A reappraisal of geology and palaeobotany of the Athgarh Sandstone, Orissa, India*

B.P. Patra & N.K. Sahoo

P.G. Department of Geology, Utkal University, Vani Vihar, Bhubaneswar-751 004, Orissa

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The Athgarh megaflora, as known today, consists of 103 taxa of which 47 belongs to pteridophytes, 5 to pteridosperms, 19 to cycadophytes, 2 to ginkgoales, 28 to coniferales, 1 to caytoniales and one type of gymnospermous seeds. Compositionally this megaflora is dominated by pteridophytes and conifers while representation of cycadophytes is fair and pteridosperms, ginkgoales and caytoniales are significant, though poor in number of taxa. No pentoxylale has been recorded in this flora.

Miofloral assemblage of the Athgarh Sandstone composed of 120 species belonging to 60 genera is dominated by gymnospermous pollen grains with fair occurrences of cryptogamic spores.

On the basis of the present knowledge of mega-and mioflora the Athgarh Sandstone is suggested to be of Early Cretaceous age, i.e. Neocomian- Aptian.

Key-Words - Geology, Palaeobotany, Athgarh Sandstone, Early Cretaceous, Orissa.

INTRODUCTION

THE Upper Gondwana (Late Mesozoic) sediments exposed in the Mahanadi basin of Orissa occupy a unique position in Indian stratigraphy. Blanford *et al.* (1859) used the term "Athgarh basin" to demarcate the area over which these sandstones are exposed. Ball (1877) first investigated the area for probable occurrence of coal and collected a few plant remains from the type locality Ghantikhal (Map 1). Feistmantel (1877) identified these fossils and assigned a Liassic age equating Athgarh Sandstone with Rajmahal Stage of Rajmahal Series. Since then many workers have visited this area and added their findings and thus a good number of plant megafossils have been collected and studied. The original concept of geology and palaeobotany of this basin has been changed considerably and recently a rich miospore assemblage has also been recorded from Athgarh Sandstone (Sahoo 1993). In this paper, an attempt has been made for a reappraisal of the geology and palaeobotany of the Athgarh Sandstone of Orissa.

GEOLOGY

Athgarh Sandstone constitutes the northernmost exposure of the East Coast Upper Gondwana units of India. It is exposed to the north, northwest and southwest of Cuttack city and is spread over an area of about 600 sq.km. The river Mahanadi divides the basin into two unequal parts such that the southern portion is about three times bigger than the northern one. The estimated thickness of the Athgarh Sandstone is about 400 meters (Kumar & Bhandari 1973). It rests unconformably over the Precambrians exposed near Sarandagarh Pahar in northwest, near Radhakishorepur railway station in north, near Gangapara in southeast, and near Dulanpur and Kalyanta in the southwest and in Charchika hill near Banki in the west (Map 1). Tiwari *et al.* (1987) have described an isolated patch of Khaki green shales of Lower Gondwana affinity (from palynological findings) near Garh Haladia in the south western corner of the basin. Till date no other Lower Gondwana exposure or megafossils have been discovered in the basin. Some portion of the Athgarh Sandstone is concealed by laterite and alluvium. However, Athgarh

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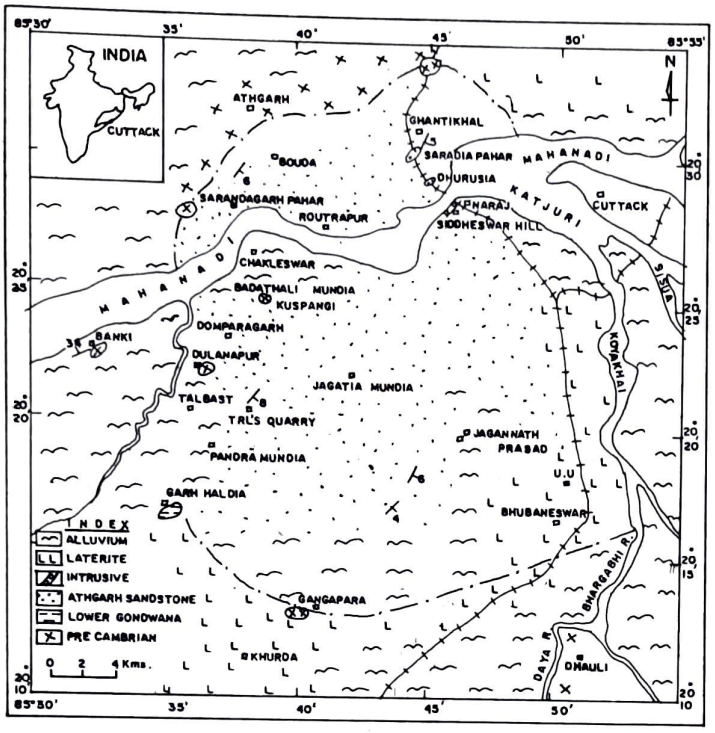

