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PALYNOLOGY OF THE BRAHMANI RIVER SECTION, TALCHER COALFIELD, ORISSA, INDIA

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ABSTRACT

The Talcher Coalfield, Orissa, is the type area for the Early Permian Talchir Formation. However, there is little palaeontological evidence for its age. Palynofossils from the rocks exposed on the left bank of the Brahmani River downstream of Sarang Village indicate Mesozoic age affiliation. The occurrence of *Contignisporites multimuratus, Klukisporites lacunus, Leptolepidites rimatus, Murospora florida, Ruffordiaspora australiensis, Santhalisporites bulbosus,* and *Todisporites minor* etc., indicates a Late Jurassic/Early Cretaceous age.

Keywords: Early Permian, Mesozoic, Palynology, Talcher Coalfield, India

INTRODUCTION

The Talcher Coalfield is located in the extreme south-eastern region of the Mahanadi Basin (Fig. 1), which is occupied by the valley of Brahmani River. Here the base of the Gondwana sediments is marked by a sequence of glacial and periglacial deposits originally recognized by Blanford *et al.* (1856), and designated as the Talchir Formation. The formation includes diamictites, sandstones, needle shales, turbidites, rythmites and varves which are dominantly khaki-green in colour. The formation is estimated to be more than 70 m in thickness and Early Permian in age. The lithostratigraphy in this coalfield is as given in Table-1.

The detail analysis of palynomorphs, comparison of assemblage and its age relationship, and subsequent geological implications of Gondwana sediments in the area have been discussed here.

MATERIAL AND METHOD

The rocks exposed on the left bank of Brahmani River, down south of Sarange Village (here designated as Sarang Section) were macerated in order to analyse the Talchir palynoflora from the type area (Figs. 2, 3). The Sarang Section lies in the Brahmani River, south of Sarang Village, which is situated nearly 3 km southeast of Talcher township. It is delimited by two major faults with Precambrian metamorphic rocks lying to the south and the Karharbari Formation in the north. A 1 km traverse was taken from the southern metamorphic/sedimentary contact, northwards along the left bank, up to a major fault, within the Talchir Formation. The samples were collected from each lithology (Fig.4). The general dips of the beds are 5-10º - NE with rolling tendency at places. There are no exposures on the right bank.

Compact laminated siltstones are exposed in the lowermost portion of the section (Sample No. TR-1). About 10 m above these bands khaki to khaki-greenish varve-like patterns develop. These siltstones occasionally exhibit pebbles, cobbles and rarely boulders (Sample Nos. TR - 2, 3, 4). The khaki or dull yellowish-brown colour predominates in the exposures. In places, fine (1-2 mm) greenish laminations alternate with the khaki-coloured layers. They may be regular or irregular in nature and simulate a rythmite pattern. The dropstones are also seen at places (Fig.5a, 5b). Silty and sandy strata become more abundant above the initial varve-like siltstone until a 20 m wide patch of alluvium is met with.

In the sequence above this zone, the soft grey sandstone is laminated, but not varved (Sample Nos. TR-12 to TR-16). Thick beds of whitish felspathic grey sandstone with fewer laminations are seen. The dip at this point trends more towards the East. After a second patch of alluvium, a suite of shale,

Table 1: Stratigraphic sequence in Talcher Coalfield (after Raja Rao, 1982).

Age	Formation	Lithology
Recent		Alluvium and Laterite
Upper Permian to Triassic	Kamthi	Fine- to medium-grained sandstone, carbonaceous shale, coal bands, with greenish sandstone, pink clays and pebbly sandstone at top
Lower Permian	Barakar	Medium- to corse-grained sandstone, shale, coalseams with oligomictic conglomerate at base
	Karharbari	Medium- to coarse-grained sandstone, shale and coal seams
	Talchir	Diamictite, fine- to medium- grained greenish sandstone, shale, rhythmite, turbidite
~~	Unconformity	~~~~~~
Pre-Crambrian		Granites, gneisses, amphipolites, magnatite

Table 2 - List of samples from Sarang Section in Brahmani River, Talcher Coalfield, Orissa (Fig. 2). The samples are arranged in sequence from older to younger strata. Index: (-) = absent, (+) = rare, (++) = common, (+++) = rich; BP = bad preservation, FP = fair preservation, GP = good preservation.

