International Journal of Geology, Earth & Environmental Sciences ISSN: 2277-2081 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jgee.htm
2015 Vol. 5 (3) September-December, pp. 98-107/Joshi et al.
Research Article

PALYNOLOGICAL STUDIES IN SUB-SURFACE SEDIMENTS FROM JANGAREDDYGUDEM AREA, CHINTALAPUDI SUB-BASIN, GODAVARI GRABEN, ANDHRA PRADESH, INDIA

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ABSTRACT
The present study has been carried out on thirty seven sub-surface samples from a bore core MJR-13 which was drilled in Jangareddygudem area of Chintalapudi Sub-basin, Godavari Graben in order to palynologically date the samples. Two palynoassemblages have been identified in this sedimentary sequence, the palynocomposition of which suggest a Late to latest Permian age to the sequence. Palynoassemblage I have been demarcated between the depth interval of 247.60 m to 232.10 m and is characterized by the dominance of striate bisaccates chiefly *Faunipollenites* and *Striatopodocarpites* in association with high incidence of *Striasulcites*. It indicates a Late Permian affinity. Palynoassemblage II has been demarcated between the depth interval of 198.60 m to 180.55 m which is also characterized by the dominance of striate bisaccates but with high incidence of *Densipollenites* in association with stratigraphically younger elements such as *Alisporites*, *Falcisporites*, *Klausipollenites*, and *Guttulapollenites* thus a latest Permian age has been assigned to this part of the sequence.

Keywords: *Late Permian, Raniganj, Jangareddygudem Area, Godavari Graben, India*

INTRODUCTION
The Pranhita–Godavari basin is a linear belt which rests on the Precambrian platform trending in the NNW-SSE direction. The basin covers an area of about 17,000 sq. km and is bound by latitudes 16°380, 19°32’ and longitudes 79°12, 81°390. It extends for a length of 470 km from the North of Boregaon in Maharashtra up to Eluru in the East Coast of Andhra Pradesh. The basin has an average width of 55 km with a constriction of 6 km width in the Paluncha–Kothagudem area. The gravity anomalies show that it is a major rift valley where the Gondwana sediments were deposited in a successively developed block faulted trough (Qureshy *et al.,* 1968). The Pranhita–Godavari basin is divided into four sub-basins based on structure and tectonics *viz.* (i) Godavari Sub-basin, (ii) Kothagudem Sub-basin, (iii) Chintalapudi Sub-basin and (iv) Krishna–Godavari Coastal tract. The present paper deals with the sub-surface sedimentary succession in bore core MJR-13 from Jangareddygudem area of Chintalapudi Sub-basin. The main objective of the study is to date the sequence based on palynological studies. Age deductions have also been drawn by comparison with co-eval sequences from intrabasinal, interbasinal and Gondwana wide context.
Several bore cores have been analysed for palynological studies in different parts of the Chintalapudi Sub-basin by different authors. Bottapagudem (Jha, 2004), Amavaram (Srivastava and Jha, 1992) from northeastern margin while Sattupalli (Jha, 2008; Srivastava and Jha, 1994) and Ayyanpalli-Gompana (Srivastava and Jha, 1993) areas from northwestern margin and Gattugudem (Jha, 2002) area of the central part of the sub-basin are subjected palynological investigations.
In the present communication, lithosequence MJR-13 from Jangareddygudem area, located on the northeastern margin of the sub-basin has been rendered for palynological studies meant for understanding of the stratigraphy, and palynofloral transition in the Godavari Graben.
Bore core MJR-13 was drilled in Jangareddygudem area by Singareni Collieries Company Limited (SCCL), Andhra Pradesh, India which is a Government coal mining company jointly possessed by the Government of Andhra Pradesh and Government of India. The details of the location map for bore hole MJR-13 are given in Figure 1.

Geology of the Area

The Pranhita-Godavari Graben, Andhra Pradesh is linear NNW-SSE trending intracratonic rift coalbelt resting on Precambrian/Vindhyan rock platform, extending from north of the Boregaon, Maharashtra in north to Eluru in the east coast of Andhra Pradesh in south. Pranhita-Godavari basin consists of marine, terrestrial and paralic signatures in the deposits comprising of Permian, Triassic, Jurassic including Lower Cretaceous periods displaying the complete span of the Gondwana period in South Indian Peninsula. In this linear belt the Lower Gondwana sediments are exposed along both the eastern and western margins of the basin while the upper Gondwana sediments cover the central/axial portion. The Lower Gondwana succession consist of Talchir, Barakar, Barren Measures and Raniganj formations, while the Upper Gondwana formations are Kamthi, Maleri, Kota and Gangapur.