Map-1 : Geological Map of Athgarh Sandstone, Cuttack & Puri dist., Orissa.

Sandstone has been encountered in the subsurface, i.e. in the offshore region of coastal Orissa in the Bay of Bengal (Kaila *et al.* 1987).

Sedimentological work on Athgarh Sandstone was initiated by Adyalkar (1962, 1965) who opined that there was no cross beddings or any other remarkable sedimentary features in Athgarh basin. But Kumar and Bhandari (1973), have studied the palaeo-currents of the Athgarh Sandstone from numerous cross- beddings encountered in the basin. These cross-beddings are exposed in almost all the hillocks or hills of Athgarh Sandstone. Adyalkar (1962) has also studied the heavy mineral assemblages of Athgarh Sandstone and concluded that sediments are ill sorted. Chatterji *et. al* (1968) have studied about the gravels exposed near Kandarpur for well shrouding. Mishra (1988), Singh Deo (1990), Pal (1992) have also contributed their findings on grain size analysis and fireclay deposits of Jagannath Prasad area.

Athgarh Sandstone, as the name indicates, constitutes various types of sandstones namely quartzose, gritty, feldspathic, clayey and ferruginuous. Other rock types include conglomerate, carbonaceous shale, yellow shale, purple shale, white, ash grey and brown coloured fireclays. These shales and fireclays are found in the exposed sections as lensoid bodies. Laterally their thickness varies from place to place. The sandstone hillocks or hills occur as elevated topography of the area. The convex sides of the hills stretch in a south-easterly direction having gentle slope. The north western side looks like a scarp and south eastern have gradual slope. The sandstones also continue in the subsurface of the basin. Mostly they are horizontal or very low dipping at 4°-10° in south-easterly direction. They are structurally undisturbed and either well bedded or massive. Sandstones are of different shades of colours such as white, grey, brickred, reddish brown. Compositionally they vary from argillaceous to ferruginous. Grain size varies from coarse to fine. In some places they grade to siltstone. The clay, sandstone, ferruginous shale, fireclay and other fine grained sediments usually preserve plant megafossils as impressions only which are often indistinct.

Fireclays are being quarried at Jagannath Prasad and Talbast areas by different mine owners such as M/S Pradhan & Co., Tata Refractories Ltd., Jhunjhunwala & Co., B.B. Sahu & Co. etc.

It is observed that a basic igneous body namely dolerite has intruded into the Athgarh Sandstone at the Sidheswar hill peak and its surrounding, west of Naraj. It has come up through a fissure developed due to faulting and pushed up the carbonaceous, pink and yellow shales to a high position. The dolerites have been studied by Acharya and Mahanti (1964-65), Acharya and Ray (1969). Agrawala and Rama (1976) have radiometrically dated the intrusive to be of 109 ± 3 my.

Lateritisation of the Athgarh Sandstone has produced extensive laterites which alongwith alluvium have concealed the original sediments. The laterites are observed on ground surface or as cappings on the hillocks and hills. These have been studied by Mahalik and Das (1982).

A generalised stratigraphic succession of the Athgarh basin is given below:

Alluvium

Laterite

Dolerite intrusive

Athgarh Sandstone with intercalations of shales and clays

_____unconformity_____

Khaki green splintery shales

_____unconformity_____

Precambrians - Charnockites, Khondalites

Basic granulites, Quartzites etc.

PALAEOBOTANY

Ball (1877) discovered the first fossil locality Ghantikhal (Saradiapahar) in the eastern margin of the Athgarh basin and to the north of the Mahanadi. Later workers like Adyalkar and Rao (1963) and Jain (1968) have also collected plant fossils from the same locality.