Sl. No.	Sample No.	Lithology	Position of sample & thickness	Yield of palynomorphs
1.	TR-1	Compact siltstone with lamination	(Lowermost sample) in contact with metamorphic	+, BP
2.	TR-2	Khaki-green shales, varve-like; pebbles, cobbles embedded	1 m thick	+, BP
3.	TR-3	Varves with pebbles, khaki green	1 m	+, BP
4.	TR-4	Varves, khaki-green	1 m	+, BP
5.	TR-5	Laminated siltstone	1 m	+, BP
6.	TR-6	Laminated siltstone	0.5 m above TR-5	-
7.	TR-7	Laminated siltstone	1.0 m above TR-6	+++, GP
8.	TR-8	Laminated siltstone	1 m	+, BP
9.	TR-9	Laminated siltstone	1 m	+, BP
10.	TR-10	Laminated siltstone hard and compact	1 m	+, BP
11.	TR-11	Laminated siltstone	1 m	-
		---------- Alluvium	---- ----------	
12.	TR-12	Laminated siltstone	Just after alluvium	+, BP
13.	TR-13	Siltstone	0.5 m above TR-12	-
14.	TR-14	Khaki siltstone	Dip turns east (Sampling along strike)	-
15.	TR-15	Whitish-grey sandstone feldspathic, laminated and soft	1 m above TR-14	-
16.	TR-16	Compact siltstone	0.5 m above TR-15	+, BP
		---------- Alluvium	---------- ----------	
17.	TR-17	Siltstone	1 m	+, BP
18.	TR-18	Mudstone	0.25 m	+, BP
19.	TR-19	Mudstone with conchoidal weathering	2.0m	+, BP
20.	TR-20	Mudstone within sandstone unit nonlaminated khaki green fine grained	5 m	-
		---------- Alluvium	---------- ----------	
21.	TR-21	Khaki-green shale within micaceous sandstone	1 m	++, B-FP
22.	TR-22	Laminated shale and sandstone	4 m thick just near the bridge	-
23.	TR-23	Laminated shale and sandstone	|2 m	+++, GP
24.	TR-24	Laminated shale and sandstone	| Under the bridge	-
25.	TR-25	Khaki-green shale and sandstone	|	-
26.	TR-26	Khaki-green shale	Above TR-25	-
27.	TR-27	Khaki-green shale	To north beyond the bridge	+, BP
28.	TR-28	Sandstone	Above TR-27	+, BP

siltstone and mudstone with typical weathering pattern dominates (Sample Nos. TR-17 to TR-20). The laminations disappear from the sediments. Khaki coloured sandstone and siltstone dominates. The lithology does not change markedly beyond a third alluvium belt, and khaki shale and sandstone continue up to and beyond the bridge (Sample Nos. TR-21 to TR-28). The sequence of lithological samples is given in Table-2.

The characteristics of the sediments exposed in the Sarang Section studied here apparently compare with Talchir lithology, in having varve-like layers, drop pebbles-rarely boulders, and khaki colour. But they are more of "coarse rhythmites" at some places, and simple laminations in most of the shale and sandstone. No boulder bed, pavement grooves, chatter mark or outwash debris have been seen in this section.

The samples were first treated with HCl and then HF. Thereafter in few samples a mild treatment of HNO3 was given. No alkali was used to liberate the palynomorphs.

PALYNOLOGICAL OBSERVATIONS

Out of 28 samples, only 17 yielded palynomorphs. The yield of spores and pollen is generally poor. Only two samples are fairly rich and hence considered for quantitative analysis. The other samples have been helpful in providing the qualitative composition. The analysis indicates that the yielding samples could be grouped in one assemblage (Table 3, 4; Plate I, Figs. 1-13; Plate II, Figs. 1-15).

The quantitative representation of palynomorphs in sample TR-7 shows dominance of *Striatopodocarpites*. The nonstriate group – *Falcisporites, Krempipollenites* and *Satsangisaccites* occupy the second place. The taeniate pollen *Arcuatipollenites* is a common form in occurrence. The other

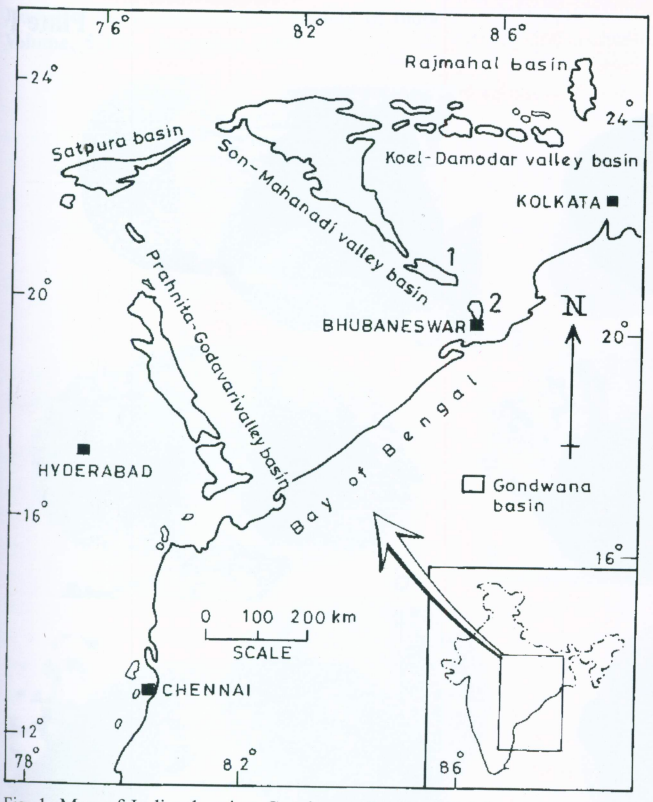


Fig. 1. Map of India showing Gondwana Basin, 1-Talcher Coalfield, 2-Athgarh Basin.

