PALYNOSTRATIGRAPHY OF COAL DEPOSITS IN JABALPUR STAGE, UPPER GONDWANA, INDIA

D. C. BHARADWAJ, P. KUMAR, & H. P. SINGH
Birbal Sahni Institute of Palaeobotany, Lucknow

ABSTRACT

The quantitative and qualitative analyses of the dispersed miospores in the coal and coaly shales of the Jabalpur Stage, Jabalpur Series, Madhya Pradesh, India have been given. The miofloral assemblage consists of 58 spore genera and 103 species. It is characterized by the prominence of *Araucariacites* associated with the common occurrence of *Callialasporites* and *Cycadopites*. The cryptogamic components are poor in occurrence.

A comparison of the mioflora with the Indian and extra-Indian Upper Gondwana miofloras reveals that the Jabalpur Stage mioflora on one hand, closely resembles with the Rajmahal Hills mioflora (Basko and Sakrigalighat) but for the higher quantities of the cryptogamic spores and lesser frequency of *Callialasporites*, *Cycadopites* and *Classopollis*, and on the other hand it also resembles the Microflora IIa of Upper Jurassic age from W. Australia (Balme, 1957), the Upper Jurassic mioflora from Upper Katrol Shales of Kutch and the mioflora from Vemavaram shales. In view of the miofloristic similarity of the mioflora from Jabalpur Stage with those from palaeontologically dated Upper Jurassic strata in India as well as Australia, the former are conclusively dated as Upper Jurassic.

INTRODUCTION

THE present study deals with the palynostratigraphy of the coal and associated coaly shales of the Jabalpur Stage. The samples were collected by Singh (1962) from Sehora and Hathnapur in Narsinghpur district and from Lameta Ghat in Jabalpur district, all belonging to the Jabalpur Stage of the Jabalpur Series, represented in the Satpura Gondwana Basin, Madhya Pradesh, India.

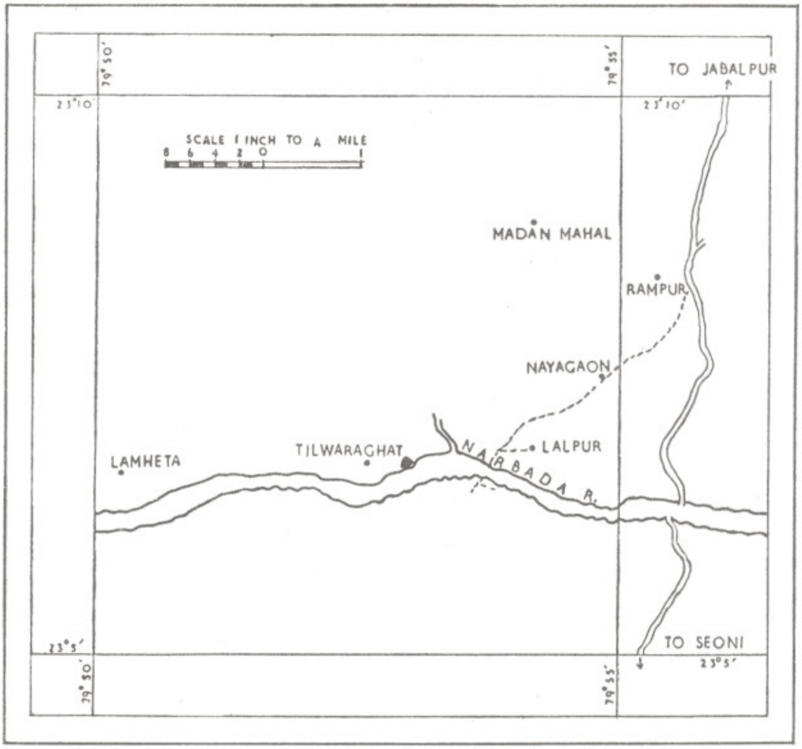
A preliminary report on the occurrence of spores and angiospermic pollen grains (Magnoliaceae) was published by Shrivastava (1954), from the shales in district Narsinghpur. Dev (1961) studied the mioflora from the shales of Sehora, exposed on Sher River in Narsinghpur district and stated that the mioflora is rich in the coniferous pollen grains but cycadophytes are poor in distribution though cryptogamic components are fairly common. He opined that the Jabalpur Series may be younger than the Rajmahal Hills assemblage. Singh (1966 & 1970) has studied the miospore contents recovered out of the coal and coaly shales from Sehora and Hathnapur (Harad River) and stated that the Jabalpur Series may be of Lower Cretaceous age in view of the presence of index miospores of Australian Lower Cretaceous.

Lithologically, Oldham (1893) suggested that the Jabalpur beds are closer in age to the Umia beds than to the Rajmahal Hills. Crookshank (1935) viewed that the Jabalpur beds may be of Oolitic (Middle-Upper Jurassic) in age and inferred that the Jabalpur Series consists of two Stages i.e. Chaugan (older) and Jabalpur (younger). Wadia (1953) opined that the Jabalpur Series might be of Upper Jurassic age. Pascoe (1959) recognizes the two stages of the Jabalpur Series as one formation for the reason of both having similar lithology. Matley (1921) observed that they may belong to Lower Cretaceous age stratigraphically.

GEOLOGY

A brief account of the geology of the area has already been given by Singh (1966). The details pertaining to the location of the coal bearing localities of the Jabalpur Stage (Satpura Coal Basin) which were visited for sampling of the material are given below.

(1) *Lameta Ghat* (Map-1) — In the eastern sector of the Satpura Coal Basin, a small section of coal and coaly shales is exposed at Lameta Ghat, situated about 9 miles W.S.W. of Jabalpur City (Jabalpur district) on the north bank of the Narbada river. The thin bed of coal and coaly shale lies above the Jabalpur sandstones probably at the base of the Lameta formation. The coal seam is about 2′-3′ thick having bright coal. This coal band is underlain by about 10′-15′ thick, pale tinted shales and sandstones. There is another coal seam lying below the sandstone, measuring



MAP 1 — Showing the coal exposure at Lameta Ghat.

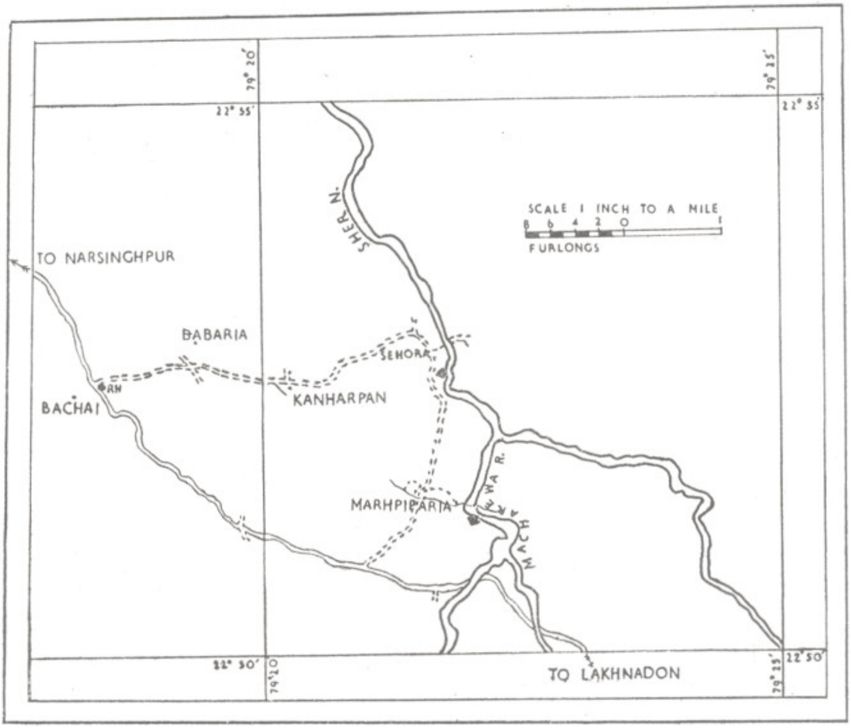
more or less 1′ in thickness and this in turn, is again underlain by pale tinted shales and then by a thick Jabalpur sandstone.

(2) *Sehora* (Map-2) — In the district of Narsinghpur near Sehora, about 150 yards from the confluence of Sher and Macharewa river, in the Sher river, the earthy and conglomeratic bottom beds are overlain, with a southerly dip, by a bed of sandstone of the Jabalpur type upon which rest shaly carbonaceous beds containing some strings of jet-coal. This band is separated from a similar carbonaceous and coaly shale band by several feet thick beds of sandstone. This upper band lies under a very thick mass of sandstone.

(3) *Hathnapur* (Map-3) — about 4 miles from Hathnapur, in the district of Narsinghpur, and about two miles from the mouth of the gorge of the Sakkar and Harad rivers, the exposures of coal bands are seen. The lowermost stratum is the pinkish earthy calcareous conglomerate, about 50′ in thickness. This conglomerate is overlain by flaggy sandstone and coaly shales, associated with some strong false-bedded sandstones. The massive beds of sandstones separate these shales from the upper band of shales which are intercalated with jet-coal and are few inches thick, in the Harad river at its confluence with the Sakkar river. This second band is covered by the strong sandstones of the same type forming the surrounding hills.

MATERIAL

All the collections were made from the exposed surfaces of coal or coaly shales along river or nallah cuttings. Considerable precautions were observed before sampling in order to avoid surface contamination. A channel was cut through the whole thickness of the seam and samples were collected (about 50 gms), in polythene bags which were sealed soon after. Samples of coal and coaly shales were collected from different localities, as mentioned above, from bottom to top at 6-8 inches interval, the details of which are appended



MAP 2 — Showing the coal exposure on Sher river near Sehora.

in Tables 1-3. The present collection of the material was made by one of us (Singh 1962 & 1963).