Since 1877 to 1968 only one fossils locality was known. But Pandya and Patra (1968) for the first time reported some species of *Ptilophyllum* from Jagannath Prasad to the south of the Mahanadi in Athgarh basin. Subsequently more megafossil horizons were located in different lithounits of the Athgarh Sandstone by various workers, like Patra (1973a, 1973b, 1980, 1982, 1983, 1985, 1987, 1989, 1990a, 1990b), Patra and Pattnaik (1974), Patra and Sahoo (1992, 1994, 1995), Pandya (1988), Sahoo (1993), Prakash and Sukh-Dev (1994). Thus at present as many as fifteen fossiliferous localities have been discovered in the Athgarh basin. They are, Ghantikhal-type locality, Ghantikhal railway cut, Dhurusia, Rautrapur, Bouda to the north of the Mahanadi and Naraj, Siddheswar hill, Chakleswar, Badathali Mundia, Jagatia Mundia, Pandra Mundia, Talbast, Jagannath Prasad-old and new localities and Kuspangi to the south of the Mahanadi. The megafossils are confined to the clayey sandstone, carbonaceous shale, yellow shale, red shale, clays, and fireclay units. All these fossils are preserved as impressions only and very often there is little or no contrast between the impressions and matrix.

Megafloral assemblage of the Athgarh Sandstone, as known till date is composed of 103 taxa belonging to different plant groups such as pteridophytes (47), pteridosperms (5), Bennettitales and cyacadophytes (19), Coniferales (28), Ginkgoales (2) and Caytoniales (1) and one gymnospermous seed. Of these, pteridophytes dominate over others followed by confierales and cycadophytes. The list of these is given below:

Equisetites rajmahalensis Oldham & Morris 1863

Equisetites sp.

Marattiopsis macrocarpa (O & M) Seward & Sahni 1920

Gleichenia gleichenoides (O & M) Bose & Sah 1968

Gleichenia nordenskiöldii Heer 1974

Gleichenia sp. cf. *G. boshai* Pant & Srivastava

Gleichenia sp.

Todites indicus (O & M) Bose & Sah, 1968

Coniopteris hymenophylloides (Brong.) Seward 1904

C. burejensis (Zalesky) Seward 1912

Coniopteris sp. cf. *C. quinqueloba* Phill.

Coniopteris sp. A

Coniopteris sp. B

Haydenia sp.

Hausmannia sp.

Eboracia lobifolia (Phill.) Thomas 1911

Dicksonia sp.

Matonidium sp.

Phlebopteris athgarhensis Jain 1968

P. polypodioides Brongniart

Phlebopteris sp. cf. *P. athgarhensis* Jain 1968

Phlebopteris sp. A

Phlebopteris sp. B

Cladophlebis indica (O & M) Feistmantel 1877

C. denticulata Brongniart

C. nebbensis (Brong.) Nath 1909

C. ankazoaboensis Appert 1973

C. medlicotiana (Oldham) Pascoe 1984

C. srivastavae Gupta 1954

C. kathiawarensis Roy 1984

C. acutipennis Oishi 1940

Cladophlebis sp. cf. *C. haiburensis* (L & H) Brongniart 1836

Cladophlebis sp. cf. *C. longipennis* Seward 1894

Cladophlebis sp. cf. *C. reversa* (Feistm.) Seward & Holttum 1922

Cladophlebis sp. A

Cladophlebis sp. B

Sphenopteris specifica (Feistm.) Roy 1968

S. otagoensis Arber 1917

S. patagonica Halle 1913

Sphenopteris sp. cf. *S. otagoensis* Arber 1917

Sphenopteris sp. A

Sphenopteris sp. B

Rhizomopteris ballii Feistmantel 1877

R. sahnii Gupta 1954

Onychiopsis sp. cf. *O. paradoxus* Bose & Sukh Dev 1961

Onychiopsis psilotoides (S & W) Ward 1905

Onychiopsis sp.

Spiropteris sp.

Fern rhizome A

Fern rhizome B

Pachypteris indica (O&M) Bose & Roy 1968

Pachypteris sp.