The Gondwana rocks of Chintalapudi Sub-basin were earlier referred to as Kamthi Sandstone (Blanford, 1872), Kamthi Formation (Raja, 1982) and Chintalapudi Formation (Raiverman *et al.*, 1986) and it was stated that this sub-basin belongs the younger generation, developed mostly during the Kamthis as represented by the general absence of Barakar and Barren Measures Formation over a large part of the sub-basin. Lakshminarayana and Murti (1990) and Lakshminarayana (1996) have revised the stratigraphic set up and observed the existence of the Upper Gondwana sequence and also the Talchir and Barakar Formations. Based on the surface and subsurface data, revised stratigraphy of the Chintalapudi Sub-basin in which Barakars are also overlain by Kamthi Formation. Raiverman *et al.*, (1986) told that basin mainly comprises of Kamthi Formation in having the absence of Barakar and Barren Measures formation. But later in the different areas of this sub-basin different workers *viz.*, Srivastava and Jha (1993) in Ayyanapalli Gompana; Srivastava and Jha (1992) in Amavaram; Srivastava and Jha (1994) in Sattupalli; Jha (2002) in Gattugudem and Jha (2004) in Bottapagudem have confirmed palynologically the presence of Talchir, Karharbari, Barakar and Raniganj palynoassemblages in this sub-basin.

The stratigraphy of this sub-basin consists of many small faults and gross reduction in the thickness of intervening Barren Measures strata between the coal-bearing horizons, Barakar and Raniganj formations from north to south of Godavari Graben. Barren Measures are almost non-existent in Chintalapudi Sub-basin and coal-bearing horizons are distributed throughout the sequence. Hence, the dating and correlation of coal-bearing and associated horizons become difficult.

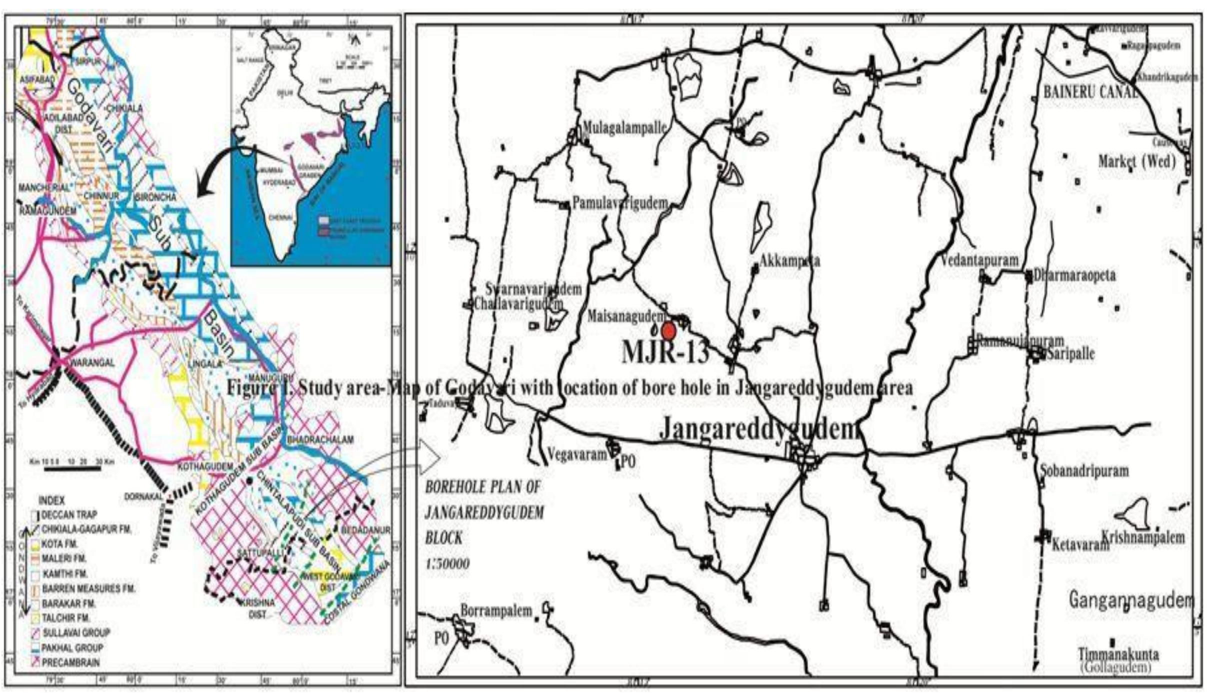

Figure 1: Study area-Map of Godavari with location of bore of hole in Jangareddygudem area

