

## UPPER JURASSIC DINOFAGELLATE BIOSTRATIGRAPHY OF SPITI SHALE (FORMATION), MALLA JOHAR AREA, TETHYS HIMALAYA, INDIA

K. P. JAIN<sup>1</sup>, RAHUL GARG<sup>1</sup>, S. KUMAR<sup>2</sup> AND I. B. SINGH<sup>2</sup>

<sup>1</sup>BIRBAL SAHNI INSTITUTE OF PALAEOBOTANY, LUCKNOW

<sup>2</sup>DEPARTMENT OF GEOLOGY, LUCKNOW UNIVERSITY, LUCKNOW

### ABSTRACT

The palynological analyses of Spiti Shale sequence near Laptal, Malla Johar area, District Pithoragarh, Uttar Pradesh, have revealed a rich assemblage of dinoflagellate cysts and acritarchs along with some spores and pollen grains. The lower ca. 70 m portion of ca. 250 m thick Spiti Shale sequence is devoid of palynomorphs. This is followed by ca. 160 m thick sequence characterised by rich microflora. The remaining uppermost 20 m succession of the Spiti Shale is again devoid of any palynomorphs.

A total of 40 genera and 67 species of dinoflagellate cysts, 3 genera and 3 species of acritarchs, and 13 genera and 17 species of miospores are documented from the Spiti Shale sequence. Of these, 7 new species of dinoflagellate cysts are proposed.

The vertical range of the dinocysts within the Spiti Shale succession is drawn and compared with other well established diocyst assemblages of the world. Five distinct microfloral assemblages are identified. The results obtained suggest Kimmeridgian-Tithonian age for the microflora bearing part of the Spiti Shale.

### INTRODUCTION

The Tethys Himalayan belt extending all along the northern side of the high mountain ranges of the Central Himalaya, exposes a thick sequence of marine sediments ranging in age from Late Precambrian to Cretaceous or even younger (Middle Palaeocene vide Singh *et al.*, 1981). The Tethyan Mesozoic succession is known to be richly fossiliferous for over a century, but detailed palaeontological investigations have been confined to the study of ammonites and other invertebrate megafossils only (Strachey, 1851; Oppel, 1863; Griesbach, 1891, 1893; Uhlig, 1903-1910; Heim and Gansser, 1939; Valdiya and Gupta, 1972).

In view of the lack of much needed micropalaeontological data for age determination, palaeogeographical reconstruction and correlation, investigation of the marine microplankton from the Tethyan Upper Palaeozoic-Mesozoic sequence in Malla Johar, Kumaun Himalaya (Fig. 1) have recently been taken up under a collaborative study programme undertaken by the Birbal Sahni Institute of Palaeobotany and the Geology Department, Lucknow University. Our investigations have revealed a diversified palynomorph assemblage comprising of dinoflagellate cysts, acritarchs and miospores. A preliminary report about these investigations has already been published (Jain *et al.*, 1978). The Tethyan Cretaceous radiolarians have subsequently been described in detail by Garg *et al.*, (1981). Tiwari *et al.*, (1984) have described the mios-

pores of Palaeozoic and lower part of Mesozoic succession of the same area.

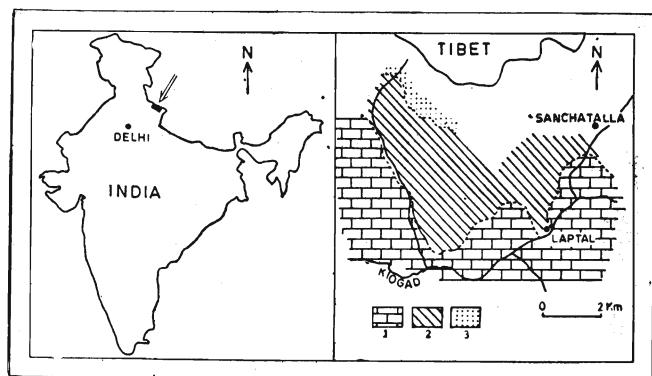


Fig. 1. Location and geological map of the Laptal area, Malla Johar, Kumaon Himalaya, India. 1. Kioto Limestone, Laptal Formation and Ferruginous Oolite Formation; 2. Spiti Shale; 3. Giumal Sandstone.

In the present paper, a rich assemblage of Upper Jurassic dinoflagellate cysts, acritarchs and miospores is documented from the Spiti Shale (Formation), a classic Upper Jurassic to Early Cretaceous stratigraphic unit of the Tethys Himalaya. An attempt is made to utilize these palynomorphs for biostratigraphic zonation and age determination of the productive sequence. The proposed dinoflagellate stratigraphy is integrated with the ammonoid biozonation scheme, recently proposed by Jai Krishna *et al.*, (1982). The samples were

collected in the neighbourhood of Laptal camping ground (Fig. 1) during an expedition to the Malla Johar area organised by the Geology Department, Lucknow University in 1974. Two of us (S. K. & I. B. S.) were members of this expedition.

#### GEOLOGICAL SETTING

The Spiti Shale (Formation) is made up of ca. 250 m thick sequence of black friable shales containing thin sandy intercalations in the lower and middle parts and sand-chert layers towards the top (Fig. 2). Exposures of the Spiti Shale extend from the Spiti Valley in Himachal Pradesh in the west to Malla Johar region (Uttar Pradesh) in the east and continue further upto the Thakkhola region in Nepal. In Malla Johar area, rocks of this formation are exposed in Laptal area in a very hazardous terrain with height ranging from 3400 m to 5400 m.

The Spiti Shale (Formation) overlies the Ferruginous Oolite Formation (Callovian) and grades upwards into the Giomal Sandstone (Hauterivian-Albian) and represents a rather continuous succession ranging in age from Oxfordian to Valanginian. It forms the part of a folded sequence with much structural complexity which often makes its lithostratigraphy quite complicated (Heim & Gansser, 1939; Kumar *et al.*, 1977).

The lithostratigraphic subdivision of the Upper Jurassic-Cretaceous succession, called Sancha Malla Group by Kumar *et al.*, (1977, Table-1), is summarised below in Table 1.

#### PREVIOUS WORK

Based on the fossiliferous nature, Griesbach (1891) proposed a threefold subdivision of Spiti Shale; (a) the lower division of dark splintary shales with only belemnoids; other fossils are rare, (b) the middle division of friable dark shales with concretions containing ammonoids, and (c) grey shales with few fossils and containing sandy layers towards the top. These subdivisions were named by Diener (1895) as (a) *Belemnites gerardi* Beds (Lower Spiti Shale)—Upper Oxfordian, (b) Chidamu Beds (Middle Spiti Shale)—Upper Kimmeridgian to Lower Tithonian and (c) Lochambel Beds (Upper Spiti Shale)—Upper Tithonian to Valanginian. Uhlig (1903-1910) worked out the ammonoid collections of Griesbach (1891, 1893) and adopted Diener's (1895) nomenclature to subdivide the Spiti Shale succession (see Arkell, 1956). Later, Heim and Gansser (1939) and Gansser (1964) reviewed the lithostratigraphy and ammonoid biostratigraphy of the Spiti Shale.

Kumar *et al.* (1977) have made some observations on the lithostratigraphy, sedimentary structures, trace

fossils and depositional environment of the Spiti Shale. Jai Krishna *et al.* (1982) restudied the ammonoid fauna of the Spiti Shale and presented a revised biostratigraphic scheme. They observed that the subdivision of the Spiti Shale adopted by Griesbach (1891) and Diener (1895) "are not described from a single section and there is a considerable overlap in them, especially between the Chidamu and Lochambel beds". Based on the abundance of belemnoids or ammonoids, Jai Krishna *et al.* (1982) subdivided the Spiti Shale into two: (a) Belemnitiferous Lower Spiti Shale division (Oxfordian to Kimmeridgian), and (b) Ammonitiferous Upper Spiti Shale division (Lower Tithonian to Valanginian or even Lowest Hauterivian). Five successive ammonoid assemblages are distinguished within the upper ammonitiferous division which allow firm correlation with Indo-East African, Southeast Asian, Southern European and South American regions. Singh *et al.* (1980) briefly discussed the biostratigraphic and palaeoecologic frame work of the Spiti Shale succession based on the evidences provided by ammonoids, dinoflagellate cysts, other palynomorphs, foraminifera and gross lithological and sedimentological characteristics. Based on this multidisciplinary approach, the Spiti Shale formation was divided into three main divisions viz., Spiti Shale A, B and C, each of which was defined to have been deposited under specific palaeoecologic conditions.

#### MATERIAL

52 stratigraphically located samples were collected from the exposed Spiti Shale sequence (see Fig. 2). These include, in the ascending order, 16 samples from the lower 50 m sequence (samples S<sub>1</sub>—S<sub>16</sub>), 31 samples from the overlying succession between 70 m and 230 m (samples L<sub>1</sub>—L<sub>31</sub>), and 5 samples from the uppermost 20 m sequence of the Spiti Shale (samples EC<sub>1</sub>—EC<sub>5</sub>, not marked in Fig. 2). Of these, only 11 samples (L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub>, L<sub>7</sub>, L<sub>14</sub>, L<sub>15</sub>, L<sub>21</sub>, L<sub>27</sub>, L<sub>28</sub>, L<sub>30</sub>, L<sub>31</sub>) yielded organic walled microfossils included in the present study.

The palynomorphs recovered from the Spiti Shale samples are highly carbonised, being dark brownish black to black in colour and are often very friable in nature. This type of preservation might be due to the highly disturbed nature of the rocks as the entire Tethyan sequence was subjected to intense tectonic disturbances during the uplift of the Himalaya. The recovered assemblage contains dinoflagellate cysts, acritarchs, spores and pollen grains, besides organic detritus frequently represented by dark opaque highly carbonised plant matter.

The dinoflagellate cysts and associated microflora were recovered by conventional maceration techniques.

SAMPLE NO.	LITHOLOGY	LITHOLOGIC DESCRIPTION
		Giumal Sandstone
		Cherty shales with chert layers
L-31		Contact of Black shales and cherty shales not clearly seen
L-30		
L-29		
L-28		Black shales and silty shales inter bedded, rare chert layers
L-27		Ca 10m Continuity not seen
L-26		Ferruginous shales with lime stone nodules, a few sand layers
L-25		
L-24		Iron-rich shales with Ca 5cm thick sand layers
L-23		
L-22		Iron-rich shales with bands of nodular lime stone Belemnites Common, more abundant in lime stone bands
L-21		
L-20		
L-19		Black friable sandy shale
L-18		Light black shales with Carbonate septarian nodules
L-17		Hard ferru.shale with abundant ammonoids
L-16		
L-15		Black friable shale with thin horizons of nodules, fossils replaced by pyrite
L-14		
L-13		
L-12		
L-11		
L-10		
L-9		
L-8		
L-7		
L-6		
L-5		
L-4		
L-3		
L-2		
L-1		
		Ca 20m Continuity not seen
S-16		
S-15		
S-14		
S-13		
S-12		
S-11		
S-10		
S-9		
S-8		
S-7		
S-6		
S-5		
S-4		
S-3		
S-2		
S-1		
20m.		
		Ferruginous Oolite Formation

Fig. 2. Lithological succession of the Spiti Shale formation near Laptel area,

Table 1. Lithostratigraphic subdivision of a part of the Tethys succession, Malla Johar area (after Heim and Gansser, 1939, modified by Kumar *et al.*, 1977;\* after Jai Krishna *et al.*, 1982).

Supergroup	Group	Formation	Lithology	Age
Malla Johar Super group	Sancha Malla Group	Giumal Sandstone (400 m) Spiti Shale (250 m)	Glauconitic sandstone, shale, siltstone and radiolarian cherts Black friable shales and siltstone with abundant nodules	Albian to Hauterivian *Berriasian-Valanginian to Oxfordian
	Rawalibagar Group	Ferruginous Oolite Formation (10 m) Laptal Formation (70 m)	Ferruginous oolitic limestone and shales with ammonites Shell Limestone, limestone, oolitic limestone, marl and shales	Callovian Lower-Middle Jurassic

However, due to relatively much longer time required for the oxidation of organic matter, the final recovery of dinocysts and miospores was poor due to breakage and friable nature of the palynmorphs. For better results, the material was, therefore, treated comparatively for a lesser time and attempts were made to procure complete dinocyst specimens by checking and differential separation of the macerate at several steps during chemical analyses of the samples. Alkali treatment and acetolysis were completely avoided.

The type and figured slides are deposited in the museum of Birbal Sahni Institute of Palaeobotany, Lucknow.