Thinnfeldia sp.

Dicroidium sp. cf. D. *odontopteroides* (Morris) Gothan 1912

Nilssoniopteris sp.

Anomozamites fissus Feistmantel 1879

Ptilophyllum acutifolium Morris 1840

P. cutchensis Morris 1840

P. oldhamii Jacob & Jacob 1954

P. indicum Jacob & Jacob 1954

P. sahnii Gupta & Sharma 1968

Ptilophyllum sp.

Otozamites penna Harris 1946

Otozamites sp.cf. *O. kachchhensis* Bose & Banerji 1984

Otozamites sp. A

Otozamites sp. B

Dictyozamites sp.

Pterophyllum kingianum Feistmantel 1877

Pterophyllum sp.cf. *P. distans* Morris 1863

Psuedoctenis sp.

Taeniopteris spatulata Oldham & Morris 1863

Taeniopteris sp. A

Taeniopteris sp. B

Cycadites sp. cf. *C. conferta &* Morris 1863

Araucarites cutchensis Feistmantel 1876

A. macropterus Feistmantel 1877

A. nipaniensis Singh 1957

A. sehoraensis Bose & Maheshwari 1973

A. minutus Bose & Maheshwari 1973

Araucarites sp. A

Araucarites sp. B

Araucaria pantiana Bose & Maheshwari 1973

Pagiophyllum magnipapillare Wesley 1956

P. peregrinum (Lindely & Hutton) Sahni 1928

P. grantii Bose & Banerji 1984

Pagiophyllum sp. cf. *P. marwarensis* Bose & Sukh Dev 1974

Pagiophyllum sp.

Brachyphyllum rhombicum (Feistmantel) Sahni 1928

B. expansum (Sternb.) Seward

B. mamillare Brongniart 1828

B. kendallium Wesley 1956

B. regularis Borkar & Chiplonkar 1973

Desmiophyllum indicum Sahni 1928

Desmiophyllum sp.

Elatocladus plana (Feistm.) Seward & Sahni 1920

E. tennerimus (Feistm.) Sahni Sahni 1928

E. conferta (Morris) Seward & Sahni 1920

E. jabalpurensis (Feistm.) 1928

Podozamites lanceolatus Lindley & Hutton

Stachyotaxus elegans Nathorst 1909

Coniferocaulon rajmahalaense Gupta 1954

PALYNOLOGY

Some lithic units of the Athgarh Sandstone have been proved to be sporiferous only very recently (Sahoo 1993). Till date three localites have been identified which yielded miospores. They are: Carbonaceous shales of Siddheswar Hill near Naraj, ash grey fireclay of Jagannath Prasad and black shales/clay of M/S Tata Refractories Ltd.'s fireclay quarry near Talbast. Out of these maximum number of miospores have been reported from the carbonaceous shales of Siddheswar hill near Naraj. The miospore assemblage recorded so far are referred to 120 species belonging to 60 genera. The *sporae dispersae* comprise trilete, monolete, hilate spores and monosaccate non-striate, bisaccate, polysaccate, monocolpate, and operculate pollen grains.

The stratigraphic position of the three lithic units mentioned above is described below:

Siddheswar Hill- It extends in ENE and WSW direction and its western portion forms the peak. The northern flank of which exposes dolerite, carbonaceous shales, purple and yellow shale with laterite capping in ascending order. On the western face a different lithological succession is observed. The dolerite intrusive which is a conspicuous feature in the northern face of the hill, is completely missing on its western face. The lithological succession observed along Northern face is as follows:

Rock Types	Thickness in meters
Laterite	10-15
Soft Yellow shale	4-5
Soft purple shale	6-8
Carbonaceous shales	4-30
Purple shale band	0-0.05
Weathered dolerite	3-4
Fresh dolerite	8-20
Base of dolerite	not seen

Western face

Laterite	20-25
Weathered Yellow shale	5-6
Purple shale	6-8
Purple shale with black hue	8-10
Carbonaceous shale	5-10
Base not seen	

Jagannath Prasad - The fireclay quarry from which spores and pollen were reported by Maheshwari (1975) has been abandoned. Lithological succession observed is given below:

Rock Types	Thickness in meters
Conglomerate	2.5-3
Sandstone	8.0-10
White and Yellow Fireclay	2.5-3
Fine grained shaley sandstone	2-3
Fireclay beds (seven) with shale and sandstone partings	16-18
Base not seen.	

