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Permian Palynoflora from Lower Gondwana Sediments of Godavari Valley Coalfield, Andhra Pradesh, South India

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Abstract
Palynological investigation of Lower Gondwana sediments of Goutham Khani Open Cast Mine (GKOCM) from Kothagudem sub basin of Godavari Valley Coalfield, Andhra Pradesh of Peninsular India have revealed two palynoassemblages are related to Early Permian (Barakar Formation). Palynoassemblage – A abundantly occurrence of Scheuringipollenites along with other common taxa like Parasaccites, Ibisporites, Primuspollenites, Sulcatisporites, Rhizomaspora, Densipollenites and Corisaccites and Palynoassemblage – B dominated by Scheuringipollenites along with sub dominance of Faunipollenites, Striatopodocarpites, Parasaccites, Striatites, Tiwariasporis, Rhizomaspora, Verticipollenites, Platysaccus, Primuspollenites, Lunatisporites, Latosporites, Ibisporites and Distriatites. The above demarcated palynoassemblages are applied to correlate with other horizons of Lower Gondwana deposits of India and also to fix the relative age for the sediments under investigation.
Key words: Permian Age, Lower Gondwana, Palynoassemblage, Godavari Valley Coalfield, Sothern India.

1.Introduction

Gondwana sediments of India can be broadly classified under two main geographic areas like Peninsular and Extra Peninsular regions. Presently based on Gondwana floral remains like mega and micro fossil evidences can be applied to divide in to Lower Gondwana and Upper Gondwana sometimes Middle Gondwana with remains of *Dicardium* floral (mixed characters of both Monocot and Dicots) remains.

Godavari Valley coalfield is a store house for non coking coal varity in Southern India. Covers an area of about 17000 sq. km (350 kms. strike length and width 50 kms) are bounded by North Latitude 16^0 32' to 19^0 33' and East Longitude 79^0 12' to 81^0 39' covers in the districts of Adilabad, Karimnagar, Warangal, Khammam and West Godavari of Andhra Pradesh eastern region of India. Its aerial extent covers about 27% of the total area. Kothagudem coal belt is located in Southern part of Godavari valley coal field. Goutham Khani Open Cast Mine (GKOCM) is located in Southeastern part of Kothagudem coal belt of Khammam district of Andhra Pradesh. The total area covers of about 2.85 sq. km (designated block) only 2.57 sq km only as quarry limit, lying between North Latitude of 17^0 27'18'' and 17^0 28'04'' and East Longitude of 80^0 37'30'' and 80^0 39'45'' falls in the survey of India topo sheet no. $65^C/_{11}$ (Fig.1).

2.Geology of the study area

Present open cast coal mine is a rectangular block with long axis approximately aligned in NE – SW direction and located at Bolligutta hills from Northern region. While in the southern boundary of the block is manifested with parallel inclined tunnels are driven for the purpose of coal exploration. Whereas in western region bounded with 9 and 10 numbers of incline tunnels and while on the eastern region with faults are noticed. Basinal structures are complex in nature, manifested with 34 faults with 10 to 200 m throw pinching and swelling behaviour of seams and all coal seams are inclined towards centre of the basin. The roof of the coal seam comprises with white and red sandstone beds with an average thickness of 45 m. In GKOCM, the middle part of sandstone bed intercalated with shaly coal and in some area covered with the brownish red sandstone. Below the sand stone upper part is occupied by top coal seam which is non workable because of its high ash content in it and also with intercalation with the overburden of sandstone beds. Present field study witnesses with cyclic sedimentation of sequences of sandstone beds.

From the evidence of field investigation Bolligutta hill area shows the Gondwana – Proterozoic contact stands up as a basement ridge all along the northern boundary. Topographically the area elevated upto 154.1 m above mean sea level as per the field data.

Lower Gondwana sequence of Godavari Valley basin was first recorded by Walker (1841) near Kota village later followed by a detail geological investigation was carried out by Wall (1857), Branford (1871), King (1872, 1881) Hughes (1877) and Raja Rao (1982). The general Lithostratigraphy of Permian sequence of Pranhita - Godavari basin was first described by King (1881). The maiden geological work on Pranhita-Godavari valley coal field carried out by King (1881). Later, by Sir William King, 1872-88 has completed the mapping of entire coal field and he suggested based on field data proposed two fold stratigraphic division for Gondwana sediments in to Lower and Upper Gondwana. Later, modified by various workers but recent lithostratigraphic classification was proposed and published by Raja Rao (1982) (Table.1). Later Pranhita-Godavari basin has been revised by several workers including Raja Rao, 1982; Ramanamurthi, 1985, G.

