ABSTRACT

Assemblages of acid-insoluble microplankton, pollen, and spores are described from the Lias of England and South Wales. They include one new genus and nineteen new acritarch species and many others previously unrecorded from the Lower Jurassic. Forty-two pollen and spore genera, one new, are also recorded. The stratigraphic distribution of microplankton, pollen, and spores is described, and it is concluded that this is environmentally controlled. The relationship between stratigraphic microfossil assemblage changes, Liassic transgressions, and facies changes is established, and its paleoecological significance is discussed.

Microplankton, pollen, and spores from the Lower Jurassic in Britain

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INTRODUCTION

Investigation of Liassic strata in England and Wales has revealed the presence of numerous acid-insoluble microfossils, including microplankton, pollen, and spores. In contrast to the existing information regarding these microfossils, the documentation concerning the stratigraphy of the British Lias is extremely abundant. The results of early pioneering work were summarised by Arkell (1933, pp. 117–188). Recent years have seen a vigorous renewal of interest in the Lias, with a series of studies on sedimentation (Hemingway, 1951; Hallam, 1960, 1961), petrography (Davies and Dixie, 1951; Bitterli, 1963), and paleontology (Dean, Donovan, and Howarth, 1961), to mention but a few. Some of these comprehensive stratigraphic data were utilised during the collection of samples and as an aid to the interpretation of results in the present study.

AGES AND LOCATIONS OF SAMPLES

The basic stratigraphy of the sections sampled is summarised in Table 1, and localities yielding the samples are indicated in text-figure 1. The ages of almost all the samples, based upon ammonite chronology, were determined previously by the respective authors cited below.

Dorset

1) *The coastal section between Pinhay Bay, Lyme Regis, and West Bay:*

Blue Lias (Lang, 1924, beds H. 29, H. 87, 18, 40, and 50); Shales-with-Beef (Lang, Spath, and Richardson, 1923, beds 74e and 74s–w); Black Ven Marls (Lang, Spath, Cox, and Muir-Wood, 1926, beds 79, 88f, and 100); Belemnite Marls (Lang, 1928, beds 110a, 114, and 120); Green Ammonite Beds (Lang, 1936, beds 112b, 123h, and 136); Three Tiers, Eype Clay, Down Cliff Sands (Wilson, Welch, Robbie, and Green, 1958, p. 37); Junction Bed (Jackson, 1926, p. 513, and Wilson *et al.*, 1958, p. 50); Down Cliff Clay (Wilson *et al.*, 1958, p. 59).

Yorkshire

1) *Robin Hoods Bay and Blea Wyke Point:*

"Jamesoni-beds" (Fox-Strangways, 1892, p. 52, beds 49, 50, and 54); "Capricornus-beds" (Fox-Strangways, 1892, p. 56, beds 4 and 12; Howarth, 1955, p. 155, bed 1v); Bituminous Shales, Hard Shales, Striatulus Shales, "Serpula Beds," and Yellow Beds (Dean, 1954, pp. 168–173, beds 2, 4, 54, 60, 80, and 82).

2) *Whitby to Port Mulgrave:*

Grey Shales, Jet Rock, Bituminous Shales (these samples were provided by Dr. C. Downie from an unpublished section kindly supplied by Professor Sylvester-Bradley). The horizons sampled correspond to beds 31, 32, 34, 38, and 39 in the section subsequently published by Howarth, 1962, pp. 387–388.

Lincolnshire

1) *Crosby Warren, Scunthorpe:*

Frodingham Ironstone (Hallam, 1963*b*, p. 555, bed 3(?)).

2) *Cokewell Strip, Scunthorpe:*

Appleby-Frodingham Borehole, 3¼ miles east of the railway station, at depths of 60, 95, 135, and 150 ft. (text-fig. 2).

3) *Bracebridge Brick Pit, Lincoln:*

Shale with *Dactylioceras semicelatum* (Trueman, 1918, p. 103).

TABLE 1

Stratigraphic subdivision of the British Lias in Dorset, Lincolnshire and Yorkshire, from which samples were obtained. Stratal thicknesses are those at the sample localities.

<table>
<tr><th>AMMONITE ZONES</th><th>DORSET</th><th>LINCOLNSHIRE</th><th>YORKSHIRE</th></tr>
<tr><td>D. levesquei</td><td>Down Cliff Clay (35 ft.)</td><td rowspan="3">Silty Clay (27 ft.)</td><td>Blea Wyke Sands (66 ft.)</td></tr>
<tr><td>G. thouarense</td><td rowspan="5">Junction Bed (1 ft. 11 in.)</td><td>Striatulus Shales (53 ft.)</td></tr>
<tr><td>H. variabilis</td><td>Peak Shales (28 ft.)</td></tr>
<tr><td>H. bifrons</td><td rowspan="3">Black Shales (75 ft.)</td><td>Cement Shales (17 ft.)
Main Alum Shales (68 ft.)
Hard Shales (14 ft.)</td></tr>
<tr><td>H. falcifer</td><td>Bituminous Shales (75 ft.)
Jet Rock (27 ft.)</td></tr>
<tr><td>D. tenuicostatum</td><td>Grey Shales (30 ft.)</td></tr>
<tr><td>P. spinatum</td><td>Marlstone (2 in.)</td><td>Marlstone (6 ft.)</td><td>Ironstone Series (80 ft.)</td></tr>
<tr><td rowspan="4">A. margaritatus</td><td>Thorncombe Sands (40 ft.)</td><td rowspan="4">Shales (81 ft.)</td><td rowspan="4">Sandy Series (50 ft.)</td></tr>
<tr><td>Down Cliff Sands (85 ft.)</td></tr>
<tr><td>Eype Clay (200 ft.)</td></tr>
<tr><td>Three Tiers (41 ft.)</td></tr>
<tr><td>P. davoei</td><td>Green Ammonite Beds (105 ft.)</td><td rowspan="4">Clays (107 ft.)</td><td>"Capricornus"-beds (155 ft.)</td></tr>
<tr><td>T. ibex
U. jamesoni</td><td>Belemnite Marls (75 ft.)</td><td>"Jamesoni"-beds (100 ft.)</td></tr>
<tr><td>E. raricostatum</td><td rowspan="3">Black Ven Marls (150 ft.)</td><td rowspan="5"></td></tr>
<tr><td>O. oxynotum</td></tr>
<tr><td>A. obtusum</td><td rowspan="3">Frodingham Ironstone (28 ft.)</td></tr>
<tr><td>C. turneri</td><td rowspan="2">Shales-with-Beef (70 ft.)</td></tr>
<tr><td>A. semicostatum</td></tr>
<tr><td>A. bucklandi</td><td rowspan="5">Blue Lias (105 ft.)</td><td colspan="2" rowspan="5">Not examined</td></tr>
<tr><td>S. angulata</td></tr>
<tr><td>A. liasicus</td></tr>
<tr><td>P. planorbis</td></tr>
</table>

South Wales

1) *Lavernock, Glamorgan*:
Ostrea-beds (Richardson, 1905, p. 392, bed 43).

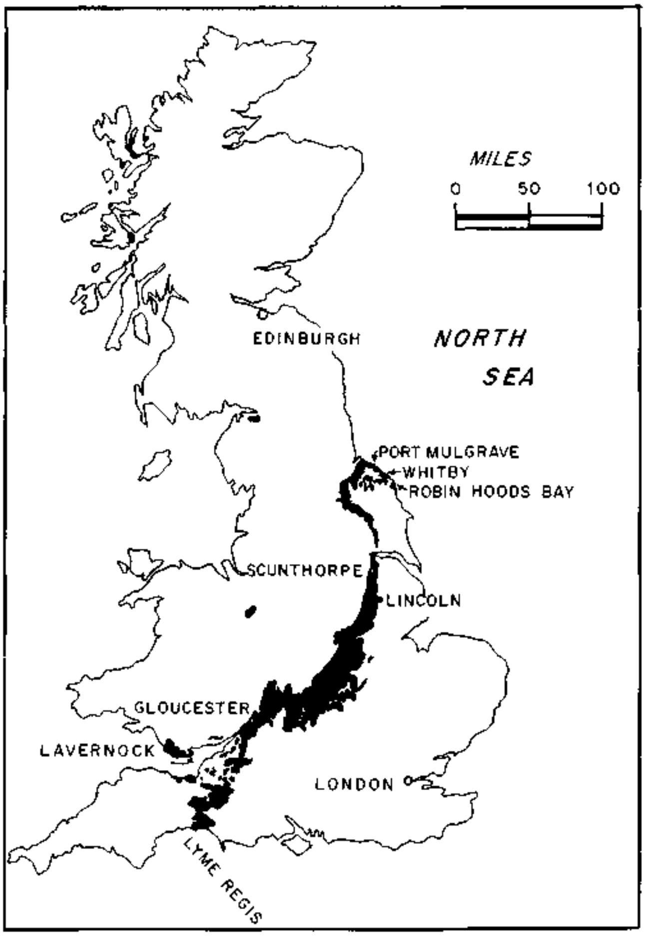
PREPARATION TECHNIQUES

Liassic dark shales and marls, in particular, yielded large quantities of organic debris in which the microfossils were often obscured by other plant tissues. To release and concentrate them, residues obtained by solution of the rock in hydrochloric and hydrofluoric acids were subjected to ultrasonic vibration. They were then centrifuged in a saturated zinc chloride solution, and the light fraction from the separation was briefly treated with Schulze's solution and diluted potassium hydroxide and stained with Safranin O. The two-stage mounting technique described by Jeffords and Jones (1959) was followed during slide preparation. Additionally, some of the organic residue from each sample was washed through a very fine sieve (mesh approximately 45μ), so that greater numbers of certain larger microfossils could be examined.

MICROPLANKTON

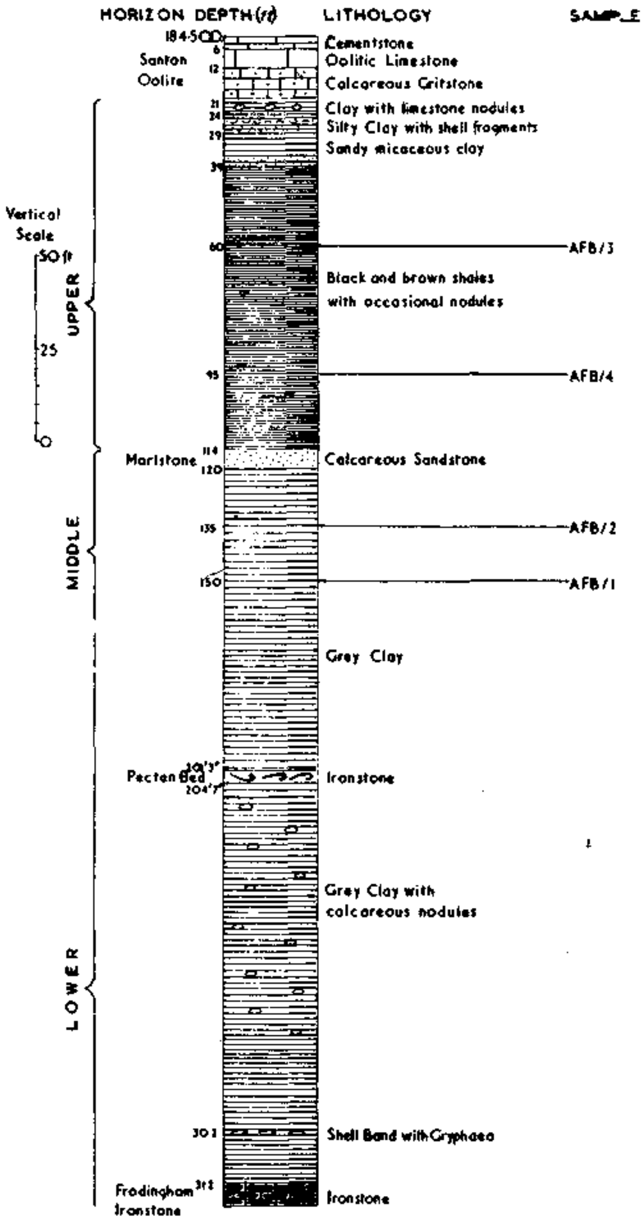
Previous literature

Evitt (1961*a*, 1961*b*) described two Liassic dinoflagellates, *Nannoceratopsis gracilis* (Alberti, 1961) Evitt, 1961, and *Dapcodinium priscum* Evitt, 1961, from the Lias of Jutland, and Eisenack (1957, 1958) described several species of *Tasmanites*, *Tytthodiscus*, *Leiosphaeridia*, and



TEXT-FIGURE 1

Outcrop of the Lias in Britain and sample localities.



TEXT-FIGURE 2

Lithologic succession in the Appleby-Frodingham Borehole M. 103 at Cokewell Strip, near Scunthorpe, Lincolnshire.

Cymatiosphaera from the Posidonia shales of Germany. Liassic spinose microplankton ("hystrichospheres") or acritarchs have not been described previously in any detail. Here, they are classified according to recent proposals by Evitt (1963), Downie and Sarjeant (1963), and Downie, Evitt, and Sarjeant (1963).

Species list

The species are listed under taxonomic categories after Downie, Evitt, and Sarjeant (1963), but with non-taxonomic subdivision of the Acanthomorphitae to correspond to those given in Table 7.

Acritarchs

1) Acanthomorphitae:

a) With variously ornate processes: *Baltisphaeridium diversispinosum* Wall, n. sp., *Micrhystridium variabile* Valensi, 1955, *M. bigoti* Deflandre, 1947, *M. clavatispinum* Wall n. sp., and *M. wattonensis* Wall, n. sp.

b) With both simple and bifurcate spines: *Micrhystridium intromittum* Wall, n. sp., and *Baltisphaeridium* sp. A.

c) With a moderately thick, often double-layered wall and simple, solid, closed spines: *Baltisphaeridium debilispinum* Wall and Downie, 1963, *B. infulatum* Wall, n. sp., *B. micropunctatum* Wall, n. sp., *B. polytrichum* Valensi, 1947, *Micrhystridium rarispinum* Sarjeant, 1960, *M. lymensis* Wall, n. sp., *M. nannacanthum* Deflandre, 1942, and *M. exilium* Wall, n. sp.

d) With a thin cell wall and hollow spines: *Baltisphaeridium delicatum* Wall, n. sp., *B. stimuliferum* (Deflandre) Sarjeant, 1961, *Micrhystridium arachnoides* Valensi, 1953, *M. deflandrei* Valensi, 1953, *M. echinoides* Valensi, 1948, *M. filigerum* Valensi, 1953, *M. fragile* Deflandre, 1947, *M. inconspicuum* Deflandre, 1937, *M. polyedricum* Valensi, 1948, *M. recurvatum* Valensi, 1953, *M. stellatum* Deflandre, 1945, and *M. minutispinum* Wall, n. sp.

2) Polygonomorphitae

Veryhachium collectum Wall, n. sp., *V. dualispinum* Wall, n. sp., *V. europaeum* Stockmans and Williere, 1960, *V. formosum* Stockmans and Williere, 1960, *V.? irregulare* Jekhowsky, 1961, *V. reductum* (Deunff) Jekhowsky, 1961, *V. rhomboidium* Downie, 1959, and *V.* sp. cf. *V. trispinosum* Eisenack, 1938.

3) Netromorphitae

Domasia liassica Wall, n. sp., *Leiofusa jurassica* Cookson and Eisenack, 1958, *L. spicata* Wall, n. sp., *Metaleiofusa arcuata* Wall, n. gen., n. sp., *M. diagonalis* Wall, n. gen., n. sp., and *Cantulodinium protuberatum* Wall, n. sp.

4) Herkomorphitae

Cymatiosphaera bleawykensis Wall, n. sp., *C. eupeplos* (Valensi, 1948) Deflandre, 1954, *C. pachytheca* Eisenack, 1957, *C.* sp. cf. *C. pachytheca* Eisenack, 1957, *C.* sp. cf. *C. stigmata* Cookson and Eisenack, 1958, *C.* sp. (A), *C.* sp. (B), *C.* sp. (C), *C.* sp. (D), and *C.* sp. (E).

5) Sphaeromorphitae

Leiosphaeridia sp.

Leiospheres (Chlorophyceae)

Tasmanites newtoni Wall, n. sp., *T. tardus* Eisenack, 1958, *Tasmanites suevicus* (Eisenack, 1957) Wall, new comb., *Tasmanites* sp. (A), and *Crassophaera hexagonalis* Wall, n. sp.

Dinoflagellates

1) Laterally compressed forms (Dinophysiales?): *Nannoceratopsis gracilis* (Alberti, 1961) Evitt, 1961.

2) Forms with distally open processes (Hystrichosphaeridiaceae): *Hystrichosphaeridium caminuspinum* Wall, n. sp., and *H. langi* Wall, n. sp.

SYSTEMATIC DESCRIPTIONS

All type material will be deposited in the collections of the Department of Micropalaeontology, The University, Sheffield. The location of specimens in slides is indicated by marking ink.

INCERTAE SEDIS
Group ACRITARCHA Evitt, 1963
Subgroup ACANTHOMORPHITAE Downie, Evitt, and Sarjeant, 1963
Genus BALTISPHAERIDIUM Eisenack, 1958

Baltisphaeridium diversispinosum Wall, new species

Plate 1, figures 1–2; plate 7, figure 1

Holotype: Preparation 01/3/3, Green Ammonite Beds (Bed 126b of Lang, 1936), St. Gabriel's Mouth, Charmouth, Dorset.