QUANTITATIVE COMPOSITION OF THE MIOFLORA

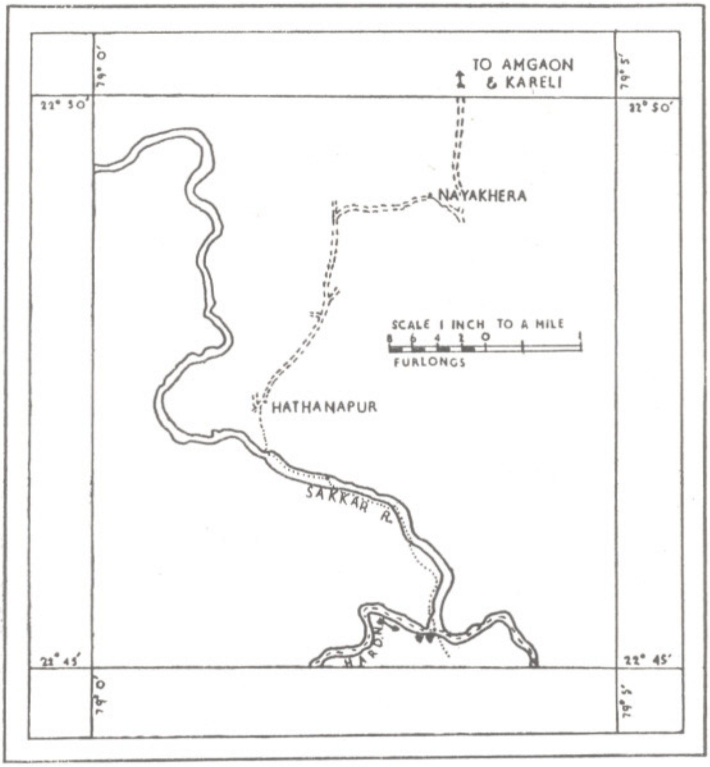
The mioflora of the Jabalpur Stage represented at Lameta Ghat, Sehora and Hathnapur consists of fifty-eight genera and one hundred and three species. Among the genera, 35 are triletes, 5 monolete, 2 hilate, 1 monosaccate, 7 bisaccate, 2 polysaccate, 2 monocolpate, 2 alete monosaccate and 2 operculate nonsaccate.

The present assemblage records many additional spore and pollen genera in comparison to those reported by Shrivastava (1954), Dev (1961) and Singh (1966) from the same beds. The occurrence of angiospermic and striated saccate pollen grains as reported by Shrivastava (*l.c.*) and Dev (*l.c.*) respectively from the Narsinghpur district have not been confirmed by the present study so far.

The qualitative analysis of the miofloral assemblage of the Jabalpur Stage appears to be quite significant in that the assemblage from Lameta Ghat is much impoverished in having the lowest number of genera, i.e. 36 genera with 58 species as compared to the Sehora assemblage containing 42 genera and 76 species and that of Hathnapur consisting of a still larger variety in miospores, i.e. 57 genera and 94 species (Tables 5 & 6).

The distribution of various miospore taxa along with their percentage frequency in the assemblages of Lameta Ghat, Sehora and Hathnapur is given in Table 4. The composition of the mioflora is based on a count of 500 spores per sample from each assemblage. Out of the 58 genera only 38 of them have figured in the counting. The remaining genera are extremely low in their numerical distribution in the assemblages (Histogram-1).

The genera represented by 20 percent or more have been treated as *prominent* members of the assemblages, whereas those which are distributed between 10 and 19 percent have been considered as *common* forms. The genera which show a frequency range between 5 and 9 percent are



MAP 3 — Showing the coal exposure on Harad river at the confluence of Sakkar and Harad rivers.

TABLE 1

Lameta Ghat — About 2 furlongs east of Tilwara Ghat. (Map 1)

SL. No.	REGD. SAMPLE No.	THICKNESS OF THE SEAM	DESCRIPTION OF THE STRATA
1	597/14 (Top)	6 inches	Coaly shales with layer of bright shining coal
2	597/13	4 ,,	Coal
3	597/12	4 ,,	,,
4	597/11	4 ,,	,,
5	597/10	4 ,,	,,
6	597/9	2 ,,	Coaly shale
7	597/8	6 ,,	Coaly shale & coal
8	597/7	4 ,,	Coaly shale
		10-15 feet	Sandstone
9	766/6	2 inches	Coaly shale
10	766/5	4 ,,	Bright coal with intercalated shale
11	766/4	2 ,,	Coaly shale
12	766/3	2 ,,	Bright coal
13	766/2	2 ,,	Bright coal
14	766/1 (Bottom)	2 ,,	Shale & coal

TABLE 2

Sehora — About 3 furlongs S.E. from Sehora village on the bank of Sher river (Map 2)

SL. No.	REGD. SAMPLE No.	THICKNESS OF THE SEAM	DESCRIPTION OF THE STRATA
1	598/6 (Top)	1 foot	Coaly shale underlying jet-coal
2	598/5	8 inches	Coal & coaly shale
3	598/4	10 ,,	Black shining coal
4	598/3	6 ,,	Black shining coal
5	598/2	1 foot	Black shining coal & coaly shale
6	598/1 (Bottom)	1 ,,	Black coaly shale

taken to be *fair* whereas the *poor* components occur with a frequency between 1 to 4 percent. Those forms which occur less than 1 percent in the assemblages have

TABLE 3

Hathnapur (Harad river)— About 3 miles south of Hathnapur village (Map 3)

SL. No.	REGD. SAMPLE No.	THICKNESS OF THE SEAM	DESCRIPTION OF THE STRATA
1	599/5 (Top)	1 foot 2 inches	Carbonaceous shale beneath the massive sandstone
2	599/4	1 foot 2 inches	Coaly shale with streaks of coal
3	599/3	1 foot	Coaly shale
4	599/2	1 foot 2 inches	Coaly shale
5	599/1 (Bottom)	1 foot 2 inehes	Carbonaceous shale at base of the bed

been termed as *rare* whereas those which do not figure in the counts but have been observed to occur, are *very rare*.

A critical appraisal of the vertical distribution of spore genera, i.e., from bottom to the top in the three assemblages (Histogram-1), has revealed that the following spore genera are quantitatively important.

Callialasporites
Podocarpidites
Araucariacites
Cycadopites
Classopollis

Lameta Ghat — In Lameta Ghat, out of 14 coal samples only sample Nos. 597/7, 8,9,12,13 and 14 in succession from bottom to the top, have yielded miospores, as represented in Histogram 1. The quantitatively significant miospore genera in the Lameta Ghat assemblage are *Araucariacites, Cycadopites, Callialasporites, Podocarpidites* and *Haradisporites*. The quantitative representation of the characteristic spore genera shows differences between the various samples in the succession.

The bottom sample Nos. 597/7-9 has prominent *Callialasporites* associated with *Podocarpidites, Cycadopites* and *Araucariacites*. However, in sample Nos. 597/12-13, *Araucariacites* is prominent and *Cycadopites* is common whereas the top most sample No. 597/14 has prominent *Cycadopites* and common *Araucariacites*. The genera *Callialasporites* and *Classopollis* are common in sample Nos. 597/12-14. However, in the bottom sample Nos. 597/7-9, *Classopollis* is poor. The other differences noticed in the assemblage are, that *Callialasporites* (30-10·4%) and *Podocarpidites* (28·8-2·0%) show gradual reducing tendency from the bottom towards the top sections and that *Araucariacites* (4·8-18·8%) and *Cycadopites* (11·8-24·8%) exhibit more or less a gradual increasing tendency from the base towards the top.

This assemblage as a whole appears to be a single assemblage in respect of the common, characteristic association of *Araucariacites, Cycadopites* and *Callialasporites*. The cryptogamic elements show more or less uniformly, a poor representation in the assemblage but for indicating an increasing trend topwards.

Sehora — The mioflora from Sehora is constituted by spores from six coal samples in succession from bottom to top (Histogram-1). The similar association of the various taxa and their frequency of occurrence in the various samples clearly indicates that the mioflora represents a single assemblage. There is no marked difference in the miofloral composition from bottom to top. The assemblage is characterized by the prominence of *Araucariacites* associated with *Cycadopites* as next high. The last genus is mostly common but it is prominent (22 and 21·2%) in sample Nos. 598/3 and 4. In general trend, *Callialasporites* (11-3·2%) shows declining tendency towards the top as also seen in Hathnapur and Lameta Ghat assemblages. On the contrary, *Podocarpidites* (7·8-15·4%) registers increase from base towards the top which is just the reverse condition of the one in Hathnapur and Lameta Ghat. The cryptogamic elements are poor in amounts throughout.

Hathnapur — The palynological mioflora from Hathnapur (Histogram-1) is constituted by spores from five coal samples in succession. Quantitatively, the assemblage exhibits two combinations of the prominent genera. In the older one, represented by sample Nos. 599/1-4, *Araucariacites* is prominent and *Cycadopites* is represented as next high. In the younger, represented by sample No. 599/5, *Cycadopites* (31. 8%) is prominent and *Araucariacites* is common.

On the whole, the assemblage is coherent inspite of certain other minor differences such as in having *Callialasporites* (28·8%)

as prominent in sample No. 599/2 and next to *Araucariacites* (42·8%) while *Cycadopites* (22·8%) is prominent in sample No. 599/3 also. *Callialasporites* and *Podocarpidites* show gradual reducing trend towards the top sections as seen in the Lameta Ghat succession. The cryptogamic elements are poor in this assemblage too.

A comparison of the miospore frequencies from the three assemblages (Histogram-2) as recovered from Lameta Ghat, Sehora and Hathnapur reveals that they are very much identical in respect of the incidence of *Araucariacites*, *Cycadopites* and *Callialasporites*. Though, *Araucariacites*, is 'prominent' in Sehora and Hathnapur, it reduces at Lameta Ghat and while *Callialasporites* is represented as 'common' in all the three assemblages, it is slightly higher in percentage in Lameta Ghat as compared to *Araucariacites*. *Cycadopites* is 'common' in all the three. Hence, it appears that all the three assemblages might have been deposited during the same time span in which the one from Lameta Ghat appears to be the youngest of the three. Thus, the miofloral assemblages of the Jabalpur Stage are chiefly characterized by the dominant association of *Araucariacites* and *Callialasporites* while *Cycadopites* is 'common'. The fairly represented genera are *Podocarpidites*, *Alisporites* and *Classopollis*. The cryptogams are poorly represented.

QUALITATIVE COMPOSITION OF THE MIOFLORA

Lameta Ghat — Qualitatively, the mioflora from Lameta Ghat is chiefly characterized by the presence of mostly coniferous and cycadalean or bennettitalean elements. The cryptogamic elements are present but poor in variety. Among the conifers, the podocarpaceous elements are represented by a monosaccate genus, viz. *Callialasporites* and two bisaccate genera, viz., *Podocarpidites* and *Phyllocladidites* as well as the polysaccates, viz., *Dacrycarpites* and *Podosporites*; the araucarian components are represented by the three genera, viz., *Araucariacites* as an alete nonsaccate and *Classopollis* and *Gliscopollis* as operculate nonsaccate *Cycadopites* and *Monosulcites* are of cycadalean or bennettitalean stock. The pteridospermous and pinaceous elements are represented by *Vitreisporites*, *Alisporites* and *Abiespollenites* respectively.