Lakshminaryana and Murti, 1990; Dasgupth,1993; Murthy and Madhusudan Rao,1996; R.C.Tewari,1998 . The Godavari valley coal field of Lower Gondwana basin comprises more or less a complete succession of the sedimentary sequence of Permo- Triassic and as well as some parts assigned to Jurassic age which comprises thickness of around 4000-5000m (SCCL.1995).

The Goutham Khani open cast coal belts are mainly divided into three coal seams according to Singareni Collieries Company Limited (1995). The three coal seams are termed as:

1. Bottom Upper seam thickness is around 8 to 11 m
2. Bottom Middle seam measures thickness is 15 to 17 m
3. Bottom Lower seam thickness is around 28 to 37 m

Present palynological studies pertain only to the open cast coal seams and top cover fine grained sandstone part.

The seam wise coal analysis reveals the following characters like moistures, ash contents in the coal seams are given. The seams are not uniform in thickness but also bottom seam thickness is maximum with maximum moisture and with ash percentage decreases accordingly. Top and Middle coal seams are fixed 'F' grade coal and Bottom coal seam as 'E' grade of coal. All coal seams in the open cast mining are workable in nature.

Seam	Thickness(m)	Moisture (%)	Ash (%)	Coal Grade
Top	8 to 11(3)	4.8	46.19	F
Middle	15 to 17 (2)	5.11	41. 27	F
Bottom	28 to 37 (9)	6.51	25.68	E

(After SCCL 1995)

3.Material and methods

Eighteen representative samples were collected from following order of super position from seam wise like bottom, middle and top seams of GKOCM. A fresh cleaned sample burnt with alcohol avoiding external contaminations if any are digested with HCl (10%) to remove all carbonate materials, further treated with HF (40%) to digest silica materials from the sample and finally treated with conc.HNO_3 to remove any humic materials if present in the samples. Acid treated samples were sieved with 20 micron sieve cloth, avoiding heavy liquid separation stage. In this sieving stage palynofossils yield will be more than in heavy liquid / oil floatation stage. Three to four palynoslides were prepared from each sample by mounting and cooking with canadabalasam as permanent palynoslides were prepared and labelled. All palynoslides are observed all detail palynomorphic structures under phase contrast binocular microscope and micro photographed.

4.Palynological analysis

Eighteen samples are analyzed from the GKOCM for the palynological investigated thoroughly. Out of eighteen samples eight samples were yielded sufficient palynomorphs from top seam and fine grained sandstone with intereticulation of thin layer of shaly coal beds. During the palynological slide observation that the amount of palynofossils were less in yielded but only in bottom and middle seams. Recovered palynotaxa from coal seams and also from fine grained sandstone are well distributed according to the coal seams wise (Fig.2). Recovered and observed palyno taxa are illustrated through photographic plate I.

During palynological investigation that the palynoassemblages are present in GKOCM which includes highly diversified palyno forms like non striate bisaccates followed by monosaccates and striate bisaccates from the area under consideration. The palynomorphs monosaccate, alete, non striated bisaccates, striate bisaccates are recovered from the bottom, middle, top seams and also fine grained sandstone with thin shaly coal bands and also projected statistically as sketch showing percentage according to lithological succession (Fig.3). From this palynological analysis it is interesting to note that the trilete forms are not to be found during the observation from any of the samples. This strongly suggests Barakar age for the sediments under investigation. A detail account on samples, order of superposition, percentage of taxa and palynoassemblages wise of GKOCM have supplemented (Fig.4).