#### CHECK LIST

- Check list of organic walled microfossils recovered from Spiti Shale sequence:
- A. Dinoflagellate cysts and Acritarchs;*
  - Adnatosphaeridium aemulum* (Deflandre) Williams & Downie, 1969
  - Apteodinium nuciforme* (Deflandre) Stover & Evitt, 1978
  - Apteodinium* sp. A.
  - cf. *Apteodinium* Eisenack, 1958.
  - Broomea simplex* Cookson & Eisenack, 1958
  - Broomea* sp. A.
  - Canningia apiculata* Jain & Garg n. sp.
  - Canningia reticulata* (Cookson & Eisenack) Below, 1981
  - Canningia* sp. A.
  - Chlamydophorella fenestrata* Jain & Garg n. sp.
  - Chytroeisphaeridia* sp. A.
  - Chytroeisphaeridia* sp. B.
  - Cleistosphaeridium tribuliferum* (Sarjeant) Davey *et al.*, 1969
  - Cribroperidinium granulatum* (Klement) Stover & Evitt, 1978
  - Cyclonephelium* sp. A.
  - cf. *Cymatiosphaera* Wetzel emend. Deflandre, 1954
  - Ellipsoidictyum cinctum* Klement, 1960
  - ?*Ellipsoidictyum* sp. A.
  - Emmetrocysta sarjeantii* (Gitmez) Stover & Evitt, 1978
  - cf. *Energlynia* Sarjeant, 1976
  - Fromea amphora* Cookson & Eisenack, 1958
  - Gonyaulacysta jurassica* (Deflandre) Subsp. *jurassica* Deflandre emend. Sarjeant, 1982
  - Histiophora ornata* Klement, 1960
  - Lanterna* sp. A.
  - Leiofusa jurassica* Cookson & Eisenack, 1958
  - Leptodinium* sp. A.
  - Lithodinia jurassica* Eisenack, emend Gocht, 1975
  - Lithodinia* sp. A.
  - cf. *Lophodictyon* Pocock, 1972
  - Membranilaracia leptoderma* (Cookson & Eisenack) Eisenack, 1963
  - Micrhystridium* sp. A.
  - Nannoceratopsis pellucida* Deflandre emend. Evitt, 1961

33. *Nummus mallajoharensis* Jain & Garg n. sp.  
 34. *Oligosphaeridium* sp. cf. *anthophorum* (Cookson & Eisenack) Davey, 1969  
 35. *Oligosphaeridium dictyophorum* (Cookson & Eisenack) Davey & Williams, 1969  
 36. *Oligosphaeridium pulcherrimum* (Deflandre & Cookson) Davey & Williams, 1966  
 37. *Omatia montgomeryii* Cookson & Eisenack, 1958  
 38. *Omatia pisciformis* Cookson & Eisenack, 1958  
 39. *Ovoidinium waltonii* (Pocock) Lentini & Williams, 1967  
 40. cf. *Palaeostomocystis* Deflandre, 1937  
 41. *Pareodinia ceratophora* Deflandre, 1947  
 42. *Pareodinia* sp. A.  
 43. *Peridictyocysta mirabilis* (Cookson & Eisenack) Cookson & Eisenack, 1974  
 44. *Prolixosphaeridium capitatum* (Cookson & Eisenack) Singh, 1971  
 45. *Prolixosphaeridium granulosum* (Deflandre) Davey et al., 1966  
 46. *Prolixosphaeridium mixtispinosum* (Klement) Davey et al., 1966  
 47. *Pseudoceratium spitiensis* Jain & Garg n. sp.  
 48. *Rhynchodiniopsis ambigua* (Deflandre) Sarjeant, 1982  
 49. *Scrinidinium galeritum* (Deflandre) Klement, 1960  
 50. *Scrinidinium echinatum* Jain & Garg n. sp.  
 51. *Scrinidinium klementii* Jain & Garg n. sp.  
 52. cf. *Scrinidinium* Klement, 1957  
 53. *Sentusidinium echinatum* (Gitmez & Sarjeant) Sarjeant & Stover, 1978  
 54. *Sentusidinium* sp. A.  
 55. *Sentusidinium* sp. B  
 56. *Sentusidinium* sp. C  
 57. *Sentusidinium* sp. D  
 58. *Surculosphaeridium vestitum* (Deflandre) Davey et al., 1966  
 59. *Systematophora* sp. cf. *S. orbifera* Klement, 1960  
 60. *Systematophora penicillata* (Ehrenberg) Sarjeant, 1980  
 61. *Tanyosphaeridium jurassicum* Jain & Garg n. sp.  
 62. *Tanyosphaeridium torynum* (Cookson & Eisenack) Stover & Evitt, 1978  
 63. *Tanyosphaeridium* sp. A.  
 64. cf. *Tanyosphaeridium* Davey & Williams, 1966  
 65. *Tubotuberella apatela* (Cookson & Eisenack) Ioannides et al., emend. Sarjeant, 1982  
 66. *Tubotuberella* sp. A.  
 67. *Veryhachium valensii* (Valensi) Downie & Sarjeant, 1963  
 68. *Wanaea clathrata* Cookson & Eisenack, 1958  
 69. *Wanaea* sp. A.  
 70. cf. *Xylochoarion* sp.
- B. Spores and Pollen grains
1. *Alisporites grandis* (Cookson) Dettmann, 1963
  2. *Alisporites* sp. A.
  3. *Appendicisporites* sp. A.
  4. *Callialasporites monoalasporus* Sukh Dev, 1961
  5. *Callialasporites trilobatus* (Balme) Sukh Dev, 1961
  6. *Cicatricosporites australiensis* (Cookson) Potonié, 1956
  7. *Concavissimisporites kutchensis* Venkatachala, 1969
  8. *Contignisporites multimuratus* Dettmann, 1963
  9. *Couperisporites vangaurdensis* Pocock, 1962
  10. *Couperisporites jurassicus* Pocock, 1971
  11. *Densoisporites velatus* Weyland & Krieger emend. Krasnova, 1961
  12. *Densoisporites* sp. cf. *D. plafordii* (Balme) Dettmann, 1963
  13. ?*Heliosporites* sp. A.
  14. *Laricoidites* sp. A.
  15. *Lycopodiumsporites* sp. A.
  16. *Podocarpidites multisinus* (Bolkhovitina) Pocock, 1962
  17. *Todisporites minor* Couper, 1953

## DESCRIPTION OF NEW TAXA

*Genus Canningia* COOKSON & EISENACK, emend. Below, 1981

*Canningia apiculata* JAIN & GARG n. sp.  
(Pl. II—27-29)

*Holotype*: Pl. II—27; B. S. I. P., No. 6783; coordinates: 116×11.

*Diagnosis*: Cyst lenticular, autophragm only; processes short, distally truncate to bifid, distantly placed; crest well developed, surface granular; paracingulum faintly indicated; apex pointed, apical horn short; antapex broad, bilobed. Archeopyle apical (tA); principal archeopyle suture zig-zag, with six precingular paraplates.

Dimensions :	Holotype	Range
Overall cyst size	80×66 $\mu\text{m}$	66—80×60-70 $\mu\text{m}$
Process length	4 $\mu\text{m}$	2—4 $\mu\text{m}$

*Remarks*: Spiti specimens show mixed characters of *Canningia* and *Aptea*. Antapical bilobation puts it closer to *Canningia* whereas autophragm ornamentation with curved ridges suggest affinity with *Aptea*. Due to lack of antapical horn, the forms are presently described under *Canningia*. The present specimens are devoid of any intercalary paraplate. The concept of Dörhöfer and Davies (1980, p. 36) is presently not acceptable.

*Locality*: Malla Johar Area, Pithoragarh District, U.P., India.

*Age* : Upper Jurassic (Kimmeridgian-Lower Tithonian).

*Genus Chlamydophorella* COOKSON & EISENACK, 1958  
*Chlamydophorella fenestrata* JAIN & GARG n. sp.

(Pl. I—18-19)

*Holotype* : Pl. I—19; BSIP Slide No. 6803; coordinates: 105.4 × 5.0

*Diagnosis* : Cyst elongate, holocavate, broadly rounded at both ends; autophragm only, covered with closely placed, slender, narrow processes, equal in size, distally open, expanded, supporting fenestrate delicate wall. Archeopyle apical. No indication of paracingulum.

*Dimensions* : Overall cyst size—85 × 70 µm

Length of processes upto 10 µm

*Comparison* : *C. fenestrata* Jain & Garg n. sp. compares best with *C. wallala* Cookson & Eisenack (1960) in having similar cyst shape but differs in its profusely fenestrate outer wall and simple processes.

*Type locality* : Malla Johar area, Pithoragarh district, U. P., India.

*Age* : Upper Jurassic (Kimmeridgian—Lower Tithonian).

*Genus Nummus* MORGAN, 1975

*Nummus mallajoharensis* JAIN & GARG n. sp.

(Pl. III—59-61)

*Holotype* : Pl. III—60; BSIP slide No. 6782; coordinates: 125.4 × 19.5.

*Diagnosis* : Cyst outline variable, spherical to ellipsoidal, single layered, thick, disintegrating ventral wall, folds on surface frequent, unornamented; true paracingulum rare, mostly not visible but in some represented by folds. Pylome apical in position, circular to oblong with thick rim.

<i>Dimensions</i> :	<i>Holotype</i>	<i>Range</i>
Cyst length	82 µm	70-85 µm
Cyst breadth	60 µm	60-75 µm
Pylome diameter	12 µm	10-20 µm

*Comparison* : The genotype *N. monocolatus* Morgan (1975) described from Neocomian-Aptian of Western Australia, differs in having grano-punctate surface and smaller size.

*Remarks* : *Nummus mallajoharensis* Jain & Garg n. sp. in the Spiti Shale section of Malla Johar area marks its first appearance at the level of L-14 and L-15. The specimen of *Nummus* has been recorded from L-31. This species has biostratigraphic significance in the section.

The position of pylome is truly apical rather than "intercalary". Recently Dutta and Jain (1980) dis-

cussed this problem in detail and emended the diagnosis of *Cyclopsiella* Drugg and Loeblich (1967) suggesting the apical position of pylome.

*Type Locality* : Malla Johar area, district Pithoragarh, U. P., India.

*Age* : Upper Jurassic (Kimmeridgian—Lower Tithonian).

*Genus Pseudoceratum* GOCHT, 1957

*Pseudoceratum spitiensis* JAIN & GARG n. sp.

(Pl. III—41-42)

*Holotype* : Pl. III—42; B. S. I. P. Slide No. 6787; coordinates: 119 × 9.4.

*Diagnosis* : Cyst ceratoid with an apical and antapical horn, the third post cingular horn indistinct, shape of cyst and position of antapical horn suggest position of post-cingular horn; autophragm only; paracingulum distinct in the middle. Archaeopyle apical (tA), suture zig-zag.

<i>Dimensions</i> :	<i>Holotype</i>	<i>Range</i>
Overall cyst size	114 × 70 µm	110-114 × 70-85 µm
Length of apical horn	30 µm	upto 30 µm
Length of antapical horn	14 µm	14-20 µm

*Comparison* : *P. spitiensis* Jain & Garg n. sp. differs from other species of the genus in not having a distinct third postcingular horn.

*Type Locality* : Malla Johar area, Pithoragarh district, U. P., India.

*Age* : Upper Jurassic (Kimmeridgian—Lower Tithonian).

*Genus Scriniodinium* KLEMENT, 1957

*Scriniodinium indicum* JAIN & GARG n. sp.

(Pl. II—22-23)

1960 *Scriniodinium luridum* (Deflandre), in Cookson & Eisenack, p. 247; pl. 37, fig. 10.

*Holotype* : Pl. II—22; B. S. I. P. Slide No. 6786; coordinates : 4 × 17.7.

*Diagnosis* : Cyst circumcavate, outline variable, mostly broadly triangular, sometimes squarish to rounded, central body broadly triangular, follows shape of cyst outline, pericyst smaller than hypocyst divided by an annular paracingulum; apical and antapical horns absent; endophragm thick, periphragm thin, ornamentation on both not discernible. Archaeopyle precingular (3"), trapeziform, both periphragm and endophragm involved in its formation.

*Dimensions :*Overall cyst size :  $85-104 \times 85-100 \mu\text{m}$ Cyst body diameter :  $60-66 \mu\text{m}$ 

Periphram extension

beyond body margin :  $8-26 \mu\text{m}$ 

*Comparison :* *Scriniodinium indicum* Jain & Garg n. sp. compares best with *S. attadelense* (Cookson & Eisenack) Eisenack (1967) in having unequal epi-and hypo-cysts and central body following the periphram outline, but differs in being broadly triangular and not possessing any antapical opening. *S. crystallinum* (Deflandre) Klement (1960) differs in its equal epi-and hypo-cyst portions and rounded antapex. The involvement of periphram and endophram in the formation of archaeopyle distinguishes this species from others of the genus except for *S. rostratum* Brideaux & McIntyre (1975) which differs in the absence of "Beak like" apex.