The pteridophytic elements are characterized by the trilete miospores viz., *Cyathidites*, *Haradisporites*, *Coniatisporites*, *Osmundacidites*, *Matonisporites*, *Lametatriletes*, *Gleicheniidites*, *Contignisporites* and *Cicatricosisporites* etc., which belong to Cyathiaceae or Dicksoniaceae, or may be to Hymenophyllaceae, Osmundaceae, Matoniaceae, Gleicheniaceae and Schizaeaceae respectively. The monolete forms viz., *Laevigatosporites*, and *Dettmannites* are also present in the assemblage and probably belong to Polypodiaceae and Marattiaceae. The bryophytic element is represented by *Coptospora*.

Sehora — The miofloral assemblage from Sehora is also characterized by the occurrence of mostly coniferous and cycadalean or bennettitalean components. The cryptogamic elements are comparatively richer in variety as compared to Lameta Ghat (Tables 5 & 6). Among the conifers, *Araucariacites* is richly represented and is of an araucarian stock. Cycadalean or bennettitalean class is represented by *Cycadopites*. The podocarpaceous elements are represented by *Callialasporites*, *Podocarpidites* and *Baculopollenites* etc. The pteridospermous and pinaceous elements as well as other conifer genera which are present in the Lameta Ghat assemblage also occur in the assemblage from Sehora.

The main trilete bearing pteridophytic elements of the assemblage are *Cyathidites*, *Haradisporites*, *Biretisporites*, *Osmundacidites*, *Biformaesporites*, *Venusteaesporites*, *Boseisporites*, *Callispora* and *Contignisporites* etc. These components probably belong to Cyathiaceae, Hymenophyllaceae, Osmundaceae, Matoniaceae and Schizaeaceae etc. The monolete forms are represented by *Laevigatosporites*, *Dettmannites* and *Metamonoletes*, etc. which are of probably polypodiaceous and marattiaceous stocks. The bryophytic elements are represented by *Coptospora* and *Rouseisporites*.

Hathnapur — The miofloral assemblage of Hathnapur appears to have the largest variety of cryptogamic components (Tables 5 & 6). The pollen grains of conifers are represented by the same contents as occur in the assemblages of Lameta Ghat and Sehora, excepting *Platysaccus*. *Araucariacites* and *Cycadopites* are richly distributed in the assemblage as is the case in Sehora.

TABLE 4

Spore genera	Lameta Ghat							Sehora							Hathnapur					
Sample Nos.	597/7	597/8	597/9	597/12	597/13	597/14	Average	598/1	598/2	598/3	598/4	598/5	598/6	Average	599/1	599/2	599/3	599/4	599/5	Average
Percentage	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Cyathidites	1·0	—	1·2	2·4	5·6	5·6	2·63	4·8	1·0	3·8	2·2	0·8	1·8	2·4	1·8	2·4	2·0	0·6	1·2	1·2
Haradisporites	6·6	8·2	5·0	11·6	9·2	6·4	7·83	3·6	2·0	6·0	4·0	3·2	2·0	3·46	9·6	1·2	5·6	2·4	5·6	4·88
Dictyophyllidites	—	—	—	—	—	—	—	—	0·4	—	—	—	—	0·06	0·4	—	0·8	0·4	0·4	0·4
Concavisporites	1·0	1·2	0·2	1·6	3·8	1·8	1·6	0·2	—	—	0·2	—	—	0·06	0·4	—	0·8	—	1·2	0·48
Todisporites	—	0·4	0·2	1·4	0·2	2·0	0·7	—	—	0·4	—	—	—	0·06	0·4	—	0·2	—	0·4	0·2
Coniatisporites	0·8	0·2	0·4	3·8	1·6	—	1·13	—	—	0·4	—	—	—	0·06	0·2	—	0·8	0·6	0·6	0·44
Osmundacidites	—	—	—	—	—	—	—	—	—	0·2	—	—	—	0·03	0·2	—	0·4	—	0·2	0·16
Baculatisporites	—	—	—	0·8	0·2	—	0·16	—	—	0·2	—	—	—	0·03	—	—	0·6	0·6	0·4	0·32
Neoraistrickia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0·4	0·2	0·12
Lycopodiumsporites	—	—	—	—	0·8	—	0·13	—	0·4	—	—	—	—	0·06	—	—	—	—	—	—
Cicatricosisporites	—	—	0·2	0·6	0·8	1·6	0·53	—	—	0·4	—	—	—	0·06	0·2	—	—	—	0·4	0·12
Densoisporites	—	—	—	—	—	—	—	—	—	0·6	—	—	—	0·1	—	—	0·6	—	—	0·12
Matonisporites	0·2	—	—	0·8	0·6	—	0·26	0·6	1·0	0·4	0·8	—	1·0	0·63	—	0·4	0·4	—	—	0·16
Lametatriletes	0·2	0·6	0·2	—	—	0·6	0·26	0·2	0·4	—	0·4	—	0·4	0·23	—	—	—	—	—	—
Callispora	—	—	—	0·4	1·6	—	0·33	1·0	0·4	1·0	0·6	1·2	2·8	1·16	—	0·2	—	—	—	0·04
Boseisporites	—	—	—	—	—	—	—	1·2	0·4	0·8	0·8	2·4	1·6	1·2	—	0·2	—	—	—	0·04
Gleicheniidites	0·4	0·4	0·2	0·8	1·8	1·2	0·8	—	—	0·2	—	—	—	0·03	0·6	0·2	0·2	0·4	0·6	0·4
Peregrinisporis	—	—	—	—	—	—	—	—	—	0·2	—	—	—	0·03	0·2	0·2	0·6	—	2·0	0·6
Contignisporites	0·4	0·4	0·8	1·4	2·4	6·0	1·9	—	0·6	—	—	0·6	—	0·2	0·6	0·2	0·4	0·4	0·2	0·36
Laevigatosporites	—	0·2	—	0·4	1·4	3·0	0·83	0·8	0·4	—	—	0·8	—	0·33	0·2	0·2	—	—	—	0·08
Leschikisporis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0·2	—	0·2	—	0·6	0·2
Dettmannites	—	0·2	—	0·6	1·0	—	0·3	—	0·6	—	0·6	—	—	0·2	0·2	0·4	0·8	0·6	9·4	2·28
Metamonoletes	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0·8	—	0·4	0·8	2·2	0·84
Rouseisporites	—	—	—	—	—	—	—	—	—	—	—	1·6	0·4	0·33	0·8	—	0·2	—	1·0	0·4
Coptospora	3·4	1·6	1·6	—	—	—	1·1	—	0·4	—	—	0·8	—	0·2	1·0	0·4	0·4	0·6	—	0·48
Callialasporites	30·0	23·2	27·8	10·2	12·8	10·4	19·06	11·0	15·6	13·4	11·0	13·8	3·2	11·33	8·6	28·8	10·2	13·4	3·0	12·8
Vitreisporites	1·6	0·2	0·8	—	—	—	0·43	0·2	0·2	0·2	1·2	0·4	0·6	0·46	2·2	0·4	0·4	0·2	1·2	0·88
Alisporites	6·6	4·0	4·8	5·8	5·4	2·8	4·9	8·0	4·8	7·2	8·0	6·4	17·6	8·66	4·2	1·6	3·8	1·0	1·4	2·4
Abiespollenites	1·8	1·8	1·2	0·6	0·8	0·8	1·16	0·6	0·8	2·0	3·2	2·6	4·8	2·33	1·4	1·2	1·6	0·4	1·0	1·12
Podocarpidites	21·8	12·0	12·8	2·0	2·8	2·0	8·9	7·8	3·8	6·0	9·8	11·6	15·4	9·06	11·2	4·8	8·2	2·2	6·2	6·52
Phyllocladidites	1·0	0·4	0·2	—	0·2	—	0·3	1·0	—	0·8	0·2	0·6	1·6	0·7	2·0	0·6	0·8	—	1·2	0·92
Dacrycarpites	1·0	0·6	0·4	—	—	—	0·33	—	0·2	—	—	0·6	—	0·13	0·4	0·6	—	0·4	0·8	0·44
Podosporites	—	1·2	0·4	—	—	0·4	0·33	1·8	2·4	2·2	1·0	2·8	2·8	2·16	6·2	1·2	0·6	1·2	2·4	2·32
Araucariacites	4·8	15·6	16·4	24·0	25·6	18·8	17·54	37·4	38·6	25·4	30·6	32·4	30·6	32·5	26·6	42·8	26·8	47·0	14·4	31·52
Cycadopites	11·8	19·2	19·6	18·0	8·8	24·8	17·03	13·8	16·8	22·0	21·2	15·0	11·6	16·73	10·6	9·0	22·8	17·2	31·8	18·28
Monosulcites	2·2	2·4	0·4	—	2·2	2·8	1·66	3·2	4·6	2·8	1·8	1·6	0·6	2·43	—	1·6	—	—	—	0·32
Classopollis	3·4	5·2	4·4	12·8	10·4	9·0	7·53	2·8	4·0	2·6	2·4	0·8	0·8	2·23	7·6	3·4	8·4	8·2	8·8	7·28
Gliscopollis	—	0·8	0·8	—	—	—	0·26	—	0·2	0·8	—	—	0·4	0·23	1·2	—	1·4	0·6	1·2	0·88