The present study will be undertaken in an unexplored, Jangareddygudem, Chintalapudi Sub-basin for palynostratigraphy and age interpretations and its correlation with Kothagudem & Godavari Sub- basins will be studied. Stratigraphic sequence in Chintalapudi Sub-basin is given in Table-1 (after Lakshminarayana, 1996).

Table 1: Stratigraphical sequence in Chintalapudi Sub-basin (after Lakshminarayana, 1996)

Age	Group	Formation	Lithology
L.PERMIAN - E.TRIASSIC	LOWER	Kamthi	Conglomerate, conglomeratic sandstone, siltstone and grey shales
Early	G O N D W A N A	Unconformity	
P E R M I A N		Barakar	**UPPER:** White felspathic sandstone, siltstone, shale, carbonaceous shale and coal seams **LOWER:** Very coarse grained, pebbly, feldspathic sandstone
		Talchir	Diamictite, rhythmite, fine-grained light green sandstone and siltstone
Unconformity			
Proterozoic Archaean			

MATERIALS AND METHODS

Seven sediment samples from the bore core MJR-13 from Jangareddygudem area drilled by the Singareni Collieiries Company Ltd. (Figure 2).

Samples were processed by standard palynological techniques which involve treatment of sediments with hydrofluoric acid, nitric acid.

This was followed by alkali treatment. The materials were sieved through a 400 micra mesh and palynological slides were prepared using Canada balsam as mounting medium. The samples were studied with an Olympus BX 61 microscope. Photographs of palynomorphs were taken with DP-25 camera using Cell A software.

The quantitative analysis is based on 200 specimens count. Coordinates of the specimens are denoted by England Finder coordinates. The slides are housed at the Museum, Birbal Sahni Institute of Palaeobotany, Lucknow.

RESULTS AND DISCUSSION

Results

The palynomorph assemblages comprise 45 genera of spores and pollen taxa, of which two genera belong to Sphenophyta, three to Pterophyta.

The Gymnosperms are represented by seven monosaccate grains, nine striate bisaccate grains, fifteen non-striate bisaccate grains, four taeniate grains and three costate grains, while two grains are of algal affinity.

List of palynocomposition at each depth in the bore core is given under Table 2. The recovered pollen grains range from well preserved to broken state. Stratigraphically significant taxa have been illustrated in Figure 3.