Cookson & Eisenack (1960, p. 247; p. 37, fig. 10) reported *Scriniodinium luridum* (Deflandre) Klement (1960) from Oxfordian to Lower Kimmeridgian or probably Tithonian of Australia. The figured specimen distinctly shows the involvement of both periphram and endophram in the formation of the precingular archaeopyle as found in the present species. The other features are also similar..

*Type Locality :* Malla Johar area, Pithoragarh district, U.P. India.

*Age :* Upper Jurassic (Kimmeridgian-Lower Tithonian)

*Scriniodinium echinatum* JAIN & GARG n. sp.

(Pl. II—2; Pl. III—45)

*Holotype :* Pl. II—21; B. S. I. P. Slide No. 6784; coordinates :  $108.4 \times 19.8$ .

*Diagnosis :* Cyst circumcavate, outline more or less square shaped, epicyst smaller than hypocyst; paracingulum annular, central body large, spherical, occupy central portion; endophram thick, periphram echinate, extends apically, antapically and laterally forming distinct apical, antapical and lateral projections appearing like horns. Antapical projection truncate, giving a pentagonal appearance to cyst outline. Archaeopyle large, trapeziform, precingular (3").

*Dimensions :* *Holotype Range*Overall cyst size  $100 \times 90 \mu\text{m}$   $90-100 \mu\text{m}$ Central body diameter  $64 \mu\text{m}$   $85-90 \mu\text{m}$ Periphram extension beyond upto  $16 \mu\text{m}$   $14-20 \mu\text{m}$   
central body margin

*Comparison :* *S. echinatum* Jain & Garg n. sp. compares best with *S. attadelense* (Cookson & Eisenack) Eisenack (1967) in having squarish cyst outline, but differs in having spherical capsule not following the shape of cyst outline and echinate periphram.

*Type Locality :* Malla Johar area, Pithoragarh district, U.P., India.

*Age :* Upper Jurassic (Kimmeridgian—Lower Tithonian).

*Genus Tanyosphaeridium* DAVEY & WILLIAMS, 1966*Tanyosphaeridium jurassicum* JAIN & GARG n. sp.

(Pl. I—10)

*Holotype :* Pl. I—10; B. S. I. P. Slide No. 6806; coordinates:  $107.0 \times 6.6$ .

*Diagnosis :* Cyst chorate, elongate; periphram forming processes; processes simple or distally branched, equal in length, arranged around cyst in regular circular manner. Archeopyle apical.

<i>Dimensions :</i>	<i>Holotype</i>	<i>Range</i>
Cyst size	$70 \times 60 \mu\text{m}$	$60 \times 45-80-88 \mu\text{m}$
Length of processes	upto $12 \mu\text{m}$	$10-12 \mu\text{m}$
Distance between processes along vertical axis	upto $12 \mu\text{m}$	$10-12 \mu\text{m}$

*Comparison :* *T. jurassicum* differs from all the known species of the genus in its smaller size and distally branched processes.

*Remarks :* The transfer of *T. torynum* to *Egmontoninium* by Davey (1979) is not acceptable as the specimens do not possess any tabulation.

*Type Locality :* Malla Johar Area, Pithoragarh district, U.P., India.

*Age :* Upper Jurassic (Kimmeridgian-Lower Tithonian).

## DISCUSSION

The complete Spiti Shale sequence exposed in Malla Johar area incorporates 250 meters thick black shales. The present palynological analysis revealed that the basal 70 meters sediments are devoid of any palynomorphs though rich organic detritus containing land derived wood tracheids and plant cuticles are present. The succeeding 160 meters of sediments are rich in organic walled microfossils. The microplankton appear for the first time at about 70 meter level. The ammonoids are also common in this section but their occurrence is recorded about 10 meters higher than dinoflagellate cysts (Fig. 2). The uppermost 20 meters deposit of the Spiti Shale (Formation) is completely devoid of palynomorphs and organic detritus but is rich in ammonoid fauna. This differential distribution of

organic matter alongwith gross lithological, sedimentological and palaeontological evidences led Singh *et al.* (1980) to distinguish three distinct divisions of the Spiti Shale (Formation) viz., Spiti Shale—A (basal ca. 70 m), Spiti Shale—B (middle ca. 160 m) and Spiti Shale—C (topmost 20 m). Each of these divisions is characterised by a specific palaeoecologic condition.

Singh *et al.* (1980) suggested that deposition of the Spiti Shale succession was initiated within the shallower part of continental shelf with depth not exceeding 50 m. Absence of dinoflagellates and ammonoids and richness of organic detritus in Spiti Shale-A is considered by them to be due to depletion of oxygen in the water column caused by some kind of coastal upwelling. Deposition of Spiti Shale-B which is characterised by abundance of dinoflagellates and other fossils, took place on the continental shelf at moderate depths of about 50-150 m with well-oxygenated waters (Singh *et al.* 1980, p. 31). Absence of dinoflagellates and organic detritus together with the presence of only a few deep water ammonoids within the Spiti Shale-C succession is attributed by Singh *et al.* (1980) to the relatively deeper site of deposition of this unit which was near the continental break and partly on the upper part of the continental slope with somewhat reduced supply of terrigenous clastics. This is further supported by the occurrence of bedded cherts and hard grounds in Spiti Shale-C.

The microfloral assemblages recovered from the Spiti Shale-B samples are not in totality due to the unsatisfactory state of preservation and friable nature of fossils. Statistical analysis of various assemblages has, therefore, not been attempted but for the recognition of some important and dominant elements. Fifty six genera and eighty seven species of organic walled microfossils could be recognised from the entire productive sequence.

The stratigraphic distribution of dinocyst, acritarch and miospore taxa within the Spiti Shale-B sequence, ranging from sample No. L-1 to L-31 (Table 2), clearly indicates five recognizable microplankton assemblages. We have referred these as Microplankton Assemblage zones A, B, C, D and E in ascending order. The boundaries of these Assemblage zones are marked where maximum microfloral change is observed in the sequence.

*Microplankton Assemblage Zone-A* : this zone extends from sample No. L-1 to the base of sample L-7 measuring about 9 meters. The macerates of these samples contain good amount of organic detritus, which dominated the underlying 50 meters sediments along with a few foraminiferal inner linings. The miospores are totally absent. The acritarchs viz., *Micrystridium*, *Lophodictyonium* and *Veryhachium* are common in the bottom

most (L-1) sample and the dinocyst taxa mark their appearance. At L-3 level the dinocyst taxa, specially the skolochorate forms, mark their dominance.

The characteristic microfloral elements of this zone are : *Criboperidinium granulatum*, *Sentusidinium echinatum*, *Prolixosphaeridium capitatum*, *Systematoiphora panicillata*, *S. orbifera*, *Oligosphaeridium dictyophorum*, *O. pulcherrimum*, *O. sp. cf. acanthophorum*, *Tubotuberella apatela*, *Scriniodinium indicum*, *Cleistosphaeridium tribuliferum*, *Pareodinia ceratophora*, *Canningia reticulata*, *Fromea amphora*, *Veryhachium valensii*, *?Ellipsoidictyum* sp. A, *Lithodinia* sp. A and several unidentified forms referred to as *Forma L M I & G*. The known stratigraphic distribution of the above mentioned species (Sarjeant, 1979) shows a mixture of Oxfordian-Kimmeridgian species (*C. granulatum*, *S. panicillata*, *P. capitatum*) and Kimmeridgian-Portlandian taxa (*S. echinatum*, *Oligosphaeridium* spp., *C. reticulata*, *T. apatela* and *F. amphora*). Some taxa are long ranging viz., *C. tribuliferum* (Callovian-Kimmeridgian) and *S. orbifera* (Oxfordian-Portlandian). Gitmez and Sarjeant (1972, pp. 188-189) observed the stratigraphic range of *F. warlinghamensis* (now *F. amphora*) within the Kimmeridgian from *A. autissiodorensis* to *P. pallasoides* Zones and *S. capitatum* (*Tenua capitata*) from *P. baylei* to *A. mutabilis* Zones in England. In British Jurassic, *T. apatela* ranges from *P. baylei* to *P. pallasoides* Zones (Ioannides *et al.* 1976; text-fig. 7). Cookson and Eisenack (1960, p. 251) recorded *C. reticulata* from probably Tithonian of western Australia. They placed Jarlemai Siltstone (Lower portion) between 1405 and 1427 feet as Oxfordian-Lower Kimmeridgian and the upper portion of Jarlemai Siltstone probably to Tithonian, which in our opinion might be Lower Tithonian or slightly older, if order of superposition is considered.

Jai Krishna *et al.* (1982, Fig. 2) tentatively placed the Lower Tithonian-Kimmeridgian boundary in the Spiti Shale sequence a few meters above L-3 level, considering the lower part to be Kimmeridgian in age on stratigraphic and palaeontologic grounds.

The dinoflagellate cyst evidence discussed above is definitive of its Kimmeridgian age and confirms the deposition of Kimmeridgian sediments in the area.

*Microplankton Assemblage Zone-B* : The occurrence of *Broomea simplex* at L-7 level has been taken as the beginning of Microplankton Assemblage Zone-B. This zone extends upto the base of L-21 measuring ca. 53 meters in thickness. It is characterized by the first appearance of *Nummus mallajaharensis* n. sp., *Broomea simplex*, *Broomea* sp., *Scriniodinium galeritum*, *S. echinatum* n. sp., *Prolixosphaeridium* sp. A., *P. granulosum*, *Wanaea clathrata*, *Cyclonephelium* sp. A, *Nannoceratopsis pellucida*, *Peridictyocysta mirabilis*, *Lantera* sp., *Fromea amphora*, *Canningia* sp. A., *Pareodinia* sp. and *Tanyosphaeridium* sp.

This microplankton assemblage is mainly dominated

by *Nummus mallajoharensis* and *Broomea simplex* with significant association of *P. mirabilis*. Cookson and Eisenack (1958, p. 48) reported *P. mirabilis* from the Upper Jurassic of New Guinea (Omati I. E. C. Well No. 1, sample Nos. 19, 20, 25, 26 and 29). In their subsequent paper, Cookson and Eisenack (1960, pp. 253-254) reported it from western Australia, extending its stratigraphic range from Late Upper Jurassic to Neocomian. The other constituents viz., *Wanaea clathrata*, *N. pellucida*, *S. galeritum* occur in either Oxfordian or Kimmeridgian or in both. In view of the stratigraphic location of the samples (Fig. 2) and the presence of ammonoid *Torquatisphinctes-Aulacospinctoides* Assemblage, the age of this zone is maintained to be lower part of Lower Tithonian.

**Microplankton Assemblage Zone-C :** This Assemblage zone is taken to extend from sample L-21 to the base of the sample L-27, including about 65m of the succession overlying Zone B. Except for the basal sample, no microfloral yield is recorded from other samples lying in this zone. The single sample L-21 is rich in dinocyst microflora. The main constituents of the older Microplankton Assemblage Zone-B viz., *P. mirabilis*, *T. apatela* and *C. reticulata* persist in this zone. The new elements that appear for the first time at this level are: *Aptedinium nuciforme*, *Canningia apiculata* n. sp. *Ovoidinium waltonii*, *Pseudoceratium spitiensis* n. sp. *Surculosphaeridium vestitum*, *Tanyosphaeridium jurassicum* n. sp. and *T. torynum*.

*Canningia apiculata* is the dominant element of this zone and does not extend in the younger zones; its associate *Ovoidinium waltonii*, the Lower Jurassic species, also behaves in a similar manner.

*T. torynum* is known to occur from probably Tithonian of western Australia (Cookson and Eisenack, 1958, p. 282). Sarjeant (1979, Text-fig. 3a) doubtfully placed its oldest record from *P. whetleyensis* Zone. Thus the age of this assemblage is taken to be Lower Tithonian in accordance with its stratigraphic position and ammonoid association. The lower and upper boundaries of the zone remain open.

**Microplankton Assemblage Zone-D :** After a gap of about 60 meters above L-21 in the vertical succession, another sample, L-27, proved productive. This assemblage zone extends from sample L-27 to the base of sample No. L-31, measuring about 31 meters of succession.

It is interesting to note that at L-27 level, the microfloral assemblage suddenly gets an influx of land derived elements e.g. spores, pollen grains, wood tracheids, leaf cuticles and fungal bodies. This constitutes about 60% of the total assemblage of the sample.

A logical explanation to this situation is provided by the fact that the sample comes from a storm generated

sand layer suggesting deposition and mixing of the terrestrial material brought during the storm from coastal plain to the shelf area.