TABLE 5

SPOROMORPHS	LAMETA GHAT	SEHORA	HATHNAPUR
Cyathidites	+	+	+
Alsophilidites	+	+	+
Haradisporites	+	+	+
Stereisporites	–	–	+
Biretisporites	–	+	+
Dictyophyllidites	+	+	+
Concavisporites	+	+	+
Todisporites	+	+	+
Leptolepidites	–	–	+
Lophotriletes	–	–	+
Coniatisporites	+	+	+
Osmundacidites	+	+	+
Baculatisporites	+	+	+
Neoraistrickia	–	–	+
Biformaesporites	–	+	+
Rugulatisporites	–	–	+
Lycopodiacidites	–	–	+
Foveosporites	+	–	+
Lycopodiumsporites	+	+	+
Klukisporites	–	–	+
Cicatricosisporites	+	+	+
Matonisporites	+	+	+
Callispora	+	+	+
Lametatriletes	+	+	+
Venusteaesporites	–	+	+
Boseisporites	+	+	+
Trilites	–	–	+
Ischyosporites	–	–	+
Gleicheniidites	+	+	+
Sestrosporites	–	–	+
Peregrinisporis	–	+	+
Murospora	+	–	–
Contignisporites	+	+	+
Densoisporites	–	–	+
Crybelosporites	–	–	+
Laevigatosporites	+	+	+
Monolites	+	+	+
Leschikisporis	–	–	+
Metamonoletes	–	+	+
Dettmannites	+	+	+
Rouseisporites	–	+	+
Coptospora	+	+	+
Callialasporites	+	+	+
Vitreisporites	+	+	+
Abiespollenites	+	+	+
Alisporites	+	+	+
Platysaccus	–	–	+
Podocarpidites	+	+	+
Baculopollenites	–	+	+
Phyllocladidites	+	+	+
Dacrycarpites	+	+	+
Podosporites	+	+	+
Araucariacites	+	+	+
Reticulatasporites	–	+	+
Cyadopites	+	+	+
Monosulcites	+	+	+
Classopollis	+	+	+
Gliscopollis	+	+	+

TABLE 6

SPORE SPECIES	LAMETA GHAT	SEHORA	HATHNAPUR
Laevigati			
Cyathidites australis	+	+	+
C. minor	+	+	+
C. punctatus	–	+	+
C. densus	–	+	+
Alsophilidites psilatus	+	+	+
Haradisporites mineri	+	+	+
H. scabratus	–	–	+
H. undulatus	–	–	+
H. sinuosus	–	–	+
H. sp.	–	–	+
Stereisporites sp.	–	–	+
Cf. *S.* sp. A	–	–	+
Cf. *S.* sp. B	–	–	+
Biretisporites sp.	–	+	+
Dictyophyllidites haradensis	+	+	+
D. sp.	–	–	+
Concavisporites novicus	+	+	+
C. sp.	–	–	+
Todisporites minor	+	+	+
Apiculati			
Leptolepidites sp.	–	–	+
Lophotriletes sp.	–	–	+
Coniatisporites haradensis	+	+	+
Osmundacidites wellmanii	+	+	+
Baculatisporites comaumensis	+	+	+
B. rotundus	–	–	+
Neoraistrickia neozealandica	+	+	+
N. pallida	–	–	+
Biformaesporites baculosus	–	+	+
B. sp.	–	+	–
Murornati			
Rugulatisporites sp.	–	–	+
Lycopodiacidites sp.	–	–	+
Foveosporites sp.	+	–	+
Lycopodiumsporites sinuosus	+	+	+
L. pallidus	–	–	+
Klukisporites haradensis	–	–	+
Cicatricosisporites ludbrooki	+	+	+
Cf. *C.* sp.	–	–	+

TABLE 6 — (*contd.*)

Spore Species	Lameta Ghat	Sehora	Hathnapur
Auriculati			
Matonisporites dubius	+	+	+
M. discoidalis	−	+	−
Callispora potoniei	+	+	+
Lametatriletes indicus	+	+	−
L. tenuis	+	+	+
L. mesozoicus	−	+	+
Venusteaesporites pallidus	−	+	+
Boseisporites praeclarus	−	+	−
B. indicus	−	+	+
B. jabalpurensis	+	+	−
B. sehoraensis	−	+	−
Trilites fusus	−	−	+
Ischyosporites haradensis	−	−	+
Tricrassati			
Gleicheniidites glaucus	+	+	+
G. apicus	+	−	+
Sestrosporites irregulatus	−	−	+
Peregrinisporis indicus	−	+	+
Cingulati			
Cf. *Murospora* sp.	+	−	−
Contignisporites glebulentus	+	+	+
C. cooksonii	+	+	+
C. fornicatus	−	−	+
C. dettmanii	−	+	+
C. psilatus	−	−	+
C. sp.	−	−	+
Perinotrilites			
Densoisporites mesozoicus	−	−	+
D. indicus	−	−	+
D. novicus	−	−	+
Crybelosporites sp. cf. *C. stylosus*	−	−	+
Monoletes			
Laevigatosporites ovatus	+	+	+
L. gracilis	+	+	+
Monolites indicus	+	+	+
M. sp.	+	+	−
Leschikisporis verrucosus	−	−	+
Metamonoletes haradensis	−	+	+
Dettmannites attenuarus	+	+	+

TAELE 6 — (*contd.*)

Spore Species	Lameta Ghat	Sehora	Hathnapur
Hilates			
Rouseisporites sehoraensis	−	+	+
R. densus	−	+	+
Coptospora mesozoica	+	+	+
C. pallida	−	−	+
Saccites			
Callialasporites trilobatus	+	+	+
C. dampieri	+	+	+
C. indicus	−	+	+
C. primus	+	+	+
C. limbatus	+	+	+
C. sehoraensis	−	+	+
C. segmentatus	+	+	+
C. enigmaticus	−	−	+
C. fimbriatus	−	−	+
C. discoidalis	−	−	+
C. plicatus	+	+	+
C. doringii	−	+	+
C. circumplectus	−	−	+
C. lametaensis	+	+	+
C. sp.	+	−	−
Vitreisporites pallidus	+	+	+
Abiespollenites triangularis	+	+	+
Alisporites mesozoicus	+	+	+
A. similis	+	+	+
A. sp. cf. *A. bilateralis*	+	+	+
A. ovalis	−	−	+
A. haradensis	−	+	+
A. sehoraensis	+	+	+
Platysaccus densus	−	−	+
P. sp. A	−	−	+
P. sp.	−	−	+
Podocarpidites ellipticus	+	+	+
P. grandis	+	+	−
P. multisemus	+	+	+
P. cristiexinus	+	+	+
P. vermiculatus	+	−	+
Baculopollenites haradensis	−	+	+
Phyllocladidites rüei	+	+	+
P. florinii	+	+	+
Podosporites tripakshi	+	+	+
P. microsaccatus	−	+	+
P. sp.	−	−	+
Dacrycarpites australiensis	+	+	+
Aletes			
Araucariacites australis	+	+	+
A. ghuneriensis	+	+	−
A. indicus	+	+	+
A. limbatus	+	+	−
Reticulatasporites sp.	−	+	+

TABLE 6 — (contd.)

Spore Species	Lameta Ghat	Sehoha	Hathnapur
Plicates			
Cycadopites gracilis	+	+	+
C. sp. cf. *C. sakrigaliensis*	—	—	+
C. couperi	+	+	—
Monosulcites ellipticus	+	+	+
Poroses			
Classopollis sp. cf. *C. torosus*	+	+	+
C. sp.	+	—	—
Gliscopollis pallidus	+	+	+

Among the podocarpaceous elements, *Callialasporites* is good in the distribution. The pteridospermous element is represented by *Vitreisporites*.

The characteristic trilete bearing pteridophytic components of the assemblage are *Cyathidites, Haradisporites, Leptolepidites, Osmundacidites, Neoraistrickia, Klukisporites, Cicatricosisporites, Densoisporites* and *Crybelosporites* etc., which probably belong to Cyathiaceae, Hymenophyllaceae, Osmundaceae, Schizaeaceae, Gleicheniaceae, Lycopodiales and Marsiliaceae etc., (Tables 5 & 6). The monolete forms are represented by five genera viz., *Laevigatosporites, Monolites, Leschikisporis, Metamonoletes* and *Dettmannites* which probably belong to Marattiaceae and Polypodiaceae etc. The bryophytic components are indicated by the presence of *Coptospora, Rouseisporites* and *Stereisporites*.

A comparative qualitative analysis of the miofloral assemblages as represented at Lameta Ghat, Sehora and Hathnapur reveals that all these assemblages are very much identical in the association of araucariaceous, cycadalean or bennettitalean and podocarpaceous components etc. The similar representation of pteridospermic and pinaceous elements is also noted in all the three assemblages. The representation of cryptogamic miospores is very much similar in all the three assemblages but Hathnapur has the largest variety of miospores as compared to Sehora and Lameta Ghat.

COMPARISON WITH EXTRA-INDIAN UPPER MESOZOIC SPORE-POLLEN ASSEMBLAGES

The assemblages selected for a comparison of the miospore assemblage of the Jabalpur Stage of the Jabalpur Series with those known from the extra-Indian upper Gondwanas are the ones described by Sah (1955), Sah and Jain (1965) and Jain and Sah (1969) from the Salt Range (W. Pakistan); Sah (1953) and Jain and Sah (1966) from Andigama, Ceylon; Martin (1960) from the Gamtoos river beds, Eastern Cape Province, South Africa; Cookson (1953), Balme (1957), Cookson and Dettmann (1958) and Dettmann (1963) from South Australia, Western Australia, Eastern Australia and South-Eastern Australia respectively.

Sah (1955), Sah and Jain (1965) and Jain and Sah (1969) have described the miospore assemblage from the variegated shales of Nammal Gorge, Salt Range (W. Pakistan) suggesting a Lower Jurassic (Liassic) age for them. The assemblage from the Variegated Shales, contains 22 miospore genera viz., *Todisporites, *Divisisporites, *Spongiosisporites, Dictyophyllidites, Matonisporites, Lycopodiumsporites, *Staplinisporites *Tigrisporites, Ischyosporites, Baculatisporites, Osmundacidites, *Cosmosporites, Classopollis, Gliscopollis, Callialasporites,* (= *Perinopollenites*), *Podocarpidites, *Eucommiidites, Cycadopites, Podosporites, *Spheripollenites, Alisporites* and *Araucariacites*. The genera marked with an asterisk are absent in Jabalpur Stage assemblage.