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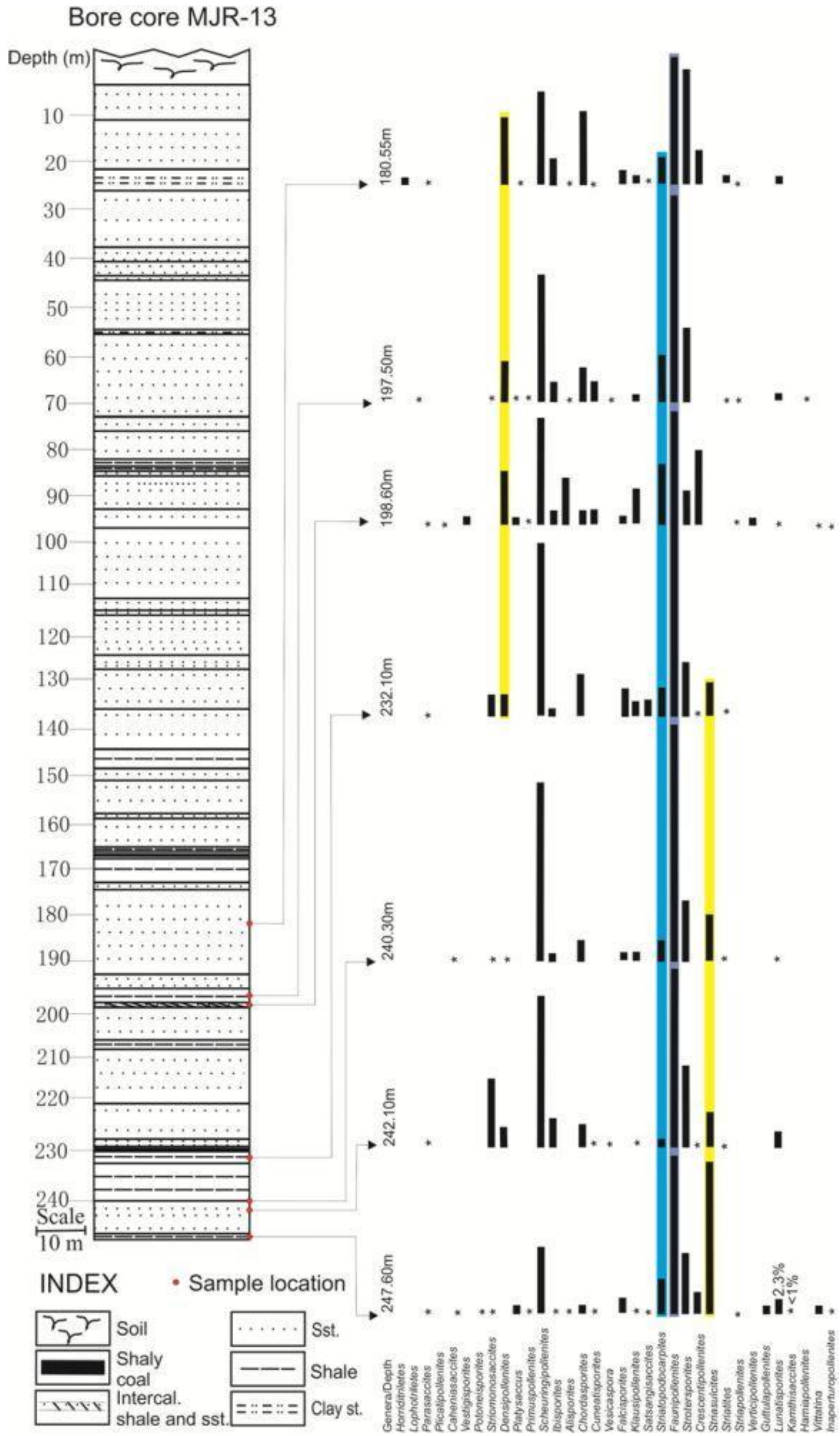

