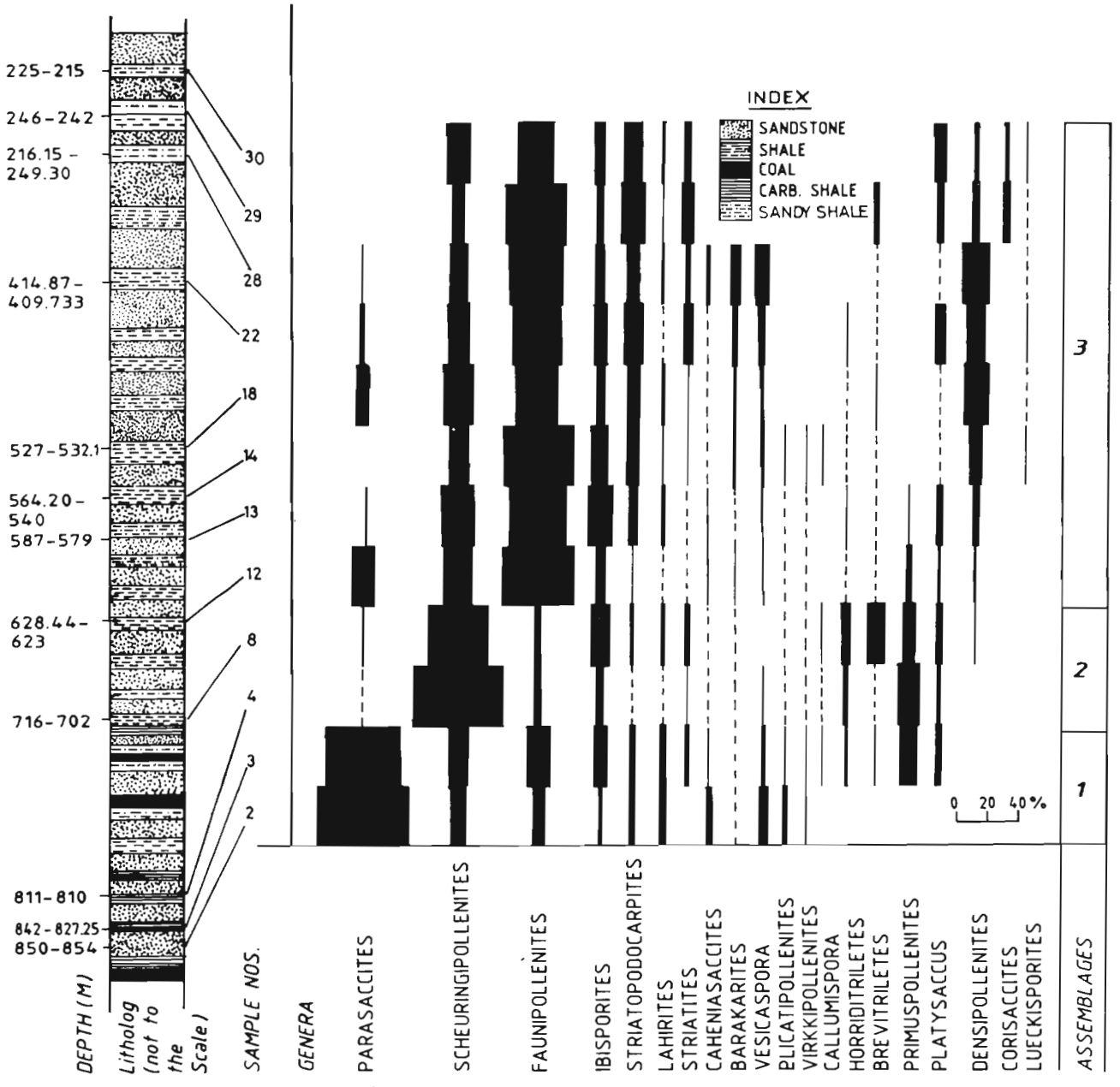
Assemblage 2 is present in the bore-hole GGK-20 between 811-702 m. The dominant element in this assemblage is *Scheuringipollenites* *Primuspollenites* declines to 6 per cent *Faunipollenites* also shows a declining tendency in the zone. Among the triletes, *Brevitriletes* and *Horriditriletes* appear in common alongwith monolete *Laevigatosporites*. The palynoassemblage is dominated by the nonstriate-disaccate pollen (74 5%) while the next group in order of dominance is trilete (11%) spores.