Talbast-Jana (1989) has reported some miospore assemblage from M/S Tata Refractories Ltd's fireclay quarry. It has 5 fireclay producing horizon. He has reported the miospere assemblages from the third horizon. Sahoo (1993) has macerated the samples collected from the above open cast quarry. The black shales which yielded miospore is a small lensoidal body. The stratigraphic succession observed here is given below:

Rock types	Thickness in meters
Alluvium or sandy clay	1
Sandstone	2
Fireclay	0.5
Sandstone	2
Fireclay	1
Sandstone	2
Clay	2
Base not seen	

Out of these maximum number of miospores have been reported from the carbonaceous shales of Siddheswar hill near Naraj.

The following is the list of spores and pollen grains found in Athgarh Sandstone:

Cyathidites australis Couper 1953

C. minor Couper 1953

C. concavus (Bolkhovitina) Dettmann 1963

C. cutchensis Singh *et al.* 1964

C. ghuneriensis Singh *et al.* 1964

Cyathidites sp. cf. *C. asper* Couper 1953

Cyathidites sp.

Deltoidospora sp.

Dictyophyllidites harrisii Couper 1958

Dictyophyllidites sp.

Todisporites major Couper 1958

T. minor Couper 1953

Todisporites sp.

Alsophyllidites bellus Venkatachala *et al.* 1969

Concavisporites indicus Venkatachala *et al.* 1969

C. crassus Venkatachala *et al.* 1969

C. novicus Kumar 1973

Concavisporites sp.

Concavissimisporites crassatus (Delcourt & Sprumont) Delcourt *et al.* 1963

Concavissimisporites sp.

Osmundacidites wellmanii Couper 1953

Osmundacidites sp.

Pilosisporites sp. cf. *P. notensis* Cookson & Dettmann 1958

Faveosporites foveolus Venkatachala *et al.* 1969

Foveosporites sp. cf. *F. canalis* Balme 1957

Foveosporites sp.

Lycopodiumsporites austroclavatidites (Cookson) Potonié 1953

L. circolumenus Dettmann 1963

Lycopodiacidites subtriangulus Venkatachala *et al.* 1969

Lycopodiacidites sp.

Boseisporites insignitus Venkatachala *et al.* 1969

B. minutus Venkatachala *et al.* 1969

B. praeclarus Sukh Dev 1961

Boseisporites sp.

Matonisporites kutchensis Venkatachala *et al.* 1969

M. crassiangulatus (Balme) Dettmann 1963

Impardecispora indica Venkatachala 1969

I. uralensis (Bolkhovitina) Venkatachala *et al.* 1969

I. apiverrucata (Couper 1958) Venkatachala *et al.* 1969

Cicatricosisporites ludbrooki Venkatachala *et al.* 1969

Neoraistrickia pallida Kumar 1973

Verrucosisporites sp.

Reticulatisporites pudens Balme 1957

Foveotriletes sp.

Klukisporites psuedoreticulatus Couper 1958

K. scaberis Coupter 1958

K. areolatus Singh 1971

K. variegatus Couper 1958

Klukisporites sp.