4.1.Palynoassemblage A

The retrieved palynotaxa forms from the top seam reveals the abundance of *Scheuringipollenites* (52.5%) with other common taxa like *Parasaccites* (12.65%), *Ibisporites* (8.25%), *Primuspollenites* (7.6%), *Sulcatisporites* (6.2%), *Rhizomaspora* (6%), *Densipollenites* (4%) and *Corisaccites* (3%) reported as assemblage **A.**

4.2.Palynoassemblage B

The palynotaxa from sandstone intercalated with bands of shaly coal comprises with high percentage of *Scheuringipollenites* (42.2%) along with sub dominance of *Faunipollenites* (18.2%), *Striatopodocarpites* (11%) and *Parasaccites* (6.65%) and other taxa *Striatites* (4%), *Tiwariasporis* (3%), *Rhizomaspora* (3%), *Verticipollenites* (2%), *Platysaccus* (2%), *Primuspollenites* (2%), *Lunatisporites* (1%), *Latosporites* (1%), *Ibisporites* (1%) and *Distriatites* (1%) falls in palynoassemblage **B.**

5.Comparison and Correlation

Palynoassemblage of *Scheuringipollenites* **A & B** Palynoflora compared with Lower Barakar Formations of Korba coalfield (Zone-3, Bharadwaj and Srivastava 1973) and Zone – 2 of Giridih coalfield (Srivastava 1973a). *Scheuringipollenites* rich assemblage has also been reported from Johilla Coalfield (Zone-3, Anand Prakash and Srivastava 1984), Umaria coalfield (zone-3 Srivastava and Anand Prakash 1984). Palynoassemblage - **A & B** is comparable with Godavari Valley coalfield palynoassemblages of Ramagundam area (Assemblage **C** Srivastava and Jha 1989), Ramakrishnapuram area (Srivastava and Jha 1992), Manuguru area (Palynoassemblage **3** of Srivastava and Jha 1992a), Budharam area (palynozone 5 of Srivastava and Jha 1995) and from Koyagudem area (Palynozone 2 of Srivastava and Jha 1996). Kar (1973) investigated palynozone from bore core KB 21. Tiwari et. al., (1981) recorded *Scheuringipollenites* dominant zone form Katrinala section of Jharia coalfield of MP. The present palynoassemblage - **A & B** is correlates with palynoassemblage – D of boreholes MLG – 23 and 28 of Gundal area of Godavari valley coalfield were found to be dominance with *Scheuringipollenites* (Neerja Jha & Neha Aggarwal, 2011) and also with palynoassemblage – III of bore hole MMK – 19 of Mamakannu area (Neerja Jha & Neha Aggarwal, 2010). Palynoassemblage - **A & B** is correlates with dominance of *Scheuringipollenites* with other taxa from borehole GSP – 9 of Satrajpalli area of Godavari Graben (Neerja Jha & Neha Aggarwal, 2010). All above mentioned Palynoassemblages reported by various authors from other areas are comparable with the present *Scheuringipollenites* A and B. Presence of *Scheuringipollenites* assemblage A and B supports that similar floral
distribution pattern in the present area of investigation.

6.Conclusion

Palynological data reveals that an interesting point to note that the GKOCM of Kothagudem sub basin of Godavari suggest very rich diversified vegetation remains as marks with the presence of rich palynofossil assemblage during the deposition of sediments. According to Tiwari and Chandra Das (1996) the occurrence of cyclic sequence of sandstone reveals braided depositional environment condition. During present investigation also with similar cyclic sequence of sandstone occurrence suggest that under braided depositional environment condition found in Kothagudem sub basin too. Palynological studies from the present area also the palynoassemblages of GKOCM suggests the abundance of *Scheuringipollenites* from the top seam of Goutham Khani open cast mine (GKOCM) belongs to Palynoassemblage - **A** indicates Lower Barakar Formation affinity towards Early Permian age. *Scheuringipollenites* shows rich in abundance from the sandstone with intrareticulation / intercalation of shaly coal beds of Goutham Khani Open Cast Mine (GKOCM) belongs to palynoassemblage – **B** strongly supports Lower Barakar Formation affinity suggests Early Permian age. The top sequence in open cast mine is fine grained sandstone beds reveals host for good number of palynofossils during the deposition but the sequence of medium grained sandstone reveals very poor in occurrence palynofossils may be due to medium grain size of sandstone. Differential in palynofossils yield may be due to sandstone grain size as the controlling factor. All the data through palynological investigations were seems to suggest Early Permian period of Indian Lower Gondwana coal formation.