Diagnosis: Test spherical to ovoid, with numerous short processes (1 to 4μ long), between 30 and 50 visible in optical section at the periphery; processes variable, either simple, capitate, or bifurcate, often with a stouter cylindrical base supporting a slender single or bifurcate distal projection, which may be capitate or minutely forked.

Description: The test appears dense, although the maximum wall thickness does not exceed 2μ and has a waxy texture. Globules of organic matter sometimes occur within the test. The processes are delicate, clearly visible only in optical section, and easily broken. The most characteristic spines have a short cylindrical base, 1μ wide and 2μ high, which may give rise to one or two distal threads with touching capitate tips. The tops of the stouter cylindrical bases of adjoining processes may also be in contact.

Dimensions: Test 18 to 34μ in diameter, spines 1 to 4μ long; holotype 28μ (test only). Twenty-five specimens measured.

Occurrence: Lower Sinemurian of Lincolnshire and Carixian and lower Domerian of Dorset and Yorkshire.

Comparisons: This species is larger than *Micrhystridium variabile* Valensi and has more variable and shorter spines. It differs from *Baltisphaeridium downiei* Sarjeant in being smaller and in having fewer and more diverse processes.

Baltisphaeridium micropunctatum Wall, new species

Plate 1, figures 3–4; plate 7, figure 2

Holotype: Preparation DC/6/6, Junction Bed, Watton Cliff, 200 yards east of Eypemouth, Dorset.

Diagnosis: A species with an ovoid test whose wall is micropunctate and bears 20 to 30 small, pointed spines.

Description: The test is ovoid in the fossil state, although it may have been spherical originally. The wall is 1μ thick and punctate. There are 20 to 30 randomly disposed spines. They are 1 to 2μ long, stout, conical, sharply pointed, and often curved.

Dimensions: Test maximum dimensions 24 to 30μ, spines 1 to 2μ long, rarely 4μ; holotype test maximum length 26μ, spines 2μ (four specimens measured).

Occurrence: Down Cliff Sands, Thorncombe Sands (upper Domerian), and the Junction Bed and Down Cliff Clay (upper Toarcian) at Eypemouth and Watton Cliff, Dorset. Uncommon, seven specimens recorded.

Comparisons: This species is similar to *Micrhystridium pachydermum* Deflandre and Cookson, 1955, described from the Lower Cretaceous and Eocene of Australia, but is larger and has fewer spines.

Baltisphaeridium infulatum Wall, new species

Holotype: C9/1/2, Three Tiers (*A. margaritatus* Zone), Golden Cap, Dorset.

Diagnosis: Test globular to weakly ellipsoidal, moderately thick-walled, smooth or micropunctate, with two to twenty-five spines approximately equal in length to the test dimensions. Spines characteristically flattened and weakly microgranular (apart from their bases) or occasionally flagelliform.

Description: Two distinctive varieties of this species can be found in the British Lias. They differ in the number of spines present and are described separately below.

Baltisphaeridium infulatum Wall var. infulatum Wall, new variety

Plate 1, figures 5–7; Plate 7, figure 3

Type: As for the species holotype.

Diagnosis: Test globular to slightly elongate, bearing two to nine spines. Spines with solid or hollow bases, circular in section, quickly becoming flattened and microgranular beyond them, variable in length but often long. A single flagelliform spine may be present.

Description: The test wall is smooth, moderately thick, easily split, and often folded. The spines are widely separated and somewhat irregularly arranged. Their length may exceed the test dimensions or be considerably less for an individual. The spine bases may be hollow or predominantly solid and penetrated only by a minute tubule; beyond their bases the spines are flattened and without a spine cavity. Here their texture is coarser. The distal extremity is very fine and pointed, and the spine, because of its delicate nature, may be split longitudinally. Most specimens also possess a single flagelliform thread whose diameter is less than 1μ throughout.

Dimensions: Maximum test dimensions 18 to 28μ, spines up to 33μ long; holotype, test only, 22μ (twenty-six specimens measured).

Occurrence: Fairly common in the lower Domerian and upper Toarcian of Dorset and lower Domerian of Lincolnshire.

Baltisphaeridium infulatum Wall var. macroinfulatum Wall, new variety

Plate 1, figure 8

Type: DC/6/6, Junction Bed, Upper Lias, Watton Cliff, Eypemouth, Dorset.

Diagnosis: A variety of *B. infulatum* with characteristically flattened, ribbon-shaped spines varying between 12 and 25 in number.

Description: The test is mostly spherical but easily distorted by folding. The wall is moderately thick (1 to 1.5μ), smooth or micropunctate. The spine bases may be relatively wide (3μ) and hollow or predominantly solid. The microgranulation of the spines may be quite pronounced or weakly developed. The spines are flexuous and commonly 17 or 18 in number but 12 and 25 in extreme cases.

Dimensions: Maximum test dimensions 18 to 28μ. Spines up to 24μ long; test of type specimen 21.5μ, the spines *ca.* 20μ (thirty specimens).

Occurrence: Fairly common in the upper Toarcian of Dorset, but also found in the *Amaltheus gibbosus* subzone of the Dorset Domerian.

Comparisons: Both varieties of *B. infulatum* differ from other acritarchs by the characteristic spine structure.

Baltisphaeridium debilispinum Wall and Downie

Plate 1, figure 9; plate 7, figure 4

Baltisphaeridium debilispinum Wall and Downie, 1963, Palaeontology, vol. 5, pp. 777–778, pl. 112, figs. 1–2.

Remarks: This species, originally recorded from the Lower Permian in England, persists into the Lower Jurassic, where it exhibits a similar degree of morphological variation and range of sizes (test 17 to 25μ). It occurs throughout the Lias but is most abundant in the lower Pliensbachian and Hettangian.

Baltisphaeridium debilispinum Wall and Downie var. brevispinosum (Sarjeant) Wall, new combination

Plate 1, figure 10; plate 7, figure 5

Baltisphaeridium ehrenbergi (Deflandre) var. *brevispinosum* Sarjeant, 1961, Palaeontology, vol. 4, p. 103, pl. 15, fig. 8, text-fig. 8a.

Holotype: K2/2/2, Blue Lias (*A. bucklandi* Zone), Lyme Regis, Dorset.

Diagnosis: A robust variety of *B. debilispinum*, with 50 to 60 short spines.

Description: The test is globular, smooth, and moderately thick-walled (1 to 2μ). The wall has a clearly defined inner margin, which may be unevenly thickened. The spines are extremely numerous (50 to 60), very short (approximately one-fifth of the test diameter), and have conical bases. They are thin, hyaline, curved, and appear to be solid.

Dimensions: Test diameter 25 to 29μ, spines 2.5 to 5μ; holotype test diameter 25.5μ, spines 4 to 5μ (seven examples).

Occurrence: Sporadic throughout the British Lias, uncommon.

Comparisons: This form is clearly related to *B. debilispinum*, differing only in its greater number of spines. The single specimen from the Oxfordian of Yorkshire described by Sarjeant (1961, p. 103) is identical with the Liassic examples and is reclassified with this variety of *B. debilispinum*.

Baltisphaeridium delicatum Wall, new species
Plate 1, figures 11–13; plate 7, figure 6

Holotype: K1/3/2, Blue Lias, (*S. angulata* Zone), Lyme Regis, Dorset.

Diagnosis: An acritarch species with a delicate, ovoid to globular test bearing 20 to 40 simple, hollow spines of medium length.

Description: The test wall is very thin and easily folded. Its spines are hollow, mostly straight, and taper from bases 2 to 3μ wide to minutely rounded tips, which may be solid. Individual spines vary between one-fifth and one-half of the maximum test dimension in length. Occasionally the test is broken at one end; this is not a constant feature but is due to the delicate nature of the test wall.

Dimensions: Test only, $16 \times 15\mu$ to $24 \times 17\mu$; spines 2.5 to 9μ; holotype $24 \times 16\mu$, spines 4μ (twenty-five specimens).

Occurrence: Lower Lias (*S. angulata* to *C. turneri* Zones), Lyme Regis, Dorset.

Comparisons: This species closely resembles *Baltisphaeridium brevispinosum* Eisenack var. *wenlockensis* Downie, 1959, p. 59, from the Silurian Wenlock Shale in England. In addition to their considerably different geological ages, the Liassic species differs in its delicate test and sometimes blunt spine tips.

Baltisphaeridium eypensis Wall, new species
Plate 7, Figure 8

Holotype: P1/5/2, base of the Down Cliff Sands (*A gibbosus* Subzone), Seatown, Dorset.

Diagnosis: A small species of *Baltisphaeridium* with a micropunctate test and approximately 18 simple, solid spines whose length is more or less equal to one-third of the test diameter.

Description: The test is spherical and micropunctate and has a moderately thick wall, which supports solid, pointed, straight or curved processes with conical bases.

Dimensions: Holotype test diameter 22.5μ, spines *ca.* 7μ; other specimens recorded were almost exactly the same size (9 examples).

Occurrence: Amaltheus gibbosus Subzone and *D. levesquei* Zone at Seatown and Watton Cliff, Eypemouth, Dorset.

Comparisons: This species differs from *B. micropunctatum* Wall, n. sp., in having longer processes.

Genus Micrhystridium Deflandre, 1937

Micrhystridium clavatispinum Wall, new species
Plate 1, figures 14–15; plate 7, figure 7

Holotype: C9/1/4, Three Tiers (*A. margaritatus* Zone), Golden Cap, Dorset.

Diagnosis: A small, subspherical acritarch bearing 10 to 20 hollow processes characterised by their wide bases and bulbous tips.

Description: The shape of the test is subspherical, but its appearance in outline is modified by the occasional fusing of spine bases. The wall is smooth, very thin, and often folded. The spine bases are relatively wide (3μ), and beyond them the spines taper gradually to a distal constriction below the closed, bulbous tip, approximately 1.5μ across. The degree of inflation of the spine extremity varies. The spines also vary in length from one-third to two-thirds of the test size.

Dimensions: Test 12 to 17μ, spine length 5 to 10μ; holotype test 16μ, spines 8μ (10 specimens, 5 measurable).

Occurrence: Lower Domerian (Three Tiers) and upper Toarcian (Junction Bed and Down Cliff Clay), Dorset: Appleby-Frodingham Bore (135 and 150 feet), Scunthorpe, Lincolnshire.

Comparisons: This species differs from *Micrhystridium rhopalicum* Sarjeant, 1962, p. 490, from the Oxfordian of Yorkshire, in the absence of the briefly bifurcate spines and in possessing a less symmetrical shape.

Micrhystridium wattonensis Wall, new species
Plate 2, figures 1–2; plate 7, figure 11

Holotype: DC/8/3, top of the Down Cliff Clay (*D. levesquei* Zone), Watton Cliff, 300 yards east of Eypemouth, Dorset.

Diagnosis: A small globular acritarch with 50 to 60 short, hollow spines with solid capitate tips.

Description: The test is spherical, smooth, and moderately thick-walled. Approximately 40 spines are visible in optical section. They are straight or curved and have narrow bases which are hollow, weakly conical, and may be connected to the test lumen by a small foramen penetrating the wall. The distal extremities are solid with a minutely capitate tip. The spine length is commonly one-quarter of the test diameter, but in a few larger specimens may be equal to one-half the diameter. The spines upon a single specimen vary from slender, hairlike projections to relatively stout processes.

Dimensions: Test diameter 10.5 to 13.5μ, rarely up to 17μ, spines 1.5 to 3μ, rarely up to 8μ; holotype test 11μ, spines 2.5μ long (fifteen specimens, seven measurable).

Occurrence: Domerian (Thorncombe Sands, *A. gibbosus* Subzone) at Eypemouth and upper Toarcian (Junction Bed and Down Cliff Clay, *D. levesquei* Zone) in Watton Cliff, near Eypemouth, Dorset.

Comparisons: This species is separable from other small acritarchs with numerous spines (*M. inconspicuum*) by the structure of its spines.

Micrhystridium intromittum Wall, new species

Holotype: C9/1/4, Three Tiers (*A. margaritatus* Zone), Golden Cap, Dorset.

Diagnosis: A small acritarch species with a more or less spherical test bearing eight to twenty spines, most of which are simple but a few of which are bifurcate (usually forked proximally).

Remarks: Two varieties of this species are described below.

Micrhystridium intromittum Wall var. intromittum Wall, new variety
Plate 2, figures 3–5; plate 7, figure 9

Type specimen: As for the species holotype, above.

Diagnosis: A variety of *M. intromittum* with a more or less spherical test bearing approximately twenty spines, only a few being bifurcate.

Description: The test is smooth, thin-walled, originally spherical or weakly polyhedral. At least two-thirds of the spines are simple, hollow, sharply pointed, and with relatively wide bases. The others are bifurcate, the division being proximal in most instances. The branches may remain parallel or diverge widely. The spines are less than the test radius in length.

Dimensions: Test 14.5 to 20μ, spines 4 to 9.5μ; holotype test 20μ, spines 9.5μ (6 specimens).

Occurrence: S. angulata, C. turneri, P. davoei, and *A. margaritatus* Zones of the Dorset coastal Lias. Relatively rare.

Comparisons: Micrhystridium heteracanthum Deflandre, 1937, from the Cretaceous of France, has a much thicker cell wall and more briefly distally divided spines.

Micrhystridium intromittum Wall var. transitorium Wall, new variety
Plate 2, figures 6–8; plate 7, figure 10

Holotype: L1/6/2, Shales-with-Beef (*C. turneri* Zone), west of Charmouth, Dorset.

Diagnosis: A variety of *M. intromittum* with eight to ten spines, one of which is bifurcate.

Description: The test is more or less globular, relatively thin-walled, smooth, and bearing from eight to ten spines of unequal length. One spine bifurcates near its base. The other spines are hollow and pointed, occasionally extremely fine but mostly stout, with relatively wide bases. The spine length varies from one-quarter to three-quarters of the test size.

Dimensions: Test 15 to 18μ, spines 4 to 12μ; holotype test 15μ (four specimens).

Occurrence: A. liasicus, S. angulata, C. turneri, and *E. raricostatum* Zones of the Dorset coastal Lias.

Comparisons: This variety differs from other Liassic acritarchs in having unequal spines and one bifurcate process.

Micrhystridium rarispinum Sarjeant
Plate 2, figure 9

Micrhystridium rarispinum SARJEANT, 1960, Yorkshire Geol. Soc., Proc., vol. 32, pt. 4, no. 18, p. 400, pl. 14, figs. [illegible], text-fig. 11.

Remarks: Examination of the type material and many Liassic examples reveals that the spines are solid. The immediate base of the spines may be penetrated by a small conical extension of the cell lumen. This species belongs to a group of Jurassic acritarchs that are common in the Lias and possess a globular test, a moderately thick wall, sometimes double-layered, and solid spines arising exogenously from the test.

Micrhystridium lymensis Wall, new species

Holotype: K1/3/2, Blue Lias, bed H. 87 of Lang (1924, p. 181) (*A. liasicus* Zone), Pinhay Bay, Lyme Regis, Dorset.

Diagnosis: A small acritarch species characterised by its globular shape, moderately thick and sometimes double-layered wall, and exogenous solid spines. These vary in number between nine and thirty and in length from 15 to 100 percent of the test diameter. Short spines are typically thornlike, but longer spines are less rigid and become flexuous.

Remarks: This species is very common in the Dorset Hettangian, where it exhibits considerable infraspecific variation. Three common varieties are described below. Transitional forms occur but are less abundant.

Micrhystridium lymensis Wall var. lymensis Wall, new variety
Plate 2, figures 16–17; plate 8, figure 3

Type specimen: As for the species holotype.

Diagnosis: A variety of *M. lymensis* with a relatively small number (nine to fourteen) of long, solid, flexuous spines whose length varies between 60 and 100 percent of the test diameter.

Description: The low number of long, rather slender spines make this a readily recognizable variety. The spines are normally completely solid, but sometimes they are penetrated, in part, by a minute tubule.

Dimensions: Test diameter 11–17μ, spines 7 to 12μ; holotype test diameter 15μ, spines 10μ.

Occurrence: Abundant in the Blue Lias (*P. planorbis, A. liasicus, S. angulata,* and *A. bucklandi* Zones) and in smaller numbers in the Sinemurian, Pliensbachian, and Toarcian of Dorset and elsewhere in Britian.

Comparisons: This variety differs from *Micrhystridium fragile* Deflandre by its relatively thicker wall and solid spines with conspicuous spine bases.

Micrhystridium lymensis Wall var. gliscum Wall, new variety

Plate 2, figures 12–15; plate 8, figure 2

Type specimen: K1/3/2, Blue Lias. Age and locality as for the previous variety.

Diagnosis: A variety of *M. lymensis* with fourteen to thirty spines whose length varies between one-third and two-thirds of the test diameter. The spines are strong.

Description: The spines are predominantly solid, well developed, straight or curved. The spine bases may be hollow, and the inner cell-wall layer, when present, lines the basal cavity of the spines. Occasionally, very fine processes are present.

Dimensions: Test diameter 14 to 18μ, spines 5.5 to 8μ; holotype test 16μ, spines 8μ.

Occurrence: Common in the Hettangian of Dorset and South Wales and present in most horizons throughout the British Lias.