Trilobosporites trioreticulatus Cookson & Dettmann 1958
Lametatriletes indicus Singh & Kumar 1972
Ischyosporites crateris Balme 1957
Ischyosporites sp.
Murospora florida Pocock 1961
Murospora sp.
Triletes sp.
Gleicheniidites ercinidites (Cookson) Dettmann 1963
Gleicheniidites sp.
Ornamentifera sp.
Contignispoites fornicatus Dettmann 1963
C. glebulentus Dettmann 1963
C. dettmanii Singh & Kumar 1972
Contignisporites sp.
Densiosporites indicus Kumar 1973
Sestrosporites sp.
Lakhnavitriletes bansaensis Maheshwari 1974
Laevigatosporites sp. Maheswari 1974
Aequitriradites spinulosus (Cookson & Dettmann) Cookson & Dettmann 1958
Aequitriradites sp.
Leschikisporis rudis Kar & Singh 1970
Leschikisporis sp.
Dettmannites sp.
Crassimonoletes surangei Singh *et al.* 1964
Crassimonoletes sp.
Monolites intragranulosus Singh *et al.* 1964
M. indicus Kumar 1973
Coptospora sp.
Psilospora sp.
Callialasporites trilobatus (Balme 1957) Sukh Dev 1961
C. monoalasporus Sukh Dev 1961
C. segmentatus (Balme 1957) Sukh Dev 1961
C. dampieri (Balme 1957) Sukh Dev 1961
C. triletus Singh *et al.* 1964
C. discoidalis (Döring) Bharadwaj & Kumar 1972
C. enigmatus (Singh & Kumar) Kumar 1973
C. lametaensis Kumar 1973
C. doering Kumar 1973
C. baculosus (Sukh Dev) Maheshwari 1974
C. rudisaccus Maheshwari 1974
C. lucidus (Pocock) Maheshwari 1974
Callialasporites sp.
Properinopollenites monoalasporus (Sukh Dev) Maheshwari 1974
P. singhii Maheshwari 1974
? *Sehorapollenites* sp.
Cedripites nudis Kar & Sah 1970
Alisporites haradensis Kumar 1973
A. grandis (Cookson) Dettmann 1973
A. ovalis Kumar 1973
A. sehoraensis Kumar 1973
Alisporites sp.
Abiespollenites sp.
Chordasporites sp.
Platysaccus densus (Venkatachala 1969) Kumar 1973
Podocarpidites novus Sah & Jain 1968
P. ellipticus Cookson 1947
P. vermiculatus Kumar 1973
P. magnus Maheshwari 1974
P. novus Sah & Jain 1965
Podocarpidites sp.
Vitreisporites pallidus (Reissinger) Nilsson 1958
Vitreisporites sp.
Podosporites tripakshii Rao 1943
P. raoi Kar & Sah 1970
Microcachryidites antarcticus Cookson 1947
Cycadopites couperi Kumar 1973
Cycadopites sp.
Ginkgocycadophytus sp.
Monosulcites ellipticus Kumar 1973
Classopollis indicus Maheshwari 1974
C. classoides (Pflug) Pocock & Jansonius 1961
Classopollis sp.
Inaperturopollenites sp.
Araucariacites australis Cookson 1947
A. ghuneriensis Singh *et al.* 1964
A. cooksoni Singh *et al.* 1964
A. limbatus Kumar 1973
Schizosporis sp.

DISCUSSION

On the basis of floral similarity Feistmantel (1877) assigned a Liassic age to the Athgarh Sandstone. Adyalkar and Rao (1963) have also supported this view. Bose (1966) has correlated Athgarh Sandstone with the Rajmahal Stage of Rajmahal Series. By that time twelve megafossil remains were known only from one locality and the geology of the Athgarh Sandstone was also not studied in detail.

In general lithological association, Athgarh Sandstone is comparable to that of Jabalpur Formation. In both the cases conglomerates, sandstones, shales, fireclay beds have been encountered. Both the formations also contain characteristic plant megafossils like *Onychiopsis* and *Weichselia* (in Athgarh its spore *Lametatriletes indicus*). According to Varadan (1977) quartz-arrenite-conglomerate white clay association of Jabalpur-Parsora-Athgarh formations is considered to be a product of warm humid climate. Varma and Mehra (1993) have raised the status of "Athgarh Sandstone" into "Athgarh Group" and divided it into three formations. The basal unit contains loose textured conglomerate and ferruginous sandstones, the middle light coloured clays with marine influence and the upper most sandstones and clays with plant fossils of Jabalpur affinity. The three formations are correlated with Kansbhat Formation, Megpahar Formation and Bhuj Formation of Kutch area, respectively. However, the tripartite division of Athgarh Group is not traceable in the field as the clays and fireclays are impersistent and occur as lensoid bodies and as such their mappability is doubtful.

It is observed that East coast sedimetnary basins occuring in river valleys of the Mahanadi, the Godavari, the Krishna, and the Cauvery were formed by similar tectonic disturbances. They are formed either due to down warping of the eastern part of Indian Shield (Sastri *et al.* 1973) or in the wake of ocean floor spreading (Datta *et al.* 1983) or due to the rifting of the Indian segment of Gondwanaland (Mitra & Rao 1987).