Figure 2: Sedimentary sequence of bore core MJR-13 with palynomorph histogram

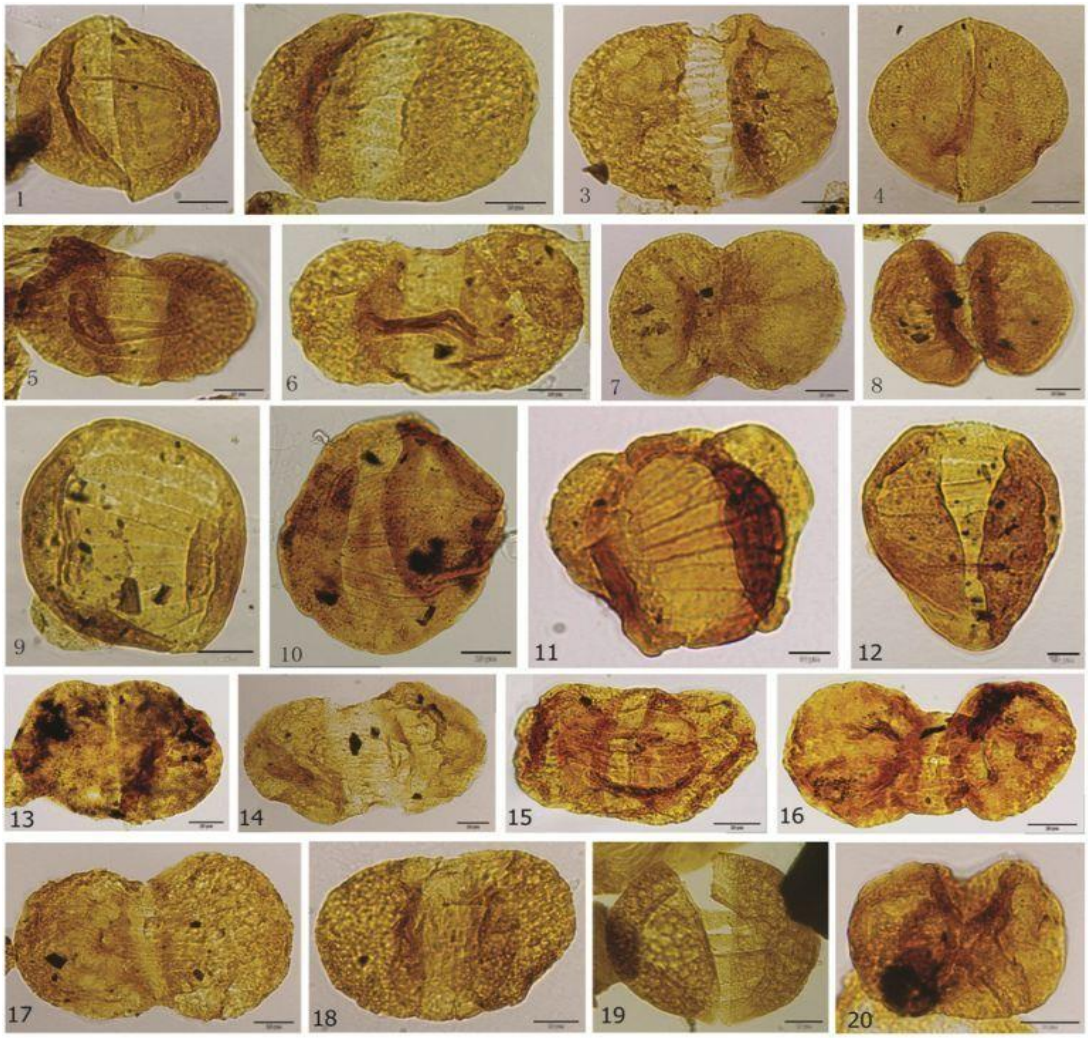

Figure 3: Palynomorph Plate showing significant taxa 1. *Faunipollenites*, BSIP Slide No. 15626, P57-3; 2. *Faunipollen*, BSIP Slide No. 15627, K48-3; 3. *Faunipollenites*, BSIP Slide No. 15623, K49; 4. *Faunipollenites*, BSIP Slide No. 15626, U57-4; 5. *Strotersporites*, BSIP Slide No. 15627, P45-4; 6. *Chordasporites*, BSIP Slide No. 15624, M44-3 60X; 7. *Striatites*, BSIP Slide No. 15626, P32-4; 8. *Striatites*, BSIP Slide No. 15627, K55-2; 9. *Striasulcites tectus*, BSIP Slide No. 15627, G62-1; 10. *Striasulcites tectus*, BSIP Slide No. 15628, E62, 60X; 11. *Striasulcites tectus*, BSIP Slide No. 15627, U54-4; 12. *Striasulcites tectus*, BSIP Slide No. 15626, H38-4; 13. *Striatopodocarpites*, BSIP Slide No. 15624, S33-3, 60X; 14. *Faunipollenites*, BSIP Slide No. 15623, K35-2; 15. *Crescentipollenites*, BSIP Slide No. 15624, 46, 60X; 16. *Striatites*, BSIP Slide No. 15622, H51-4, 60X; 17. *Striatites*, BSIP Slide No. 15623, G49-1; 18. *Striatopodocarpites* BSIP Slide No. 15623, A, M39-1; 19. *Lunatisporites*, BSIP Slide No. 15621, S61-2; 20. *Verticipollenites*, BSIP Slide No. 15632, C37-4

Palynoassemblage I

It has been discriminated at the depth level of 247.60 m to 232.10 m. The palynoassemblage is characterized by the dominance of striate bisaccates chiefly species of *Faunipollenites* (24-36 %), along with *Striasulcites* (5-23%) are representative of the palynoassemblage. The other significant palynomorphs marked their presence in the palynoassemblage are *Klausipollenites* (1-5%), *Crescentipollenites* (0-3%), *Striatopodocarpites* (2-6%), *Lunatisporites* (0-2%), *Alisporites* (0-1%), *Caheniasaccites* (0-1%), *Chordasporites* (1-7%), *Cuneatisporites* (0-1%), *Densipollenites* (0-5%), *Falcisporites* (0-2%), *Ibisporites* (1-4%), *Inaperturopollenites* (0-1%), *Latosporites* (0-3%), *Parasaccites*

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(0-1%), *Scheuringipollenites* (10-28%), *Striomonosaccites* (1-3%) *Strotersporites* (0-9%) and *Vittatina* (0-1%). Other recorded palyno-components, those are present in the assemblasge below two percent are represented by *Crucisaccites, Dicappipollenites, Guttulapollenites, Kamthisaccites, Lophotriletes, Platysaccus, Primuspollenites, Protoeusaccites, Rhizomaspora, Satsangisaccites, Striapollenites, Striatites, Tiwariasporis, Vesicaspora.*

Palynoassemblage II

This is marked between the depths of 198.60 m to 180.55 m.