Comparisons: This variety differs from *Micrhystridium recurvatum* Valensi in having a thicker wall and solid spines. *Baltisphaeridium debilispinum* has weaker, shorter spines and is larger.

Micrhystridium lymensis Wall var. rigidum Wall, new variety

Plate 2, figures 10–11; plate 8, figure 1

Type specimen: K1/3/2, Blue Lias. Age and locality as for the previous two varieties.

Diagnosis: A variety of *M. lymensis* with ten to twenty rigid, straight or slightly curved spines varying from 15 to 33 percent of the test diameter in length.

Description: The test wall is relatively thick and bears short, thornlike spines that are characteristically rigid, usually straight, but sometimes weakly curved. The wall may be prominently double-layered.

Dimensions: Test diameter 10 to 20μ, spines 2 to 6μ; holotype test diameter 15μ, spines 2μ.

Occurrence: As for *M. lymensis* var. *gliscum*.

Comparisons: Liassic forms of this variety differ from *M. rarispinum* Sarjeant (1960, p. 400) in their rigid spines.

Micrhystridium exilium Wall, new species

Plate 2, figures 18–23; plate 8, figure 4

Holotype: DC/8/3, top of the Down Cliff Clay (*D. levesquei* Zone), Watton Cliff, Eypemouth, Dorset.

Diagnosis: A species of *Micrhystridium* with a globular, moderately thick-walled test and a small number (two to seven) of spines whose lengths vary for and between individuals.

Description: The test is spherical or slightly elongate, moderately thick-walled and smooth or micropunctate. It is frequently split but has no primary apertures. The spines are simple, pointed, straight or flexuous; they are solid, apart from a short proximal cavity connecting with the test lumen. The spines vary greatly in length, from a small fraction of the test diameter to twice as great. The spines of individuals are also variable in length.

Dimensions: Test diameter 13 to 19μ, spines 2 to 40μ; holotype test 15μ, spines up to 10.5μ (twenty examples, twelve measured).

Occurrence: Fairly common in the Eype Clay, Thorncombe Sands (lower Domerian), and Junction Bed and Down Cliff Clay (upper Toarcian) of Dorset at Eypemouth; Appleby-Frodingham Bore, depth 60 feet.

Comparisons: This species most closely resembles *B. infulatum* Wall, n. sp., but has simple spines and is smaller. The small number of spines possessed by *M. exilium* is atypical for an acanthomorphitid acritarch. Extreme variants with only two spines are morphologically convergent with *Leiofusa jurassica* but have a thicker cell wall.

Micrhystridium minutispinum Wall, new species

Plate 3, figures 8–10; plate 7, figure 12

Holotype: C9/1/2, Three Tiers (*A. margaritatus* Zone), Golden Cap, Dorset.

Diagnosis: A small acritarch with a globular to slightly polyhedral test bearing from two to over twenty minute, conical spines.

Description: The test may appear circular, ovoid, or weakly polyhedral in outline and has a very thin, easily folded wall. The spines are extremely reduced, being one micron or less high and straight, curved, and pointed.

Dimensions: Test 6 to 15μ, spines 0.5 to 1μ; holotype test 8μ, spines 0.5 to 1μ (forty specimens measured).

Occurrence: Abundant in the *A. margaritatus* Zone (Three Tiers horizon, in particular) of Dorset and in the *U. jamesoni* Zone at Robin Hoods Bay, Yorkshire.

Comparisons: Small, polyhedral forms with fewer than seven spines found in association with *M. minutispinum* are very similar and probably related to specimens with a greater number of spines. However, such forms were referred to *V.? irregulare* Jekhowsky on the basis of their morphology, a geometrical rather than a natural system of classification being adapted for these small and problematical acritarchs.

Subgroup Polygonomorphitae Downie, Evitt, and Sarjeant, 1963
Genus Veryhachium Deunff, 1958, emend. Downie and Sarjeant, 1963

Veryhachium collectum Wall, new species
Plate 3, figures 11–14; plate 8, figure 6

Holotype: Prep. 01/3/4, Green Ammonite Beds (Bed 126b of Lang, 1936), *P. davoei* Zone, St. Gabriels Mouth, Charmouth, Dorset.

Diagnosis: Test subtriangular to subrectangular (trapezoidal), tapering toward one end and bearing from four to eight simple spines.

Description: In outline, the test shows three equilateral sides and a fourth shorter side. One spine occurs at each corner of the test, and two or three additional spines may ornament the test faces at its broader end. A minute spine may occur at the base of a larger "apical" spine at one corner of the test. Length of the spines varies from slightly less than half to as long as the maximum dimension of the test (for the "apical" spines). Their bases may be narrow or relatively expanded.

Dimensions: Test 11 to 16μ (maximum length); holotype test 15 × 12μ (eleven specimens, eight measured).

Occurrence: Green Ammonite Beds (*P. davoei* Zone) and Three Tiers, Eype Clay, and Down Cliff Sands (*A. margaritatus* Zone), Dorset; rarely in the Frodingham Ironstone (lower Sinemurian), Lincolnshire.

Comparisons: Micrhystridium polyedricum Valensi, 1948, is smaller, possessing an inflated test which does not taper. Forms of *Veryhachium collectum* may become transitional toward *V. formosum* as the test assumes a triangular outline or toward *V. reductum* when only four spines are present.

Veryhachium dualispinum Wall, new species
Plate 3, figures 15–18; plate 8, figure 7

Holotype: DC/6/6, Junction Bed (*D. levesquei* Zone?) Watton Cliff, Eypemouth, Dorset.

Diagnosis: Test triangular in outline, sides straight to strongly convex, bearing six to nine short spines. At one and often two apices of the test, two spines are situated close together.

Description: Characteristically, the test has an asymmetrical shape due to convexity of a side or rounding of an apex. The spines are usually curved, hollow or solid, and vary in length in an individual, sometimes being diminutive but not exceeding one-half of the test size. In addition to apical spines, which are sometimes paired, other spines ornament the test faces. The test has a brittle nature and is easily split.

Dimensions: Test 15 to 18μ, spines 2.5 to 8μ; holotype test 16μ (six specimens measured).

Occurrence: Green Ammonite Beds (*P. davoei* Zone), Three Tiers, Eype Clay, Thorncombe Sands (*A. margaritatus* Zone), and Junction Bed (*D. levesquei* Zone), Dorset.

Comparisons: This species differs from others belonging to the same genus in its spine arrangement and shape.

Veryhachium europaeum Stockmans and Williere
Plate 4, figures 1–2

Veryhachium europaeum Stockmans and Williere, 1960, Senckenbergiana Lethaea, vol. 41, p. 3, pl. 2, fig. 25. – Wall and Downie, 1963, Palaeontology, vol. 5, pt. 4, p. 782, pl. 114, figs. 4–6, text-fig. 1.

Remarks: Specimens identical with those described from the British Lower Permian by Wall and Downie (1963, p. 782) also occur in the English Lias, together with several new forms.

Veryhachium europaeum Stockmans and Williere forma nervosum Wall, new forma
Plate 4, figures 3–5

Type specimen: DC/6/3, Junction Bed (*D. levesquei* Zone), Watton Cliff, Eypemouth, Dorset.

Description: Test tetrahedral, with straight sides whose edges are sharp and pronounced; four apical spines not exceeding one-third of the test size in length are present.

Dimensions: Test size (apex to the side opposite) 8 to 14μ, spines 1 to 4μ; type specimen test 12μ, spines 4μ (numerous examples).

Occurrence: Green Ammonite Beds (*P. davoei* Zone) to the Down Cliff Clay (*D. levesquei* Zone), Dorset Lias; very rarely in the Frodingham Ironstone (lower Sinemurian), Lincolnshire.

Veryhachium formosum Stockmans and Williere
Plate 4, figures 6–7

Veryhachium formosum Stockmans and Williere, 1960, Senckenbergiana Lethaea, vol. 41, p. 2, pl. 2, fig. 28. – Wall and Downie, 1963, Palaeontology, vol. 5, pt. 4, p. 783, pl. 114, figs. 7–11, text-fig. 1.

Remarks: Specimens identifiable as *V. formosum* forma *formosum* Stockmans and Williere and formae 1 and 2 of Wall and Downie occur in the British Lias.

Veryhachium formosum Stockmans and Williere forma ancorastrum Wall, new forma
Plate 4, figures 8–9; plate 8, figure 5

Type specimen: K2/2/2, Blue Lias (*A. bucklandi* Zone), Lyme Regis, Dorset.

Description: Test outline triangular with convex sides, bearing five to six strong, curved spines whose length is 100 to 200 percent of the test size; the spine bases are narrow. Three spines are apical, the remainder ornament test faces.

Dimensions: Test 9.5 to 14.5μ; type specimen test 14.5μ (ten examples).

Occurrence: Blue Lias (*A. bucklandi* Zone), Dorset; Appleby-Frodingham B. H. 103, depth 150 feet.

Comparisons: This form differs from the species holotype in its inflated test and restricted spine bases, and from *V. ambiguum* Deunff (1955, pl. 3, fig. 2), from the Devonian of Canada, in its smaller size.

Veryhachium? irregulare Jekhowsky
Plate 3, figures 19–24

Veryhachium? irregulare DE JEKHOWSKY, 1961, Rev. Micropal., pp. 208–210, pl. 1, figs. 1–21. – WALL and DOWNIE, 1963, Palaeontology, vol. 5, pt. 4, p. 781, pl. 113, figs. 6–8, text-fig. 1.

Remarks: All the previously described morphotypes of *V.? irregulare* (formae *irregulare, subhexaedron, subtetraedron,* and *pirula* of Jekhowsky (1961) and forma 1 of Wall and Downie) were recorded from the Lias. One additional form, forma *quadratum* Wall, new form, occurs in the Green Ammonite Beds (*P. davoei* Zone) of Dorset. Its test is small (9–10μ), quadrate to subrectangular in outline with five or six small spines (pl. 3, figs. 23–24; pl. 7, fig. 4).

Veryhachium reductum (Deunff) Jekhowsky
Plate 4, figures 10–11

Veryhachium trisulcum Deunff var. *reductum* DEUNFF, 1958, Soc. Géol. Min. Bretagne, Bull., new ser., vol. 2, p. 27, pl. 1, figs. 8, 11.
Veryhachium reductum (Deunff). – JEKHOWSKY, 1961, Rev. Micropal., vol. 3, no. 4, pp. 210–212, pl. 2, figs. 22–44. – WALL and DOWNIE, 1963, Palaeontology, vol. 5, pt. 4, p. 780, pl. 112, figs. 7–9.

Remarks: V. reductum formae *trispinoides, reductum,* and *breve* of Jekhowsky (1961) are frequently seen in the British Lias. Distinctive examples of forma *breve* with inflated tests and rounded spine tips (comparable with the specimen figured by Jekhowsky in pl. 2, fig. 38) are common in the Lias in the *P. davoei* and lower *A. margaritatus* Zones in the British province (pl. 4, fig. 11).

Veryhachium sp. cf. V. trispinosum (Eisenack) Deunff
Plate 4, figures 12–13

Hystrichosphaeridium trispinosum EISENACK, 1938, Zeitschr. Gesch. u. Flachlandsgeol., vol. 14, p. 16, text-fig. 2.

Remarks: Several specimens, basically similar to *Veryhachium reductum* but larger (test 30μ), were recorded from the Shales-with-Beef, Three Tiers, and Eype Clay of the Dorset Lias. They differ from the Lower Palaeozoic type material described by Eisenack (1938, p. 16) in possessing shorter spines.

Subgroup NETROMORPHITAE Downie, Evitt, and Sarjeant, 1963
Genus CANTULODINIUM Alberti, 1961

Cantulodinium protuberatum Wall, new species
Plate 4, figures 14–20; plate 8, figure 8

Holotype: C9/1/4, Three Tiers (*A. margaritatus* Zone), Golden Cap, Dorset.

Diagnosis: Test elongate, fusiform to subrectangular or, rarely, subtriangular in outline, bearing from four to seven short, rounded protuberances or bluntly pointed spines.

Description: The hollow test is thin-walled and occurs in a variety of shapes but is most often fusiform and somewhat bell-shaped in outline, having a bluntly pointed apex and a broader basal region. The spines are characteristically short, rounded, hollow protuberances but occasionally are narrower and pointed. A few forms with the same type of protuberances but having a minute tetrahedral test are believed to belong to this variable species.

Dimensions: Overall size 9–26μ, spines 1–4μ; holotype 26μ overall (25 specimens measured, over 30 recorded).

Occurrence: Green Ammonite Beds (*P. davoei* Zone), Three Tiers, Down Cliff Sands and Thorncombe Sands (*A. margaritatus* Zone) and Junction Bed (*D. levesquei* Zone), Dorset Lias.

Comparisons: The shape and nature of the processes of this species strongly recall those of the Lower Cretaceous species *Cantulodinium speciosum* Alberti (1961, p. 23). The Liassic species is smaller and has a less inflated test. In view of the close similarity of the two species and the uncertainty of the dinoflagellate affinity of *C. speciosum, Cantulodinium* is provisionally classified as a netromorphitid acritarch.

Genus DOMASIA Downie, 1960

Domasia liassica Wall, new species
Plate 5, figures 1–3; plate 8, figure 9

Holotype: 01/3/4, Green Ammonite Beds (*P. davoei* Zone), Golden Cap, Dorset.

Diagnosis: Test elongate, slightly ellipsoidal to elongate triangular, length approximately twice the breadth. The two anterior and single posterior spines merge gradually with the test; their length is variable but approximates the width of the test.

Description: The test is thin-walled, and the spines are hollow. They often curve distally and are finely pointed. The anterior spines lie 6–8μ apart, and the test outline between their bases is more or less straight.

Dimensions: Test 17 × 10 to 24 × 10μ; holotype test 19 × 11μ (7 specimens measured).

Occurrence: Green Ammonite Beds, Three Tiers and Eype Clay, Dorset; Appleby-Frodingham B. H. 103, depths 135 and 150 feet; *P. davoei* Zone, Yorkshire Lias.

Comparisons: This species closely resembles *Domasia trispinosa* Downie, 1960, from the Wenlockian of Shropshire. This latter species is known only from the Silurian, and the Liassic forms are probably homoeomorphs of separate origin. *D. liassica* differs from *D. trispinosa* in having shorter, nonseptate spines and its two anterior spines more widely spaced.

Genus Leiofusa Eisenack, 1938

Leiofusa jurassica Cookson and Eisenack
Plate 5, figures 6–11; plate 10, figure 10

Leiofusa jurassica Cookson and Eisenack, 1958, Roy. Soc. Victoria, Proc., vol. 70, p. 51, pl. 10, figs. 3–4.

Remarks: Liassic forms vary from slender, elongate bodies (length-breadth ratio 3:1 for the test alone) to broad forms (length-breadth ratio 3:2), whilst the spine bases, normally relatively narrow, may become inseparable from the test. Spine length relative to the longest axis of the test varies between 15 and 100 percent. Often they are smaller than the holotype.

Dimensions: Maximum test length 10–30μ, commonly 19–25μ, overall length 24–62μ.

Occurrence: Found regularly in the Lias above the base of the *P. davoei* Zone and rarely in the Frodingham Ironstone.

Leiofusa spicata Wall, new species
Plate 5, figures 12–17; plate 8, figures 11–14

Holotype: 01/3/3, Green Ammonite Beds (*P. davoei* Zone), Golden Cap, Dorset.

Diagnosis: Body spindle-shaped, small, unornamented, with sharply pointed to rounded apices.

Description: The test is thin-walled, smooth, and spineless. Forms can be recognised with both apices completely rounded, with only one rounded apex, and with both apices pointed, sometimes with a minute apical protuberance. The length-breadth ratio varies from 1.3:1 to 3.5:1.

Dimensions: Test length 10–43μ, breadth 6–19μ; holotype test 31 × 16μ (120 measurements).

Occurrence: Abundant in the *P. davoei* Zone, especially in Yorkshire; less abundant but frequent in younger horizons of the Lias.

Comparisons: Differs from *L. jurassica* in lacking spines, although some forms are transitional toward this species. Differs from other spineless leiofusids in its small size.

Genus Metaleiofusa Wall, new genus

Diagnosis: Test small, about 20μ in length, fusiform, ornamented by an apical spine at each pole and a small number of additional subapical or lateral equatorial processes of a simple nature.

Type species: Metaleiofusa arcuata Wall, n. sp.

Remarks: This genus is established for a problematical group of acritarchs which resemble *Leiofusa*, *Domasia*, and *Veryhachium* in certain respects but differ sufficiently to prevent satisfactory allocation to them. *Metaleiofusa* differs from *Leiofusa* in possessing more than two spines and hence lacking radial axial symmetry, and from *Domasia* in lacking truncation of the anterior extremity of the test. Unlike certain species of *Veryhachium*, the species of *Metaleiofusa* possess a wholly fusiform test which cannot appear triangular in surface view.

Metaleiofusa arcuata Wall, new species
Plate 5, figures 18–20; plate 9, figures 1–2

Holotype: C9/1/2, Three Tiers (*A. margaritatus* Zone), Golden Cap, Dorset.

Diagnosis: Test ellipsoidal with a single apical spine at each pole and a third subapical or lateral equatorial spine.

Description: The test is distinctly fusiform with a length-breadth ratio of approximately 2:1. The two apical spines may not be directly opposed but may lie along an arcuate polar axis. The additional spine may lie close to a pole or to the equator. Spine length varies from a few microns to approximately 20μ.