Assemblage 3

Assemblage 3 is present in bore-hole GGK-20 between 628.44 to 215 m (sample nos. 12-14, 18, 22, 28-30) in which *Faunipollenites* form the dominance. *Scheuringipollenites* reduces to subdominance. In addition to these *Densipollenites* shows significant increase, being 2-8 per cent in the beginning, up to 16 per cent in the middle and then reduced to 3 per cent in the upper part of the bore-core. Triletes are rare in occurrence. *Parasaccites* is up to 15 per cent at the beginning but the same suddenly declines upwards and ultimately loses significance at 246 m. Thus, the palynoflora is dominated by the striate-disaccate pollen (44.4%), followed by nonstriate-disaccate (29.2%). The presence of *Densipollenites* in subdominance is a characteristic feature of this assemblage.

PALYNOZONATION AND STRATIGRAPHIC CORRELATION

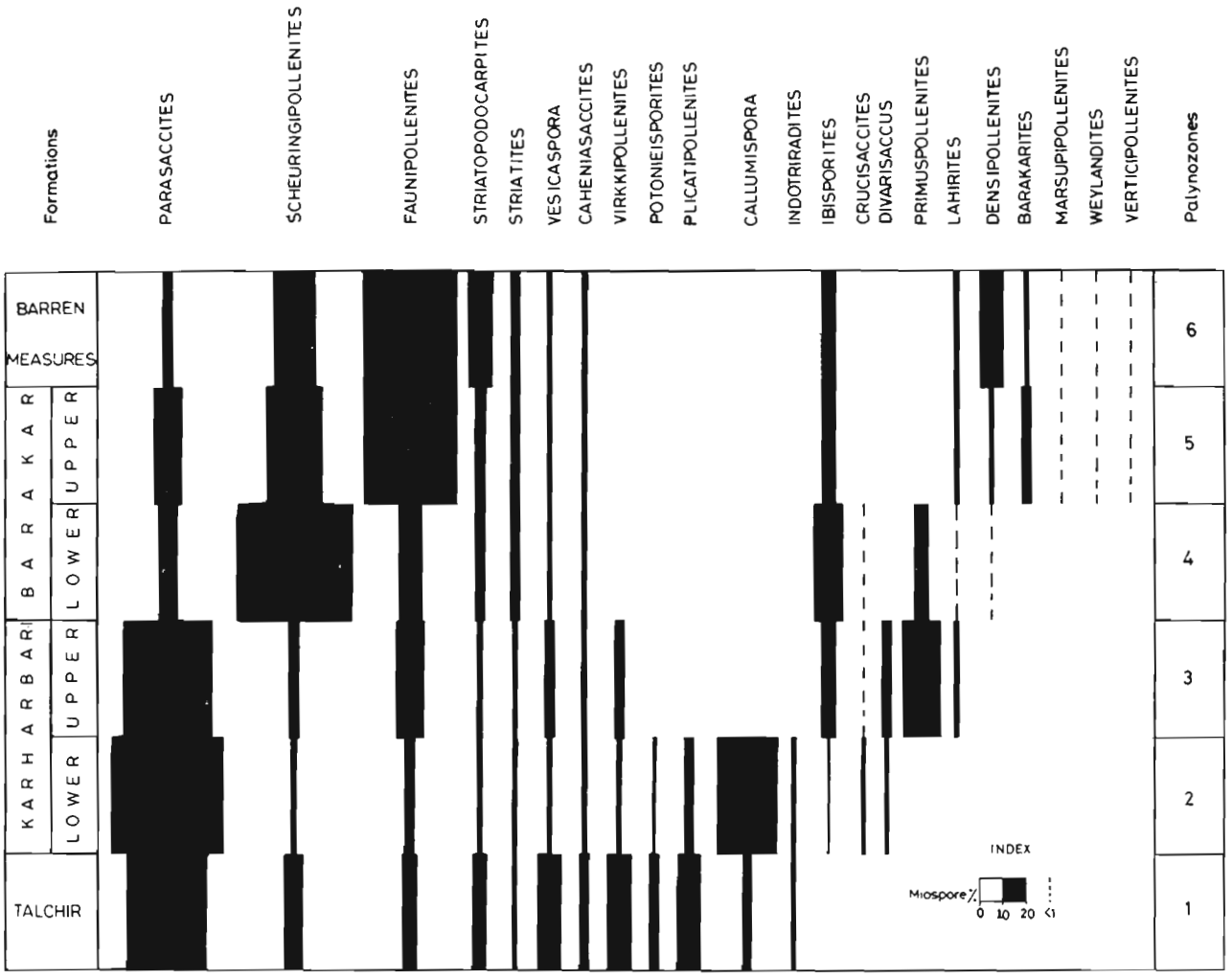
The present investigation has revealed that Assemblage-A in bore-hole GRK-1 is dominant in *Parasaccites* and other monosaccate pollen grains and *Callumispora* is low in percentage (3%). Hence,