Fig. 2a. A view of Brahmani River showing the exposures of the presently studied material on the left bank.

Fig. 2b. Basement rocks on the left bank of the river which could be seen well within the river.

significant taxa are – *Callumispora, Playfordiaspora, Todisporites, Verrucosisporites,* and *Araucariacites, Goubinispora, Guttulapollenites, Podocarpidites,* etc.

In Sample TR-23 the palynoflora is dominated by *Podocaripidites,* while *Araucariacites* is sub-dominant. The genera *Callialasporites, Cyathidites, Osmundacidites* and *Concavissimisporites* are common to rare. The qualitatively significant taxa, although rare includes *Aequitriradites, Coptospora, Densoisporites, Klukisporites, Leptolepidites, Murospora, Ruffordiaspora, Santhalisporites,* and *Todisporites.*

The overall composition of the palynoflora (Table 4) recovered shows mixing of Triassic and Late Jurassic/Early Cretaceous forms. The presence of taxa *Araucariacites, Callialasporites, Podocarpidites* and *Murospora* throughout and in sample TR-2 and TR-23 clearly indicates one assemblage. A reworking of Triassic forms is concluded here.

COMPARISON

The prominence of *Podocarpidites* and *Araucariacites* (Table- 4) amounting to 95 percent of the total counts makes this a closely comparable assemblage with those which are generally dated as Late Jurassic/Early Cretaceous in age. The occurrence of *Aequitriradites, Callialasporites, Contignisporites, Coptospora, Klukisporites, Lametatriletes, Murospora, Ruffordiaspora, Santhalisporites,* etc., further supports such affiliation. Although the overwhelming dominance of the gymnospermous pollen and the rare record of other taxa as listed for the present assemblage do not expose the relief for detailed comparisons, still certain degree of relationship, both qualitative as well as quantitative, can be identified with certain well-known records of palyno-assemblages (see Sah & Jain 1965; Venkatachala 1974; Jain, Garg, Kumar & Singh 1984; Tiwari, Kumar & Tripath 1984; Tiwari, Singh, Kumar & Singh 1984; Helby, Morgan & Partridge 1987; Vijaya 2000; Tripathi & Ray 2006; Tripathi 2008, Vijaya & Tripathi 2008).