The genera which are quantitatively important in the Variegated Shale (in Bharadwaj, 1969) are *Classopollis complex* (incl. *Gliscopollis*) 50% and *Callialasporites* (= *Perinopollenites*) 22% represented dominantly while the other characteristic elements are *Matonisporites, Dictyophyllidites, Podocarpidites* and *Araucariacites* 4% each, together with *Eucommiidites* 3%, *Tigrisporites* 1%, *Todisporites* + *Divisisporites* + *Spongiosisporites* + *Cosmosporites* + *Staplinisporites* + *Lycopodiumsporites* + *Ischyosporites* + *Baculatisporites, Osmundacidites and Monolites* constituting 8% of the assemblage. In Lameta Ghat, Sehora and Hathnapur of the Jabalpur Stage respectively, *Araucariacites* (17·5, 32·5 and 31·52%) is much more and *Classopollis* complex (7·79, 2·46 and 8·16%) and

Callialasporites (19·06, 11·33 and 12·8%) are lower. Moreover, the assemblages of the Jabalpur Stage are characterized by the "common" occurrence of *Cycadopites*. Hence, the assemblages of the Jabalpur Stage are strikingly different from that of the Variegated Shales.

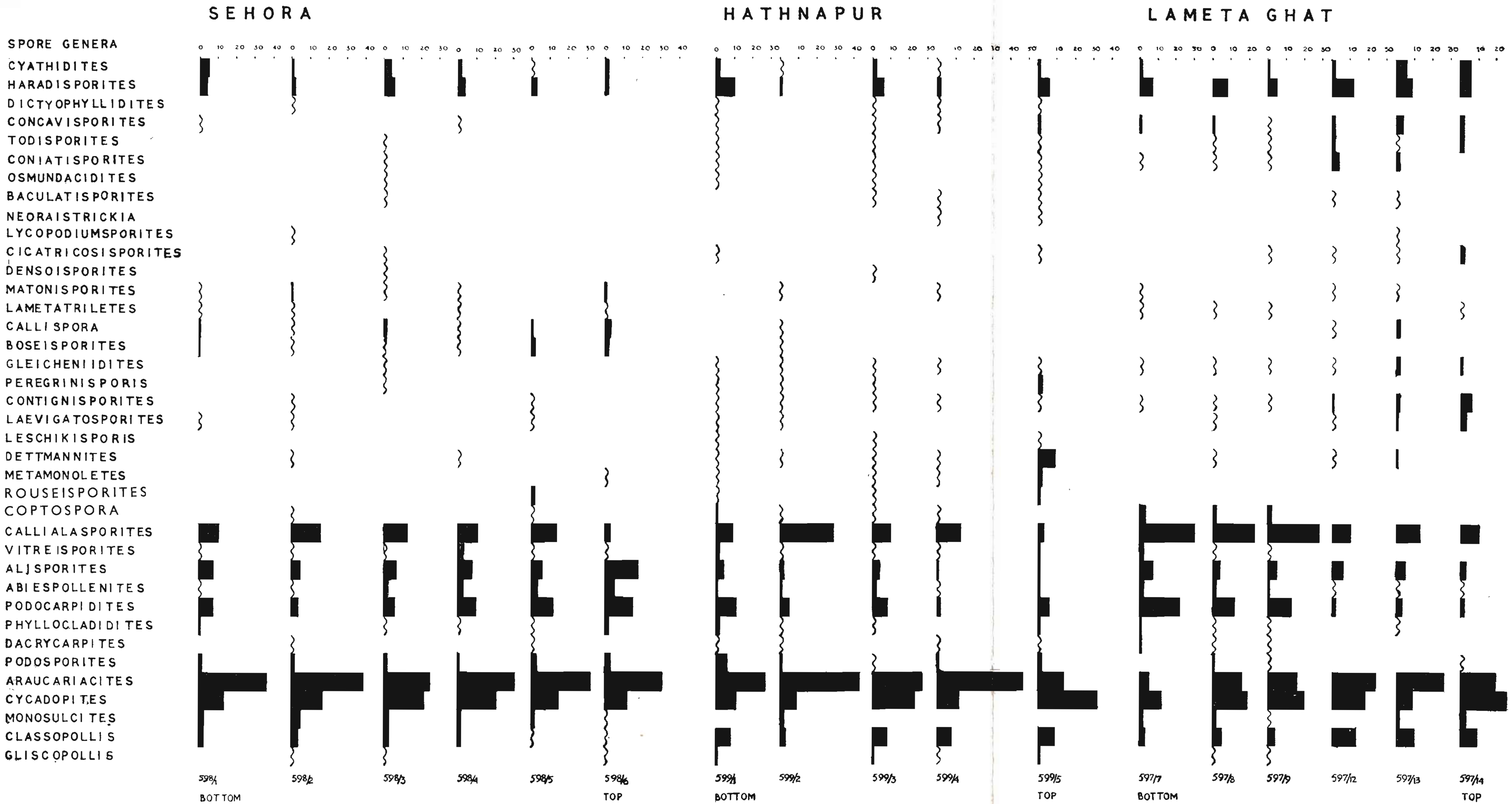
Sah (1953) and Jain and Sah (1966) have described the miospores from Andigama, Ceylon and have suggested an upper Jurassic (younger than Rajmahal Stage) age. The assemblage contains 26 spore-pollen genera. Some of them are viz., *Cyathidites, Deltoidospora, Stereisporites Osmundacidites, *Verrucosisporites, *Concavissimisporites, *Ceratosporites Baculatisporites, Cicatricosisporites, *Perotriletes, Lycopodiumsporites, Contignisporites* (*C. cooksonii*), *Callialasporites, Podocarpidites, Podosporites, Araucariacites* (*Laricoidites*), *Cycadopites* and **Ephedripites* etc. The genera marked with an asterisk are absent in the Jabalpur Stage. Jain and Sah (*l.c.*) state that the assemblage has equally abundant trilete spores and saccate or monosaccate pollen grains, while the cycadophytic pollen grains are comparatively less abundant. Unfortunately, the quantitative analysis of assemblage has not been given by the authors. Hence, a closer comparison is not feasible. It appears that in quantitative composition, the assemblages of Rajmahal Hills (Basko and Sakrigalighat as presented by Bharadwaj 1969, Histogram-II) resemble Andigama Shales in having similar dominance of trilete spores and saccate or nonsaccate pollen grains whereas the cycadophytic pollen grains are represented as next high.

The Andigama assemblage compares favourably with the assemblages of the Jabalpur Stage as represented at Lameta Ghat, Sehora and Hathnapur, in the prominence of gymnospermous pollen grains viz., *Araucariacites* (± 27%) followed by *Cycadopites* (± 17%) but the pteridophytic elements are poorly represented in the Jabalpur Stage.

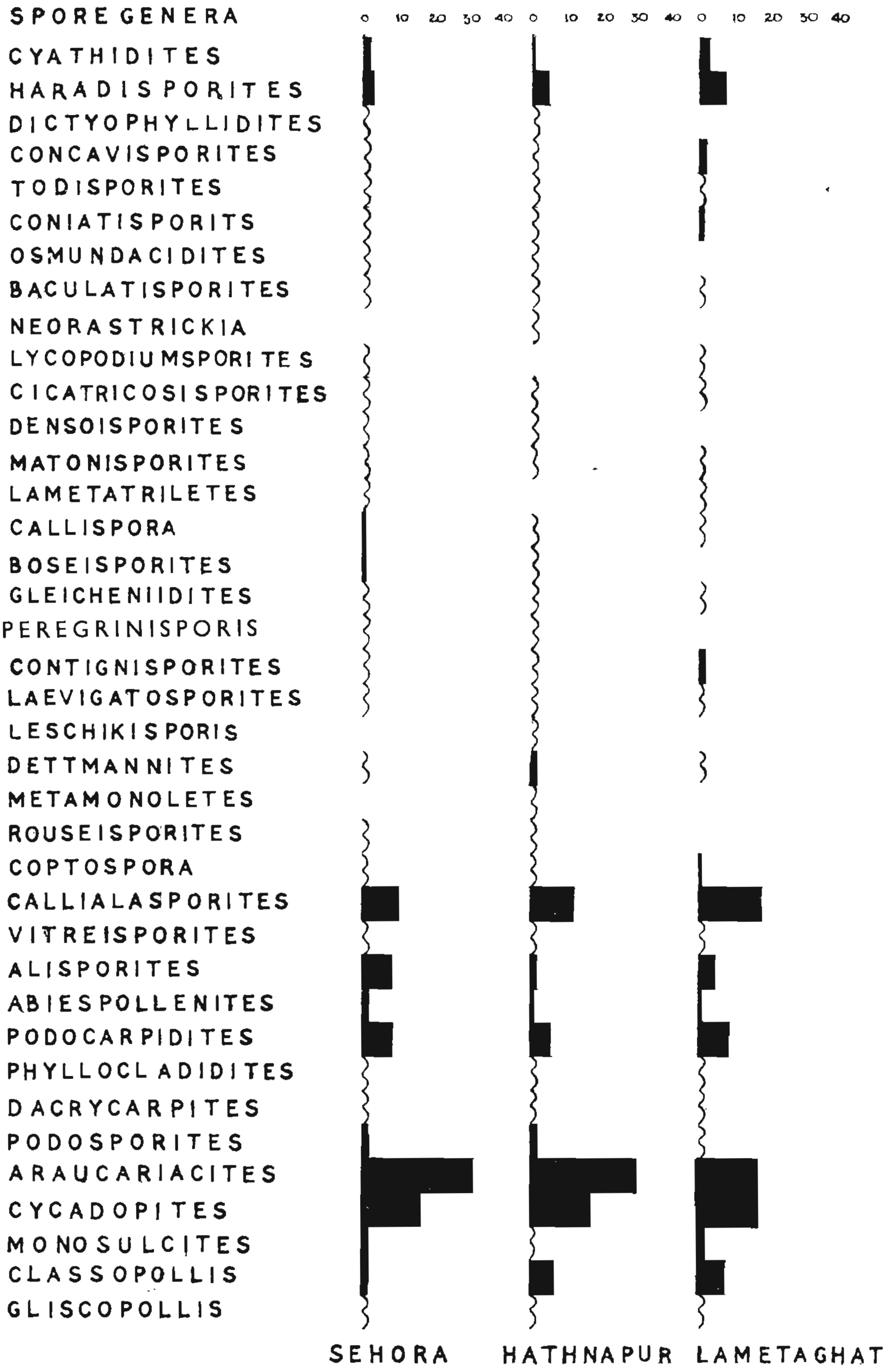
Martin (1960) has recorded miospores from the Gamtoos river, Eastern Cape Province, South Africa, and considers the assemblage to be belonging to Upper Jurassic or Lower Cretaceous. It is characterized by the spores of Cyathiaceae, Dicksoniaceae, Matoniaceae, Gleicheniaceae, Schizaeaceae together with pollen grains, viz., *Vitreisporites pallidus, Callialasporites, Classopollis, Cycadopites, Podocarpidites* and *Podosporites* etc., which are also present in the assemblages of the Jabalpur Stage. Unfortunately, the quantitative break up of the various genera has not been given by Martin (*l.c.*). Hence, it is not possible to judge as to how far it differs or corresponds with the mioflora from the Jabalpur Stage. However, the absence of *Araucariacites* decides that the above assemblage is not comparable with that of Jabalpur Stage.