Text-figure 2—Showing percentage frequency of palynotaxa in bore-hole GGK-20.

Assemblage A represents palynoflora of the Talchir Formation. This assemblage has been referred to Palynozone 1 in this investigation (Text-fig. 3). Such an assemblage has not been observed in bore-hole GGK-20.

Karharbari sediments which overlie Talchir Formation, are palynologically divisible into two parts. The lower part of the older zone is characterised by a combination of *Callumispora* and *Parasaccites* (Bharadwaj, 1976) as is found in Korba Coalfield (Bharadwaj & Srivastava, 1973). The upper part or the younger zone contains a *Parasaccites* dominant assemblage with *Callumispora* sub-dominant and with some nonstriate-disaccates. However, in the present study samples between 798.90-795.6 m in bore-hole GRK-1 contain Assemblage B which has *Parasaccites* dominance as well as high incidence of *Callumispora* (22%) alongwith low disaccate pollen. Obviously, Assemblage B represents Lower Karharbari palynoflora (Palynozone 2). This palynozone has not been encountered in bore-hole GGK-20. Assemblage 1 in bore-hole GGK-20 is dominant in *Parasaccites*. *Callumispora* is negligible and nonstriate-disaccate and striate-disaccate pollen increase in percentage as compared to Assemblage B. Hence, it represents



Text-figure 3—Showing succession of palynofloras in Ramagundam and Ramakrishnapuram areas, Godavari Graben.

the Upper Karharbari palynoflora and is designated here as Palynozone 3.

The next formation of the Lower Gondwana sequence is the Barakar Formation, which is palynologically divisible into the older, *Scheuringipollenites* dominated palynoflora, and the younger with exclusively striate-disaccate dominated assemblage (Bharadwaj, 1975). In the present study the Assemblage C (bore-hole GRK-1) has dominant *Scheuringipollenites* and subdominant striate-disaccate pollen grains. Similar palynofloral assemblage is also found in Assemblage 2 (bore-hole GGK-20), hence, the two can be correlated. Both the assemblages demarcated in Palynozone 4, closely compare with the palynoflora of Barakar Formation. Assemblage D (bore-hole GRK-1) has dominant striate-disaccate chiefly *Faunipollenites* and subdominant *Scheuringipollenites*. Such an association (Palynozone 5) has not been found in bore-hole GGK-20 described here, hence not correlatable. Barren Measures palynoflora is characterised by *Densipollenites* associated with striate-disaccate pollen. Similar association has also been found in the present Assemblages E (bore-hole GRK-1) and Assemblage 3 (bore-hole GGK-20). Hence, these assemblages represent the Barren measures palynoflora (Palynozone 6). Evidently, there are six palynological assemblages each representing a distinct palynozone summarised below :

PALYNO-ZONE	ASSEMBLAGE	FORMATION
6	Striate-disaccate + *Densipollenites* (Assemblage E, Bore-hole GRK-1, depth 369-109.45 m; Assemblage 3, Bore-hole GGK-20, depth 628-215 m)	**Barren Measures**
5	Striate-disaccate (*Faunipollenites*) dominant, nonstriate-disaccate subdominant (Assemblage D, bore-hole GRK-1, depth 493.57-422.40 m)	Upper **Barakar**