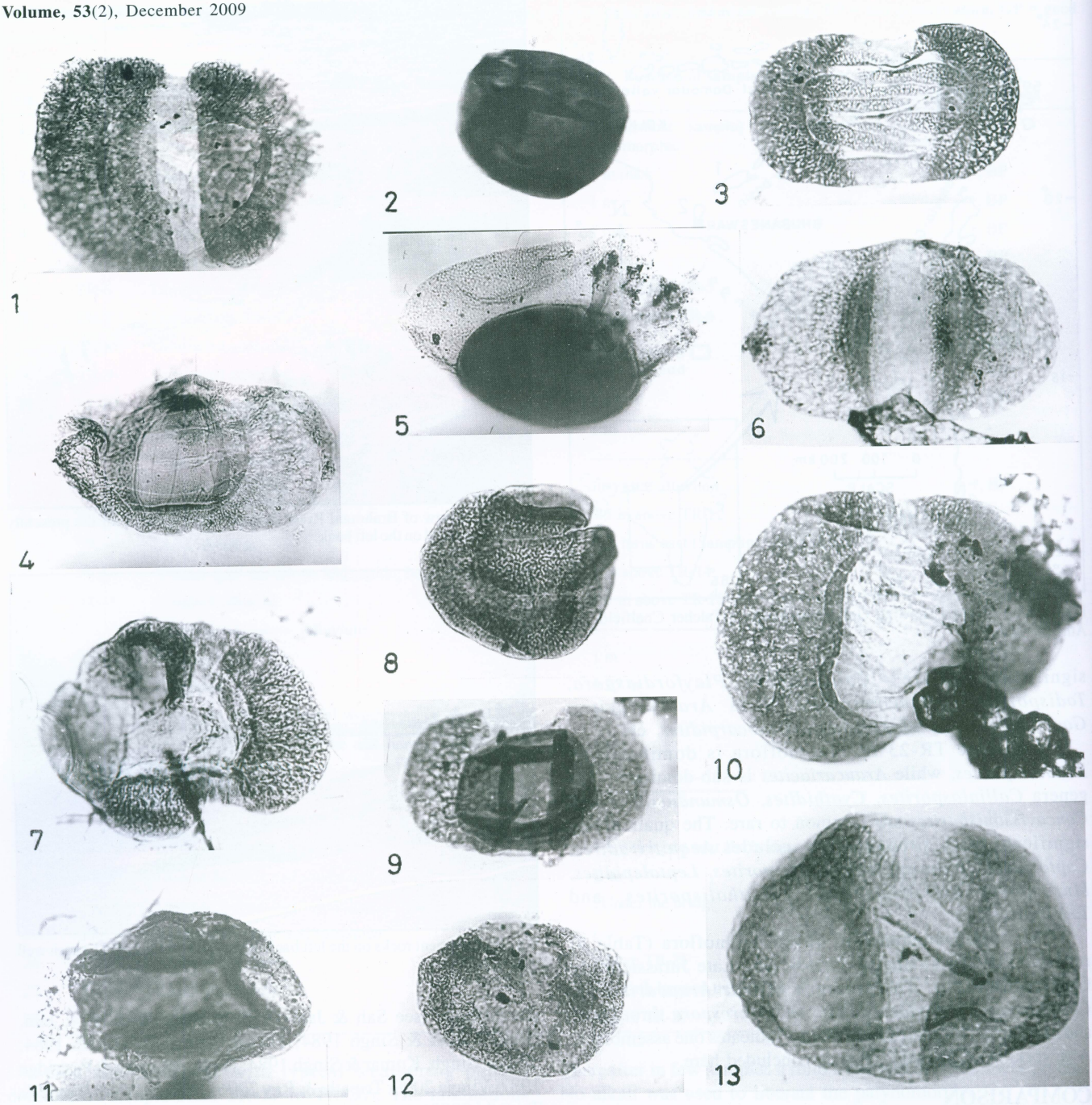
A comparison with the recent data (Tripathi 2001; 2008; Vijaya 2004) a Late Jurassic/Early Cretaceous (Neocomian) relationship appears to be plausible for the present assemblage.

DISCUSSION

The Sarang Section in Brahmani River analysed here for palynological contents lies almost in the central region of the east-west track of the sediments classified as Talchir. In this section, neither the typical boulder bed nor the blue nodular shales is present which are the characteristic features of the Talchir in this basin (Blandford *et al.*1856).

Lithologically, the Brahmani river section has apparent similarity with the Talchir sediments. The finer laminations in