Acknowledgment

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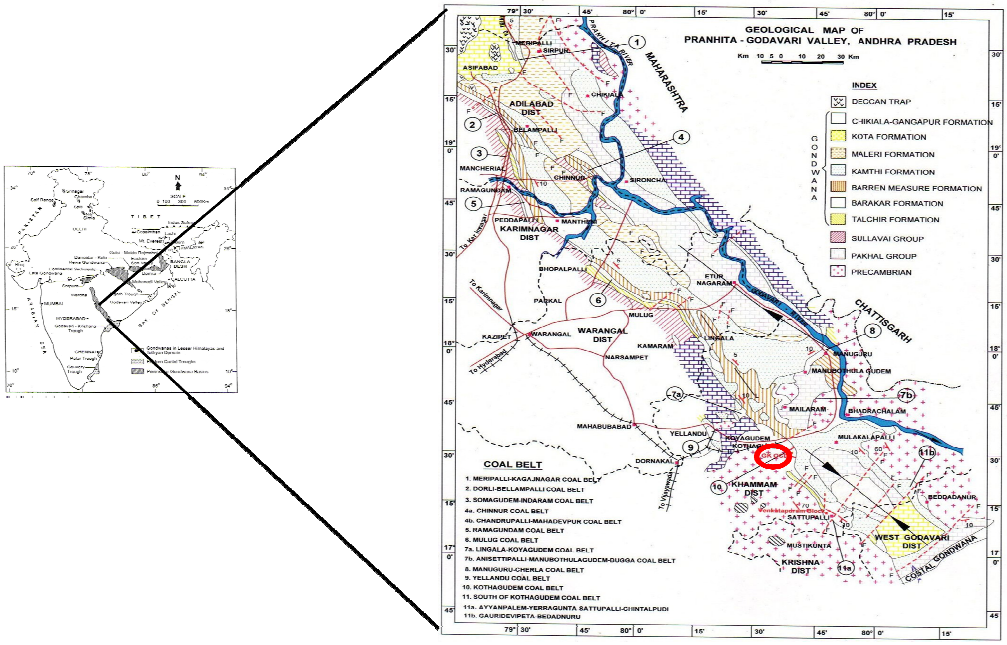


Fig.1. Geological and location map of Godavari valley Coalfield (After: SCCL 2008)

	Bottom seam	Middle seam	Top seam	Sandstone
Densipollenites	x	x	x	
Vestigisporites	x			
Playfordiaspora		x		
Tiwariasporis				x
Latosporites	x	x		x
Sulcatisporites			x	
Virkkipollenites	x			
Parasaccites	x		x	x
Plicatipollenites				x
Lueckisporites				x
Lunatisporites				x
Corisaccites			x	
Striatites				x
Verticipollenites				x
Striatopodocarpites				x
Faunipollenites				x
Distriatites				x
Rhizomaspora		x	x	x
Primuspollenites			x	x
Crescentipollenites	x			
Scheuringipollenites		x	x	x
Ibisporites		x	x	x