In Western Australia Balme (*l.c.*) has recognized three assemblages viz., Microflora I, IIa and IIb, belonging to Lower Jurassic, Oxfordian-Kimmeridgian and Neocomian-Aptian in age respectively. The miospore genera occurring in the above three microfloras are **Stereisporites, *Cyathidites, *Osmundacidites, *Cycadopites* (= *Entylissa*), **Araucariacites, *Podocarpidites* (*Pityosporites ellipticus*), **Callialasporites* (= *Inaperturopollenites* and *Zonalapollenites*), **Vitreisporites* (*Pityosporites pallidus*), *Polypodiidites, Pilasporites* and *Classopollis*. In addition to these, some spores are characteristic of respective microfloras like **Gliscopollis* (= *Exesipollenites*), *Marsupipollenites* in Microflora I; *Cingulatisporites* (*C. saevus*) in Microflora IIa whereas; *Reticulatisporites, *Callispora* (*Microreticulatisporites parviretis*), **Murospora* (*Cingulatisporites florida*) *and Aequitriradites* (= *Zonalasporites*) etc., in Microflora IIb. **Lycopodiumsporites* (= *Lycopodium austroclavatidites*), **Contignisporites* (= *Cicatricosisporites cooksonii*), **Gleicheniidites* (= *Gleichenia* cf. *circinidites*), **Ischyosporites, Microcachryidites, *Alisporites* (*Pityosporites similis* and *P. grandis*), *Coronatispora* (= *Microreticulatisporites telatus*), *Staplinisporites* (= *Cingulatisporites caminus*) and **Neoraistrickia* (= *Baculatisporites truncatus*) occur in Microfloras IIa as well as IIb. The genera marked with an asterisk are common with the Jabalpur Stage.

The quantitative analysis reveals that Microflora I is different from the assemblages of the Jabalpur Stage in the abundance of *Classopollis* complex (incl. *Gliscopollis*) and *Callialasporites*, while plentiful occurrence of *Cyathidites* and *Podocarpidites*, and rarity of *Cycadopites*. It seems to resemble the Variegated Shales mioflora from the Salt Range (W. Pakistan) in view of the abundance of *Classopollis*



HISTOGRAM I — Percentage frequency of miospore genera in samples of Jabalpur Stage from Sehora, Hathnapur and Lameta Ghat.



HISTOGRAM II — Average percentage of the miospore genera in assemblages of Jabalpur Stage from Sehora, Hathnapur and Lameta Ghat.

complex. Microflora IIa compares more favourably with the assemblages of Sehora, Hathnapur and Lameta Ghat with slight variations in having *Araucariacites* (*A. australis*) as the most abundant genus and *Podocarpidites* as well as *Callialasporites* (*C. dampieri*) in substantial (over 5%) quantities. However, there is a notable difference in the representation of *Gleicheniidites* which is over 5% in Microflora IIa, but rarely met with in Jabalpur assemblage. Considering the association of the quantitatively more plentiful spore genera, Microflora IIa seems to be agreeing significantly with the assemblages of the Jabalpur Stage. In Microflora IIb, the most abundant components are *Microcachryidites* and *Podocarpidites* associated with fair quantities of *Cycadopites* and *Classopollis*. This association compares favourably with the assemblages of the Jabalpur Stage in respect of only the subordinate genera.

Among the Lower Cretaceous miofloral assemblages described by Cookson (1953), Cookson and Dettmann (1958) and the detailed palynological work were done by Dettmann (1963) from the Australian deposits described 60 genera. Among them are **Cyathidites*, **Stereisporites*, **Dictyophyllidites*, **Osmundacidites*, **Baculatisporites*, *Pilosisporites*, **Lycopodiumsporites*, **Klukisporites*, *Dictyotosporites*, **Cicatricosisporites*, *Staplinisporites*, *Balmaesporites*, *Impardecispora* (*Trilobosporites spp.*), *Ischyosporites*, **Gleicheniidites*, *Coronatispora*, **Murospora*, *Foraminisporis*, **Contignisporites*, **Crybelosporites*, **Densoisporites*, **Laevigatosporites*, *Reticuloidosporites*, **Coptospora*, *Aequitriradites*, **Rouseisporites*, **Callialasporites* (= *Tsugaepollenites*), **Podocarpidites*, **Alisporites*, *Microcachryidites*, **Podosporites*, **Cycadopites* (= *Ginkgocycadophytus*), **Classopollis*, **Araucariacites* and *Schizosporis* etc. The genera marked with an asterisk are common with the various assemblages of the Jabalpur Stage. She has referred them to three miofloral assemblages viz., *Stylosus*, *Speciosus* and *Paradoxa* assemblages based upon the restricted occurrence of *Crybelosporites stylosus*, *Dictyotosporites speciosus* and *Coptospora paradoxa* respectively.

Unfortunately, Dettmann (*l.c.*) has not given the quantitative analysis of the assemblages described by her to enable others to compare the association of dominant genera and species in them. It seems that in her assemblages, podocarpaceous pollen grains were most numerous with high *Microcachryidites* as in Microflora IIb of Balme (*l.c.*). This genus has not been reported plentiful from any of the Indian Upper Mesozoic sediments so far. In general tendency, the *Microcachryidites* mioflora of Australia might be resembling the Dalmiapuram Grey Shale assemblage (Bharadwaj, 1969) of Lower Cretaceous. The age of the three assemblages, as recognized by Dettmann (*l.c.*) is Valanginian or older, Valanginian-Aptian and Aptian-Albian respectively.

COMPARISON OF THE MIOFLORA WITH SOME INDIAN UPPER MESOZOIC SPORE-POLLEN ASSEMBLAGES

Fossil spores and pollen grains have been described by Srivastava (1963, 1966) from the Lathi Formation in the Jaisalmer area of W. Rajasthan. Ramanujam (1957), Bharadwaj (1969) and Kar and Sah (1970) have studied the mioflora from Vemavaram on the East Coast of India. Rao (1943) and Vishnu-Mittre (1954) have studied the miospore contents from the Nipania Chert, Rajmahal Hills, Bihar. Later on, Sah & Jain (1965) have described miospores in detail from the carbonaceous shales of Sakrigalighat and Basko, Rajmahal Hills. Venkatachala, Kar and Raza (1969) have studied the miospores from the Upper Jurassic beds of Upper Katrol near Bhuj, Kutch.

Varma and Rawat (1964) from Dhrangadhra Formation (Saurashtra), Venkatachala (1969b) and Bharadwaj (1969) from the Bhuj sediments, Venkatachala (1969a) and Venkatachala & Kar (1970) from the marine beds of Bhuj near Walkamata, and Singh, Srivastava and Roy (1964) from Trambau and Ghuneri coals of Umia, Kutch, have studied the miofloral assemblages. Shrivastava (1954) has reported miospores of various families from carbonaceous shales of Narsinghpur district. Dev (1961) and Singh (1966) have studied the miofloras from Sehora and Hathnapur in Narsinghpur district respectively.

Srivastava (1963 & 1966) has studied the sporological assemblage from the Lathi and overlying Jaisalmer Formations in W. Rajasthan, said to be Lower to Middle Jurassic in age. The assemblage contains

15 genera such as *Cyathidites*, *Osmundacidites*, **Dictyototriletes*, **Cingulatisporites*, **Trilobozonosporites*, **Triangulatisporites*, **Polypodiisporites*, **Callialasporites*, *Podocarpidites*, **Araucariacites*, **Cycadopites* (= *Ginkgocycadophytus*) and *Classopollis* etc. The genera marked with an asterisk are absent in the asseblages of the Jabalpur Stage.

Srivastava (*l.c.*) has stated that pteridophytic spores are low in numbers. *Cycadopites* and *Callialasporites* are fairly well represented. *Podocarpidites* is very rare. *Classopollis* is dominantly represented in the assemblage and sometimes constitutes ± 80% of the mioflora. Evidently, Lathi Formation is different from the assemblages of the Jabalpur Stage in respect of *Classopollis*. Lathi Formation resembles very much the Variegated Shales of the Salt Range which has an abundance of *Classopollis* complex (50%) and the younger beds in Leigh Creek Coal Measures of Australia (Playford & Dettmann, 1965).

Ramanujam (1957), Kar and Sah (1970) and Bharadwaj (1969) have studied miospores from the Jurassic rocks of Vemavaram (Kota Stage) near Madras on the East Coast of India. Qualitatively, the characteristic miospore genera of the assemblage are *Cyathidites*, *Gleicheniidites*, *Osmundacidites*, *Neoraistrickia*, *Lycopodiumsporites*, *Cicatricosisporites*, *Alisporites*, *Callialasporites*, *Podocarpidites*, *Araucariacites*, *Cycadopites* (= *Ginkgocycadophytus*), **Singhiapollis*, **Cedripites*, *Classopollis*, **Laricoidites* and **Granuloperculatipollis* etc. The asterisk marked genera have not been found in the assemblages of the Jabalpur Stage.

Kar and Sah (*l.c.*) state that the pteridophytic spores are scarcely represented. Among the gymnospermous pollen grains *Callialasporites*, *Singhiapollis*, *Podocarpidites*, *Araucariacites* and *Laricoidites* are fairly common but *Alisporites*, *Cedripites*, *Podosporites*, *Cycadopites*, *Classopollis* and *Granuloperculatipollis* are meagre. According to Bharadwaj (1969, Histogram-III), it is dominated by *Araucariacites* (± 70%) with *Callialasporites* (± 18%), *Podocarpidites* (± 11%) and pteridophytic miospores which are represented only by *Cyathidites* (± 2%). This assemblage contains very high *Araucariacites* as compared to only 32·5% in Sehora, 31·52% in Hathnapur and 17·54% in Lameta Ghat. Moreover the Jabalpur Stage assemblage has *Cycadopites* (± 17%) which is quantitatively lacking in Vemavaram shales.