Plate I

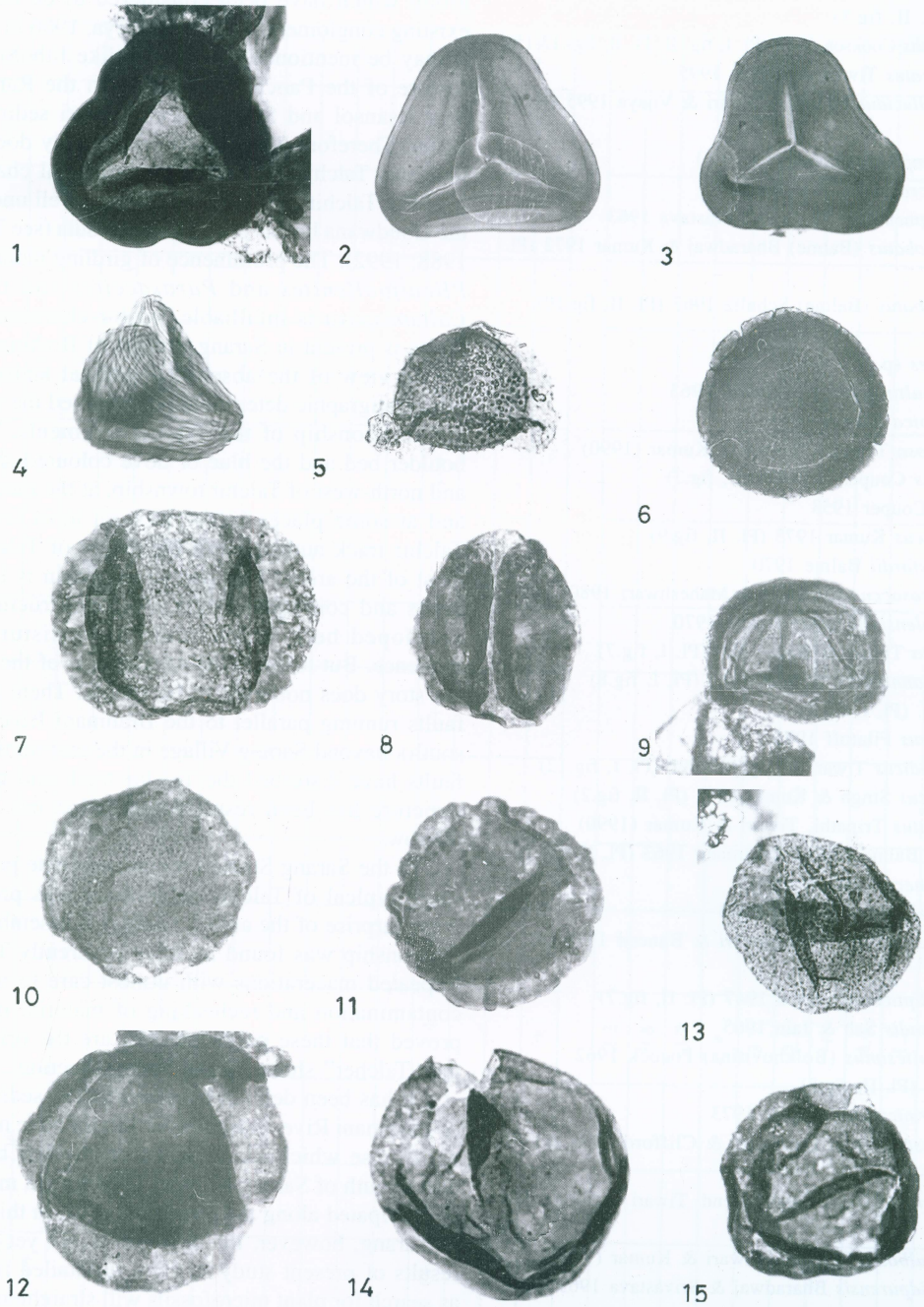


EXPLANATION OF PLATE I

(All photomicrographs are 500x)

1. ***Striatopodocarpites*** sp. A, BSIP Slide No. 10112
2. ***Todisporites minor*** Couper 1958, BSIP Slide No. 10112
3. ***Arcuatipollenites pellucidus*** (Goubin) Tiwari & Vijaya 1995, BSIP Slide No. 10113
4. ***Hamiapollenites*** sp. BSIP Slide No. 10113
5. ***Playfordiaspora cancellosa*** Maheshwari & Banerji 1975, BSIP Slide No. 10113
6. ***Satsangisaccites nidpurensis*** Bharadwaj & Srivastava 1969, BSIP Slide No. 10114
7. ***Goubinispora indica*** Tiwari & Rana 1980, BSIP Slide No. 10114
8. ***Guttulapollenites hannonicus*** Goubin 1965, BSIP Slide No. 10114
9. ***Sahnites gondwanensis*** (Mehta) Pant emend. Tiwari & Singh 1987, BSIP Slide No. 10113
10. ***Striatopodocarpites dubrajpurensis*** Tripathi, Tiwari & Kumar 1990, BSIP Slide No. 10114
11. ***Araucariacites australis*** Cookson 1947, BSIP Slide No. 10114
12. ***Krempipollenites indicus*** Tiwari & Vijaya, BSIP Slide No. 10114
13. ***Striatopodocarpites auriculatus*** Vijaya & Tiwari 1988, BSIP Slide No. 10113

Plate II



TRIPATHI

EXPLANATION OF PLATE II

(All photomicrographs are 500x)

1. ***Murospora florida*** Balme emend. Dettmann 1963, BSIP Slide No. 10118
2. ***Lametatriletes indicus*** Singh & Kumar 1972, BSIP Slide No. 10119
3. ***Cyathidites australis*** Couper, BSIP Slide No. 10120
4. ***Ruffordiaspora australiensis*** (Cookson) Dettmann & Clifford 1995, BSIP Slide No. 10119
5. ***Aequitriradites spinulosus*** (Cookson & Dettmann) Cookson & Dettmann 1956, BSIP Slide No. 10120
6. ***Coptospora verrucosa*** Tripathi, Tiwari & Kumar 1990, BSIP Slide No. 10119
7. ***Podocarpidites ellipticus*** Cookson 1947, BSIP Slide No. 10120
8. ***Podocarpidites*** sp., BSIP Slide No. 10120
9. ***Densoisporites playfordii*** Balme 1970, BSIP Slide No. 10119
10. ***Callialasporites turbatus*** (Balme) Schultz 1967, BSIP Slide No. 10118

11-12. ***Callialasporites trilobatus*** (Balme) Bharadwaj & Kumar 1972, BSIP Slide Nos. 10118, 10120

13-15. ***Araucariacites australis*** Cookson 1947, BSIP Slide Nos. 10118, 10118, 10121

Table 3: List of spore pollen species recorded in the assemblage.