Fig. 2. Coal seam wise distribution of palynotaxa present in GKOCM

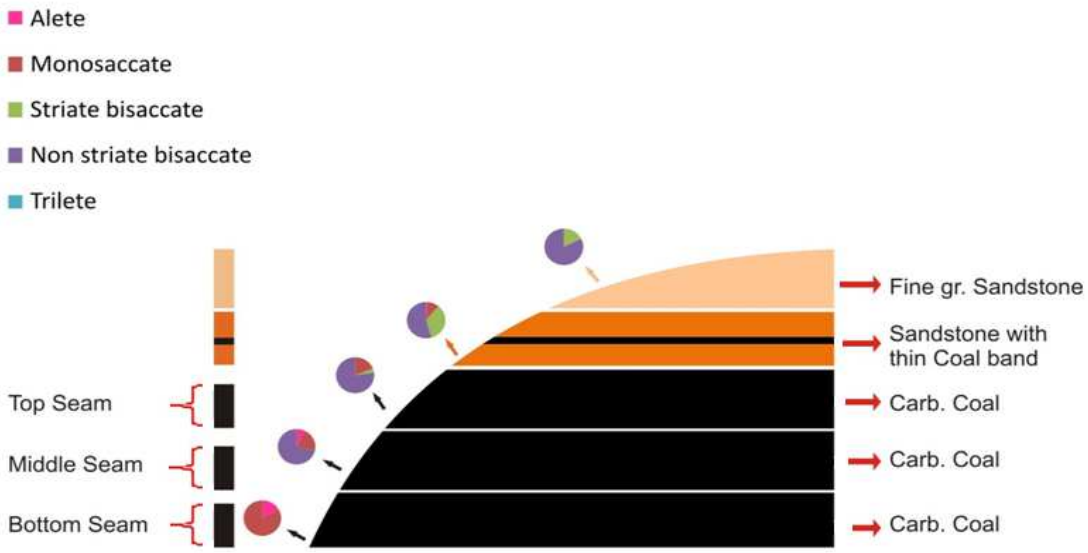


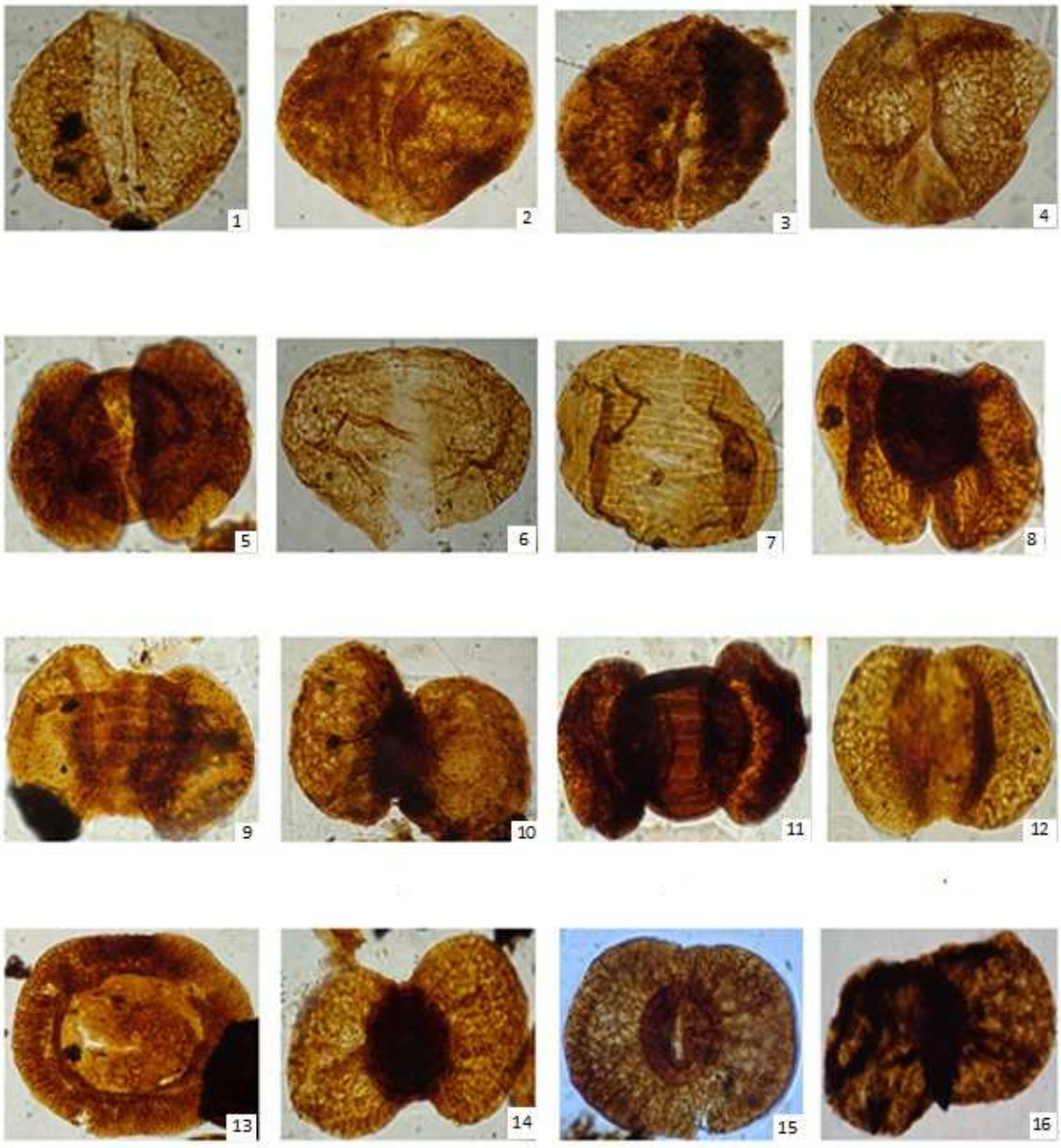
Fig. 3. Sketched illustration showing percentage and distribution of Palynoforms from lithology of GKOCM