The dinoflagellate microflora is very poorly represented. Only sporadic occurrence of the following species is noted: *Sentisidinium* spp. *Adnatosphaeridium aemulum*, *Oligosphaeridium pulcherrimum*, *Pareodinia* sp. A, *Canningia reticulata*, *Scriniodinium indicum*, *Pareodinia ceratophora* and *Lithodinia jurassica*. The miospore elements identified in the assemblage are: *Alisporites grandis*, *Appendicisporites* sp., *Callialasporites* spp., *Cicatricosisporites australiensis*, *Concavissimisporites kutchensis*, *Contignisporites multimuratus*, *Couperisporites jurassicus*, *C. vangaurdensis*, *Densoisporites* sp. cf. *D. plafordii*, *D. velatus*, *?Heliosporites* sp. A, *Laricoidites* sp. A., *?Lycopodiumsporites* sp. A, *Podocarpidites multisinus*, *Todisporites minor*.

The occurrence of *Canningia reticulata* and *Oligosphaeridium pulcherrimum* as discussed elsewhere, maintains Kimmeridgian aspect of the assemblage. Amongst the miospores taxa, *Cicatricosisporites australiensis* and *Appendicisporites* sp. alongwith *Contignisporites multimuratus* are significant.

Hughes and Moody-Stuart (1966) reported *C. australiensis* from the top of the Kimmeridge Clay in England. Dettmann and Plaford (1968) state that the genus *Cicatricosisporites* first occurs in Australia in strata directly overlying rocks not younger in age than Kimmeridgian. Norris (1969) referred this species from Upper Kimmeridgian and Portlandian (=Upper Lower and Upper Tithonian) and younger strata.

Brideaux and Fisher (1976, p. 37) described some dinocysts and miospores from Arctic Canada, containing *Cicatricosisporites australiensis*, *Contignisporites glebulentus*, *G. jurassica*, *S. luridum* and *L. eumorphum*. They recovered this assemblage between the depths of 1000-1010 feet and concluded it to be Late Kimmeridgian in age.

Batten (1978, p. 99) mentions, "the typically Early Cretaceous genus *Cicatricosisporites* has its oldest occurrence in the upper part of the Late Kimmeridgian (*Rotunda-Pallasioides* Zones), but its distribution is sporadic in the Jurassic".

Williams (1978, p. 783) described *C. australiensis* from the Kimmeridgian sediments of DSDP cores 367-38 and 367-35 at the interval of 1148-1081.5 m.

Pocock (1980, p. 379) is of the opinion that *Cicatricosisporites* is not restricted only to the Cretaceous or younger sediments but extends downwards at least into Kimmeridgian and possibly into Upper Oxfordian. Herngreen *et al.* (1980, fig. 5) extend the range of *Cicatricosisporites* upto the base of upper Malm (Upper Jurassic) in Netherlands.

In view of the above discussion and distribution of

by *Nummus mallajoharensis* and *Broomea simplex* with significant association of *P. mirabilis*. Cookson and Eisenack (1958, p. 48) reported *P. mirabilis* from the Upper Jurassic of New Guinea (Omati I. E. C. Well No. 1, sample Nos. 19, 20, 25, 26 and 29). In their subsequent paper, Cookson and Eisenack (1960, pp. 253-254) reported it from western Australia, extending its stratigraphic range from Late Upper Jurassic to Neocomian. The other constituents viz., *Wanaea clathrata*, *N. pellucida*, *S. galeritum* occur in either Oxfordian or Kimmeridgian or in both. In view of the stratigraphic location of the samples (Fig. 2) and the presence of ammonoid *Torquatisphinctes-Aulacospinctoides* Assemblage, the age of this zone is maintained to be lower part of Lower Tithonian.

**Microplankton Assemblage Zone-C :** This Assemblage zone is taken to extend from sample L-21 to the base of the sample L-27, including about 65m of the succession overlying Zone B. Except for the basal sample, no microfloral yield is recorded from other samples lying in this zone. The single sample L-21 is rich in dinocyst microflora. The main constituents of the older Microplankton Assemblage Zone-B viz., *P. mirabilis*, *T. apatela* and *C. reticulata* persist in this zone. The new elements that appear for the first time at this level are: *Aptedinium nuciforme*, *Canningia apiculata* n. sp. *Ovoidinium waltonii*, *Pseudoceratium spitiensis* n. sp. *Surculosphaeridium vestitum*, *Tanyosphaeridium jurassicum* n. sp. and *T. torynum*.

*Canningia apiculata* is the dominant element of this zone and does not extend in the younger zones; its associate *Ovoidinium waltonii*, the Lower Jurassic species, also behaves in a similar manner.

*T. torynum* is known to occur from probably Tithonian of western Australia (Cookson and Eisenack, 1958, p. 282). Sarjeant (1979, Text-fig. 3a) doubtfully placed its oldest record from *P. whetleyensis* Zone. Thus the age of this assemblage is taken to be Lower Tithonian in accordance with its stratigraphic position and ammonoid association. The lower and upper boundaries of the zone remain open.

**Microplankton Assemblage Zone-D :** After a gap of about 60 meters above L-21 in the vertical succession, another sample, L-27, proved productive. This assemblage zone extends from sample L-27 to the base of sample No. L-31, measuring about 31 meters of succession.

It is interesting to note that at L-27 level, the microfloral assemblage suddenly gets an influx of land derived elements e.g. spores, pollen grains, wood tracheids, leaf cuticles and fungal bodies. This constitutes about 60% of the total assemblage of the sample.

A logical explanation to this situation is provided by the fact that the sample comes from a storm generated

sand layer suggesting deposition and mixing of the terrestrial material brought during the storm from coastal plain to the shelf area.

The dinoflagellate microflora is very poorly represented. Only sporadic occurrence of the following species is noted: *Sentusidinium* spp. *Adnatosphaeridium aemulum*, *Oligosphaeridium pulcherrimum*, *Pareodinia* sp. A, *Canningia reticulata*, *Scriniodinium indicum*, *Pareodinia ceratophora* and *Lithodinia jurassica*. The miospore elements identified in the assemblage are: *Alisporites grandis*, *Appendicisporites* sp., *Callialasporites* spp., *Cicatricosisporites australiensis*, *Concavissimisporites kutchensis*, *Contignisporites multimuratus*, *Couperisporites jurassicus*, *C. vangaurdensis*, *Densoisporites* sp. cf. *D. plafordii*, *D. velatus*, *?Heliosporites* sp. A, *Laricoidites* sp. A., *?Lyco-podiumsporites* sp. A, *Podocarpidites multisinus*, *Todisporites minor*.

The occurrence of *Canningia reticulata* and *Oligosphaeridium pulcherrimum* as discussed elsewhere, maintains Kimmeridgian aspect of the assemblage. Amongst the miospores taxa, *Cicatricosisporites australiensis* and *Appendicisporites* sp. alongwith *Contignisporites multimuratus* are significant.

Hughes and Moody-Stuart (1966) reported *C. australiensis* from the top of the Kimmeridge Clay in England. Dettmann and Plaford (1968) state that the genus *Cicatricosisporites* first occurs in Australia in strata directly overlying rocks not younger in age than Kimmeridgian. Norris (1969) referred this species from Upper Kimmeridgian and Portlandian (=Upper Lower and Upper Tithonian) and younger strata.

Brideaux and Fisher (1976, p. 37) described some dinocysts and miospores from Arctic Canada, containing *Cicatricosisporites australiensis*, *Contignisporites glebulentus*, *G. jurassica*, *S. luridum* and *L. eumorphum*. They recovered this assemblage between the depths of 1000-1010 feet and concluded it to be Late Kimmeridgian in age.

Batten (1978, p. 99) mentions, "the typically Early Cretaceous genus *Cicatricosisporites* has its oldest occurrence in the upper part of the Late Kimmeridgian (*Rotunda-Pallasiodoides* Zones), but its distribution is sporadic in the Jurassic".

Williams (1978, p. 783) described *C. australiensis* from the Kimmeridgian sediments of DSDP cores 367-38 and 367-35 at the interval of 1148-1081.5 m.

Pocock (1980, p. 379) is of the opinion that *Cicatricosisporites* is not restricted only to the Cretaceous or younger sediments but extends downwards at least into Kimmeridgian and possibly into Upper Oxfordian. Herngreen et al. (1980, fig. 5) extend the range of *Cicatricosisporites* upto the base of upper Malm (Upper Jurassic) in Netherlands.

In view of the above discussion and distribution of

The present record of *Omatia* species in association with *G. jurassica* from the Spiti Shale, supports the Upper Jurassic age derived for Omati well samples 19 to 24 by Cookson and Eisenack 1958, 1960).

In view of the above discussion, it is evident that the age of Microplankton Assemblage Zone E is Late Kimmeridgian, equivalent to the lower part of Upper Tithonian as the extinction of *G. jurassica* and first appearance of *O. montgomeryi* both lie within the *Pectinatus* Zone of the European Jurassic. However, on the basis of ammonoid assemblage, Jai Krishna *et al.*

(1982) have assigned an Uppermost Tithonian age to this horizon of the Spiti Shale, containing sample no. L-31. Correspondence of dinocyst and ammonoid assemblages defined in the Spiti Shale sequence is shown in Fig. 3. It also becomes quite apparent that on the basis of the evidence provided by dinocyst assemblage of Zone E, the boundary between Tithonian and Berriasian in the Spiti Shale sequence tentatively placed by Jai Krishna *et al.* (1982), should be slightly modified and be placed a few meters above its present position. However, at present in the absence of dinocyst data

LITHOLOGY	DINOCYST ZONES (Present study)	AMMONOID ZONES (Jai Krishna <i>et al.</i> 1982)	AGE
	GIUMAL SANDSTONE	GIUMAL SANDSTONE	HAUTERIVIAN- ALBIAN
240	SPITI SHALE C L-31 L-30 L-28 L-27	NO DINOCYSTS & ACRITARCHS, DEVOID OF ORGANIC DETRITUS MICROPLANK. ASSEMB. ZONE E	NEOCOSMOCERAS-DISTOLOCERAS ASSEMBLAGE
210		MICROPLANKTON ASSEMBLAGE ZONE D	BLANFORDICERAS ASSEMBLAGE
180			HIMALAYITES-CORONGOCERAS- AULACOSPHINCTES ASSEMBLAGE
150	SPITI SHALE B L-21	MICROPLANKTON ASSEMBLAGE ZONE C	HILDGLOCHICERAS- VIRGATOSPHINCTES ASSEMBLAGE
120		MICROPLANKTON ASSEMBLAGE ZONE B	TORQUATISPHEINCTES- AULACOSPHINCTODES ASSEMBLAGE
90	L-15 L-14 L-7 L-6	MICROPLANK. ASSEMB. ZONE A	LOWER TITHONIAN
60	SPITI SHALE A	NO DINOCYSTS & ACRITARCHS, RICH IN ORGANIC DETRITUS	BELEMNOID-DOMINATED UNIT
30			NO AMMONIODS
0		FERRUGINOUS OOLITE FORMATION	OXFORDIAN- KIMMERIDGIAN CALLOVIAN



Fig. 3. Integration of Microplankton (mainly Dinoflagellate cysts) and Ammonoid Assemblage Zones in the Spiti Shale sequence 1. Shales; 2. Sandy intercalations; 3. Nodules/concretions; 4. Carbonate septarian nodules; 5. Bands of nodular limestone; 6. Chert layers.

Table 2. Stratigraphic distribution of organic walled microfossils in Spiti Shale sequence of Malla Johar area.

Microplankton Assemblage Zones		A			B			C		D		E
Taxa	Sample Nos.	L-1	L-2	L-3	L-7	L-14	L-15	L-21	L-27	L-28	L-30	L-31
<b>Microplankton:</b>												
<i>Griboperidinium granulatum</i>		+	+									
<i>Micrhystridium</i> sp. A.		+	+	+								
<i>Veryhachium valensii</i>		+	+	+								
<i>Chytroeisphaeridia</i> sp. A.		+	+									
<i>Sentusidinium echinatum</i>		+	+	+								
? <i>Ellipsoidictyum</i> sp. A.			+									
<i>Prolixosphaeridium capitatum</i>			+									
<i>Systematophora panicillata</i>			+									
<i>Oligosphaeridium dictyophorum</i>		+	+									
<i>O.</i> sp. cf. <i>anthophorum</i>		+	+									
cf. <i>Scriniodinium</i>		+	+									
<i>Pareodinia</i> sp. A.		+	+				+				+	
<i>Oligosphaeridium pulcherrimum</i>		+	+									+
<i>Canningia reticulata</i>		+	+					+		+	+	+
<i>Tubotuberella apatela</i>		+	+						+			
<i>Scriniodinium indicum</i> n. sp.		+	+			+	+	+	+	+		
<i>Frömea amphora</i>		+	+	+								
<i>Pareodinia ceratophora</i>		+	+	+					+			+
<i>Lithodinia</i> sp. A.			+									
<i>Forma G.</i>			+									
<i>Systematophora</i> sp. cf. <i>S. orbifera</i>			+									
<i>Broomea simplex</i>					+	+	+					+
<i>Scriniodinium galeritum</i>							+					
<i>Scriniodinium echinatum</i> n. sp.							+					
<i>Broomea</i> sp. A.								+	+	+		
<i>Prolixosphaeridium</i> sp. A.							+	+				
<i>Wanaea clathrata</i>								+	+			
<i>Cyclonephelium</i> sp. A.								+	+			+
<i>Nummus mallaoharensis</i> n. sp.								+	+			+
<i>Prolixosphaeridium granulosum</i>								+	+			+
<i>Nannoceratopsis pellucida</i>								+	+	+		
<i>Peridictyocysta mirabilis</i>								+	+	+		
<i>Lanterna</i> sp. A.									+	+		
<i>Forma E.</i>										+		
<i>Apteodinium nuciforme</i>										+		
<i>Canningia apiculata</i> n. sp.										+		

Table 2—(Contd.)

from stratigraphically younger samples from this section, the precise location of Jurassic-Cretaceous boundary can not be decided.