While attempting a biostratigraphic division of the Upper Gondwanas of India, Shah (1966) placed Athgarh Sandstone in his "Zone B" characterised by abundance of cycads which are typically developed in Rajmahal hills. He equated Kota and Athgarh floras with Rajmahal flora and assigned a Lower to Middle Jurassic age. Rajmahal hills contains highest number of megafossil genera among the Upper Condwana units of India. Here we have taken both Rajmahal Formation and Dubrajpur Formation's megafloral assemblage together. Rajmahal contains highest number of Bennettitales and cycadophytes. These are characterised by broad leaved forms like *Nilssonia* which is an unique feature for the forms recovered from Rajmahal basin. Moreover a large number of petrified woods, pentoxylae, have also been reported from Rajmahal basin which are totally absent in Athgarh Sandstone. The of cycads and broad leaved cycadian elements are rare in Athgarh. Sengupta (1988) has studied the megafloral assemblage of Dubrajpur and Rajmahal formations. His *Taeniopteris spatulata-Brachyphyllum rhombicum* Assemblage Zone may be compared with megaflora of Athgarh Sandstone as it is devoid of these cycadophytes and presence of some fern and conifers. Recent finding of plant fossil genera such as *Gleichenia Gleichenoides, Cladophlebis indica, Onychiopsis* sp., *Pagiophyllum* sp., *Pterophyllum distans* etc. from Dubrajpur Formation (Banerji 1989) may to some extent compare to megaflora of Athgarh Sandstone. But there is a marked difference between the floras of Rajmahal and Athgarh in general. Shah *et al* (1971) have named this floral zone as *Dictyozamites-Pterophyllum* assemblage subzone belonging to *Ptilophyllum* assemblage zone. But the availability of cycads and broad leaved cycadian elements are very rare in the Athgarh flora. Hence this correlation is not acceptable. However, Patra (1982) has correlated Athgarh megafloral assemblage zone with other Upper Gondwana assembages and equated it with the *Pagiophyllum - Brachyphyllum* assemblage subzone of Shah *et al.* (1971). Recently, Sukh Dev (1988) has given twelve floristic zones of all the Mesozoic formations of India and their relative ages. Of these three floral zones cover all the East Coast Upper Gondwana units and other late Gondwana units of India. They are *Dictyozamites - Pterophyllum-Anomozamites* assemblage zone (Zone-8), *Allocladus-Brachyphyllum- Pagiophyllum* assemblage zone (Zone-9), and *Weichselia-Onychiopsis-Gleichenia* assemblage zone (Zone-10). Assemblage Zone-8 contains a number of cycadophytes. Cycadophytes dominate over pteridophytes and conifers. Athgarh Sandstone contains less number of cycadophytes and will not fit to this assemblage zone. *Allocladus-Brachyphyllum-Pagiophyllum* assemblage zone is characterised by richness of conifers with less cycadophytes and pteridophytes. The characteristic genera *Onychiopsis, Doratophyllum, Allocladus* and *Satpuria* are new in this zone. Except *Onychiopsis* others are not recorded in Athgarh Sandstone so far. The Assemblage Zone-10 i.e *Weicheselia-Onychiopsis-Gleichenia* assemblage zone is characterised by richness of pteridophytes and conifers and paucity of cycadophytes and pteridosperms. Characterstic megafossils of this assemblage zone are *Weichselia, Onychiopsis, Phlebopteris, Hausmannia, Cycadopteris* and

proliferation of *Glelchenią*, *Araucaria*, *Allocladus*, *Brachyphyllum*, *Pagiophyllum*. The Athgarh assemblage contains all the above genera except *Allocladus* and *Araucaria* but *Gleichenia*, *Pagiophyllum* are found in significant numbers. Hence Sukh Dev has put Athgarh Sandstone in this zone assigning an Aptian-Albian age. Prakash and Sukh Dev (1994) have also correlated the Athgarh flora with the Bansa flora (Assemblage Zone-10, Sukh Dev 1988). Present work reaffirms the placement of Athgarh Sandstone in the floral zone 10 of Sukh Dev (1988).