Dimensions: Test only 17 × 12 to 25 × 12μ; holotype test 20 × 10μ, spines 8–14μ (12 measurements).

Occurrence: Found in small numbers in the *P. davoei* Zone and younger horizons in Dorset, Yorkshire, and Gloucestershire and in the Frodingham Ironstone and Appleby-Frodingham B. H. 103 at depths of 135 and 150 feet in Lincolnshire.

Remarks: Metaleiofusa arcuata differs from *Domasia liassica* n. sp. in possessing two pointed apices, but transitional forms occur.

Metaleiofusa diagonalis Wall, new species
Plate 5, figures 21–23; plate 9, figure 3

Holotype: P1/2/2, Eype Clay (*A. margaritatus* Zone), east of Seatown, Dorset.

Diagnosis: Test ellipsoidal, bearing four or five spines, two of which are apical; the others are normally subapical.

Description: The test is thin-walled, smooth, and ellipsoidal and has a length-breadth ratio of approximately 2:1. There is a single apical spine at each pole; the remainder may be distributed one at each pole or all situated around one pole. Length of the spines varies from equivalent to the test breadth to 75 percent of the maximum length.

Dimensions: Maximum length of the test 16–23μ, spines up to 12μ long; holotype test 20 × 11μ.

Occurrence: Occasionally found in post-*T. ibex* zones of the Lias and rarely in older horizons.

Comparisons: This species differs from *Domasia liassica* and *Metaleiofusa arcuata* in possessing at least four spines. Some forms of *Cantulodinium protuberatum* n. sp. are similar but have rounded spine tips.

Subgroup Herkomorphitae Downie, Evitt, and Sarjeant, 1963
Genus Cymatiosphaera O. Wetzel 1933, emend. Deflandre, 1954

Cymatiosphaera bleawykensis Wall, new species
Plate 6, figures 2–3

Holotype: DC/8/4, Down Cliff Clay (*D. levesquei* Zone), Watton Cliff, Dorset.

Diagnosis: Central body spherical, small, wall up to 1μ thick; membrane delicate, its height approximately equal to the radius of the central body, supported by solid spines, of which four to six appear in optical section.

Description: The outline varies from subrectangular to circular but the central body remains globular. Only a few fields are present, and these are poorly defined in some specimens.

Dimensions: Test 8–11μ, flanges 3–4μ high (5 specimens).

Occurrence: Upper Toarcian, Dorset and Yorkshire. Rare.

Comparisons: Cymatiosphaera exilissima Deflandre, 1947, a Middle Jurassic species, is also very small but has a lower membrane.

Cymatiosphaera pachytheca Eisenack
Plate 9, figure 12

Cymatiosphaera pachytheca Eisenack, 1957, Neues Jahrb. Geol. Pal., Abh., vol. 15, p. 245, pl. 19, figs. 4–5; pl. 20, fig. 11.

Remarks: Specimens very similar to those described by Eisenack (1957, p. 245) from the Swabian Lias occur in the British Hettangian and lower Toarcian in Dorset, Yorkshire, and Lincolnshire. Others (identified as *C.* cf. *pachytheca*) from the same horizons have thinner walls (5 to 7 percent of the test radius) and lower ridges (1–1.5μ high), lack wall pores, and show small interstitial fields formed at the corners of the larger fields.

Cymatiosphaera sp. cf. C. stigmata Cookson and Eisenack
Plate 6, figures 4–5

?*Cymatiosphaera stigmata* Cookson and Eisenack, 1958, Roy. Soc. Victoria, Proc., vol. 70, p. 50, pl. 9, fig. 14.

Remarks: A single specimen from the Down Cliff Clay (*D. levesquei* Zone) at Watton Cliff resembles *C. stigmata*, described by Cookson and Eisenack (1958, p. 50) from the Lower Cretaceous of Western Australia. The Liassic specimen is 64μ across and is ornamented with 70 to 80 polygonal fields (approximately 8μ across), each with a central tubercle and defined by low ridges (1μ high). This specimen differs from the holotype in possessing more numerous fields.

Cymatiosphaera sp. A
Plate 6, figure 7

Type specimen: DC/8/2, Down Cliff Clay (*D. levesquei* Zone), Watton Cliff, Dorset.

Description: The central body is circular to ovoid in outline, 26μ in size, dark and relatively thin-walled. The ridges or muri are 5μ high and strengthened at their intersections by thin pillars, rarely bifurcate at their tips. The number of fields per hemisphere appears to vary between six and twelve, and approximately twelve to fifteen pillars are visible in optical section. Individual lumina may be up to 10μ across.

Occurrence: Upper Toarcian, Dorset.

Comparisons: Cymatiosphaera kraeuseli Stockmans and Williere from the Devonian of Belgium is similar, but its test is enclosed within an outer membrane. *Cymatiospaera nebulosa* Deunff, also a Devonian species, has a slightly smaller central body (20μ) and a relatively wider flange (equal to one-quarter of the body).

Cymatiosphaera sp. B
Plate 9, figure 8

Type specimen: DC/8/4, Down Cliff Clay (*D. levesquei* Zone), Watton Cliff, Dorset.

Description: A single specimen closely resembling *Cymatiosphaera* sp. A but almost twice as large was observed also in the Down Cliff Clay. Its test measured 40μ across, and the muri of the reticulum were an additional 8μ high. The flange is folded and poorly preserved but appears to be supported by thin, tubular processes. There are approximately twelve such processes visible in optical section, which indicates that there is a relatively small number (about fifteen) of fields present with a mesh of approximately 20μ each.

Comparisons: In general morphology and size, this form resembles *Cymatiosphaera mirabilis* Deunff, from the Caradocian of Brittany, but it cannot be positively identified as that species.

Cymatiosphaera sp. C
Plate 9, figure 6

Type specimen: M1/2/2, Black Ven Marls (*A. turneri* Zone), east of Charmouth, Dorset.

Description: Test central body ovoid, extremely thin-walled and delicate, 24–30μ across, ornamented by a delicate, membranous reticulum whose height is 5μ. The intersections of the fields are strengthened by thin pillars with capitate or minutely forked tips. As many as 35 pillars may appear in optical section, and the width of the fields is approximately 12μ.

Occurrence: Black Ven Marls (*A. turneri* Zone), Dorset; Frodingham Ironstone, Lincolnshire.

Comparisons: Although of a similar size to *Cymatiosphaera* sp. A, from the Upper Lias, the present form has a thinner wall and more numerous and capitate processes.

Cymatiosphaera sp. D
Plate 6, figure 8; plate 9, figure 7

Type specimen: K2/2/T3, Blue Lias (*A. bucklandi* Zone), Lyme Regis, Dorset.

Description: The central body is more or less circular in outline, approximately 43μ in diameter, and smooth or weakly granular and supports a reticulum whose height is equal to three-quarters of the diameter of the central body. The overall size is around 100μ. The lumina of the reticulum widen distally, and the membrane becomes folded and crenulate in surface view. Approximately six fields are visible on each hemisphere.

Occurrence: This species was recorded only from the *A. bucklandi* Zone in Dorset; here it was fairly abundant, but only a few specimens were well preserved.

Comparisons: This large form does not compare closely with any other known species of *Cymatiosphaera*.

Class Chlorophyceae
Family Tasmanaceae Sommer, 1956
Genus Tasmanites Newton, 1875

Tasmanites newtoni Wall, new species
Plate 9, figure 11; text-figure 3A–D

Tasmanites sp. cf. *T. tardus* Eisenack. – Wall, 1962, Geol. Mag., vol. 99, no. 4, p. 358, pl. 17, figs. 7–8; text-fig. 2a–b.

Holotype: K1/4/T3, Blue Lias (bed 18 (Lang, 1924, p. 180), *A. bucklandi* Zone), Lyme Regis, Dorset.

Diagnosis: Test spherical but normally compressed to become disk-shaped, characterised by a thick wall penetrated wholly or partly by closely spaced, minute punctae and more widely spaced, coarser pore-canals, both arranged radially. A short, simple linear suture is often present.

Description: The test is circular in outline but variable in overall shape according to the degree of compression it has undergone. The wall is light yellow to dark brown and is penetrated by two kinds of radial pores. These are fine punctations, whosed ensity is 150–300/100 sq. μ of wall surface, and coarser pore-canals, two to five of which occur in an equivalent area. A simple suture is often present and constitutes a line of weakness along which the test easily splits.

Dimensions: Test diameter 44–110μ, wall thickness 2–7μ (8–22 percent of the diameter); holotype 84μ in diameter, wall 5μ thick.

Occurrence: Occurs throughout the Lias but is most abundant in the Dorset Hettangian and the Lincolnshire and Yorkshire lower Toarcian.

Comparisons: *Tasmanites tardus* Eisenack is known to possess pore-canals but lacks the characteristic fine punctations of *T. newtoni*. The pore-canals of *Tasmanites noremi* Eisenack, which is larger than *T. newtoni*, widen internally and are more numerous.

Comments: The present author previously compared *T. newtoni* n. sp. with a Recent species of green alga (*Pachysphaera* sp.), under the name *Tasmanites* sp. cf. *T. tardus* Eisenack (Wall, 1962, p. 358); that name now becomes a synonym of *T. newtoni*. In addition, specimens figured by Eisenack (1957, pl. 20, fig. 6) and by Gocht (1959, pl. 8, fig. 13) probably also belong to *T. newtoni*.

Tasmanites suevicus (Eisenack) Wall, new combination
Text-figure 3E–G

Tytthodiscus suevicus Eisenack, 1957, Neues Jahrb. Geol. Pal., Abh., vol. 105, p. 241, pl. 19, figs. 1–3; pl. 20, figs. 1–3.
Tytthodiscus sp. cf. *T. suevicus* Eisenack. – Gocht, 1959, Pal. Zeitschr., vol. 33, no. 1–2, p. 78, pl. 6, figs. 1, 7.
Tytthodiscus suevicus Eisenack. – Brosius, 1963, Deutsch. Geol. Ges., Zeitschr., vol. 114, pt. 1, p. 50, pl. 6, fig. 4.

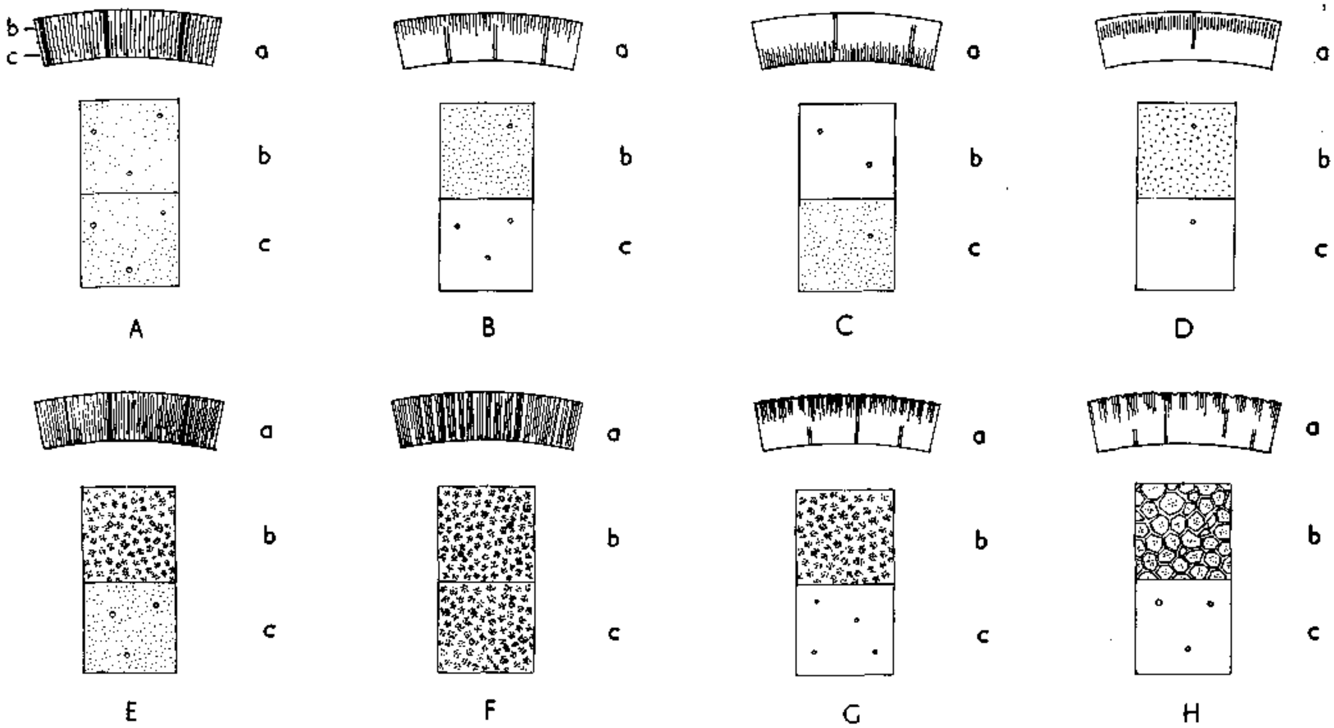
Remarks: At lower magnifications, the wall of this species has a honeycombed surface pattern comparable with that of *Tytthodiscus* Norem, 1955. The authors quoted in the synonymy above have each commented that clusters of minute radial pores (punctae) are instrumental in forming this pattern. The present writer's examinations of numerous Liassic specimens confirms this conclusion. Also, pore-canals ("*Tasmanites*-pores") are present in many instances, so that the species in question differs from *Tasmanites newtoni* n. sp. only in the concentration of the punctations into groups, three to eight in number for Liassic examples. There are no discrete hexagonal columnar units with central tubules.

The close relationship between *Tasmanites newtoni* and *Tytthodiscus suevicus* Eisenack is confirmed by the discovery of Liassic forms in the Dorset Hettangian whose punctae are grouped into clusters in the outer wall region but uniformly distributed over the inner wall surface. Consequently, *Tytthodiscus suevicus* is transferred to *Tasmanites*. The surface ornamentation is so weakly developed that allocation to *Crassosphaera* is precluded.

Tasmanites sp. A

Type specimen: K2/2/T1, Blue Lias (*A. bucklandi* Zone), Lyme Regis, Dorset.

Description: The test is weakly ovoid, relatively thick-walled, almost colourless, and normally perforated by an irregular aperture on one surface. Although small



TEXT-FIGURE 3

Wall structure of Liassic Tasmanaceae: a, optical section; b–c, surface views at two different levels of focus shown in A. A–D, *Tasmanites newtoni* Wall, n. sp.; E–G, *Tasmanites suevicus* (Eisenack), n. comb.; H, *Crassophaera hexagonalis* Wall, n. sp.

areas of the wall appear smooth, the greater part is penetrated by porelike structures. The test always appears to be corroded, and it is difficult to determine whether the pores are primary or secondary in origin.

Dimensions: Test 94μ, wall thickness 10μ.

Occurrence: Fairly numerous in the *A. bucklandi* Zone of the Blue Lias in Dorset but not observed elsewhere.

Genus Crassosphaera Cookson and Manum, 1960

Crassosphaera hexagonalis Wall, new species
Plate 9, figure 10; text-figure 3H

Holotype: W11/1/T1, Jet Rock (*H. exaratum* Subzone, bed 32 of Howarth, 1962), Port Mulgrave, Yorkshire.

Diagnosis: Test spherical, thick-walled, with a distinctive surface ornament of very low, polygonal prominences with flat or weakly rounded tops. The surface polygons and the outer wall are penetrated by clusters of minute punctae which mostly originate in the mid-wall and end in the centre of the surficial prominences. More widely spaced, coarser canal pores are present, partially or completely penetrating the wall.

Description: The punctae occur in groups of three to six and appear in the centre of the four- to six-sided polygonal areas on the surface and as radial striations in optical section. The prominences are 1μ high and 1–1.5μ across. They are visible only at the surface of the test. Pore-canals have a density of 2–4/100 sq. μ of wall surface.

Dimensions: Test diameter 60–150μ, wall 3–27μ thick; holotype test 142μ, wall 8μ thick (120 measurements).

Occurrence: Jet Rock (*H. exaratum* Subzone), Yorkshire.

Comparisons: This species differs from *Crassosphaera concinna* Cookson and Manum in the presence of punctae and pore-canals beneath the surface ornamentation. *Tasmanites suevicus* Eisenack has a similar subsurface wall structure, but its surface ornamentation is less pronounced and less polygonal in shape. *C. hexagonalis* lacks the columnar wall structure of *Tytthodiscus chondrotus* Norem.

Class Dinoflagellata
Order Dinophysiales Lindemann?
Genus Nannoceratopsis Deflandre, 1938, emend. Evitt, 1961

Nannoceratopsis gracilis Alberti, emend. Evitt
Plate 6, figures 12–13

Nannoceratopsis? gracilis Alberti, 1961, Palaeontographica, vol. 116, pt. A, p. 30, pl. 7, figs. 16–17.
Nannoceratopsis deflandrei Evitt, 1961, Micropaleontology, vol. 7, no. 3, pp. 308–312, pl. 1, figs. 1–14; pl. 2, figs. 1–29; text-figs. 5, 9–17.
Nannoceratopsis gracilis Alberti, emend. Evitt. – Evitt, 1962, Jour. Pal., vol. 36, no. 5, pp. 1129–1130.