#### ACKNOWLEDGEMENTS

The authors are grateful to the authorities of the Birbal Sahni Institute of Palaeobotany, Lucknow and the Department of Geology, Lucknow, University for approving this collaborative project. Our sincere thanks are due to Mr. D. C. Joshi for the chemical treatment of the samples.

#### REFERENCES

- ARKELL, W. J. 1956. *Jurassic geology of the world*. London and Edinburgh (Oliver and Boyd): 1-806.
- BATTEN, D.J. 1978. Early Cretaceous to Middle Jurassic miospores and palynofacies of the northwest European continental Shelf. *Continental Shelf Inst. Publ.* **100** : 97-101.
- BRIDEAUX, W. W. & FISHER, M. J. 1976. Upper Jurassic-Lower Cretaceous dinoflagellate assemblages from Arctic Canada. *Canadian Geol. Surv. Bull.* **259** : 1-53.
- COOKSON, I. C. & EISENACK, A. 1958. Microplankton from Australian and New Guinea Upper Mesozoic sediments. *Proc. R. Soc. Vict.* **70**(1) : 19-79.
- COOKSON, I. C. & EISENACK, A. 1960. Upper Mesozoic microplankton from Australia and New Guinea. *Palaeontology*. **2**(2) : 243-261.
- DAVEY, R. J. 1979. The stratigraphic distribution of dinocysts in the Portlandian (Latest Jurassic) to Barremian (Early Cretaceous) of North-West Europe. *Am. Assoc. Strat. Palynol.* **5B** : 49-82.
- DETTMANN, M. E. & PLAYFORD, G. 1968. Taxonomy of some Cretaceous spores and pollen grains from eastern Australia. *Proc. R. Soc. Vict.* **81** : 69-93.
- DIENER, C. 1895. Ergebnisse einer geol. Expedition in den Zentral-Himalaya von Johar, Hundes und Painkanda. *Denkschr. Akad. Wiss. (M. N. Cl.)*, **62** : 1-533.
- DÖRHÖFER, G. & DAVIES, F. D. 1980. Evolution of archaeophyle and tabulation in Rhaetogonyaulacinean dinoflagellate cysts. *Roy. Ont. Mus. Life Sci. Misc. publ.* : 1-91.
- DUTTA, S. K. & JAIN, K. P. 1980. Geology and palynology around Lumshnong area, Jaintia Hills, Meghalaya, India. *Biol. Mem.* **5**(1) : 56-81.
- GANSER, A. 1964. *Geology of the Himalaya*. Interscience Publ. John Wiley & Sons. New York. 1-289.
- GARG, RAHUL, JAIN, K. P., SINGH, I. B., KUMAR, S. & SINGH, S. K. 1981. Tethyan Cretaceous radiolaria from Malla Johar area, Kumaon Himalaya, Uttar Pradesh, India. *J. Palaeont. Soc. India*. **25** : 1-12.
- GITMEZ, G. U. & SARJEANT, W. A. S. 1972. Dinoflagellate cysts and acritarchs from the basal Kimmeridgian (Upper Jurassic) of England, Scotland and France. *Bull. Brit. Mus. (N. H.) geol.* **21**(5) : 171-257.
- GREISBACH, C. L. 1891. Geology of Central Himalaya. *Mem. Geol. Surv. India*, **23** : 1-232.
- GREISBACH, C. L. 1893. Notes on the Central Himalaya. *Rec. Geol. Surv. India*, **26**(1) : 19-25.
- HEIM, A. & GANSER, A. 1939. Central Himalaya geological observations of the Swiss expedition 1936. *Mem. Soc. Helv. Sci. Nat.* **73**(1) : 1-245.
- HERNGREEN, G. F. W., VAN HOCKEN-KLINKENBERG, P. M. J. & DEBOER, K. F. 1980. Some remarks on selected palynomorphs near Jurassic-Cretaceous boundary in The Netherlands. *IV Int. Palynol. Conf. Lucknow* (1976-77). **2** : 357-367.
- HUGHES, N. F. & MOODY-STUART, J. C. 1966. Palynological facies and correlation in the English Wealden. *Rev. Palaeobot. Palynol.* **1**(1-4) : 259-268.
- IOANNIDES, N. S., STAVRINOS, G. N. & DOWNIE, C. 1976. Kimmeridgian microplankton from Clavell's Hard Dorset, England. *Micropalaeontology*. **22**(4) : 443-478.
- JAI KRISHNA, KUMAR, S. & SINGH, I. B. 1982. Ammonoid stratigraphy of the Spiti Shale (Upper Jurassic), Tethys Himalaya, India. *N. Jb. Geol. Palaeont. Mh.* **10** : 580-592.
- JAIN, K. P., GARG, RAHUL, KUMAR, S., SINGH, I. B. & SINGH, S. K. 1978. Diinoflagellates and radiolarians from the Tethyan sediments, Malla Johar area, Kumaon Himalaya. A preliminary report. *J. Palaeont. Soc. India*. **21** & **22** : 116-119.
- JOHNSON, C. D. & HILLS, L. V. 1973. Microplankton zones of the Savik Formation (Jurassic), Axel Heiberg and Ellesmere Islands, district of Franklin. *Bull. Canadian Petroleum Geol.* **21**(2) : 178-218.
- KUMAR, G., MEHDI, S. H. & PRAKASH, G. 1972. A review of stratigraphy of parts of Uttar Pradesh, Tethys Himalaya. *J. Palaeont. Soc. India*. **15** : 86-98.
- KUMAR, S., SINGH, I. B. & SINGH, S. K. 1977. Lithostratigraphy, structure, depositional environment, palaeocurrent and trace fossils of the Tethyan sediments of Malla Johar area, Pithoragarh-Chamoli District, Uttar Pradesh, India. *Jour. Palaeont. Soc. India*. **20** : 396-435.
- NORRIS, G. 1969. Miospores from the Purbeck beds and marine Upper Jurassic of southern England. *Palaeontology*. **12** : 574-620.
- OPPEL, A. 1863. Über ostindische fossiles aus den Sekundären Ablagerungen von Spiti und Gnari-Khoesum in Tibet. *Pal. Mitt.* **1**: 1-267.
- POCOCK, S. A. J. 1976. A preliminary dinoflagellate zonation of the uppermost Jurassic and lower part of the Cretaceous, Canadian Arctic and possible correlation in the western Canada basin. *Geosci. Man.* **15** : 101-104.
- POCOCK, S. A. J. 1980. Palynology at the Jurassic-Cretaceous boundary in North America. *IV Int. Palynol. Conf. Lucknow* (1976-77) **2** : 377-385.
- RILEY, L. A. 1979. Dinocyst from the Upper Kimmeridgian (Pectinatus Zone) of Marton; Yorkshire. *Mercian Geol.* **7**(3) : 219-222.
- SARJEANT, W. A. S. 1978. A guide to the identification of Jurassic dinoflagellate cysts. *Sch. Geosci., Louisiana State University Misc. Publ.* No. 78-1 : 1-107.
- SARJEANT, W. A. S. 1979. Middle and Upper Jurassic dinoflagellate cysts: The world excluding North America. *Contributions of Stratigraphic Palynology (with emphasis on North America)*, 2, *AASP Contribution Series*. **513** : 133-151.
- SARJEANT, W. A. S. 1982. The dinoflagellate cysts of the Gonyalacysta group: a morphological and taxonomical restudy. *Amer. Assoc. Strat. Palynol. Ser.* **9** : 1-180.
- SINGH, I. B., KUMAR, S., SINGH, S. K., JAI KRISHNA, JAIN K. P., SINGH, M. P. & GARG, RAHUL. 1980. Biostratigraphy and palaeo-ecology of the Spiti Shale (Formation) near Laptal, Malla Johar area, Kumaon Himalaya, Uttar Pradesh. (Abstract). *Him. Geol. Seminar* : 11, Dehra Dun.
- SINGH, S. K., KUMAR, S. & SINGH, I. B. 1981. On the upper age limit of UPper Flysch of Heim and Gansser, Malla Johar area, Pithoragarh District, India. *Proc. VII Indian Colloq. Micropal., Strat., Madras*, 382-387.
- STRACHEY, R. 1851. On the geology of part of the Himalayan mountains and Tibet. *Quart. J. Geol. Soc. London*. **7** : 292-310.
- TIWARI, R. S., SINGH, V., KUMAR, S. & SINGH, I. B. 1984. Palynological studies of the Tethyan sequence in Malla Johar area,

- Kumaon Himalaya, India. *Palaeobotanist*. **32**(3) : 341-367.
- UHLIG, V. 1903-1910. The fauna of the Spiti Shales. *Pal. Ind. Ser.* 15-4 (1-3) : 1-511.
- VALDIYA, K. S. & GUPTA, V. J. 1972. A contribution to the geology of northeastern Kumaun with special reference to the Hercynian gap in Tethys Himalaya. *Him. Geol.* **2** : 1-33.
- WILLIAMS, G. L. 1978. Palynological biostratigraphy, Deep Sea Drilling Project sites 367 and 370. In Lancelot, Y., Seibold, E. et al., *Initial Reports of the Deep Sea Drilling Project, Washington* **31** : 783-815.
- WOOLAM, R. & RIDING, J. B. 1983. Dinoflagellate cyst zonation of the English Jurassic. *Rep. Inst. Geol. Sci.* No. **83/2**:1-41.

## EXPLANATION OF PLATES

(All microphotographs magnified  $\times 500$  unless otherwise stated. Coordinates refer to Carl Ziess Amplival Jena microscope. The figured and type slides are deposited in the museum, B S I P, Lucknow)

## PLATE I

- 1—4. *Gonyaulacysta jurassica* (Deflandre) subsp. *Jurassica* Deflandre emend. Sarjeant, 1982; BSIP Slide Nos. 6801, 6807 and 6810; coordinates:  $104 \times 24$ ;  $125.1 \times 16$ ;  $130.6 \times 11.6$  and  $133 \times 12$  respectively.
- 5—6. *Wanaea clathrata* Cookson & Eisenack, 1958; BSIP Slide Nos. 6776 and 6778; coordinates:  $138.8 \times 23.7$  and  $128 \times 19.3$  respectively.
- 7—9. *Tanyosphaeridium torynum* (Cookson & Eisenack) Stover & Evitt, 1978; BSIP Slide nos. 6812, 6809 and 6805; coordinates:  $135.9 \times 7.8$ ,  $118 \times 5$  and  $116.3 \times 8$  respectively.
10. *Tanyosphaeridium jurassicum* Jain & Garg n. sp. BSIP Slide No. 6806; coordinates:  $107 \times 6.6$  (holotype).
11. *Peridictyocystis mirabilis* (Cookson & Eisenack) Cookson & Eisenack, 1974; BSIP Slide No. 6783; coordinates:  $123.2 \times 22.4$ .
12. *Nannocertopsis pellucida* Deflandre, 1938; BSIP Slide No. 6808; coordinates:  $105.7 \times 17$ .
13. *Tubotuberella apatela* (Cookson & Eisenack) Brideaux, 1977; BSIP Slide No. 6785; coordinates:  $105.7 \times 20.8$ .
14. *Tubotuberella* sp. A; BSIP Slide No. 6810; coordinates:  $128.6 \times 12.5$ .
- 15—16. *Omatia montgomeryii* Cookson & Eisenack, 1958; BSIP Slide Nos. 6808 and 6804; coordinates:  $127.8 \times 3.5$  and  $104.6 \times 11.6$  respectively.
17. *Omatia pisciformis* Cookson & Eisenack, 1958; BSIP Slide No. 6806; coordinates:  $100.4 \times 11.6$ .
- 18—19. *Chlamydophorella fenestrata* Jain & Garg n. sp. BSIP Slide Nos. 6808 and 6803; coordinates:  $130.8 \times 12.7$  and  $105.4 \times 5$  respectively (19, holotype).
20. *Pareodinia ceratophora* Deflandre, 1947; BSIP Slide No. 6783 coordinates:  $118.7 \times 19.5$ .