The miofloral assemblage from the Jurassic intertrappean beds of Rajmahal Hills has been studied by Rao (1943) and Vishnu-Mittre (1954) in Nipania Chert. Later on, Sah and Jain (1965) have described miospores from the Middle Upper Jurassic carbonaceous shales of Basko and Sakrigalighat, Rajmahal Hills. Thirty five miospore genera have been described by the last authors. Some of which are viz., *Cyathidites*, *Gleicheniidites*, *Cicatricosisporites*, *Osmundacidites*, *Neoraistrickia*, *Lycopodiumsporites*, *Ischyosporites*, *Foveosporites*, *Callialasporites*, *Podocarpidites*, *Vitreisporites*, *Dacrycarpites*, *Araucariacites*, *Cycadopites*, **Divisisporites*, **Converrucosisporites*, **Concavissimisporites*, **Verrucosisporites*, **Paucibaculisporites*, **Impardecispora* (= *Trilobosporites*) and *Classopollis* etc. The genera marked with an asterisk are absent in the Jabalpur Stage assemblages.

According to Vishnu-Mittre (*l.c.*) the pteridophytic spores, saccate and cycadophytic pollen grains are numerously and equally distributed in the assemblage but without giving any details of the counting. For Basko and Sakrigalighat, Sah and Jain (*l.c.*) state that monolete forms are entirely absent, the coniferous pollen grains are predominantly present, the saccates and nonsaccates pollen grains are equally common and the cycadophytic contents are fairly common. The trilete miospores are richer in Sakrigalighat as compared to Basko which has more coniferous pollen grains. The quantitative analysis of Basko and Sakrigalighat, as given by Bharadwaj (1969, Histogram-II), shows that the assemblage has *Araucariacites* ± 30%, *Podocarpidites* and *Cyathidites* ± 17% each, *Gleicheniidites* ± 12%, *Callialasporites* and *Deltoidospora* ± 6% each with *Cycadopites* ± 4% and *Classopollis* ± 2%. As compared to Rajmahal assemblage, the assemblages from Sehora and Hathnapur have comparable frequency of *Araucariacites* (32·5 and 31·52%) but they are richer in *Cycadopites* and *Callialasporites* (Histogram II, Table 4). Lameta Ghat assemblage appreciably differs from the Rajmahal assemblages in the higher frequencies of *Callialasporites* (19·06%) and *Cycadopites* (17·03%) and reduction of *Araucariacites* to 17·54%. Moreover, triletes are poorly present in the assemblages of the Jabalpur stage.

Venkatachala *et al.* (1969) have studied the miospore contents from the Upper Jurassic beds of Upper Katrol around Bhuj Kutch, India. The genera present are: *Cyathidites*, **Concavissimisporites*, *Concavisporites*, *Lycopodiumsporites*, *Callispora triangulus* (= *Foveotriletes triangulus*), *Klukisporites*, *Cicatricosisporites*, *Boseisporites*, *Contignisporites*, *Densoisporites* sp., *Coptospora sp.*, *Polypodiisporites*, **Impardecispora*, **Pilosisporites*, **Bhujiasporites*, **Katrolaites*, *Callialasporites* (= *Applanopsis*), *Alisporites*, *Podocarpidites*, *Podosporites*, *Microcachryidites*, *Classopollis*, **Schizosporis*, *Araucariacites*, **Laricoidites*, and *Gliscopollis* (= *Exesipollenites*) etc. The genera marked with an asterisk have not been noted in the assemblages of the Jabalpur Stage.

Venkatachala *et al.* (*l.c.*) have divided the Upper Katrol assemblage into 5 palynological sections. Recently, Bharadwaj (1969, Histogram-IV) has preferred to divide this Upper Katrol mioflora into 3 zones i.e., Bottom zone, Middle zone and Top zone.

Bottom Zone is characterized by *Callialasporites* ± 50%, *Araucariacites* ± 25%, *Laricoidites* ± 15% and *Podocarpidites* ± 5%.

Middle Zone has *Araucariacites* ± 50%, *Callialasporites* ± 20%, *Laricoidites* and *Podocarpidites* ± 15% each.

Top Zone possesses *Laricoidites* ± 40%, *Araucariacites* ± 20%, *Callialasporites* ± 10%, *Podocarpidites* ± 5% and *Schizosporis* ± 15%.

Top Zone is seemingly equivalent to Middle Zone in having the dominance of araucarian element (incl. *Laricoidites* which is rather morphographically similar to *Araucariacites*). The presence of *Schizosporis* in Top Zone seems to be due to local or marine influence thereby reducing the frequency of other genera. The Jablapur assemblages compare with those of Upper Katrol but for *Cycadopites* which occurs in the former and is almost absent in the latter. Quantitatively, the assemblages from the two regions show similarity in the dominant association of the genera.

Varma and Rawat (1964) have published a short account of the miospores distributed in the Dhrangadhra Formation (Saurashtra), W. India, and have suggested a Lower Cretaceous age (Hauterivian Stage) for it. Some of the genera in the assemblage are: *Cyathidites*, *Gleicheniidits*, *Osmundacidites*, **Lycopodiumsporites*, **Contignisporites*, **Polypodiaceoisporites*, **Impardecispora apiverrucatus* (= *Trilobatus, apiverrucatus*), **Lygodiumsporites*, **Cingulatisporites*, *Callialasporites*, *Araucariacites*, *Cycadopites* and *Classopollis* etc., together with angiospermic pollen grains viz., **Granatricolporites*, **Punctatriporites* and **Granatriporites*. The genera marked with an asterisk are absent in the Jabalpur Stage.

A quantitative analysis of Dhrangadhra Formation has not been given by the authors. Hence, a quantitative comparision of the mioflora with that of the Jabalpur Stage has not been attempted here. The occurrence of angiospermic pollen grains suggests the possibilities of a much younger age for it.

The miofloral assemblage from the Bhuj sediments (Lower Cretaceous) has been studied by Venkatachala (1969b) and Bharadwaj (1969). The assemblage contains chiefly the miospore genera, viz. *Cyathidites*, *Osmundacidites*, *contignisporites*, *Gleicheniidites*, **Concavissimisporites*, **Impardecispora*, *Lycopodiumsporites*, **Frangospora*, **Cingutriletes*, **Bhujiasporites*, **Aequitriradites*, **Schizosporis*, *Callispora* (= *Foveotriletes parviretus* and *F. kutchensis*), *Klukisporites*, *Ischyosporites*, *Cooksonites*, *Boseisporites*, *Matonisporites*, *Cicatricosisporites*, *Densoisporites*, *Callialasporites*, *Podocarpidites*, *Araucariacites*, *Vitreisporites*, **Microcachryidites*, and *Classopollis* etc. The genera marked with an asterisk lack in the Jabalpur Stage.

According to Venkatachala (1969b) Sections J and L are dominated by *Callialasporites* and *Impardecispora* Respectively. *Schizosporis* is in good abundance in Section J, but **Cyathidites*, **Concavissimisporites*, **Bhujiasporites*, *Matonisporites*, *Boseisporites*, *Podocarpidites*, **Laricoidites* and **Alisporites* are meagre. The genera marked with an asterisk and *Schizosporis* are seen within the counts of Section L. Section K of Bhuj has the dominance of *Araucariacites*. *Callialasporites* and *Laricoidites* are also in abundance, while

Cyathidites, *Impardecispora* *Podocarpidites* and *Schizosporis* are meagrely represented. Bharadwaj (1969, Histogram-V) considers the Section J and L quantitatively to be the same and thus, he has combined them as J (younger bed) and supposed the Section K to be an older one. Accordingly, Section K has the dominance of *Araucariacites* (± 56%) and *Callialasporites* (± 32%). Section K compares with the present assemblages of Sehora and Hathnapur in having the prominence, though lesser, in quantities, of *Araucariacites* (32·5 and 31·52%) and *Callialasporites* (11·33 and 12·8%) respectively, but it differs in lacking *Cycadopites* which is commonly (± 17%) represented in the Jabalpur Stage. Section K also closely compares with the middle Zone of Upper Katrol in the dominance of *Araucariacites* (± 50%) and *Callialasporites* (± 20%) and both have poor representation of pteridophytic components and lack of *Cycadopites*. Section J totally differs from the Jabalpur Stage in having the dominance of pteridophytic elements viz., *Impardecispora* (± 54%), *Bhujiasporites* (± 10%) whereas, the gymnospermic miospores are *Callialasporites* (± 8%) and *Araucariacites* (± 10%). *Schizosporis* is ± 9% in the assemblage. Thus, in the Jabalpur Stage, a bed corresponding palynologically to Section J of Bhuj is not represented.

Venkatachala (1969a) and Venkatachala and Kar (1970) have studied the palynology of the marine sediments from Upper Bhuj near Walkamata and Dayapar in Kutch, in which they recognize Zone 3 as belonging to the Umia Series (Lower Cretaceous).

According to the latter authors, Zone 3 is well represented by pteridophytic miospores viz., *Cicatricosisporites*, *Polycingulatisporites*, *Ceratosporites*, *Staplinisporites*, *Neoraistrickia*, *Leptolepidites*, *Impardecispora* (= *Trilobosporites trioreticulosus*), *Sestrosporites*, *Coronatispora* and *Foraminisporis* while the coniferous pollen grains viz., *Callialasporites*, *Podosporites*, *Alisporites*, *Microcachryidites* and *Classopollis* are in great abundance. As no factual quantitative analysis has been given the authenticity of the epithets well represented and 'great abundance' is doubtful. However, the Jabalpur assemblages are different from Zone 3 in the 'prominence' of *Araucariacites* associated with *Cycadopites* and *Callialasporites* and also that the pteridophytic elements are poorly represented in all the three assemblages of the Jabalpur Stage as compared to Zone 3.

The miofloral assemblage described by Singh *et al.* (1964) from the Umia beds (Lower Cretaceous) contains 35 spore-pollen genera. Some of which are *Cyathidites*, *Gleicheniidites*, *Concavisporites*, *Osmundacidites*, *Staplinisporites*, *Baculatisporites*, *Ischyosporites*, *Contignisporites*, *Impardecispora* (= *Trilobosporites apiverrucatus* and *T. trioreticulosus*), *Boseisporites*, *Densoisporites*, *Aequitriradites*, *Leschikisporis*, *Callialasporites*, *Podocarpidites*, *Podosporites*, *Microcachryidites*, *Araucariacites*, *Cycadopites*, *Classopollis* and *Schizosporis* etc.