4	Nonstriate-disaccate (*Scheuringipollenites*) dominant; Striate-disaccate subdominant (Assemblage C, bore-hole GRK-1, depth 647.85-533 m; Assemblage 2, bore-hole GGK-20, depth 811-702 m)	Lower	
3	Radial monosaccate (*Parasaccites*) dominant, nonstriate-disaccate subdominant (Assemblage 1, bore-hole GGK-20, depth 854-827.25 m)	Upper	**Karharbari**
2	Radial monosaccate (*Parasaccites*) dominant, *Callumispora* subdominant (Assemblage B, bore-hole GRK-1, depth 798.90-795.6 m)	Lower	
1	Radial monosaccate (*Parasaccites*) dominant (Assemblage A, bore-hole GRK-1, depth 825-807 m)		**Talchir**

COMPARISON OF PALYNODATA WITH LITHODATA

Bore-hole GRK-1

The Talchir Formation has been delimited lithologically between 919.01-807.46 m. The palynoflora recovered between 825-807 m is characteristic of Talchir Formation. Thus, the palynological findings and lithological characters for Talchir Formation correspond with each other.

The Barakar Formation which overlies the Talchir Formation, has been marked lithologically between 807.46-571.85 m and the Barren Measures Formation has been demarcated between 571.85-105.30 m. However, the palynoflora present at the level of 798.90-795.6 m, is characteristic of upper part of Lower Karharbari and the palynoflora found at the level of 647.85-533 m is characteristic of Lower Barakar. Thus, the zone which has lithologically been marked as Barakar Formation, has yielded two palynological assemblages—the older characteristic of lower part of Karharbari Formation and the younger of Lower part of Barakar Formation. The palynodata has enabled finer differentiation in a lithologically undifferentiated sequence which is quite normal for Barakar sedimentation.

Further, the samples present at 493.57-422.40 m have yielded a palynoflora characteristic of upper part of Barakar Formation. The youngest assemblage present at the level of 369-109.45 m is characteristic of Barren Measures Formation. Hence, here also the palynological data do not correspond with the lithological characters wholly, the older part exhibiting Barakar time equivalence and only the younger part corresponding to Barren Measures time.

Bore-hole GGK-20

In this bore-hole the samples of Talchir Formation have not been obtained. The next Barakar Formation has been demarcated lithologically between 900.15-702.26 m. Palynologically, the samples between 854-827.25 m have yielded younger Upper Karharbari mioflora. The samples from 811-702 m have yielded a palynoflora characteristic of the Lower Barakar Formation. Thus, the palynodata do not correspond with the lithodata as the Barakar Formation is seen to include younger Karharbari palynoassemblage as well.

Above the Barakar Formation a thick stratum of Barren Measures Formation has been demarcated between the levels of 702-200 m. Palynoflora present in this zone is characteristic of Barren Measures Formation. Thus, obviously the palynodata correspond here with the lithodata.

DISCUSSION

The foregoing account of palynology of the Lower Gondwana Sequence in Ramagundam area of Godavari Valley coalfields suggests that a rich and diversified vegetation grew in the region during the formation of these sediments. The sporae dispersae recovered from different formations has been assigned to 52 genera and 124 species. The quantitative estimation of various taxa at generic level shows a marked change in mioflora from Talchir to Barren Measures Formation. A total of six palynological zones have been demarcated. The oldest Palynozone 1 is marked by the dominance of radial monosaccates (chiefly *Parasaccites*) and is present in bore-hole GRK-1 (between 825.20-807 m) which was drilled north of Godavari River. This assemblage compares with younger Talchir miofloras known from other basins of Peninsular Gondwanas (Bharadwaj, Srivastava & Anand-Prakash, 1979). This observation shows complete agreement with the lithological observation since the bore-hole was closed at 919.01 m after cutting nearly 111.35 m of Talchir sediments. This indicates that Talchir sediments continue further more down below containing in all probability the older Talchir palynofloras known from other basins.