## PLATE II

21. *Scriniodinium echinatum* Jain & Garg n. sp.; BSIP Slide No. 6784; coordinates:  $108.4 \times 19.8$  (holotype).
- 22—23. *Scriniodinium indicum* Jain & Garg n. sp.; BSIP Slide No. 6786; coordinates:  $120.4 \times 17.7$  and  $125.6 \times 21.4$  respectively (22, holotype).
24. *Aptedinium nuciforme* (Deflandre) Stever & Evitt, 1978; BSIP Slide No. 6787; coordinates:  $92.5 \times 14.6$ .
- 25—26. *Canningia reticulata* Cookson & Eisenack, 1960; BSIP Slide Nos. 6787 and 6783; coordinates:  $128.8 \times 18$  &  $118.2 \times 5$  respectively.
- 27—29. *Canningia apiculata* Jain & Garg n. sp.; BSIP Slide No. 6783; coordinates:  $116.6 \times 11$ ,  $131 \times 6.6$  and  $106.5 \times 22.3$  respectively; (27, holotype).
30. *Membranilarnacia leptoderma* (Cookson & Eisenack) Eisenack, 1963; BSIP Slide No. 6808; coordinates:  $115.1 \times 10.6$ .
31. *Ovoidinium waltonii* (Pocock) Leatin & Williams, 1967; BSIP Slide No. 6783; coordinates:  $108 \times 13.5$ .
32. *Ellipsoidictyon cinctum* Klement, 1960; BSIP Slide No. 6814; coordinates:  $118.4 \times 17.8$ .
33. *Tubotuberella apatela* (Cookson & Eisenack) Brideaux, 1977; BSIP Slide No. 6807; coordinates:  $137 \times 16$ .
34. *Prolixosphaeridium granulosum* (Deflandre) Davey et al., 1966; BSIP Slide No. 6806; coordinates:  $98.2 \times 6.3$ .
35. *Prolixosphaeridium mixtispinosum* (Klement) Davey et al., 1966; BSIP Slide No. 6810; coordinates:  $108.4 \times 18.4$ .
36. *Adnatospheeridium aemulum* (Deflandre) Williams & Downie, 1969; BSIP Slide No. 6801; coordinates:  $115.5 \times 21.5$ .
- 37—38. *Surculosphaeridium vestitum* (Deflandre) Davey et al., 1966; BSIP Slide No. 6786; coordinates:  $102.2 \times 15.4$  and  $97.4 \times 12.2$  respectively.
- 39—40. *Emmetrocysta sarjeantii* (Gitmez) Stover & Evitt, 1978; BSIP Slide Nos. 6800 and 6807; coordinates:  $125.8 \times 4.8$  and  $114.4 \times 20$  respectively.

## PLATE III

- 41—42. *Psudoceratium spitiensis* Jain & Garg n. sp.; BSIP Slide No. 6787; coordinates:  $126.7 \times 19.4$  and  $119 \times 9.4$  respectively; (42, holotype).
43. *Chytroeisphaeridium* sp. A; BSIP Slide No. 6762; coordinates:  $109.6 \times 21.5$ .
44. *Sentusidinium* sp. D; BSIP Slide No. 6786; coordinates:  $113.6 \times 12.8$ .
45. *Scriniodinium echinatum* Jain & Garg n. sp.; BSIP Slide 6774; coordinates:  $106.0 \times 19.4$ .
46. *Chytroeisphaeridium* sp. A; BSIP Slide No. 6771; coordinates:  $95.8 \times 8.8$ ,

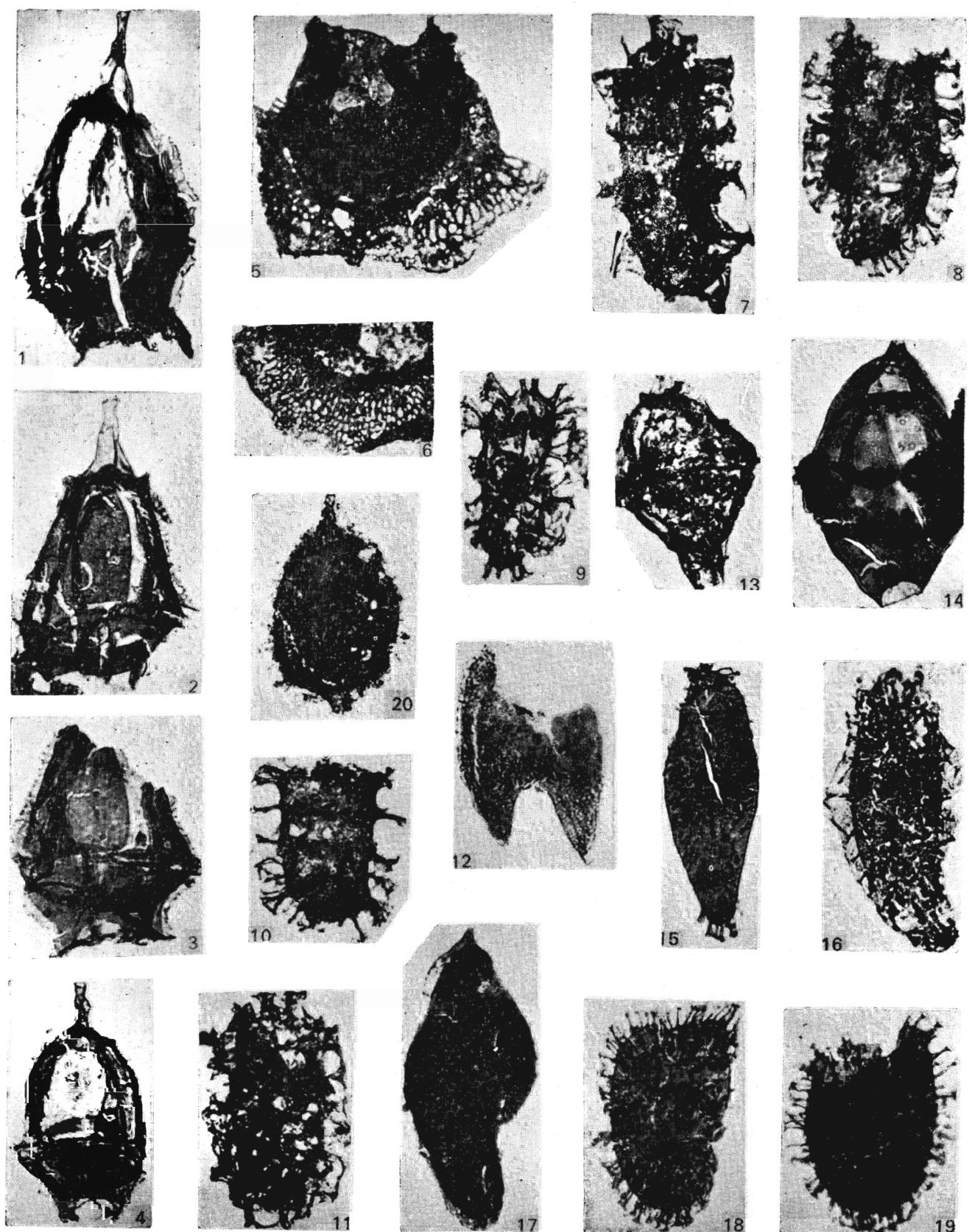
47. *Canningia* sp. A; BSIP Slide No. 6771a; coordinates:  $131.5 \times 16.4$ .  
 48. *Broomea* sp. A; BSIP Slide No. 6777; coordinates:  $115.5 \times 25$ .  
 49. *Pareodinia* sp. A; BSIP Slide No. 6781; coordinates:  $96.4 \times 20.6$ .  
 50. *Leptodinium* sp. A; BSIP Slide No. 6805; coordinates:  $115.6 \times 14.0$ .  
 51. *Sentusidinium* sp. A; BSIP Slide No. 6794; coordinates:  $117.7 \times 16.4$ .  
 52. *Prolixosphaeridium capitatum* (Cookson & Eisenack) Singh, 1971; BSIP Slide No. 6762; coordinates:  $113.7 \times 16.8$ .  
 53. *Fromea amphora* Cookson & Eisenack, 1958; BSIP Slide No. 6771; coordinates:  $108.5 \times 25.2$ .  
 54. ?*Ellipsoidictyum* sp. A; BSIP Slide No. 6762; coordinates:  $136.4 \times 19.5$ .  
 55—56. *Lanterna* sp. A; BSIP Slide Nos. 6781 and 6787; coordinates:  $114.6 \times 15$  and  $122.8 \times 8$  respectively.  
 57. *Tanyosphaeridium* sp. A; BSIP Slide No. 6779; coordinates:  $106.4 \times 24.5$ .  
 58. *Lithodinia jurassica* Eisenack, 1935; BSIP Slide No. 6798; coordinates:  $96 \times 18.5$ .  
 59—61. *Nummus malla Joharense* Jain & Garg n. sp.; BSIP Slide nos. 6805 and 6782; coordinates:  $115 \times 13.3$ ;  $125.4 \times 19.5$  and  $135.8 \times 9.7$  respectively; (60. holotype).  
 62. *Broomea simplex* Cookson and Eisenack, 1958; BSIP Slide No. 6778; coordinates:  $117.7 \times 13.7$ .  
 63. *Sentusidinium echinatum* (Gitmez & Sarjeant) Sarjeant & Stover, 1978; BSIP Slide No. 6805; coordinates:  $125.3 \times 21.5$ .  
 64. *Pareodinia ceratophora* Deflandre, 1947; BSIP Slide No. 6808; coordinates:  $103 \times 15.2$ .  
 65. *Histiophora ornata* Klement, 1960; BSIP Slide No. 6805; coordinates:  $118.8 \times 14.6$ .