A miospore assemblage from Siddhewsar Hill, Naraj and Jagannath Prasad was first reported by Maheshwari (1975). Further records of miospores were followed by Patra (1982, 1990a), Jana and Tiwari (1986), Jana (1990) and Sahoo (1993). Miofloral assemblage of Athgarh Sandstone as known today is composed of 120 species belonging to 60 genera. This flora is dominated by gymnospermous pollen grains with fair occurrence of cryptogamic spores. Bharadwaj (1969) has described palynological assemblage zones from Mesozoic rocks of India. Here the Lower Jurassic assemblage is dominated by *Classopollis* complex. Middle to Upper Jurassic palynofloras are characterised by varying proportions of *Araucariacties* and *Callialasporites* pollen complex. It may be noted that *Araucariactes* and *Callialasporites* pollens types continue to enjoy the dominance during Lower Cretaceous but were joined during this age by a number of new distinctive spore and pollen types such as *Appendicisporites*, *Aequitriradites*, *Impardecispora*, *Lametatriletes*, *Cicatricosisporites*, *Trilobosporites*. These incoming palynomorphs have qualitatively changed the palynospectra of Lower Cretaceous *vis-a-vis* the Jurassic.

At present the palyno-assemblage of Athgarh Sandstone can be closely comparable to the top zone in *Araucariacites* complex of Bharadwaj (1972) whose composition is alete nonsaccates, prominent monocolpates, non- striated saccates, bisaccates, triletes, operculate, non-saccate elements. Prominent spore and pollen genera are *Arucariacites*, *Cycadopites*, and *Podocarpidites* and its age is Lower Cretaceous.

According to Ramanujam (1993) the Necomian-Aptian palynoassemblages the worldover, are known for remarkable morphographic diversity and amplication in the cryptogamic sporomorphs. *Aequitriradites*, *Cooksonites*, *Coptspora*, *Impardecispora*, *Foraminisporis*, *Crybelosporites*, *Pilosisporites*, *Cicatricosisporites*, *Ornamentifera*, *Taurocusporites* are some examples in support of this general observation. Though, it is well known that considerable number of spore and pollen taxa simply run through and straddle the Upper Jurassic and Lower Cretaceous boundary, it is the appearance and incoming of the above mentioned characteristic cryptogamic sporomorphs that herlads the dawn of Cretaceous and, this incidentally, is a global phenomenon.

Maheshwari (1974) while discussing the palynoassemblages from Rajmahal, Jabalpur and Bansa considered them to belong to one biostratigraphic zone i.e. *Araucariacites-Callialasporites* assemblage zone and postulates the existence of three subzones:

1. *Podocarpidites - Cyathidites - Gleicheniidites* assemblage subzone of Rajmahal intertrappean beds;
2. *Cycadopites - Podocarpdites - Classopollis* assemblage subzone of Lametaghat, Hathnapur and Sehora;
3. *Cycadopites - Podocarpidites-Properinopollenites* assemblage subzone of Bansa.

The Athgarh miospore assemblage fits more appropriately to the assemblage subzone 3. i.e. *Cycadopites -Podocarpidites-Properinopollenites* subzone though it has a significant number of *Murospora*. Jana (1990) while discussing the palynoassemblage of Talbast points towards a Lower Cretaceous age to this *Murospora* rich assemblage.

The Athgarh miospore assemblage can also be compared with the palynological zones of Maheshwari and Jana (1988) of Jhuran and Bhuj formations. Athgarh miofloral assemblge can be closely matched with Bhuj Formation which has a variety of spores and pollens and total absence of marine elements. Athgarh assemblage also matches with the palynozone II where *Impardecispora*, *Bhujiasporites* and *Lycopodiumsporites* etc. are common (Maheshwari & Jana 1988).

It is observed that on the basis of both mega-and mioflora Athgarh Sandstone is suggested to be of Lower Cretaceous age. While discussing the Wealdean palaeoflora of Gondwana basin Borkar (1993) has placed Athgarh younger to the other East Coast basins. Tectonic set up suggests that all the East Coast Upper Gondwana basins are formed in Lower Cretaceous. Moreover, till date no angiospermic element has been reported from Athgarh Sandstone. Hence, its upper limit is within Albian. Taking into account of all these Athgarh Sandstone is suggested to be of Lower Cretaceous age.

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