1. *Aequitriradites spinulosus* (Cookson & Dettmann) Cookson & Dettmann 1966 (Pl. II, fig.5)
2. *Araucariacites australis* Cookson 1947 (Pl. I, fig. II; Pl. II, figs.13-15)
3. *Arcuatipollenites ovatus* Tiwari & Vijaya 1995
4. *Arcuatipollenites pellucidus* (Goubin) Tiwari & Vijaya 1995 (Pl. I, fig.3)
5. *Callialasporites dampieri* (Balme) Dev 1961
6. *Callialasporites microvelatus* Schultz 1966
7. *Callialasporites segmentatus* (Balme) Srivastava 1963
8. *Callialasporites trilobatus* (Balme) Bharadwaj & Kumar 1972 (Pl. II, figs.11, 12)
9. *Callialasporites turbatus* (Balme) Schultz 1967 (Pl. II, fig.10)
10. *Chordasporites* sp.
11. *Concavissimisporites* sp.
12. *Contignisporites multimuratus* Dettmann 1963
13. *Coptospora mesozoica* Kumar 1973
14. *Coptospora verrucosa* Tripathi, Tiwari & Kumar (1990)
15. *Cyathidites australis* Couper 1953 (Pl. II, fig.3)
16. *Cyathidites minor* Couper 1953
17. *Densoisporites indicus* Kumar 1973 (Pl. II, fig.9)
18. *Densoisporites playfordii* Balme 1970
19. *Falcisporites minutosaccus* Kumaran & Maheshwari 1980
20. *Falcisporites nuthalensis* (Clarke) Balme 1970
21. *Goubinispora indica* Tiwari & Rana 1980 (Pl. I, fig.7)
22. *Guttulapollenites hannonicus* Goubin 1965 (Pl. I, fig.8)
23. *Hamiapollenites* sp. (Pl. I, fig.4)
24. *Klukisporites lacunus* Filatoff 1975
25. *Krempipollenites indicus* Tiwari & Vijaya 1995 (Pl. I, fig.12)
26. *Lametatriletes indicus* Singh & Kumar 1972 (Pl. II, fig.2)
27. *Leptolepidites rimatus* Tripathi, Tiwari & Kumar (1990)
28. *Murospora florida* Balme emend. Dettmann 1963 (Pl. II, fig.1)
29. *Osmundacidites senectus* Balme 1963
30. *Osmundacidites wellemanii* Couper 1953
31. *Playfordiaspora cancellosa* Maheshwari & Banerji 1975 (Pl. I, fig.5)
32. *Podocarpidites ellipticus* Cookson 1947 (Pl. II, fig.7)
33. *Podocarpidites grandis* Sah & Jain 1965
34. *Podocarpidites multesimus* (Bolkhovitina) Pocock 1962
35. *Podocarpidites* sp. (Pl. II, fig.8)
36. *Podocarpidites vermiculatus* Kumar 1973
37. *Ruffordiaspora australiensis* Dettmann & Clifford 1995 (Pl. II, fig.4)
38. *Sahnites gondwanensis* (Mehta) Pant emend. Tiwari & Singh 1987 (Pl. II, fig.9)
39. *Santhalisporites bulbosus* Tripathi, Tiwari & Kumar (1990)
40. *Satsangisaccites nidpurensis* Bharadwaj & Srivastava 1969 (Pl. I, fig.6)
41. *Striatopodocarpites auriculatus* Tiwari & Vijaya1988 (Pl. I, fig.13)
42. *Striatopodocarpites dubrajpurensis* Tripathi, Tiwari & Kumar 1990 (Pl. I, fig.10)
43. *Striatopodocarpites* sp. A (Pl. I, fig.1)
44. *Striatopodocarpites* sp. B
45. *Todisporites minor* Couper 1958 (Pl. I, fig.2)
46. *Verrucosisporites* sp.

the Brahmani siltstones appear to be comparable to the Talchir varves. But a closer examination reveals that these layers are not very regular in their thicknesses as well as in rhythmic occurrences. Another point of similarity is the presence of small pebbles, cobbles rarely bigger boulders, which could be seen in the shales and siltstones of the Sarang Section; but such feature could also be found in the Damuda and Mahadeva group which have been considered to be derived from pre-existing conglomerates (Bhattacharya, 1966 in Raja Rao, 1982). It may be mentioned that Talchir-like lithology is a common feature of the Panchet Formation in the Raniganj Coalfield, near Asansol and Sukhtawa and Bijori sediments in Satpura Basin. Therefore, the section under study does not assertively indicates Talchir glacegene or periglacial characters.

The Talchir palynofloras are very well understood from all the Gondwana basins of Indian Peninsula (see Tiwari & Tripathi 1988; 1992). The prominence of girdling monosaccate pollen – *Plicatipollenites* and *Parasaccites* and the spore genus *Callumispora* is infalliable Talchir character. None of these forms is present in Sarang Section of Brahmani River.