The authors have not attempted a quantitative analysis but state that *Callialasporites* is dominant and the subdominants are *Araucariacites* and *Abiespollenites* (= *Pityosporites* spp.). This quantitative estimations is doubtful. Monolete forms are very rare, while the pteridophytic miospores remain characteristic of the spore spectrum.

Shrivstava (1954) has reported angiospermic pollen grains probably of Magnoliaceae from the carbonaceous shales of Narsinghpur district and noticed the predominance of bennettitalean components. On the other hand, Dev (1961) has described striated pollen grains, viz. *Striatites*, *Striatopodocarpites* and *Sulcatisporites* (= *Protoconiferus*) etc., besides Upper Mesozoic forms from Sehora in Narsinghpur district. Singh (1966) has listed 32 miospore genera from Sehora and Hathnapur in Narsinghpur district, and has suggested it to be (Lower Cretaceous) younger than Rajmahal Hills and slightly older than Umia beds, on the basis of age index genera and species, viz., *Contignisporites glebulentus*, *Rouseisporites*, *Crybelosporites*, *Cyathidites punctatus* and *Murospora* so considered by others like Dettmann (1963), Samoilovitch *et al.* (1961), Pocock (1962), Delcourt and Sprumont (1955) etc., and which are supposed to have a wider geographical distribution in a restricted time zone.

The angiospermic and striated saccate pollen grains have not been reported by Singh (*l.c.*) from Sehora and Hathnapur. Likewise, the present study also does not confirm the occurrence of striated saccate pollen grains (Dev, 1961) or angiospermic pollen grains (Shrivastava, 1954) in the assemblages from the same localities of the Jabalpur Stage. The index forms as stated by Singh (*l.c.*) and others are rarely noticed with in the counting of 500 specimens in each sample of the Jabalpur Stage.

GENERAL DISCUSSION AND CONCLUSION

The Jabalpur miofloral assemblage consists of 58 genera and 103 species. Among these, there are 35 trilete, 5 monolete, 2 hilate, one monosaccate, 7 bisaccate, 2 polysaccate, 2 monocolpate, 2 alete and 2 operculate nonsaccate genera.

The qualitative and quantitative palynological analyses of the Jabalpur Stage, particularly its broad based comparison with those assemblages known from the comparable horizons, have revealed that it contains a number of miospore genera which are known from the Jurassic to Lower Cretaceous deposits of the world. They are *Cyathidites*, *Gleicheniidites*, *Osmundacidites*, *Cicatricosisporites*, *Baculatisporites*, *Lycopodiumsporites*, *Callialasporites*, *Podocarpidites*, *Alisporites*, *Podosporites*, *Araucariacites*, *Cycadopites* and *Classopollis* etc. These forms constitute a major proportion of the whole assemblage. Quantitatively, the Jabalpur Stage assemblage is characterized by the 'prominence' of *Araucariacites* followed by the 'common' occurrence of *Cycadopites and Callialasporites*. The genera having 'fair' representation in the assemblage are *Podocarpidites*, *Alisporites* and *Classopollis* while *Podosporites* is 'poor' represented. The cryptogamic components are poorly represented here. A similar type of miospore association is also encountered in the Rajmahal Hills assemblage (Basko and Sakrigalighat) but with higher quantities of the cryptogams. Both show a prominence of *Araucariacites* associated with *Callialasporites*, *Cycadopites* and *Classopollis* together with *Podosporites* but for the higher representation of *Cycadopites*, *Alisporites* and *Classopollis* in the Jabalpur assemblage. The same association is also characteristic of Upper Jurassic mioflora (Balme 1957, Microflora IIa) from W. Australia with minor differences. Likewise, the assemblages from Upper Katrol and Section K of Bhuj (Umia Stage) compare with the Jabalpur assemblage because they share the characteristic miospore association of *Callialasporites* and *Podocarpidites* with prominent *Araucariacites*.

The miofloras from the Lower Cretaceous sediments of Western Australia and South-Eastern Australia as described by Balme (1957, Microflora IIb) and Dettmann (1963, *Stylosus* assemblage) respectively, are mainly characterized by the abundance of *Microcachryidites* and *Podocarpidites* (= *Pityosporites* cf. *ellipticus*) which is associated with *Cycadopites*, *Classopollis* and *Araucariacites* in low percentages (2-5%). The Jabalpur mioflora differs from these in having abundance of *Araucariacites*, *Callialasporites* and *Podocarpidites* in association with *Cycadopites*, and *Classopollis*. So far, no mioflora which may be quantitatively and qualitatively similar to that from Lower Cretaceous of Australia has been described from India.

From the above facts and their discussion it is apparent that the mioflora of Jabalpur Stage belongs to the same time zone during which the sediments containing a miospore assemblage with a dominant association of *Araucariacites* and *Callialasporites* were deposited, such as in the basal intertrappeans of Rajmahal Hills, Vemavaram Shale, Upper Katrol sediments and Bhuj deposits in India and the Upper Jurassic sediments from Western Australia. However, among these, the assemblages from Vemavaram, Upper Katrol and Bhuj deposits have richer representation of the dominant association along with *Podocarpidites* as compared to those from Jabalpur Stage and the Rajmahal Hills. In the latter two, the associated *Cycadopites* and *Classopollis* while distinguishing them further from the former two, indicate miofloristic nearness between themselves. *Classopollis* in high percentages, associated with *Callialasporites* and *Cycadopites* is characteristic of Liassic in India as well as Western (Balme, 1957) and Eastern Australia (Playford & Dettmann, 1965). It is succeeded by *Araucariacites* + *Callialasporites* dominated mioflora during Oolitic in India as well as Australia. Hence, the sediments of Jabalpur Stage which contain a dominant *Araucariacites* + *Callialasporites* association can be only of Oolitic age. At the sametime the association of *Classopollis* and *Cycadopites* in significant percentages in the Jabalpur Stage assemblages, lends an oldish aspect within the Oolitic, older than the Rajmahal intertrappean mioflora even.

Some time back, one of us (Singh 1966) observed the presence of *Cyathidites punctatus*, *Contignisporites glebulentus*, *Aequittriradites* sp., *Cooksonites* sp., *Crybelosporites* sp., *Foveotriletes* sp., and *Rouseisporites simplex* in the assemblage from Jabalpur Stage and in view of the usual presence of these species in the assemblages of Lower Cretaceous age in Eastern Australia, Western canada and Siberia provisionally opined that the Jabalpur Stage could also be Lower Cretaceous age. However, the detailed quantitative analysis completed later by us has revealed, that the total picture of the spore assemblage from Jabalpur Stage conforms most to the palaeontologically dated Upper Jurassic assemblages from Katrol deposits around Bhuj (Presumably Upper Katrol Shales) and the Jarlemai Siltstone in Canning Basin near Broome Town, Western Australia. The Upper Katrol Shales on the basis of the ammonite faunas, esp., *Hildoglochiceras*, is of Tithonian age (based upon Spath's work-Arkell 1955, pp. 387-88). In Canning Basin, the dark shale which has yielded an *Araucariacites* + *Callialasporites* dominating spore assemblage underlies beds containing *Buchia subspitiensis* (Krumbeck) and *Belemnopsis* cf. *incisa* Stolley of East Indian affinities and considered by Teichert (1940) to be of Oxfordian age (Balme 1957). Regarding the age of Rajmahal intertrappean beds wherefrom an assemblage showing closest agreement with that of the Jabalpur Stage is on record, the concensus of opinion among palaeobotanists and geologists of India has been for Upper Jurassic but for Arkell (1956) who favours putting them in the Lower Cretaceous on the basis of Spath's (1933) surmise that there is an enormous gap between the Lower Gondwanas and the Rajmahal plant beds ... involving at least the whole of Jurassic and perhaps not only the Rhaetic but also the lowest Cretaceous. On the basis of Spath's work on Kutch ammonites, Upper Katrol Shales are Upper Jurassic. But these contain a mioflora which belongs to the same miofloral zone of which the Rajmahal, Jabalpur and Vemavaram assemblages appear to be a part. Evidently Spath's hypothesis is not supported by palynological as well as palaeobotanical evidence unless his dating of the Upper Katrol Shales is wrong and the whole set is ascribed an Upper Neocomian age. We believe that Spath's dating of Upper Katrol Shales is correct and thus, all those strata from where nearly similar mioflora is on record are of nearly similar age, i.e. Upper Jurassic. The association of Upper Jurassic plant fossils and Upper Neocomian ammonites in east coast Gondwanas is improbable and the explanation for such an occurrence should be sought in the East coast as to whether the two kinds of fossils are really intrabedded, and if so, whether or not the plant fossil bearing chunks of rocks could be reworked ones.

As our later scrutiny has revealed, none of the spore taxa considered by Singh (1966) as suggestive of a Lower Cretaceous age for the strata investigated here, can be accepted as undoubted index or marker species for Lower Cretaceous even in SE Australia. Dettmann (1963) who has utilized the restricted distribution of some spore species for zonation of the Lower Cretaceous strata locally has neither confirmed the same for horizons overlying or underlying locally or inter-regionally. Hence, the earlier suggestion, especially in view of the evidence from the composition of the total spore assemblage, has been dispensed with and the coals of the Jabalpur Stage from Lameta Ghat, Hathnapur and Sehora are hereby conclusively dated as belonging to Upper Jurassic.

Considering the succession of *Sporae dispersae* during the Upper Mesozoic in India, it is apparent that Araucarinae was the most prominent constituent of the flora and Podocarpinae next to it. However, in the Lower Jurassic, those producing *Classopollis* type of pollen grains were dominant but others producing *Araucariacites* type of pollen grains became dominant during the Upper Jurassic. Comparing this with the succession in Australia one finds that during the Jurassic both continents had similar composition of the miofloras. However, in Lower Cretaceous, as apparent from the mioflora known from Australia, there was a reversal in the dominance, Podocarpinae becoming dominant and Araucarinae subdominant or even less.

The absence of hystrichosphaerids, dinoflagellates, microforams and other marine entities in the assemblage of the Jabalpur

Stage and the presence of spore-pollen flora of terrestrial communities indicate that the strata were deposited under fresh water conditions.

The well preserved spores and pollen grains in the assemblages of Sehora and Hathnapur, and poorly preserved specimens in the Lameta Ghat assemblage may indicate that the conditions for the preservation of organic matter were not identical at different sites in the basin of accumulation.

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