Remarks: Nannoceratopsis gracilis occurs in the Yorkshire and Lincolnshire lower Toarcian. Here, it exhibits a range of morphological variation similar to that described by Evitt (1961*a*) for this species on the basis of specimens from the Domerian of Jutland.

Order HYSTRICHOSPHAERALES Evitt, 1963
Family HYSTRICHOSPHARIDIACEAE Evitt, 1963
Genus HYSTRICHOSPHAERIDIUM Deflandre, 1937, emend. Eisenack, 1958

Hystrichosphaeridium caminuspinum Wall, new species
Plate 9, figure 4

Holotype: L1/6/2, Shales-with-Beef (bed 74 of Lang, 1923, *C. turneri* Zone), The Spittles, east of Lyme Regis, Dorset.

Diagnosis: Test spherical or weakly polygonal, thin-walled and smooth. Spines hollow, normally equal in length to the test radius, tapering to a narrow distal part with a thickened rim and small aperture. Between 20 and 30 spines are present.

Description: The processes are characterised by their thickened distal extremities which project laterally for 0.5μ beyond the edges of the spines. Rarely, the tips are divided. The spine bases are relatively wide (2μ across), and the cavity of the spines is continiuous with the cell lumen.

Dimensions: Test diameter 16–20μ, spine length 9–11μ; holotype test 18μ, spines 10μ (6 specimens measured).

Occurrence: Shales-with-Beef (*C. turneri* Zone), Dorset.

Comparisons: Micrhystridium clavatispinum n. sp. is similar in general appearance but has closed, bulbous spine tips.

Hystrichosphaeridium langi Wall, new species
Plate 6, figures 9–11; plate 9, figure 9

Holotype: K1/2/3, Blue Lias (bed H. 29 of Lang, 1924, p. 184, *P. planorbis* Zone), Lyme Regis, Dorset.

Diagnosis: A small species of *Hystrichosphaeridium* with a micrograngular test and a relatively small number (25–40) of short, open appendages with a minute lateral rim or divided tip.

Description: The test is round, ovoid or subrectangular in outline, its wall thin and microgranular. Approximately twenty spines are visible in optical section, and they are equal to approximately 25 percent of the test diameter in length. The spines are small, and precise determination of the nature of the spine tip is difficult. They usually appear to be minutely bifurcate or trifurcate or even to produce several projections. Often the test is broken at one end, but not regularly so.

Dimensions: Maximum test dimensions 21–32μ, spines 3–6.5μ long; holotype test 24 × 22μ, spines 5.5μ maximum.

Occurrence: P. planorbis to *E. raricostatum* Zones, Dorset Lias; most frequent in the Hettangian.

Comparisons: Hystrichosphaeridium capitatum Cookson and Eisenack and *H. rhabdophorum* Valensi are similar, but both are larger and bear more numerous processes.

Comments: Prior to the classification of *Hystrichosphaeridium* with the Dinoflagellata by Evitt (1963), the two species here described from the Lias would have been confidently assigned to this genus; to do so now implies dinoflagellate affinity. This seems plausible but is uncertain.

POLLEN AND SPORES
Previous literature

Lower Jurassic pollen and spores have been described from Britain (Couper, 1958; Lantz, 1958), Germany (Pflug, 1953; Reissinger, 1950; Thiergart, 1949), Sweden (Nilsson, 1958), Hungary (Góczán, 1956), Poland (Rogalska, 1954, 1956), Russia (Bolkhovitina, 1952, 1956, 1959), and Australia (Balme, 1957). A bibliography of 88 works relevant to the palynology of the European Rhaetic and Lias is given by Jekhowsky (1960). Different systems of classification and nomenclature were employed by several of the authors mentioned above, and taxonomic revisions are needed, but these are beyond the scope of the present work. Here, existing taxa are utilised, and salient features of the stratigraphic distribution of pollen and spores are illustrated by reference to morphological groups. The generic and specific compositions of these groups are defined below.

Species list

1) Trilete, triangular spores with a smooth exine:

Leiotriletes adrienniformis Nilsson, 1958; *L. medius* Nilsson, 1958; *L. parvus* Nilsson, 1958; *Dictyophyllidites harrisii* Couper, 1958; *Sphagnumsporites psilatus* Couper, 1958; *Concavisporites toralis* (Leschik) Nilsson, 1958; *C. subgranulosus* Couper, 1958; *Auritulinasporites interstriatus* Nilsson, 1958.

2) Trilete spores with a sculptured exine:

Trachysporites punctulosus Nilsson, 1958; *T. fuscus* Nilsson, 1958; *T. trigonus* Nilsson, 1958; *T. asper* Nilsson, 1958; *Acanthotriletes ovalis* Nilsson, 1958; *A. varius* Nilsson, 1958; *Lophotriletes* sp.; *Osmundacidites wellmanii* Couper, 1958; *Lycopodiumsporites gracilis* Nilsson, 1958; *L. pseudoannotinum* Nilsson, 1958; *L. clavatoides* Couper, 1958; *L. cerniidites* (Ross) Delcourt and Sprumont; *Tripartina (Leiotriletes) stelloides* Bolkhovitina, 1956; *Corrugatisporites klukiformis* Nilsson; *C. scanicus* Nilsson, and *Rugulatisporites* sp.

3) Trilete spores with a smooth exine and circular outline:

Calamospora mesozoica Couper, 1958; *C.* sp. cf. *C. mesozoica* Couper, 1958 (indicated jointly as "*Calamospora*" in Table 4); *Todisporites minor* Couper, 1958.

4) Spores with a two-layered exine, the outer concentric around the inner:

Concentrisporites hallei Wall, n. gen., n. sp. (indicated as "pseudozonate spores" in Table 4).

5) Monolete spores:

Chasmatosporites major Nilsson, 1958; *C. rimatus* Nilsson, 1958; *C. hians* Nilsson, 1958; *C. minor* Nilsson, 1958; *C. apertus* Nilsson, 1958; *C. elegans* Nilsson, 1958; *Marattisporites scabratus* Couper, 1958.

6) Bisaccate pollen:

Vitreisporites pallidus (Reissinger) Nilsson, 1958; *Alisporites thomasii* (Couper) Nilsson, 1958; *A. robustus* Nilsson, 1958; *Abietineaepollenites minimus* Couper, 1958; *Protopinus scanicus* Nilsson, 1958; *Protopinus* sp.; *Schismatosporites ovalis* Nilsson; *Sulcatisporites quadratus* Nilsson, 1958; *S. pinoides* Nilsson, 1958; *Abiespollenites* sp.; *Protopicea* sp.; *Piceaepollenites* sp.

7) Inaperturate pollen:

Tsugaepollenites mesozoicus Couper, 1958; *Inaperturopollenites orbiculatus* Nilsson, 1958; *I. globulus* Nilsson. 1958; *Araurcariacites (Granulonapites) punctatus* (Cookson) Nilsson, 1958 (the latter species is indicated as "*araucarian* pollen" in Table 4).

8) Monosulcate pollen:

Monosulcites minimus (Cookson) Couper, 1953; *M. (Monocolpopollenites) ovalis* Nilsson, 1958; *M. (Monocolpopollenites) fusiformis* Nilsson, 1958; *M. subgranulosus* Couper, 1958.

9) Monoporate pollen:

Spheripollenites scabratus Couper, 1958; *Classopollis torosus* (Reissinger) Couper, 1958 (the latter species is considered to remain valid despite criticisms by Pocock and Jansonius, 1961, p. 442, of the botanical affinities of the species suggested by Couper, 1958, p. 156, since it is diagnosed upon the basis of its morphology).

SYSTEMATIC DESCRIPTIONS

Genus **Concentrisporites** Wall, **new genus**

Diagnosis: Spores with a spherical to subspherical central body surrounded by an outer coat, which is attached proximally but elsewhere clearly separated from the central body. The inner body is thicker-walled and may or may not show a trilete scar. Both layers smooth or weakly sculptured.

Type species: Concentrisporites hallei (Nilsson) Wall, new combination.

Comments: This genus is established for spores previously allocated to *Equisetosporites* Daugherty, 1941, by Nilsson (1958). Scott (1960, p. 276) demonstrated that the genotype of *Equisetosporites*, from the Upper Triassic of Arizona, is *Ephedra* pollen, and recommended that the genus *Equisetosporites* be abandoned.

Concentrisporites hallei (Nilsson) Wall, **new combination**
Plate 9, figure 13

Equisetosporites hallei Nilsson, 1958, Lund, Univ., Arsskr., new ser., sec. 2, vol. 54, no. 10, p. 66, pl. 5, figs. 20–21.

Holotype: Equisetosporites hallei Nilsson (1958, p. 66, pl. 5, fig. 20), Rhaetic of Bjuv, Scania, Sweden.

Diagnosis: Spores with a darker central body, rarely showing a trilete mark, normally characteristically split and gaping, surrounded by a loose, delicate, minutely sculptured outer layer. Outer layer not extending beyond the central body by more than 10μ when undamaged.

Dimensions: Overall size 40–60μ; holotype central body 43μ, overall size 47μ.

Occurrence: Found most abundantly in the British Lias in the Frodingham Ironstone of Lincolnshire.

Comments: In their compressed state of preservation, these spores bear a superficial resemblance to some zonate spores (for example, *Hymenospora* Neves, 1961), and hence they are termed pseudozonate spores. Nilsson (1958, p. 66) suggests that the botanical affinities of *C. hallei* lie with *Equisetites (Equisetostachys) suecicus* (Nathorst) Halle (1908, p. 30, pl. 9, figs. 1–3).

STRATIGRAPHIC DISTRIBUTION OF MICROFOSSILS

Hettangian

A single species of *Hystrichosphaeridium (H. langi)*, several species of leiospheres, and nineteen acritarch species were found in the Hettangian strata of the Blue Lias at Lyme Regis. The acritarch population was dominated strongly by *Micrhystridium lymensis*, but *M. fragile, M. nannacanthum, M. echinoides, M. stellatum, M. recurvatum, Baltisphaeridium delicatum* and *B. debilispinum* were also commonly encountered. Only two species of *Veryhachium (V. formosum* and *V.? irregulare)* were seen, and these rarely.

The pollen-spore association was dominated by *Classopollis, Araucariacites* being the only other pollen genus that was at all common. The Hettangian of South Wales yielded a similar assemblage: *Classopollis* was the dominant pollen, and *Micrhystridium lymensis* the most common acritarch.

Lower Sinemurian

The uppermost strata of the Blue Lias contained twenty-three acritarch species, several of which were absent from the beds below. These were *Baltisphaeridium polytrichum, Micrhystridium deflandrei, M. arachnoides, Veryhachium europaeum, V. reductum, V. formosum* f. *ancorastrum, Cymatiosphaera eupeplos, C.* sp. cf. *areolatum, C.* sp. D and *Tasmanites* sp. A. Three further species, *Hystrichosphaeridium caminuspinum, Veryhachium* cf. *trispinosum,* and *Cymatiosphaera* sp. C, were encountered first in the overlying Shales-with-Beef. The microplankton of both horizons

TABLE 2

Stratigraphical distribution of microplankton in the Lias of England.

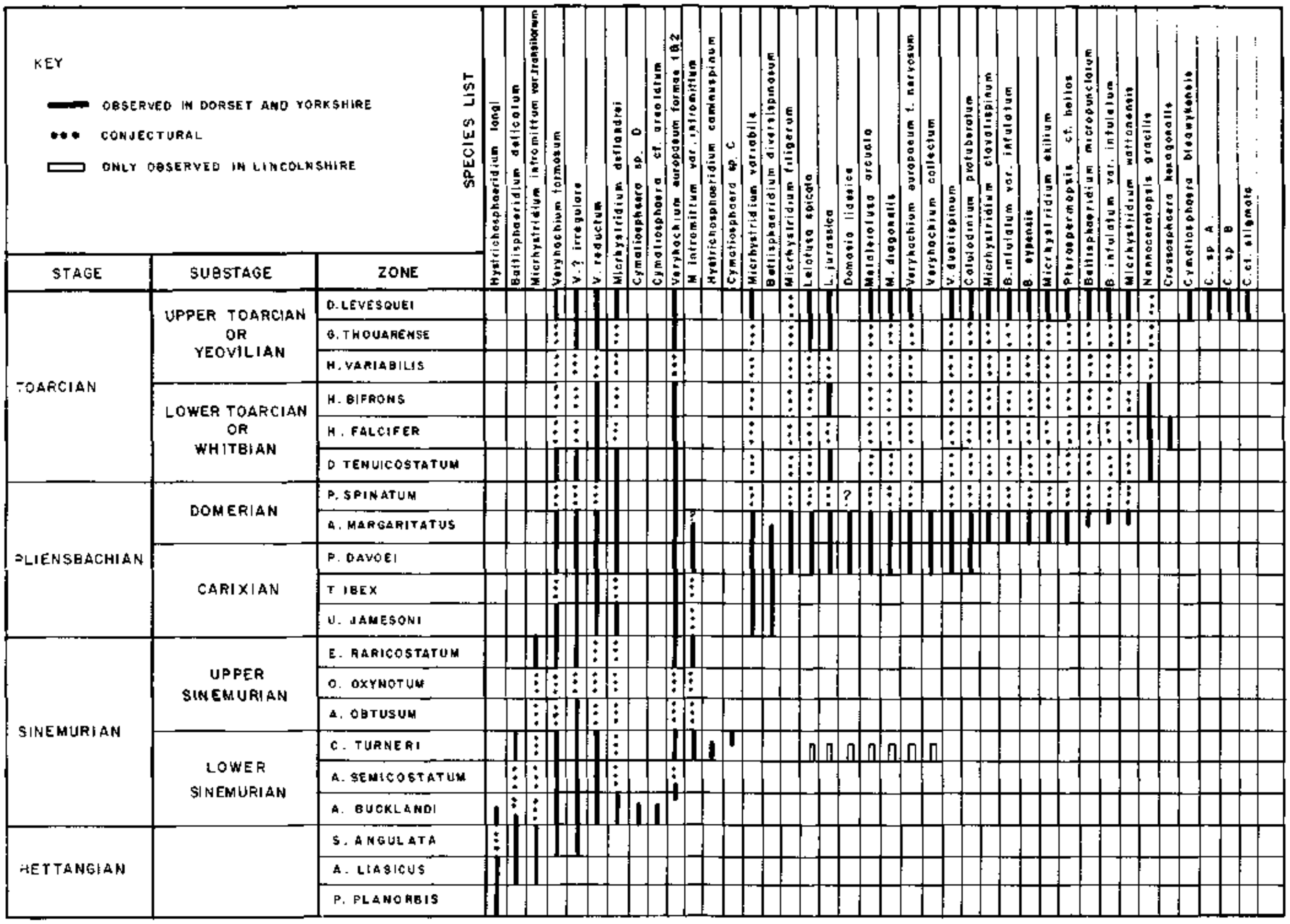


TABLE 3

Stratigraphical relative frequency distribution of Acritarcha in the coastal Lias of Dorset. Units I–XI are those recognized as Klupfelian cycles of sedimentation by Hallam, 1961. Stratal thicknesses are given in Table I.