In view of the absence of animal and plant fossils, the lithostratigraphic determination remained the main criterion for age relationship of the Talchir sediments. The presence of boulder bed and the blue or dove coloured shales at the north and north-west of Talchir township, at the metamorphic contact and at some places in the western most terminal region of Talchir track authenticates the extent of Talchir Formation in most of the areas. This part of the basin is least disturbed by faults and consequently no complex structure seem to have developed here which could have disturbed the Talchir sequence. But towards the eastern side of the Brahmani River, the story does not seem to be simple. There are several major faults running parallel to the Brahmani River (broadly north-south), beyond Sarang Village in the east north-east side. These faults have disturbed the Talchir track and more complicated structure has been resulted than what has been understood till now.

In the Sarang Section no monosaccate pollen or any other spore typical of Talchir palynoflora was present But, to the great surprise of the author fairly rich assemblage of Mesozoic relationship was found in these apparently Talchir sediments. Repeated macerations with utmost care to negate chances of contamination and rechecking of material in collection have proved that these palynomorphs are the original contents of the "Talcher" shales in the Sarang Section.

It has been derived by now that the sediments to the west of Brahmani River classified as Talchir have no age relationship with those which are exposed on the left bank of the river, down south of Sarang Village. Therefore, a major displacement is anticipated along the river flow itself in this part. To the east of Sarang, however, the situation is not yet clear keeping the results of present study in view, a detailed field study as well as search for plant microfossils will straighten out this problem. An analogue with Talchir/Cretaceous relationship in Athgarh Basin may also be considered when stratigraphic tangle in Talcher Basin is further tackled (Tiwari *et al.,* 1987).

CONCLUSIONS

The so far delimited track of the Talchir Formation in the type area i.e., Talcher Coalfield, Orissa also encompasses Mesozoic sediments at the Brahmani River, Sarang Section, down south of Sarang village. The lithological comparability of the rocks exposed in Sarang Section with those of typical Talchir Formation in the western area is apparent. Although presently there are no palynological evidences at hand to indicate glacial effect, the embedded pebbles, cobbles and boulders in laminated shales could be of great significance in

Table 4: Qualitative and quantitative distribution of various palynotaxa recovered from the samples of Sarang Section, Brahmani River, Talcher Coalfield, Orissa. (+) mark is for presence of palynotaxa (+=one specimen, ++=2-4 specimens, +++=more than 5 specimens).

Palynotaxa\Sample No.	1	2	3	4	7	8	9	10	12	17	19	21	23	25	26	27	28
Aequitriradites													+				
Araucariacites		++		+++	2.2			++	++		+	+++	36.7		+	++	+
Callialasporites		+++		+					+			++	3.1				
Concavissimisporites													0.6				
Contignisporites													+				
Coptospora													+				
Cyathidites					0.7								0.6				
Densoisporites												+	+				
Klukisporites													+				
Lametatriletes													+				
Leptolepidites													+				
Murospora		+											+				
Osmundacidites													0.6				
Podocarpidites		++	+	+++	1.4	+++	+	+++	+++	+		+++	58.2	+	+	+++	+
Ruffordiaspora				+									+				
Santhalisporites													+				
Todisporites					+								+				
Reworked Palynotaxa																	
Alisporites					2.2												
Arcuatipollenites					9.8												+
Callumispora					0.7												
Falcisporites					+												
Goubinispora					3.7												
Guttulapollenites					2.2												
Hamiapollenites					+												
Krempipollenites					4.4												
Playfordiaspora					1.5												
Sahnites					+												
Satsangisaccites					14.9						+						+
Striatopodocarpites	+	+	++		53.0	+	+	++	+++		+++	+++				+	++ +
Verrucosisporites					1.4					+							