Table 2: List of palynocomposition at each depth in the bore core MJR-13

BORE CORE	**DEPTH**	TAXA
MJR-13/14	180.55m	*Faunipollenites* (19%), *Densipollenites* (11%), *Alisporites* (+), *Calamospora* (+), *Chordasporites* (12%), *Crescentipollenites* (5%), *Cuneatisporites* (1%), *Falcisporites* (3%),*Horriditriletes* (1%), *Ibisporites* (4%), *Klausipollenites* (2%), *Lunatisporites* (2%), *Parasaccites* (+), *Platysaccus* (+), *Scheuringipollenites* (14%), *Striapollenites* (+), *Striatites* (2%), *Striatopodocarpites* (4%), *Strotersporites* (18%), *Weylandites* (1%).
MJR-13/16	197.50m	*Faunipollenites* (32%), *Densipollenites* (6%), *Alisporites* (1%), *Chordasporites* (6%), *Cuneatisporites* (4%), *Hamiapollenites* (+), *Ibisporites* (3%), *Klausipollenites* (2%), *Latosporites* (+), *Lophotriletes* (+), *Lunatisporites* (1%), *Monosulcites* (+), *Platysaccus* (+), *Primuspollenites* (1%), *Scheuringipollenites* (19%), *Striapollenites* (+), *Striatites* (1%), *Striatopodocarpites* (7%), *Striomonosaccites* (1%), *Strotersporites* (11%), *Vesicaspora* (+), *Weylandites* (+).
MJR-13/17	198.60m	*Faunipollenites* (18%), *Densipollenites* (8%), *Alisporites* (7%), *Chordasporites* (2%), *Crescentipollenites* (11%), *Cuneatisporites* (2%), *Falcisporites* (1%), *Ibisporites* (2%), *Inaperturopollenites* (+), *Klausipollenites* (6%), *Limitisporites* (+), *Lunatisporites* (+), *Parasaccites (+), Platysaccus* (1%), *Plicatipollenites* (+), *Primuspollenites* (+), *Sahnites* (+), *Satsangisaccites* (1%), *Scheuringipollenites* (17%), *Striapollenites* (+), *Striatopodocarpites* (9%), *Strotersporites* (5%), *Verticipollenites* (2%), *Vestigisporites* (2%), *Vittatina* (+).
MJR-13/19	232.10m	*Faunipollenites* (31%), *Densipollenites* (3%), *Chordasporites* (7%), *Crescentipollenites* (1%), *Crucisaccites* (+), *Ibisporites* (2%), *Klausipollenites* (5%), *Parasaccites* (+), *Protoeusaccites* (+), *Scheuringipollenites* (26%), *Striasulcites* (5%), *Striatites* (+), *Striatopodocarpites* (5%), *Striomonosaccites* (3%), *Strotersporites* (9%).
MJR-13/21	240.30m	*Faunipollenites* (36%), *Striasulcites* (8%), *Caheniasaccites* (+), *Chordasporites* (3%), *Densipollenites* (+), *Falcisporites* (1%), *Ibisporites* (2%), *Klausipollenites* (2%), *Latosporites* (3%), *Leiotriletes* (+), *Lunatisporites* (+), *Rhizomaspora* (+), *Scheuringipollenites* (28%), *Striatites* (+), *Striatopodocarpites* (4%), *Striomonosaccites* (1%).
MJR-13/22	242.10m	*Faunipollenites* (28%), *Striasulcites* (6%), *Calamospora* (+), *Chordasporites* (4%), *Crescentipollenites* (+), *Cuneatisporites* (+), *Densipollenites* (5%), *Ibisporites* (4%), *Klausipollenites* (+), *Lunatisporites* (2%), *Parasaccites* (+), *Scheuringipollenites* (23%), *Striatites* (+), *Striatopodocarpites* (2%), *Striomonosaccites* (1%), *Vesicaspora* (+).
MJR-13/23	247.60m	*Faunipollenites* (24%), *Striasulcites* (23%), *Alisporites* (+), *Caheniasaccites* (+), *Chordasporites* (1%), *Crescentipollenites* (3%), *Crucisaccites* (1%), *Cuneatisporites* (+), *Dicappipollenites* (1%), *Falcisporites* (2%), *Guttulapollenites* (2%), *Ibisporites* (1%), *Inaperturopollenites* (1%), *Kamthisaccites* (1%), *Klausipollenites* (+), *Latosporites* (1%), *Lophotriletes* (+), *Lunatisporites* (2%), *Parasaccites* (1%), *Platysaccus* (1%), *Potoniesporites* (+), *Primuspollenites* (+), *Satsangisaccites* (1%), *Scheuringipollenites* (10%), *Striapollenites* (1%), *Striatopodocarpites* (6%), *Striomonosaccites* (1%), *Tiwariasporis* (+), *Vittatina* (1%).