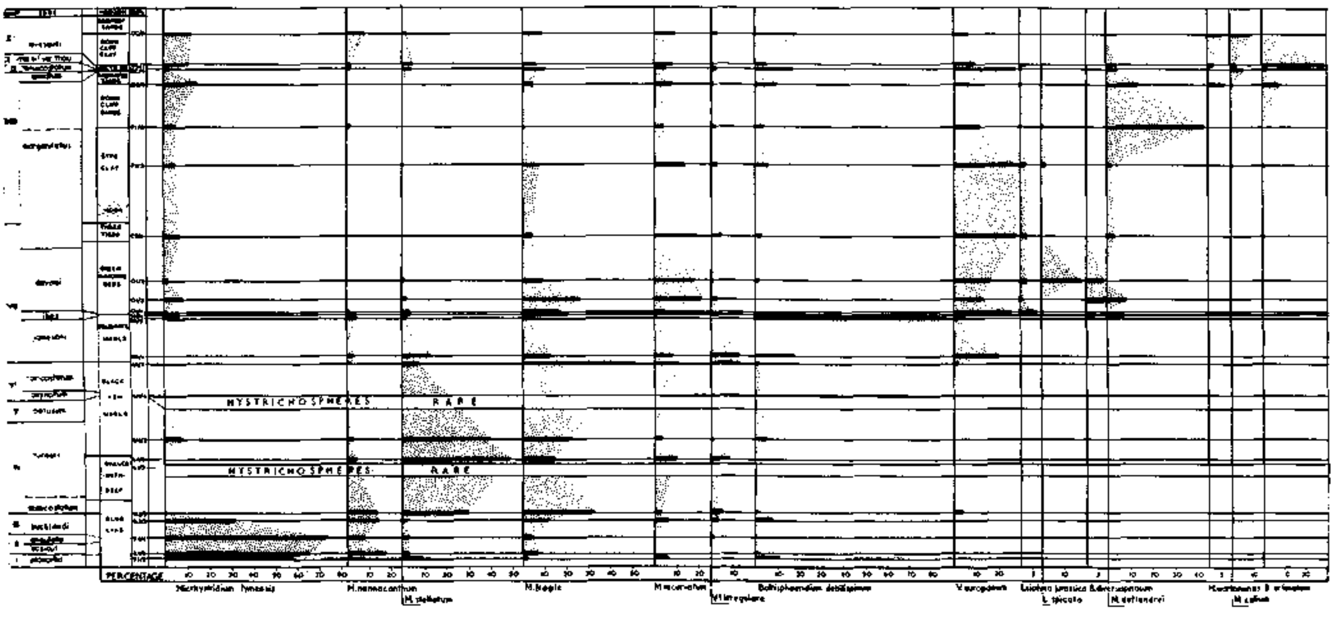
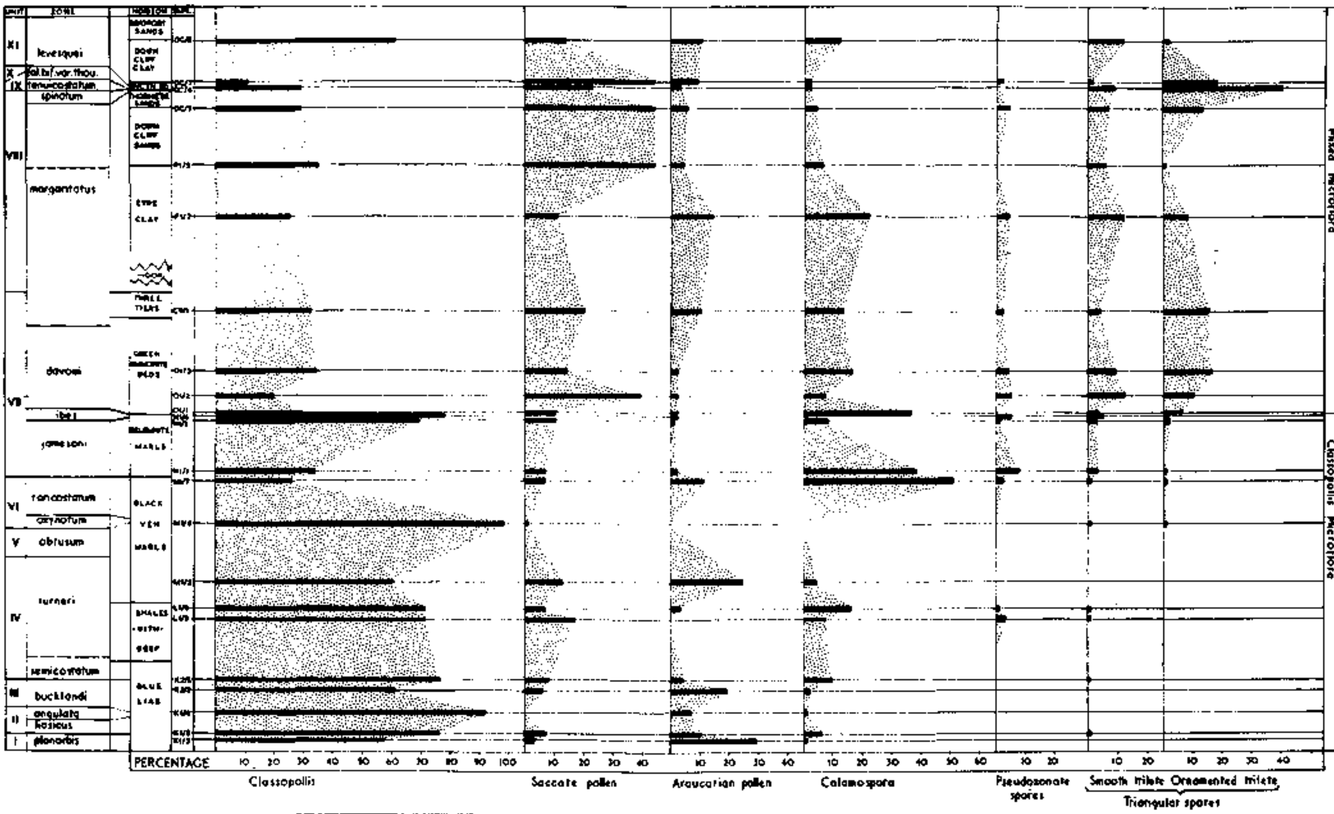


TABLE 4

Stratigraphical distribution of commonly represented morphological groups of pollen and spores in the coastal Lias of Dorset.



was dominated by *Micrhystridium stellatum* and *M. fragile.* The pollen-spore association was almost identical with that of the Hettangian, being largely composed of *Classopollis,* with some araucarian and bisaccate pollen and *Calamospora.*

The Frodingham Ironstone was sampled at Crosby Warren Mine, Lincolnshire, in a section subsequently described by Hallam (1963*b*, p. 555). The best preserved specimens were from a nonoolitic chamosite mudstone parting of the type illustrated by Hallam (1963*b*, p. 560, fig. 3). The microplankton assemblage contained twenty acritarch species, of which *Micrhystridium stellatum* was most abundant and *M. fragile* and *V.? irregulare* were fairly common. In this respect the assemblage was comparable with those from the *C. turneri* Zone in Dorset. However, several additional species were represented only in Lincolnshire *(Leiofusa spicata, L. jurassica, Domasia liassica, Metaleiofusa arcuata, M. diagonalis, Veryhachium europaeum* f. *nervosum, V. collectum,* and *Baltisphaeridium diversispinosum),* although they were very rare.

The most abundant forms in the pollen-spore association were *Concentrisporites,* saccate grains, and *Classopollis,* but there was present a variety of trilete spores including *Lycopodiumsporites. Classopollis* represented only approximately one-fifth of the association. In the latter respects, the Frodingham Ironstone association differed from the lower Sinemurian associations of Dorset.

Upper Sinemurian

Only sixteen acritarch species, all of which also occurred in older horizons, were found in the upper Sinemurian Black Ven Marls of Dorset. *Micrhystridium stellatum* had decreased in abundance, and *M. fragile* became the dominant species. There was a relatively increased abundance of veryhachid acritarchs, although only three species were recorded *(V. europaeum, V. formosum,* and *V.? irregulare).*

The pollen-spore association found at the top of the *A. obtusum* Zone consisted almost entirely of *Classopollis*; that at the top of the *E. raricostatum* Zone differed in its greater content of *Calamospora,* which contributed almost half of the grains.

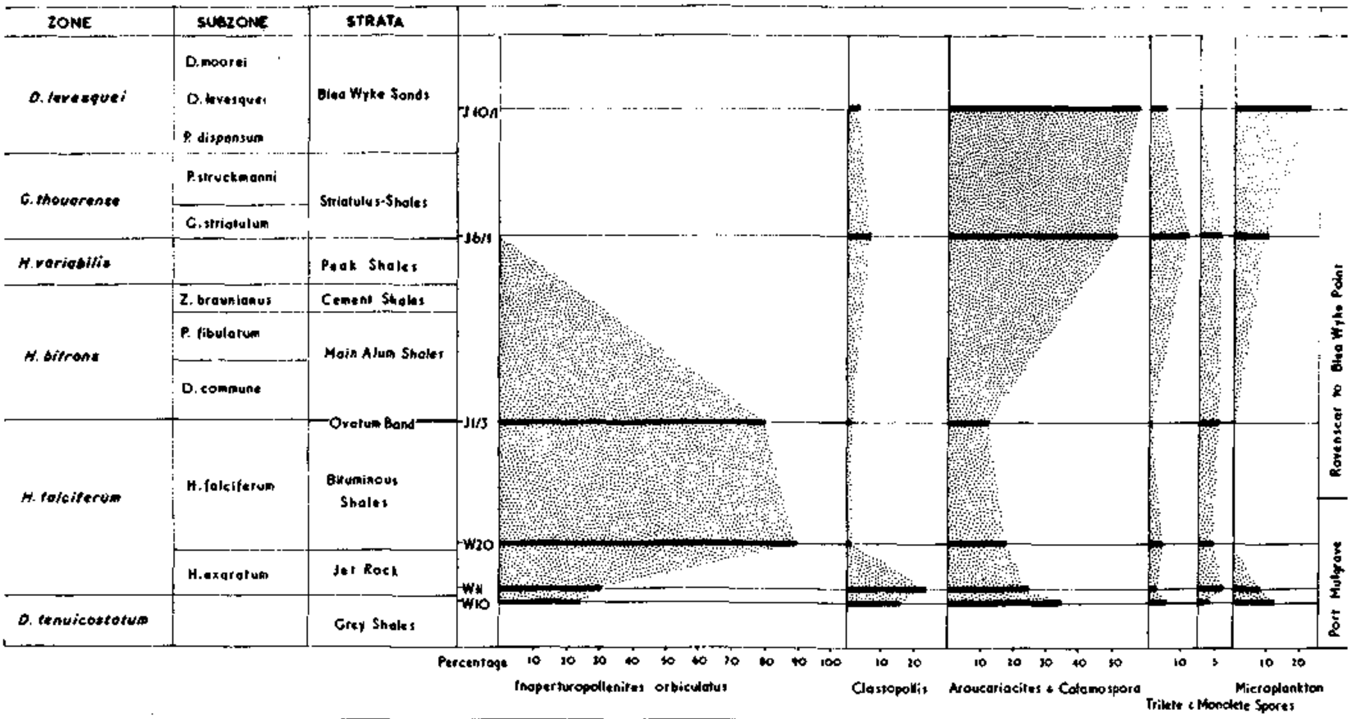
Lower Pliensbachian (Carixian)

1) Belemnite Marls (*U. jamesoni* and *T. ibex* Zones):

Only ten acritarch species were found in the *U. jamesoni* Zone and fifteen in the *T. ibex* Zone. The lowest beds of the Belemnite Marls (*U. jamesoni* Zone) contained a microplankton population which did not differ significantly from that of the upper Sinemurian beds below. The upper Belemnite Marls were characterised by an abundance of *Baltisphaeridium debilispinum* and the presence of *Micrhystridium variabile.* In the *T. ibex* Zone, *B. debilispinum* was far less abundant relative to other acritarchs, and *B. diversispinosum* was recorded.

TABLE 5

Stratigraphical distribution of pollen and spores in the Toarcian of Yorkshire.



The pollen-spore association of the Belemnite Marls also varied vertically. There was a relative decline in the abundance of *Calamospora* and a relative increase in *Classopollis* from older to younger beds.

The "Jamesoni"-beds of Robin Hoods Bay, Yorkshire, contained a microplankton assemblage very similar to that found in the lower horizons of the Belemnite Marls in Dorset. The Yorkshire assemblages also contained *M. variabile*, and *B. diversispinosum* occurred here in the *U. jamesoni* Zone. *Calamospora* and *Classopollis* were the most common palynomorphs.

2) Green Ammonite Beds (*P. davoei* Zone):

The Green Ammonite Beds contained a number of acritarchs absent from older Liassic strata in Dorset. These included *Leiofusa spicata*, *L. jurassica*, *Metaleiofusa arcuata*, *M. diagonalis*, *Cantulodinium protuberatum*, *Domasia liassica*, *Veryhachium europaeum* f. *nervosum*, *V. collectum* and *V. dualispinum*. There was no clearly dominant species; the most abundant forms were *Micrhystridium fragile*, *M. recurvatum*, *M. deflandrei*, *Veryhachium europaeum*, *Leiofusa spicata*, and *B. diversispinosum*.

The pollen-spore association could be regarded as a "mixed microflora," since no single species or type of grain was clearly more abundant than the remainder. The association comprised *Classopollis*, bisaccate pollen, *Calamospora*, and both smooth and ornamented types of small, trilete spores. The "Capricornus"-beds of Yorkshire were characterised by an abundance of *Leiofusa spicata* and the presence of species of *Metaleiofusa* and *Veryhachium collectum*.

Upper Pliensbachian (Domerian)

The Three Tiers and Eype Clay (*Amaltheus subnodosus* Subzone) of the Dorset coastal Lias contained over 30 Acritarcha species, including several believed to be important stratigraphically. These are *Baltisphaeridium infulatum* var. *infulatum*, *M. exilium*, *B. eypensis*, *Micrhystridium clavatispinum*, and *Pterospermopsis* cf. *helios*. The most abundant form was *Veryhachium europaeum*.

The Down Cliff Sands (*A. gibbosus* Subzone) contained a less prolific assemblage of microplankton, which included several new species, namely, *Baltisphaeridium micropunctatum*, *B. infulatum* var. *macroinfulatum*, and *Micrhystridium wattonensis*. *M. deflandrei* was dominant in the lower but not in the higher strata of the Down Cliff Sands.

The pollen-spore association in the Eype Clay was a species-rich "mixed microflora" without dominance by any one type of palynomorph, but in the overlying Down Cliff Sands bisaccate grains were noticeably abundant.

Two samples from depths of 135 and 150 feet in the Appleby-Frodingham B. H. 103 contained prolific but less well preserved microplankton. Species present included *B. infulatum* var. *infulatum*, *M. clavatispinum*, and *V. europaeum* f. *nervosum*, which suggests that the age of the samples is lower Domerian.

TABLE 6

Stratigraphical distribution of pollen, spores and microplankton in the Lias of Lincolnshire.

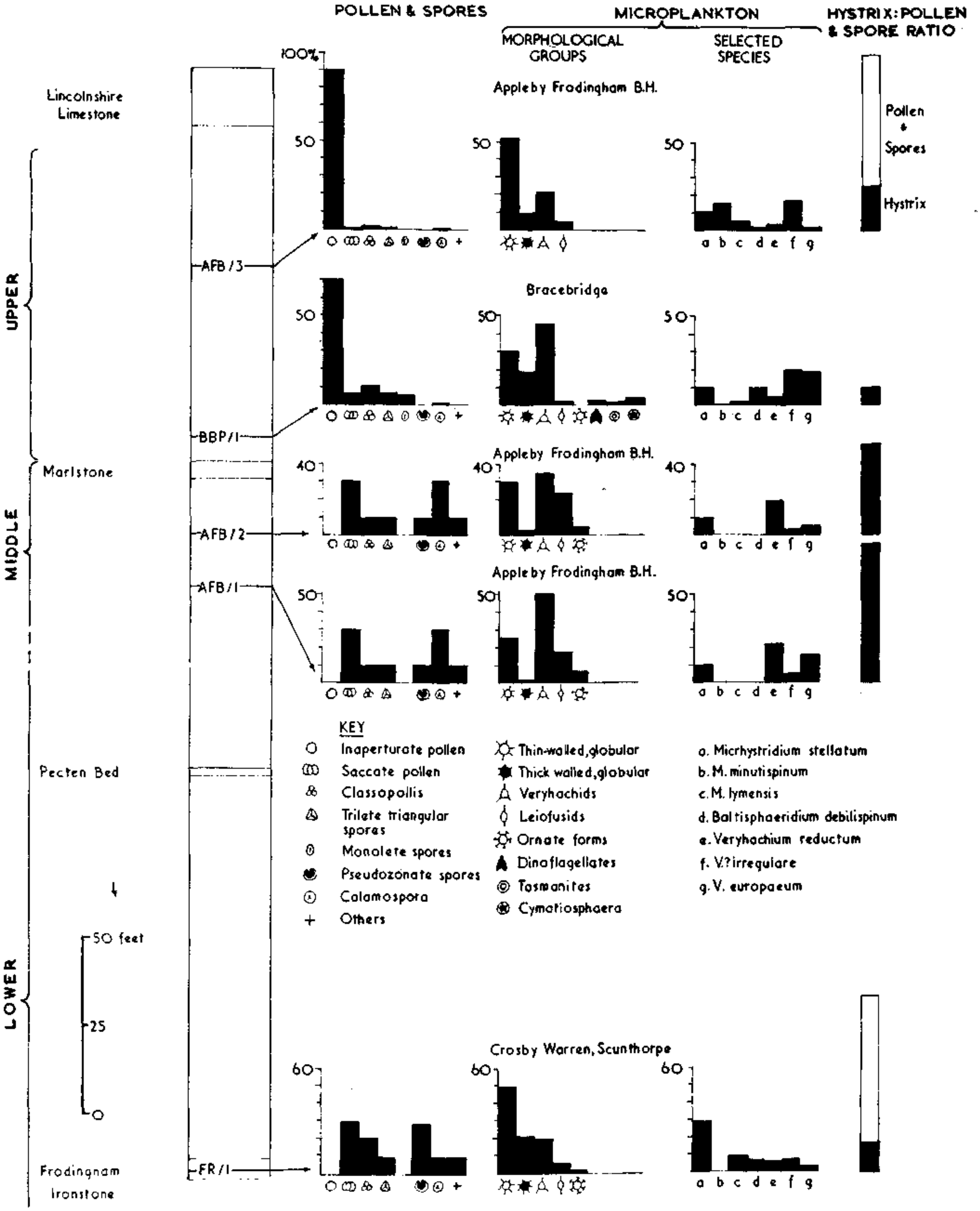
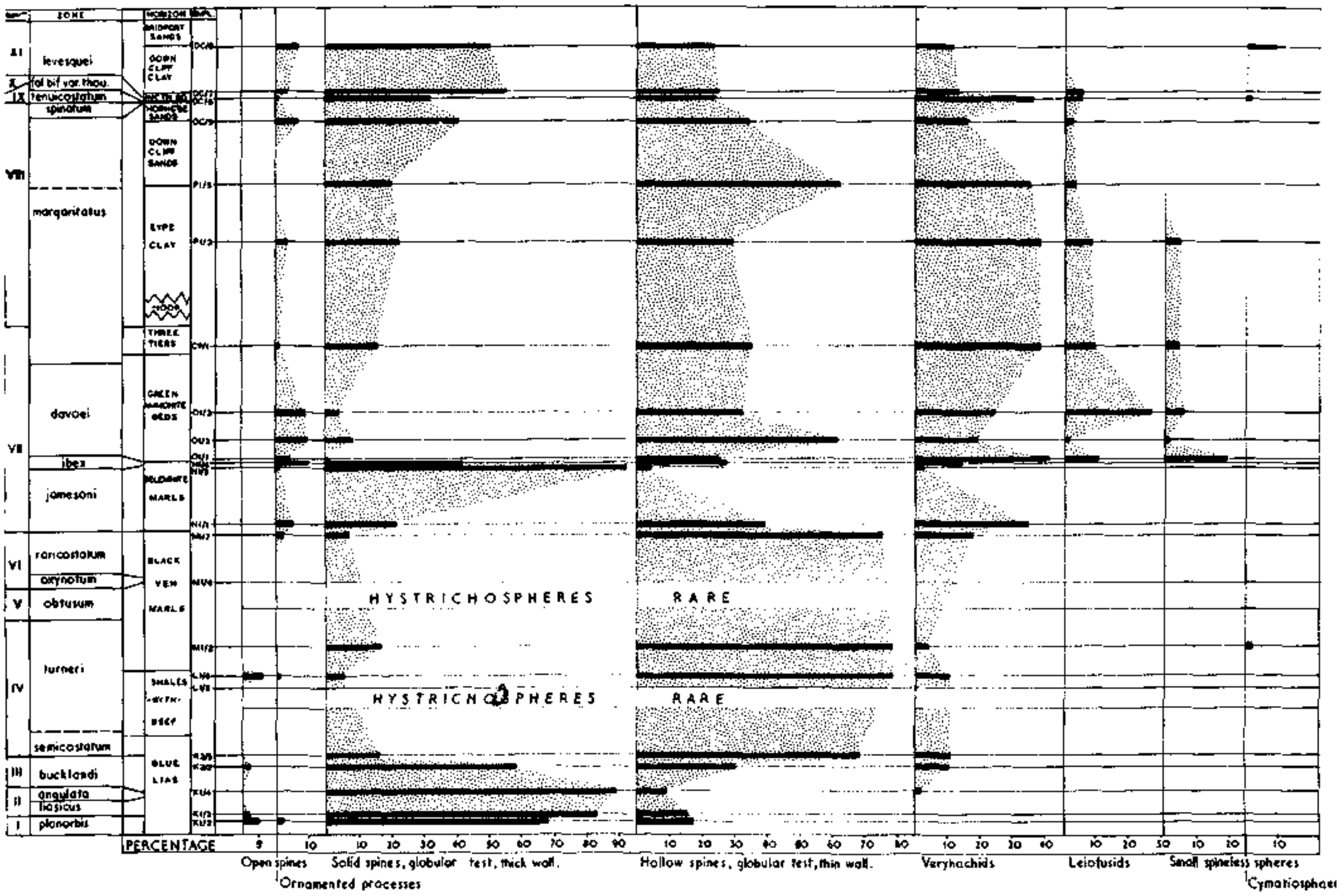