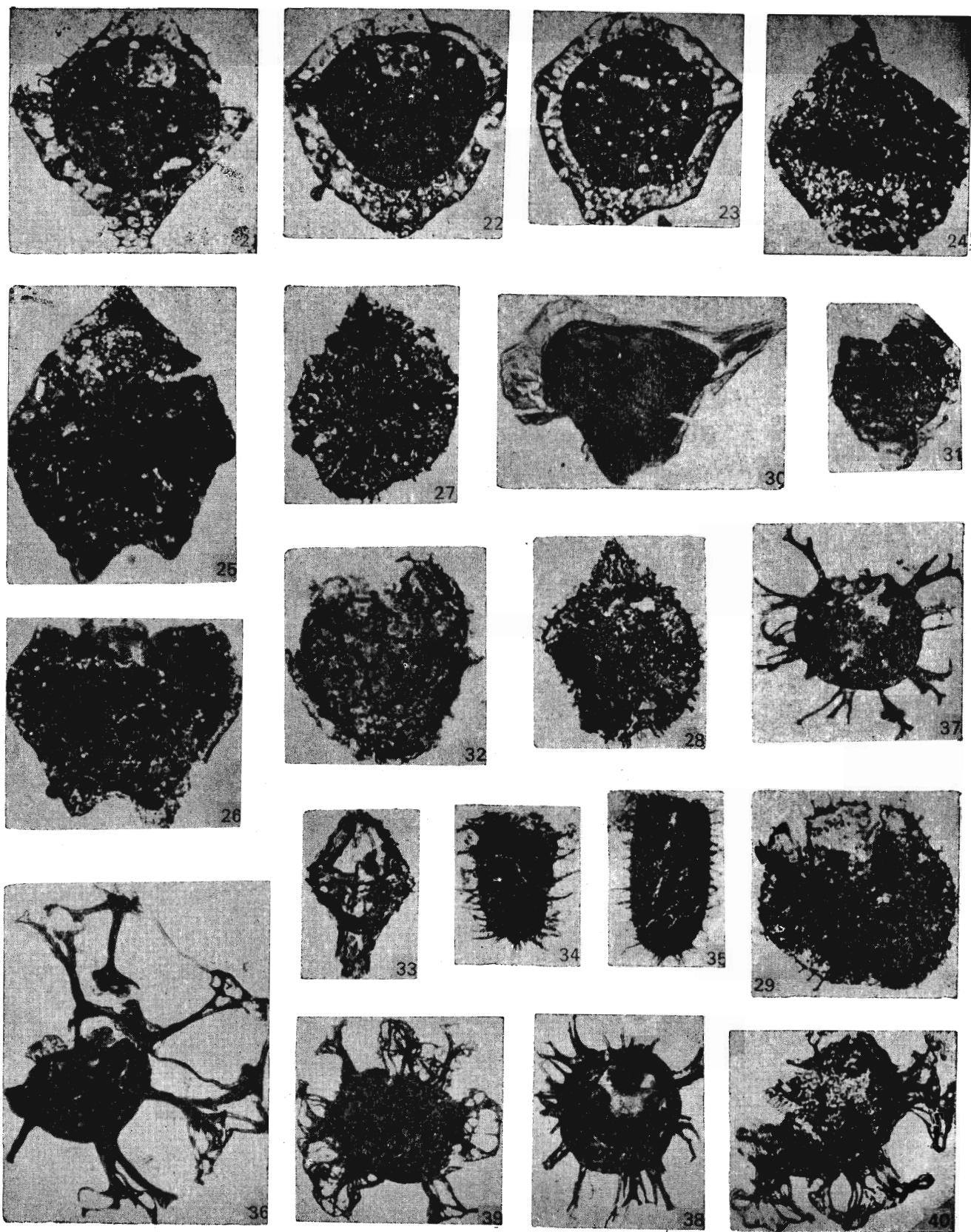
## PLATE IV

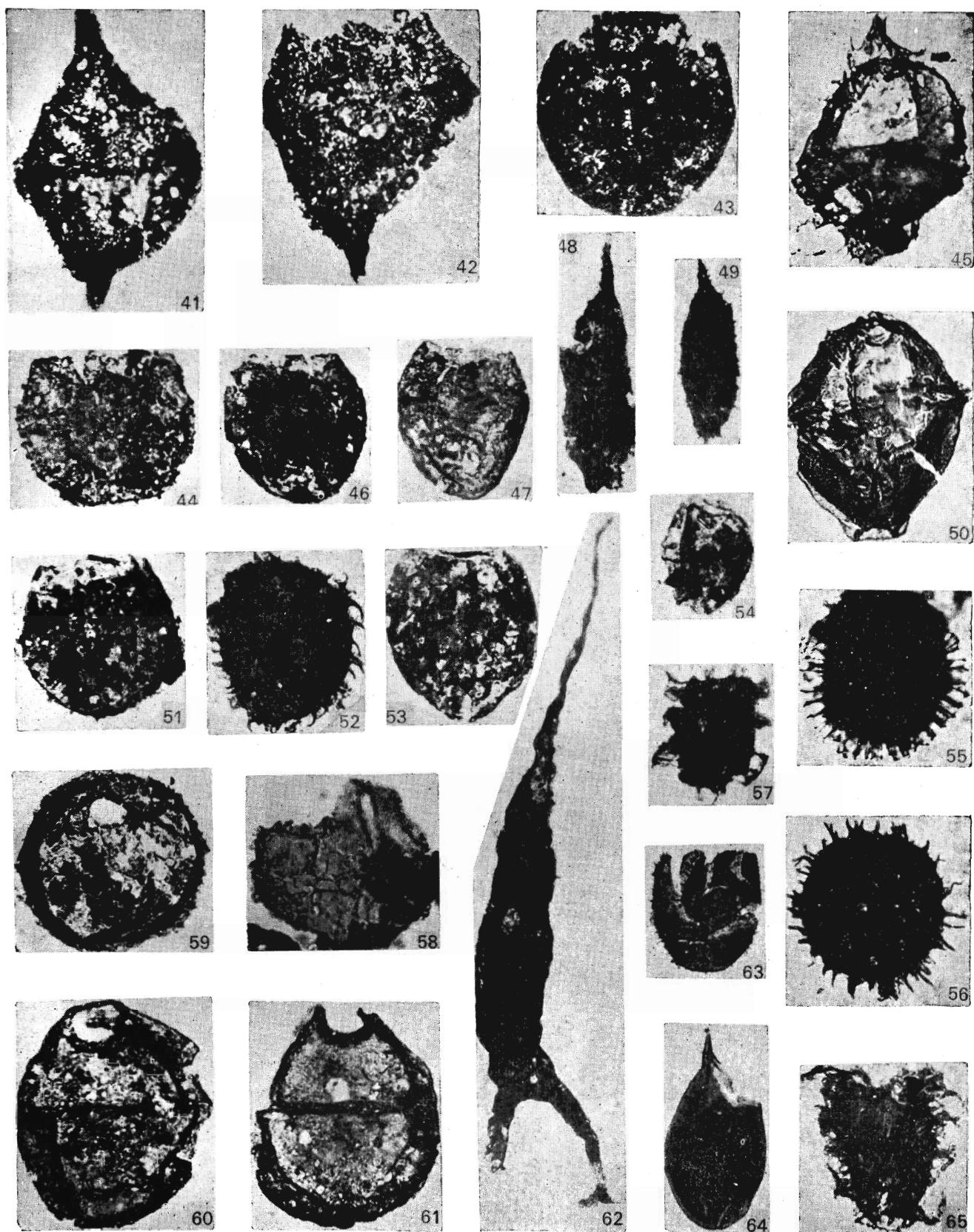
66. *Oligosphaeridium dictyophorum* (Cookson & Eisenack) Davey & Williams 1969; BSIP Slide No. 6766; coordinates:  $136 \times 13$ .  
 67. *Oligosphaeridium* sp. cf. *anthophorum* (Cookson & Eisenack) Davey, 1969; BSIP Slide No. 6767; coordinates:  $107.4 \times 2.9$ .  
 68—69. *Systematopora* sp. cf. *S. orbifera* Klement, 1960; BSIP Slide No. 6766; coordinates:  $99.8 \times 22.7$  and  $113 \times 16.6$  respectively.  
 70—71. *Systematopora penicillata* (Ehrenberg) Sarjeant, 1980; BSIP Slide Nos. 6786 and 6763; coordinates:  $125.5 \times 15.5$  and  $106.6 \times 21.6$  respectively.  
 72. *Cyclonephelium* sp. A; BSIP Slide No. 6806; coordinates:  $95 \times 11.9$ .  
 73. *Chytroisphaeridia* sp. B; BSIP Slide No. 6811; coordinates:  $105.2 \times 5.3$ .  
 74. *Cribroperidinium granulatum* (Klement) Stover & Evitt, 1978; BSIP Slide No. 6761; coordinates:  $135.9 \times 24$ .  
 75. *Lithodinia* sp. A; BSIP Slide No. 6766; coordinates:  $114.4 \times 11.2$ .  
 76. *Scriinodinium galertum* (Deflandre) Klement, 1960; BSIP Slide No. 6772; coordinates:  $98.2 \times 11.3$ .  
 77. *Rhynchodiniopsis ambigua* (Deflandre) Sarjeant, 1982; BSIP Slide No. 6813; coordinates:  $128.7 \times 18.4$ .  
 78. Forma O; BSIP Slide No. 6791; coordinates:  $130.6 \times 12.6$ .  
 79. *Micrhystridium* sp. A; BSIP Slide No. 6764; coordinates:  $100.5 \times 20.3$ .  
 80. cf. *Lophodictyotum* Pocock, 1972; BSIP Slide No. 6768; coordinates:  $101.3 \times 11$ .  
 81. *Wanaea* sp. A; BSIP Slide No. 6808; coordinates:  $122.3 \times 10.6$ .  
 82—83. *Rhynchodiniopsis ambigua* Sarjeant 1982; BSIP Slide Nos. 6802 & 6808; coordinates:  $108 \times 25.2$  and  $106.6 \times 16$  respectively.  
 84. *Cyclonephelium* sp. A; BSIP Slide No. 6780; coordinates:  $93 \times 14.4$ .  
 85. *Leiosphaera jurassica* Cookson & Eisenack, 1958; BSIP Slide No. 6805; coordinates:  $118.2 \times 20.7$ .  
 86. *Veryhachium valensii* (Valensi) Downie & Sarjeant, 1963; BSIP Slide No. 6764; coordinates:  $125.1 \times 7.8$ .  
 87. *Apteodinium* sp. A; BSIP Slide No. 6771; coordinates:  $102.5 \times 11.8$ .