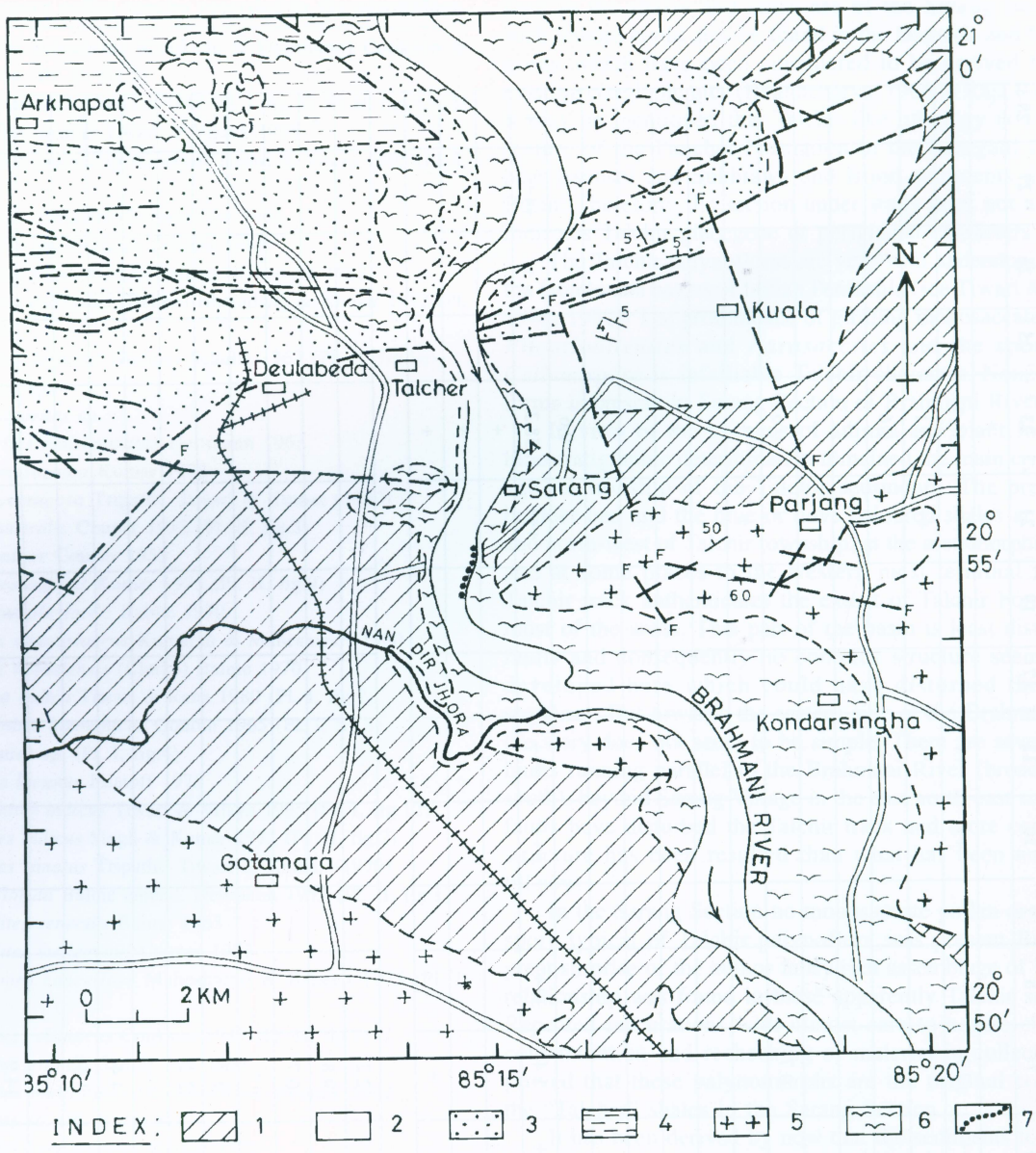


Fig. 3. Geological map of part of Talcher Coalfield showing the "Talchir exposure" of Brahmani River Section (after Raja Rao 1982). Index: 1-Talchir Formation, 2-Karharbari Formation, 3-Barakar Formation, 4-Barren Measures Formation, 5-Metamorphics, 6-Alluvium, 7-Sample site.

deciphering the environment during the deposition of sediments in this region. The Talchir/Late Jurassic/Early Cretaceous relationship thus emerging in Talcher Basin could be compared with similar situation in other basins on east coast peninsula.

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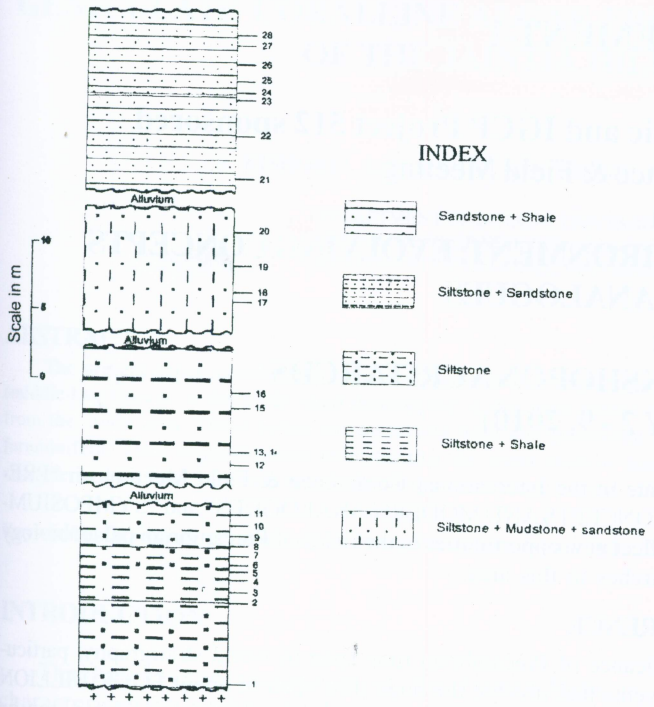

Fig. 4. Lithocolumn of the Sarang Section showing sample location.

Figs. 5a, 5b. Dropstones in the Sarang Section.

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