TABLE 7

Relative frequency distribution of morphological groups of Acritarcha in the coastal Lias of Dorset.



Lower Toarcian

Microplankton assemblages from the lower Toarcian of Yorkshire and Lincolnshire were characterised by the presence of the dinoflagellate *Nannoceratopsis gracilis* and an abundance of leiospheres, including *Tasmanites newtoni*, *T. tardus*, and *T. suevicus*. The latter were always common, but *Crassosphaera hexagonalis* was found only in the Jet Rock (*H. exaratum* Subzone). Acritarchs were rare and poorly preserved in the Yorkshire lower Toarcian, but twenty-two species were identified in Lincolnshire.

In both regions, the pollen-spore associations of the lower Toarcian were similar and distinctive. They primarily contained an enormous number of small inaperturate pollen grains belonging to the species *Inaperturopollenites orbiculatus* and *I. globulus*, which were recorded also in large numbers by Nilsson (1958) in Liassic shales at Sandakra, Sweden. Smaller but significant numbers of the monolete spore *Chasmatosporites* were also present, in contrast to their absence from older beds. *Classopollis*, *Araucariacites*, bisaccate grains, and a variety of smaller spores made up the remainder of the assemblage.

Upper Toarcian

Upper Toarcian strata at Blea Wyke, Yorkshire, yielded only poorly preserved microfossils which did not permit statistical evaluation of the assemblages. However, it was possible to see that these assemblages were considerably different from those in the lower Toarcian; leiospheres were rare, dinoflagellates were absent, and *Inaperturopollenites* and *Chasmatosporites* were uncommon. The microflora essentially comprised a mixture of *Classopollis*, bisaccates, *Calamospora*, and a few other palynomorphs.

Well-preserved assemblages were obtained from the Dorset upper Toarcian near West Bay. Five species of *Cymatiosphaera* were among the twenty-five species recorded. *Baltisphaeridium infulatum* was common in one sample from the base of the Down Cliff Clay (*D. levesquei* Zone).

The pollen-spore association varied vertically from the Junction Bed to the base of the Bridport Sands. The Junction Bed contained a relatively high content of small trilete spores, but the basal Down Cliff Clay contained more numerous bisaccate pollen, and the upper beds were richer in *Classopollis*.

Transgressions and Palynological Changes

Hallam (1961, 1963*a*, *b*) discussed the transgressions, cyclic sedimentation, and invertebrate faunal changes in the Lower Jurassic of Europe and elsewhere and drew attention to the widespread facies changes in the Pliensbachian (1961, p. 139; 1963*a*, p. 445) and lower Toarcian (1961, p. 154; 1963*a*, p. 445). He concluded that there was widespread transgression accompanied by faunal evolutionary migration during the early Pliensbachian and extensive subsidence and temporary diminution of faunas during the early Toarcian.

Important palynological changes were also found in the Pliensbachian and lower Toarcian, involving both pollen-spore associations and microplankton assemblages. In the Dorset Hettangian and Sinemurian, *Classopollis* dominated the associations but was replaced in the late Carixian by a more varied microflora following a temporary abundance of *Calamospora* in the early Carixian. During the lower Toarcian there was an influx of small inaperturate pollen and *Chasmatosporites*. Similarly, older populations dominated by acanthomorphitid acritarchs (*Micrhystridium* and *Baltisphaeridium*) were replaced in the early Pliensbachian by populations richer in species of *Veryhachium*, *Leiofusa*, *Metaleiofusa*, and *Cantulodinium*. A reduction in the number of species took place with the onset of the lower Toarcian, but there was an increased abundance of leiospheres and the arrival of dinoflagellates.

Palaeoecology of pollen and spore associations

During Liassic times, the area that is now Britain lay along the northwestern shoreline of the Tethyean Sea, which covered much of Europe. There were four main basins of deposition in the British area: the southern Wessex Basin, the Midland Basin, the northeastern Yorkshire Basin, and the northwestern Hebridean Basin. These basins were bordered by the Armorican, Welsh, and Scottish Massifs in the west and north and by the London-Ardennes landmass in the southeast. Submergence and emergence of the coastal regions of these landmasses was of prime importance in effecting changes in floras and resultant pollen-spore associations accumulated in the adjacent basins.

Two Liassic microfloras, the lower Lias *Classopollis*-dominated association and the lower Toarcian *Inaperturopollenites*-dominated association, were probably of local derivation, from more or less homogeneous coastal floras. There is strong evidence from much of the Jurassic that *Classopollis* microfloras were produced by parent plants densely inhabiting coastal regions (Pocock and Jansonius, 1961, p. 445). Unique confirmatory evidence comes from the close agreement between the Hettangian dispersed pollen association and a macroflora found in South Wales. Fissures in Carboniferous Limestone immediately beneath the Hettangian at Cnap Twt, Bridgend, contain a macroflora almost entirely composed of the wood, leaves,

PLATE 1

1–2 *Baltisphaeridium diversispinosum* Wall, n. sp.
1, paratype, Green Ammonite Beds, Dorset (Prep. 01/3/3); 2, processes, at a greater magnification.

3–4 *Baltisphaeridium micropunctatum* Wall, n. sp.
3, holotype, Junction Bed, Watton Cliff, Dorset (Prep. DC/6/6); 4, paratype (Prep. DC/6/5).

5–7 *Baltisphaeridium infulatum* var. *infulatum* Wall, n. sp., n. var.
5, holotype, Three Tiers, Golden Cap, Dorset (Prep. C9/1/2); 6–7, paratypes.

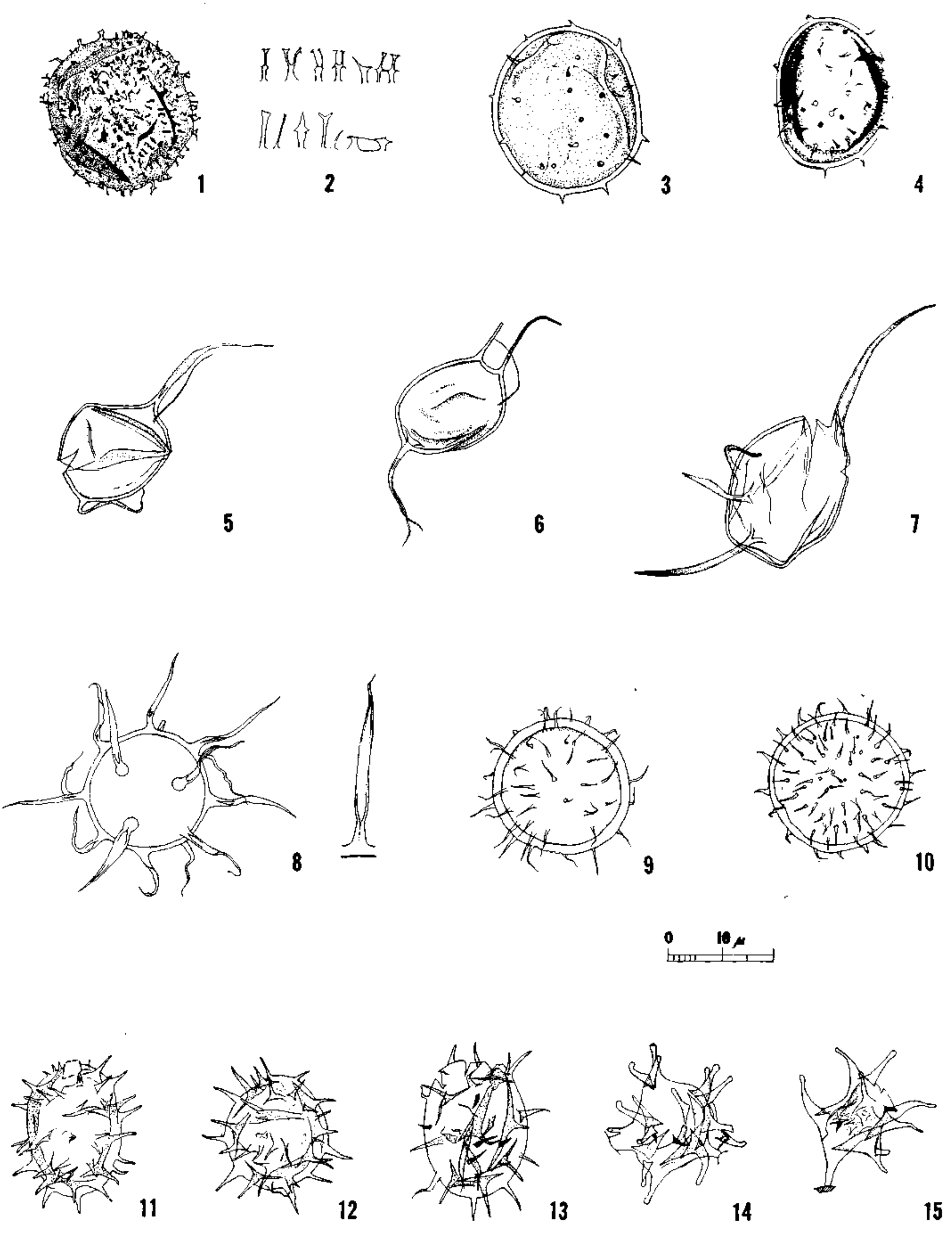
8 *Baltisphaeridium infulatum* var. *macroinfulatum* Wall, n. sp., n. var.
Holotype, Junction Bed, Watton Cliff, Dorset (Prep. DC/6/6).

9 *Baltisphaeridium debilispinum* Wall and Downie
Belemnite Marls, near Hawkfish Ledge, Dorset coastal Lias.

10 *Baltisphaeridium debilispinum* var. *brevispinosum* (Sarjeant) Wall, n. comb.
Type specimen, Blue Lias, Lyme Regis (Prep. K2/2/2).

11–13 *Baltisphaeridium delicatum* Wall, n. sp.
11, holotype, Blue Lias, Lyme Regis (Prep. K1/3/2); 12, paratype; 13, Blue Lias, Lyme Regis (Prep. K2/2/2).

14–15 *Micrhystridium clavatispinum* Wall, n. sp.
14, holotype, Three Tiers, Golden Cap, Dorset (Prep. C9/1/4); 15, Appleby-Frodingham Bore M. 103, depth 150 ft.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stems, and microsporophylls of *Cheirolepsis muensteri* (Schenk) Schimper, described by Lewarne and Pallot (1957) and Harris (1957). The pollen from the microsporangia of this plant, described and illustrated by Harris (1957, p. 300, pl. 8, figs. 7–9) is identical with the pollen of *Classopollis*, which makes up over 90 percent of the grains in nearby sediments.

Hettangian strata in South Wales are proven littoral deposits with conglomerates marking the position of the ancient shoreline. The close similarity of South Wales and Dorset Hettangian microfloras suggests that the shoreline also passed very close to Lyme Regis in the south. This has always been implied in palaeogeographic reconstructions.

In its structure, the *Inaperturopollenites* microflora of the lower Toarcian in Yorkshire and vicinity parallels a *Classopollis* microflora; that is, it is more or less homogeneous. By analogy, it is also believed to have originated from a relatively nearby coastal flora. The pollen also has some morphological similarity to *Classopollis*.

Palynological History

Although the Hettangian and lower Sinemurian microfloras were dominated by pollen of *Classopollis* from coastal floras rich in *Cheirolepis*, a consideration of palynological data, together with stratigraphic information regarding the history of the Wessex Basin, suggests that regression in the late Sinemurian temporarily created marginal swampy ground favourable for inhabitation by equisetalean plants, producing *Calamospora* and *Concentrisporites*. Later, with the advance of the Pliensbachian transgression, this ground and previously emergent coastal plains were submerged. A flora of somewhat different aspect, relatively richer in pinaceous and pteridophytic vegetation, appears to have resulted. The supply of pteridophytic spores in particular increased in the southern province during late Pliensbachian times, when there was regional uplift in this domain with shallowing of the Wessex Basin of deposition toward the onset of lower Toarcian times.

In the northeastern province, pronounced vegetational change associated with some coastline regression is suggested by the reversion from a sparse microflora to a rich *Inaperturopollenites* microflora coincident with a facies change from sandstone and ironstone to organic black shales at the Domerian-lower Toarcian boundary. Eustatic rise in sea level, as postulated by Hallam (1963*a*), must have been compensated for by regional uplift related to the Market Weighton Swell and the Pennines and by relative downwarping of the Yorkshire Basin.

PLATE 2

1–2 *Micrhystridium wattonensis* Wall, n. sp.
1, holotype, Down Cliff Clay, Watton Cliff, Dorset (Prep. DC/8/3); 2, paratype (Prep. DC/8/4).

3–5 *Micrhystridium intromittum* var. *intromittum* Wall, n. sp., n. var.
3, holotype, Three Tiers, Dorset (Prep. C9/1/4); 4, Black Ven Marls, Charmouth, Dorset (Prep. M1/2/3); 5, Shales-with-Beef, Charmouth, Dorset (Prep. L1/3/2).

6–8 *Micrhystridium intromittum* var. *transitorium* Wall, n. sp., n. var.
6, type specimen, Blue Lias, Lyme Regis (Prep. K1/3/2); 7, Shales-with-Beef, Charmouth (Prep. L1/6/2); 8, paratype (Prep. K1/3/3).