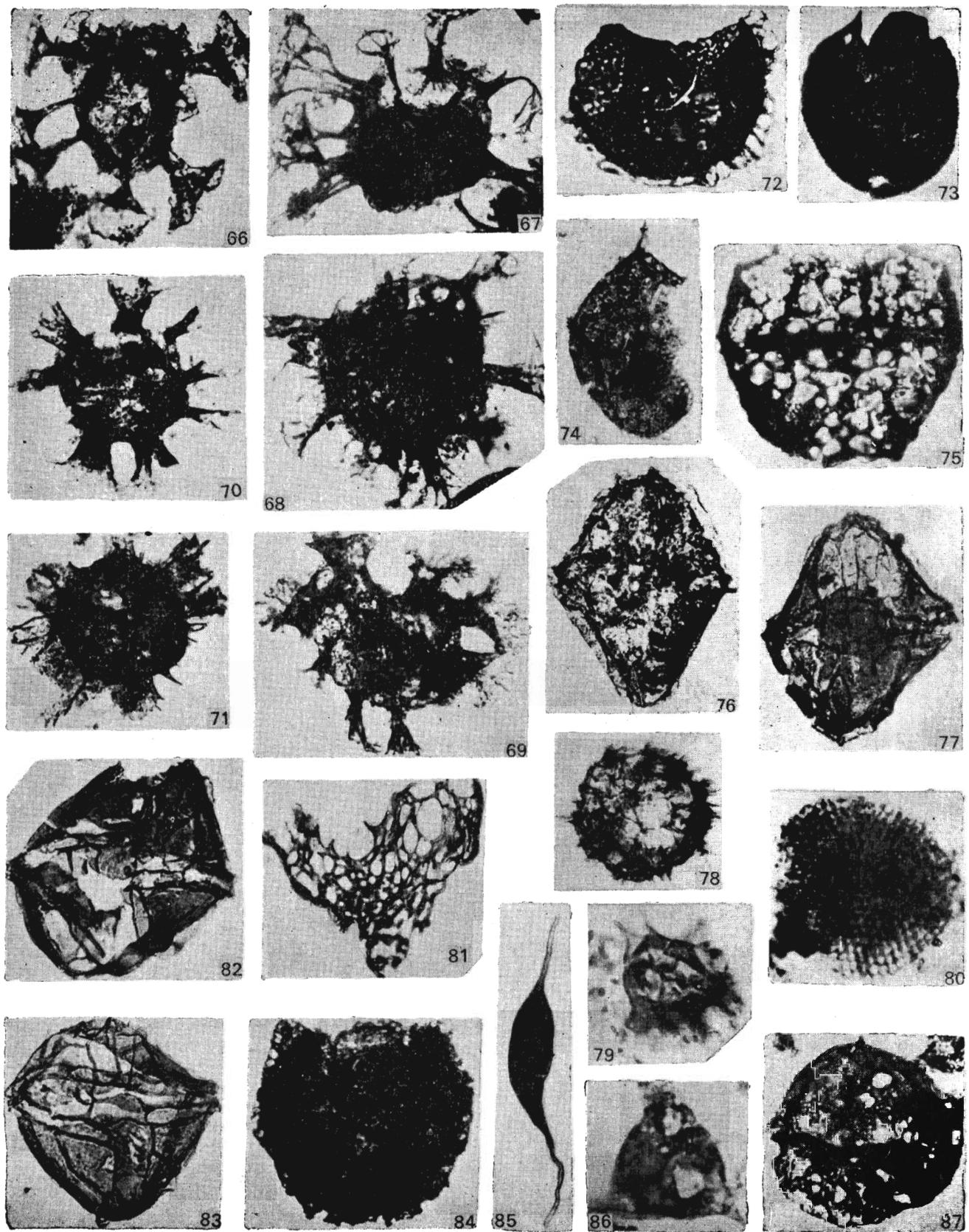
## PLATE V

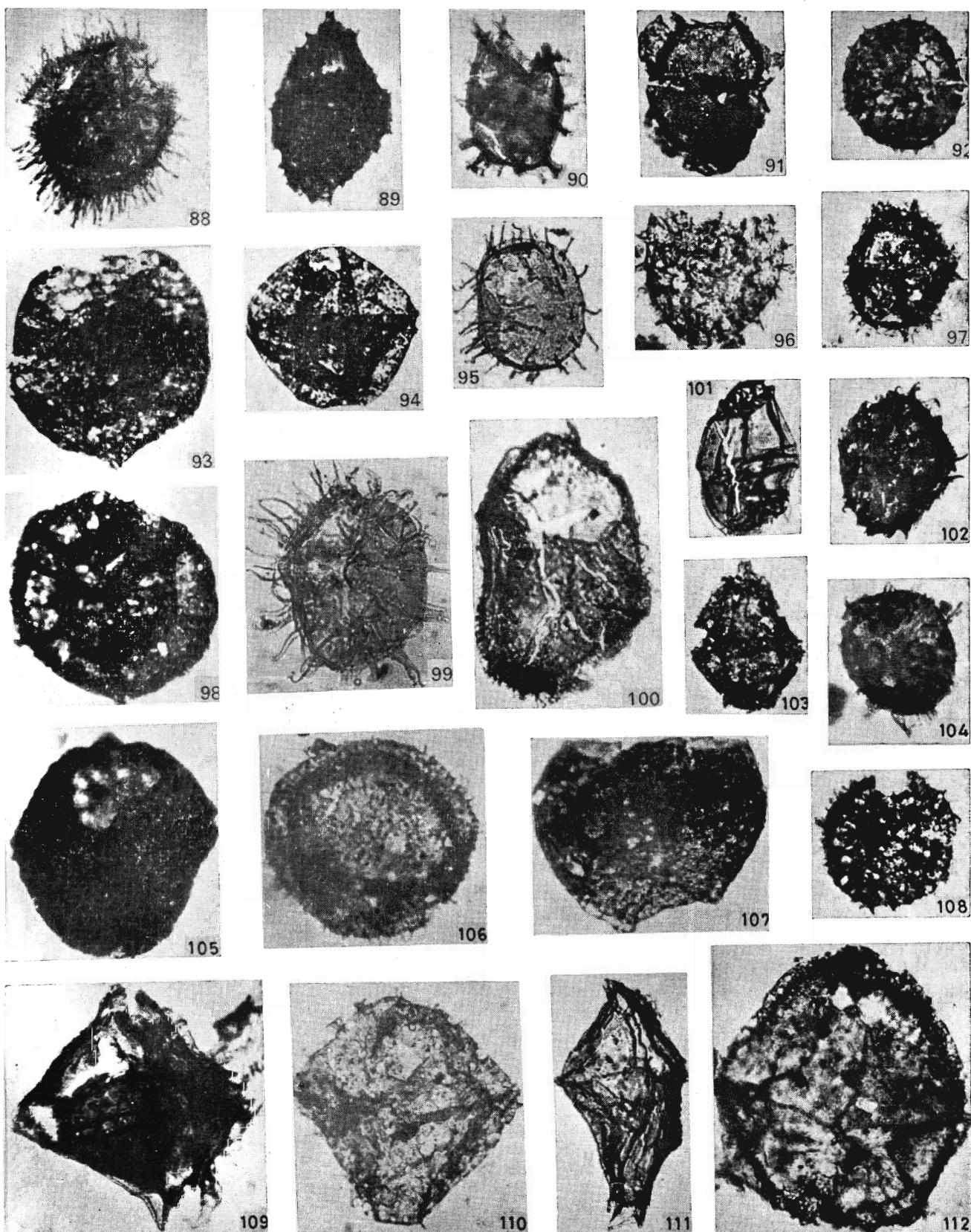
88. cf. *Xylochoarion*; BSIP Slide No. 6809; coordinates:  $107.4 \times 8.7$ .  
 89. Forma A; BSIP Slide No. 6778; Coordinates:  $121.8 \times 5.5$ .  
 90. cf. *Tanyosphaeridium* Davey & Williams, 1966; BSIP Slide No. 6810; coordinates:  $97.3 \times 6.3$ .  
 91. Forma B.; BSIP Slide No. 6772; coordinates:  $122 \times 12.4$ .  
 92. Forma C; BSIP Slide No. 6761; coordinates:  $102.1 \times 12$ .  
 93. Forma D; BSIP Slide No. 6770; coordinates:  $116.4 \times 4$ .  
 94. Forma E; BSIP Slide No. 6788; coordinates:  $116.5 \times 10$ .  
 95. Forma F; BSIP Slide No. 6773; coordinates:  $95 \times 10.6$ .  
 96. *Sentusidinium* sp. B; BSIP Slide No. 6765; coordinates:  $102.2 \times 8.8$ .  
 97. Forma G; BSIP Slide No. 6768; coordinates:  $98 \times 19.2$ .  
 98. cf. *Cymatiosphaera* Wetzel emend. Deflandre, 1954; BSIP Slide No. 6769; coordinates:  $102 \times 8$ .  
 99. *Cleistosphaeridium tribuliferum* (Sarjeant) Davey et al.; BSIP Slide No. 6763; coordinates:  $108.8 \times 12.3$ .  
 100. cf. *Palaeostomocystis* Deflandre, 1937; BSIP Slide No. 6808; coordinates:  $119.7 \times 9$ .  
 101. Forma H; BSIP Slide No. 6806; coordinates:  $119.4 \times 6$ .  
 102. Forma I; BSIP Slide No. 6806; coordinates:  $95.1 \times 5.8$ .  
 103. Forma J; BSIP Slide No. 6783; coordinates:  $109.0 \times 11.1$ .  
 104. Forma K; BSIP Slide No. 6761; coordinates:  $139.9 \times 20.8$ .  
 105. cf. *Apteodinium* Eisenack, 1958; BSIP Slide No. 6778; coordinates:  $102.2 \times 9.4$ .  
 106. *Micrhystridium* sp. A; BSIP Slide No. 6764; coordinates:  $100.4 \times 3.5$ .  
 107. *Canningia* sp. A; BSIP Slide No. 6766; coordinates:  $134 \times 5$ .  
 108. Forma L; BSIP No. 6761; coordinates:  $136.2 \times 19$ .  
 109. cf. *Euryglynia* Sarjeant, 1976; BSIP Slide No. 6801; coordinates:  $99.5 \times 7.8$ .

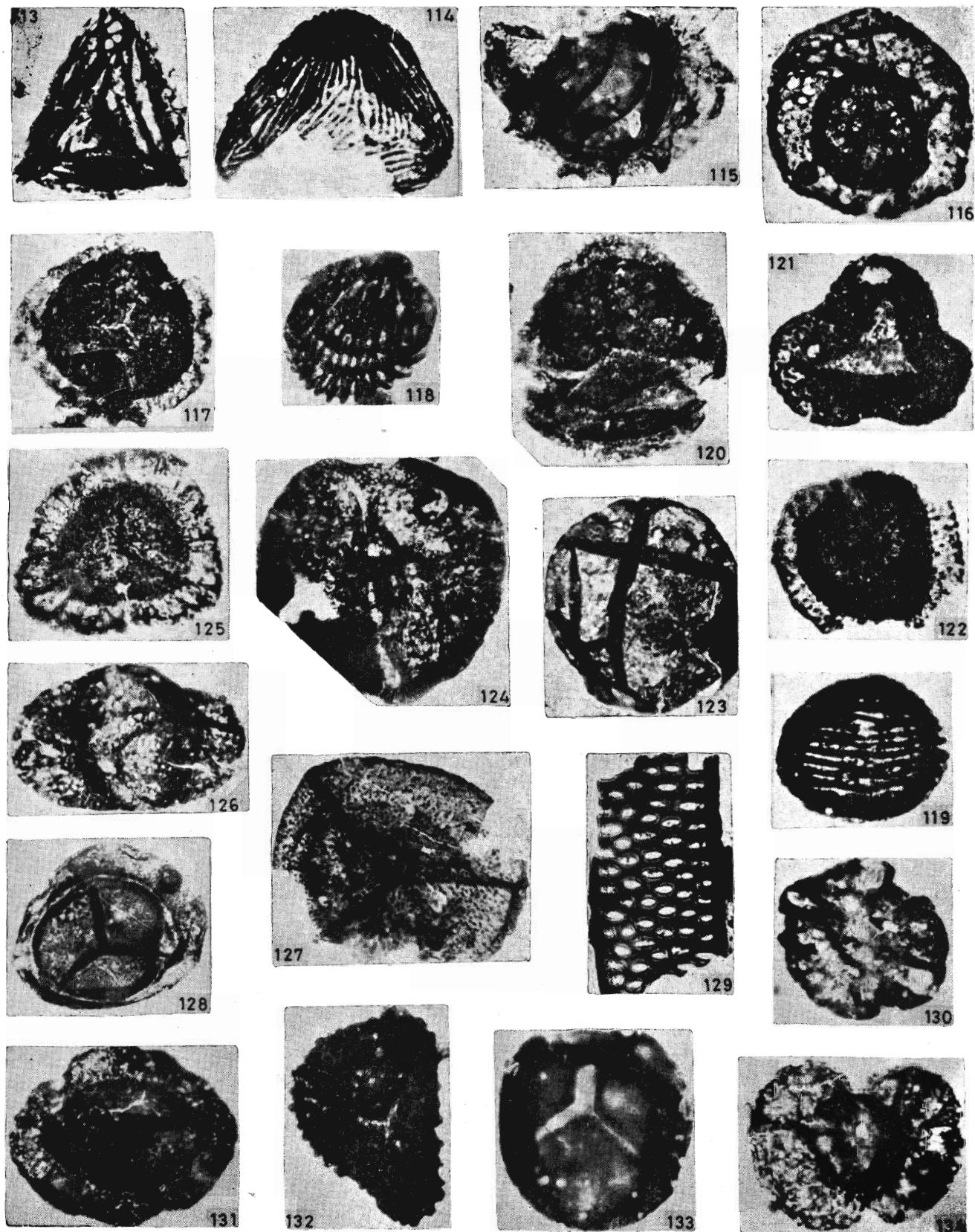












110. Forma M; BSIP Slide No. 6766; coordinates:  $108.9 \times 10$ .
111. cf. *Scriniodinium* Klement, 1957; BSIP Slide No. 6805; coordinates:  $118.5 \times 8.3$ .
112. Forma N; BSIP Slide No. 6775; coordinates:  $109.5 \times 20$ .

## PLATE VI

113. *Appendicisporites* sp. A; BSIP Slide No. 6796; coordinates:  $95.7 \times 14.2$ .
114. *Cicatricosporites australiensis* (Cookson) Potonié, 1956; BSIP Slide No. 6796; coordinates:  $118.6 \times 5.4$ .
115. ?*Heliosporites* sp. A; BSIP Slide No. 6789; coordinates:  $120 \times 16$ .
116. *Densisporites* sp. cf. *D. playfordii* (Balme) Dettmann, 1963; BSIP Slide No. 6792; coordinates:  $128.5 \times 4.2$ .
117. Trilete spore type B; BSIP Slide No. 6794; coordinates:  $125.7 \times 8.8$ .
- 118-119 *Contignisporites multimuratus* Dettmann, 1963; BSIP Slide No. 6795 and 6792; coordinates:  $108 \times 13.5$  and  $97.8 \times 8.8$  respectively.
120. Trilete spore type A; BSIP Slide No. 6792; coordinates:  $107.7 \times 8.9$ .
121. *Concavissimisporites kutchensis* Venkatachala, 1969; BSIP Slide No. 6789; coordinates:  $111.0 \times 15.5$ .
122. *Couperisporites vangaudensis* Pocock, 1962; BSIP Slide No. 6797; coordinates:  $115.9 \times 19.9$ .
123. *Laricoidites* sp. A; BSIP Slide No. 6792; coordinates:  $108.7 \times 11$ .
124. *Alisporites* sp. A; BSIP Slide No. 6790; coordinates:  $102.6 \times 11$ .
125. *Lycopodiumsporites* sp. A; BSIP Slide No. 6794; coordinates:  $128.5 \times 5.5$ .
126. *Alisporites grandis* (Cookson) Dettmann 1963; BSIP Slide No. 6792; coordinates:  $100.6 \times 5.5$ .
127. *Couperisporites jurassicus* Pocock, 1971; BSIP Slide No. 6789; coordinates:  $103.4 \times 17.7$ .
128. *Densisporites valatus* Weyland & Krieger emend. Krasnova, 1961; BSIP Slide No. 6793; coordinates:  $135.3 \times 13.7$ .
129. A piece of wood tracheid; BSIP Slide No. 6815; coordinates:  $100.4 \times 10.5$ .
130. *Callialasporites trilobatus* (Balme) Sukh Dev, 1961; BSIP Slide No. 6790; coordinates:  $105.4 \times 18.6$ .
131. *Callialasporites monoalasporus* Sukh Dev, 1959; BSIP Slide No. 6799; coordinates:  $119 \times 14.4$ .
132. Trilete spore type C; BSIP Slide No. 6771; coordinates:  $135 \times 25.4$ .
133. *Todisporites minor* Couper, 1953; BSIP Slide No. 6792; coordinates:  $126.2 \times 14.6$ .
134. *Podocarpidites multisinus* (Bolkhovitina) Pocock, 1962; BSIP Slide No. 6791; coordinates:  $114.5 \times 15.5$ .