Age	Group	Formation	Maximum Thickness (m)	Lithology
			500	*Upper Member:* Coarse-grained, ferruginous sandstones with Lower Triassic clay, clasts and pebbles and subordinate violet cherty siltstones and pebble beds.
Upper Permian to Lower Triassic		Kamthi	600	*Middle Member:* Alternating Sequence of medium-grained white to greenish grey white sandstones and buff to greenish grey clays.
			200	*Lower Member:* Medium to coarse-grained, greyish white calcareous sandstones with a few coal seams.
Late Permian	LOWER GONDWANA	Barren Measures	500	Medium to coarse-grained, greenish grey to greyish white felspathic sandstones with subordinate variegated and micaceous sandstones.
Upper part of Lower Permian		Barakar	300	*Upper Member:* Coarse, white sandstones with subordinate Lower Permian shales and coal seams.
				Lower Member: Coarse-grained sandstones with lenses of conglomerates, subordinate shales/clays and a few thin bands of coal.
Early Permian		Talchir	350	Fine-grained sandstones, splintery green clays/shales, chocolate coloured clays, pebble beds and tillite.
				- - - - - - - -Unconformity - - - - - -
? Late Proterozoic		Sullavai	545	Medium to coarse-grained, white to brick red sandstones, at place quartzitic and mottled shales.
				- - - - - - - -Unconformity - - - - - -
Early Proterozoic		Pakhal	3355	Greyish white to buff quartzites, grey shales, phyllites and marble.
				-- - - - - - - -Unconformity - - - - -
Precambrian		-	-	Granites, banded gneisses, biotite gneisses, hornblende gneisses, quartz magnetite schists, biotite schists, quartz and pegmatite veins.

Table 1. Lithostratigraphy of Godavari Valley Coalfield (After Raja Rao, 1982).

Sl. No.	OCM Seam	Lithology of the samples	Dominant taxa	Subdominant taxa	Other taxa	Palynoflora	Assemblage	Age
1		Sandstone	Scheuringipollenites, Faunipollenites, Striatopodocarpites, Striatites, Tiwariasporis and Lunatisporites	Not yielded.				
2		Sandstone with shaly coal	Scheuringipollenites (42.2%)	Faunipollenites (18.2%), Striatopodocarpites (11%) and Parasaccites (6.65%).	Striatites (4%), Tiwariasporis (3%), Rhizomaspora (3%), Verticipollenites (2%), Platysaccus (2%), Primuspollenites (2%), Lunatisporites (1%), Latosporites (1%), Ibisporites (1%) and Distriatites (1%).	Barakar	**B**	Early Permian
3	Top	Carbonaceous coal	Scheuringipollenites (52.5%)	Parasaccites (12.65%), Ibisporites (8.25%), Primuspollenites (7.6%),	Sulcatisporites (6.2%), Rhizomaspora (6%), Densipollenites (4%) and Corisaccites (3%).	Barakar	**A**	Early Permian
4	Middle	Carbonaceous coal	Densipollenites, Latosporites, Ibisporites, Playfordiaspora, Rhizomaspora and Scheuringipollenites	Not yielded				
5	Bottom	Carbonaceous coal	Densipollenites, Latosporites, Parasaccites and Virkkipollenites	Not yielded				

Fig. 4. Table showing details of samples, depth control and characters of palynoassemblages in Gautham Khani Open Cast Mine



Palte I Explanation of Photographic Plate

(All the photographs are taken under 1000 x magnifications in oil immersion until and unless mentioned)
1,2. Faunipollenites perexiguus, 3. Scheuringipollenites ovatus, 4. Scheuringipollenites tentulus, 5.Straiatipodocarpites labrus, 6.Faunipollenites varius, 7. Tiwariasporis sp., 8. Rhizomaspora monosulcata, 9. Striatites tentulus, 10. Platysaccus densus, 11. Striatites cf reticuloidus 12.Lunatisporites cf amplus, 13. Plicatipollenites gondwanensis, 15. Platysaccus sp., 14, 16. Rhizomaspora costa.