The palynoassemblage is distinguishable by the chief representation of striate bisaccates with *Densipollenites* (6-11%). In the palynoassemblage most of the striate bisaccates are represented by *Faunipollenites* (18-32%), *Striatopodocarpidites* (4-9%), *Striapollenites* (1%), *Striatites* (1-2%), *Crescentipollenites* (0-11%), *Strotersporites* (5-18). While other taxa those are contributing to the palynoassemblage are comprised of *Klausipollenites* (2-6%), *Alisporites* (1-7%), *Chordasporites* (2-12%), *Cuneatisporites* (1-4%), *Falcisporites* (1-3%), *Ibisporites* (0-4%), *Inaperturopollenites* (1%), *Latosporites* (1%), *Platysaccus* (1%), *Scheuringipollenite*s (14-19%). Some palynoelements are marked by two or below the two percent contribution in the assemblage formation are enumerated as *Calamospora*, *Hamiapollenites*, *Horriditriletes*, *Lophotriletes*, *Lunatisporites* (1%), *Monosulcites*, *Parasaccites*, *Plicatipollenites*, *Primuspollenites*, *Sahnites*, *Satsangisaccites*, *Striomonosaccites*, *Verticipollenites*, *Vesicaspora*, *Vestigisporites*, *Vittatina*, *Weylandites.*

Discussion

The palynoassemblage I of the present study is recognised between the depths 247.60 m to 232.10 m and is characterized by the dominance of striate bisaccates chiefly *Faunipollenites* in association with high incidence of *striasulcites* and corresponds to the *Faunipollenites-Striasulcites* assemblage zone of Jha (2006).

In the Wardha-Godavari Basin this assemblage has been reported from Ramagundam, Ramakrishnapuram (Srivastava and Jha, 1988) and Bhopalpalli coalfields (Srivastava and Jha, 1998), Manuguru area (Srivastava and Jha, 1992), Budharam (Srivastava and Jha, 1995), Satrajpalli (Jha and Aggarwal, 2010c), Gundala (Jha and Aggarwal, 2010a, 2011), Mamakannu (Jha and Aggarwal, 2010b), Kachinapalli coalfields (Jha *et al.*, 2011) and Gauridevipet area of Chintalapudi Sub-basin (Jha *et al.*, 2014). This assemblage has not been reported from other basins in India. Sedimentary sequence of bore core MJR-13 with palynomorph histogram is given in Figure 2.

The palynoassemblage II of the present study is recognised between the depths 198.60 m to 180.55 m and is characterized by the dominance of striate bisaccates chiefly *Faunipollenites* in association with high incidence of *Densipollenites* along with minor proportions of younger elements such as *Guttulapollenites*, *Alisporites*, *Klausipollenites*, *Falcisporites*, and corresponds to the striate bisaccates –*Densipollenites* assemblage of Jha (2006). The latest Permian *Striatopodocarpites-Faunipollenites* assemblage in association with high incidence of *Densipollenites* have been reported from a number of bore holes and outcrop sections in different basins of India.