The next younger Lower Karharbari palynoflora is observed above Palynozone 1 in bore-hole GRK-1 between 798.90-795.66 m. The lithological change-over from Talchir to Barakar Formation is gradational and there is no evidence of a break in sedimentation. Thus, the presence of a Lower Karharbari assemblage in a lithologically undifferentiated sequence is noteworthy. Further, the sediments between 795.66 to 647.85 m in bore-

hole GRK-1 have not yielded palynofossils but the overlying sediments from 647.85 to 533 m contain Lower Barakar palynoflora dominated by nonstriate-disaccate, chiefly *Scheuringipollenites*. Thus, the palynoflora representing the Upper Karharbari has not been observed in bore-hole GRK-1. However, it is present in bore-hole GGK-20 between 854-827.25 m. The sediments between 795.66 to 647.85 m in bore-hole GRK-1 contain four thin bands of coal and several bands of shales and the Upper Karharbari mioflora in all probability is expected to be interpolated in between these sediments.

The Upper Karharbari palynoflora (Palynozone 3) is succeeded by Palynozone 4 which is present in both the bore-holes. This assemblage is similar to the Lower Barakar palynofloras known from other areas. It is observed that the mioflora of coal seams 1-4 presently being worked out in various collieries of Ramagundam area fall essentially within Assemblage C of bore-hole GRK-1 and Assemblage 2 of bore-hole GGK-20 in view of having a nonstriate-disaccate dominant assemblage and thus are correlatable. Besides, almost all the working coal seams of Yellandu, Kothagudem, Belampalli, Mandamari and Ramkrishnapuram areas can be accommodated within this zone in view of having nonstriate-disaccate dominant assemblages and represent Barakar (Lower) mioflora. However, the assemblages described by Srivastava (1987) contain better evidence of trilete miospores than that encountered in the present bore-holes.

In addition to these, the miospore Assemblage 1 in bore-hole GGK-20 is correlatable with the mioflora of King Seam being worked out in Yellandu area as both of them contain *Parasaccites* dominant assemblage representing Upper Karharbari mioflora.

The Upper Barakar palynoflora (Palynozone 5) has been observed in bore-hole GRK-1 between 493.57 to 422.40 m strata which is devoid of coal seams and was lithologically placed in Barren Measures Formation (Histogram 1). The palynological change from Lower Barakar to Upper Barakar is normal but the lithological sequence is, however, not in agreement with these palynological observations. The Upper Barakar assemblage has been differentiated in a lithologically differentiated Barren Measures sequence.

It is further noteworthy to observe that the Upper Barakar assemblage is not present in bore-hole GGK-20 as the Lower Barakar palynoflora is directly succeeded by Barren Measures palynoflora (Palynozone 6). The succession of palynofloras from Upper Barakar to Barren Measures, while being sequential in bore-hole GRK-1, is discordant in bore-hole GGK-20 in view of the absence of striate-disaccate dominant Upper Barakar palynoflora. Thus, the lithological change-over from Barakar to Barren Measures Formation in bore-hole GGK-20 is normal but palynologically it is not so.

The lithologically differentiated Lower Member of the Barakar Formation which is practically devoid of workable coal seams in the present bore-holes, in fact contains a Karharbari palynoflora. In other coal basins this is known to contain workable coal seams having high grade coal. The present finding thus, opens up new possibilities for the search of Karharbari coal in Godavari Basin which is known to contain the large better quality coal. The Upper Member of the Barakar Formation containing workable coal seams of the area corresponds palynologically with the Lower Barakar. The sediments containing Upper Barakar palynoflora are virtually devoid of coal facies in the present bore-hole investigated.

The Barren Measures palynoflora present in both the bore-holes shows a complete epibole and confirms palynologically the existence of Barren Measures Formation in Ramagundam area of Godavari Valley coalfields. Obviously, this parameter can help in delineating Barren Measures Formation in other areas of Godavari Valley coalfields indicating the possible evidence of underlying Barakar Formation and the overlying Lower Member of the Kamthi Formation, both of which are promising coal horizons in this basin.

CONCLUSIONS

The palynological investigation of the Lower Gondwana sediments in the subsurface sediments of Ramagundam and Ramakrishnapuram areas in Godavari Valley coalfields suggests the following points:

1. The palynological succession, in general, corresponds with the palynological successions known from other Lower Gondwana basins of India.
2. Karharbari palynoflora has been recognised palynologically in a lithologically undifferentiated Barakar sequence. Further, a slight discordance is apparent on the basis of palynological evidences in one of the bore-holes (GGK-20) before the commencement of Barren Measures sequence.
3. Existence of Barren Measures Formation in Ramagundam area has been confirmed by palynological evidences.

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