Within the Wardha-Godavari Basin they can be correlated with palynoassemblage III of bore hole GAM-3 and palynoassemblage III of bore hole GAM-7 from Mailaram area (Jha and Aggarwal, 2012), palynoassemblage I of bore hole GBR-7 from Budharam area (Srivastava and Jha, 1995), palynoassemblage V of bore hole GS-3 and palynoassemblage V of bore hole GS-4 from Sattupalli area (Srivastava and Jha, 1994), palynoassemblage I of bore hole SGG-1 from Gattugudem area (Jha, 2002), palynoassemblage II of bore hole MAB-1 from Bottapagudem area (Jha, 2004), palynoassemblage I of bore hole MGP-4 from Gauridevipet area (Jha *et al.*, 2014), palynoassemblage IV of bore hole GM-8 and palynoassemblage IV of bore hole GM-4 from Manuguru area (Srivastava and Jha, 1992) of the Godavari Basin and palynoassemblage I of bore hole DGW-6 from Bazargaon area of Kamptee Coalfield of Wardha Basin (Srivastava and Bhattacharyya, 1996) on the basis of similar taxa shared between the two which include *Densipollenites* and *Striatopodocarpites* along with *Faunipollenites*, *Crescentipollenites*, *Verticipollenites*, *Chordasporites*, *Guttulapollenites*, *Arcuatipollenites*, *Alisporites*, *Falcisporites*, *Klausipollenites*, *Platysaccus* and *Rhizomaspora.*

From other basins of India, latest Permian palynoassemblage has been reported from Singrauli Coalfield (Vijaya *et al.*, 2012b), middle Pali out-crop from section near Dargaon and Salaia village (Ram-Awatar, 1987), the assemblage from Jeer-Daser road in Son Valley (Tiwari and Anand-Prakash, 1974), the assemblage from outcrop samples exposed in Johilla River (Tiwari and Ram-Awatar, 1987) of Son-Mahanadi Basin. In Damodar Basin it has been reported from a number of bore holes from Raniganj coalfield (Murthy *et al.,* 2010 a & b; Vijaya 2011; Vijaya and Tiwari, 1987; Bharadwaj and Tiwari, 1977; Tiwari *et al.*,1992; Rana and Tiwari, 1980; Singh and Tiwari, 1982), East Bokaro Coalfield (Vijaya *et al.*, 2012a). In Rajmahal Basin it has been reported from Deocha-Pachami area of the Birbhum Coalfield (Vijaya, 2006, 2009) and northern part of the Rajmahal Basin (Tripathi, 1986, 1989). From Satpura Basin it has been reported from Pench Valley Coalfield (Bharadwaj *et al.*, 1978; Kumar 1996; Murthy *et al.*, 2013).

Conclusion

A number of palynological studies have been carried out in different areas of the Chintalapudi Sub-basin (Sattupalli *et al.*, 1993, 1994; Jha, 2008; Gattugudem and Jha, 2002; Bottapagudem and Jha, 2004; Gauridevipet and Jha *et al.*, 2014); however, this is the first palynological study from the Jangareddygudem area. Palynological studies were carried out in bore core MJR-13 from this area and a Late to latest Permian age has been assigned to this sub-surface sedimentary sequence based on its palynocomposition. Two palynoassemblages have been identified in this sequence, Palynoassemblage I which is characterized by the dominance of striate bisaccates chiefly *Faunipollenites* in association with high incidence of *Striasulcites* and corresponds to the Late Permian *Faunipollenites-Striasulcites* assemblage zone of Jha (2006) and Palynoassemblage II is characterized by the dominance of striate bisaccates chiefly *Faunipollenites* in association with high incidence of *Densipollenites* along with minor proportions of younger elements such as *Guttulapollenites*, *Alisporites*, *Klausipollenites*, *Falcisporites*, and corresponds to the Sriate bisaccates –*Densipollenites* assemblage of Jha (2006). This zone can be correlated with the latest Permian *Densipollenites magnicorpus* zone of Tiwari and Tripathi of Damodar Basin (1992).

Therefore based on palynological studies Late to latest Permian age has been assigned to sub-surface sedimentary sequence MJR-13, in which the interval between 247.60 m to 232.10 m (Palynoassemblage I) is of Late Permian age while the interval between 198.60 m to 180.55 m (Palynoassemblage II) is of latest Permian age.

ACKNOWLEDGEMENTS

One of the authors, Harinam Joshi is thankful to Dr. Neerja Jha for providing the sediment material and considerable help in the studies & Sri M. Basva Chari, former Chief General Manager, Singareni Collieries Company limited for his help during sample collection, discussions and necessary facilities extended. Sri ADP Rao is thankfully acknowledged for providing necessary details. We express our gratitude to Prof. Sunil Bajpai, Director BSIP for providing the necessary facilities to carry out this work and permitting us to publish the paper

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