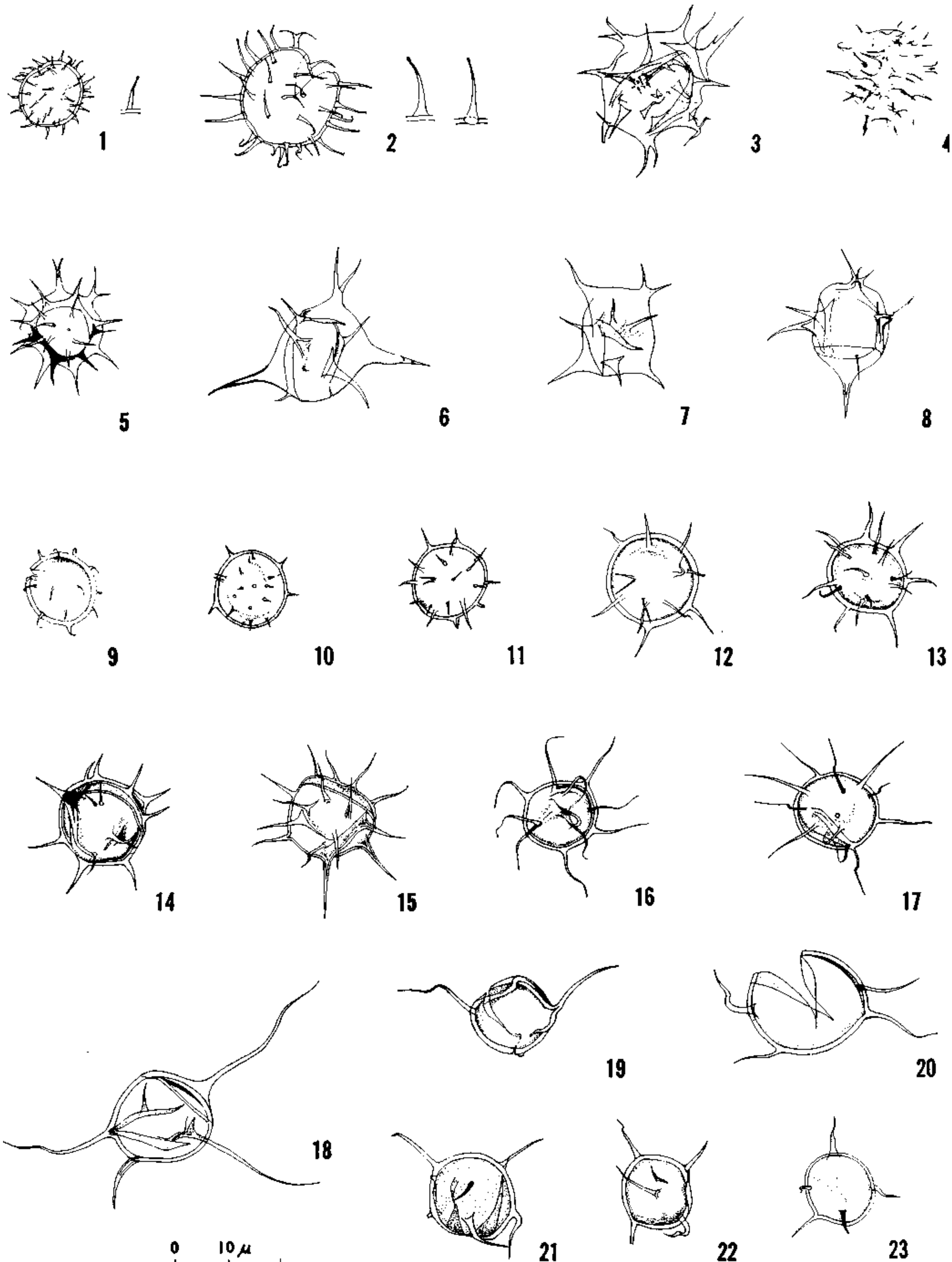
9 *Micrhystridium rarispinum* Sarjeant
Blue Lias, Lyme Regis (Prep. K1/3/3).

10–11 *Micrhystridium lymensis* var. *rigidum* Wall, n. sp., n. var.
10, type specimen, Blue Lias, Lyme Regis (Prep. K1/3/2); 11, paratype.

12–15 *Micrhystridium lymensis* var. *gliscum* Wall, n. sp., n. var.
12, Blue Lias, Lyme Regis (Prep. K1/2/4); 13, type specimen, Blue Lias, Lyme Regis (Prep. K1/3/2); 14–15, paratypes.

16–17 *Micrhystridium lymensis* var. *lymensis* Wall, n. sp., n. var.
16, holotype, Blue Lias, Lyme Regis (Prep. K1/3/2); 17, paratype.

18–23 *Micrhystridium exilium* Wall, n. sp.
18–20, Junction Bed, Watton Cliff, Dorset, Sample DC/6; 22, holotype, Down Cliff Clay, Watton Cliff (Prep. DC/8/3); 21, 23, paratypes.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Palaeoecology of Microplankton Assemblages

The distribution of Liassic microplankton was also environmentally controlled, the configuration of depositional basins and the oceanographic conditions prevailing in them being instrumental in this respect. The influence of environmental controlling factors upon the distribution of the microplankton is shown by the diachronous occurrence of some acritarchs and dinoflagellates. For example, *Nannoceratopsis gracilis* occurred in the Domerian of Jutland (Evitt, 1961*a*) but only in the lower Toarcian in Britain, whereas *Dapcodinium priscum*, present in the Hettangian of Jutland (Evitt, 1961*b*), was found only in parts of the Rhaetic in England. Moreover, there were significant fluctuations in the abundance of many common, long-ranging acritarchs throughout the Lias. Assemblages from different horizons were dominated variously by acritarchs persisting from the Upper Palaeozoic (*Micrhystridium stellatum, Baltisphaeridium debilispinum*) and others which have been found commonly in the Middle and Upper Jurassic (*Micrhystridium fragile, M. recurvatum* and *M. deflandrei*).

Within the Lias, two types of assemblage can be distinguished in many instances, one showing a tendency towards uniformity of composition by virtue of strong domination by a single species, the other being more varied in composition, the dominant species accounting for but a small number of the cells. Consideration of the distribution of these two types of assemblages in connection with other palynological and stratigraphic data suggests that populations dominated strongly by a single species were derived from algae inhabiting inshore waters, whereas the species-rich, heterogeneous assemblages were accumulated in an offshore environment. This distributional pattern is analogous to that of present-day phytoplankton populations described from the Atlantic Ocean between New England and Bermuda by Hulburt (1963), who recorded a reduction in the diversity of species within populations taken from estuarine and bay environments as compared with populations from open-sea, coastal, and deep-ocean habitats. This suggests that a relatively simple relationship may have existed between the fossil acritarch remains and the populations from which they were derived.

Furthermore, it appears that morphologically different groups of acritarchs exhibited preference for specific habitats during the Lias. Hence, members of the Acanthomorphitae (*Micrhystridium* and *Baltisphaeridium*) appear to have favoured an inshore, partly enclosed environment, whereas members of the Polygono-

PLATE 3

1–4 *Micrhystridium stellatum* Deflandre
Black Ven Marls, Charmouth, Dorset.

5–6 *Micrhystridium fragile* Deflandre
Blue Lias, Lyme Regis.

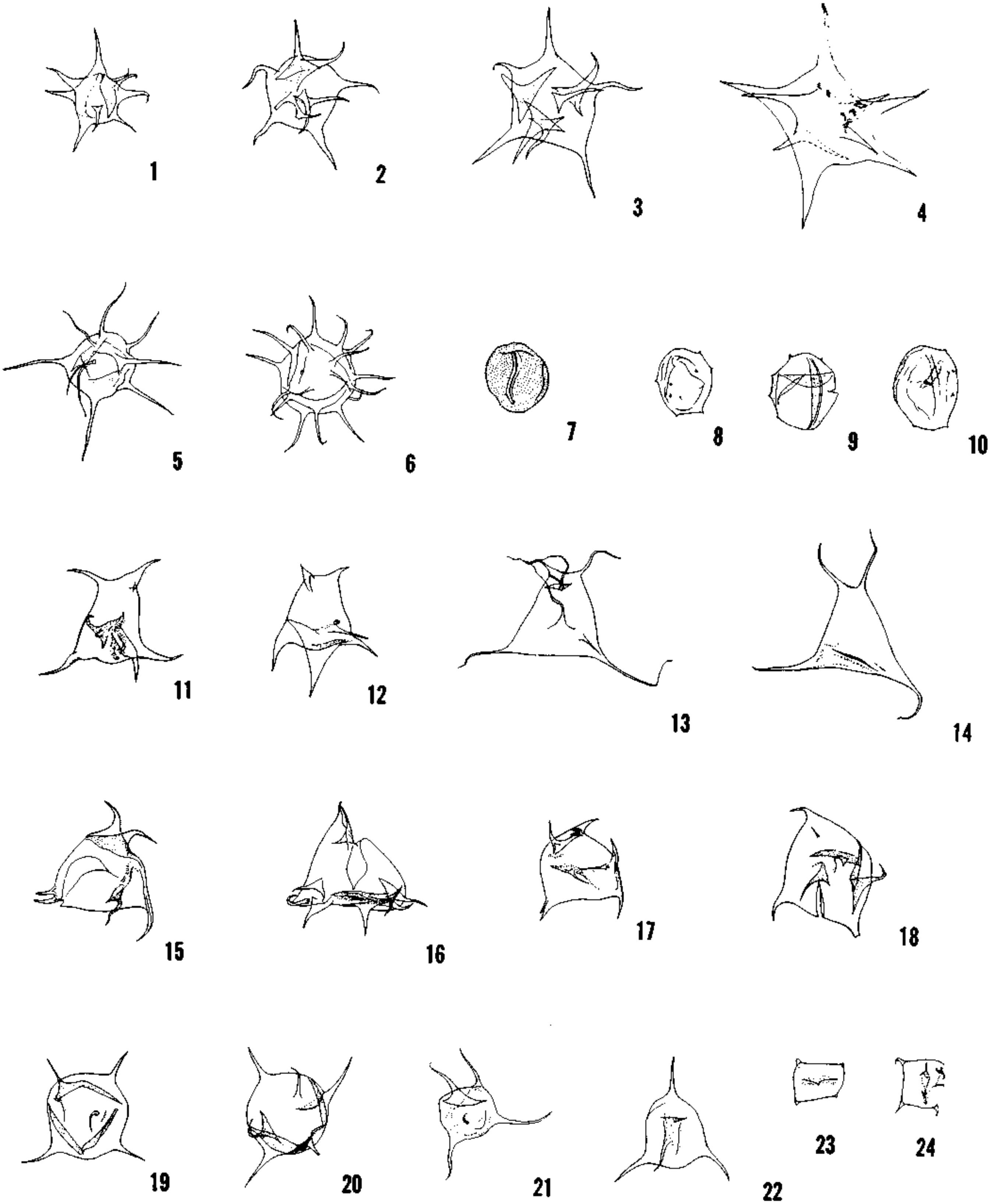
7 *Micrhystridium deflandrei* Valensi
"Capricornus"-beds, Robin Hoods Bay, Yorkshire.

8–10 *Micrhystridium minutispinum* Wall, n. sp.
8, holotype, Three Tiers, Dorset (Prep. C9/1/2); 9–10, paratypes.

11–14 *Veryhachium collectum* Wall, n. sp.
11, Holotype, Green Ammonite Beds, Golden Cap, Dorset (Prep. O1/3/4); 12–13, paratypes; 14, Eype Clay, Eypemouth, Dorset.

15–18 *Veryhachium dualispinum* Wall, n. sp.
15, holotype, Three Tiers, Golden Cap, Dorset (Prep. C9/1/2); 16, paratype; 17–18, Junction Bed, Watton Cliff, Sample DC/6.

19–24 *Veryhachium? irregulare* Jekhowsky
19–22, Blue Lias, Lyme Regis, Dorset; 23, forma *quadratum* n. f., Three Tiers, Dorset (Prep. C9/1/2); 24, paratype.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morphitae (*Veryhachium*) and Netromorphitae (*Leiofusa, Metaleiofusa, Domasia,* and *Cantulodinium*) appear to have favoured the open-sea environment.

Wherever palaeogeographical data (lithological, faunal, and palynological) indicated the existence of an inshore, basinal environment, populations were found to be dominated by the morphologically comparable acanthomorphitids *Micrhystridium stellatum, M. fragile, M. recurvatum, M. deflandrei, M. lymensis,* or *Baltisphaeridium debilispinum.* In a more refined sense, it appears that forms with long spines (*M. fragile, M. lymensis*) favoured regions of quiet deposition, whereas those with very reduced spines (*M. deflandrei*) were more tolerant of turbulent conditions associated with sandstone deposition. The latter species, for example, was most abundant in the Down Cliff Sands of Dorset and the sandy beds of the Gloucestershire Domerian. This is a pattern of distribution analogous to that described around reef environments in the Devonian of Alberta by Staplin (1961).

Stratigraphic changes in Liassic microplankton populations can be related to the onset and progression of Hettangian, Sinemurian, Pliensbachian, and Toarcian cycles of sedimentation. Initiation and later development of each cycle created a series of changing environments to which the plankton apparently responded (Table 7). During the early phase of each cycle, fossil microplankton populations tended to be uniform in composition and dominated by acanthomorphitid acritarchs. Production of plankton, however, varied between the two extremes of abundance and paucity. It accumulated when relative deepening of depositional basins took place, temporarily aiding the genesis of bituminous strata (Hallam, 1961, p. 152; Bitterli, 1963, p. 199); ecological conditions were probably a combination of intermittently good growing conditions in a physically adverse environment such as favours reduction in diversity of Recent phytoplankton populations (Hulburt, 1963, p. 81).

Succeeding transgressive phases of the cycles (in particular that of the late Carixian in the Dorset Pliensbachian) created more open-sea conditions wherein marl and silty clay facies were accumulated. Their microplankton was richer in species and included a greater proportion of polygonomorphitid and netromorphitid acritarchs as well as some morphologically ornate forms. The final regressive phases of the cycles, noticeably the period when coarser sediments were laid down in the British region, again saw reduction in the diversity and abundance of microplankton.

PLATE 4

1–5 *Veryhachium europaeum* Stockmans and Williere
1, f. *europaeum*, "Capricornus"-beds, Robin Hoods Bay; 2, f. 1 Wall and Downie, Three Tiers, Golden Cap, Dorset; 3–5, f. *nervosum* Wall, n. f., Three Tiers, Dorset: 4, type specimen.

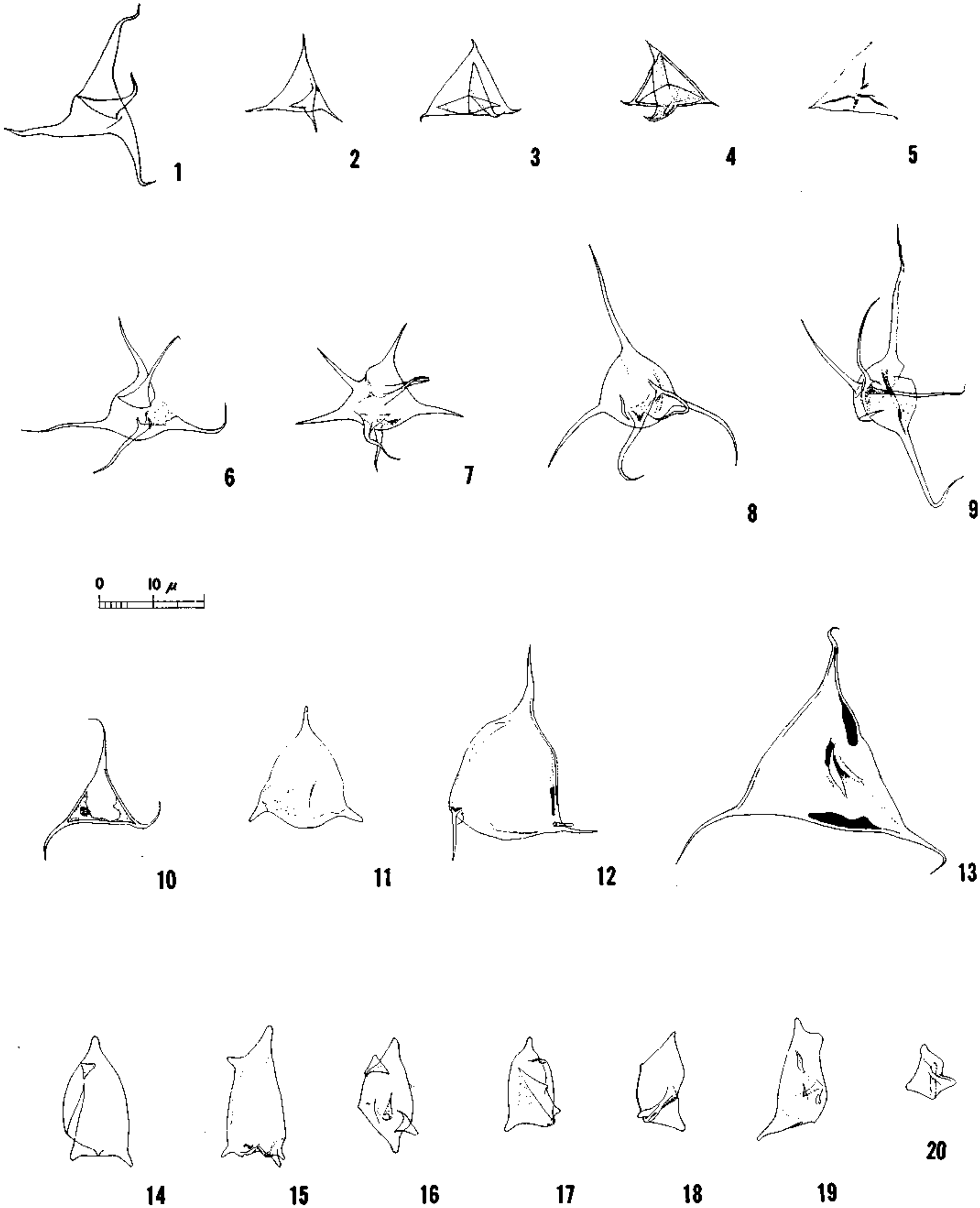
6–7 *Veryhachium formosum* Stockmans and Williere
6, f. *formosum*, Black Ven Marls, Charmouth, Dorset; 7, forma 2 Wall and Downie, Black Ven Marls, Dorset.

8–9 *Veryhachium formosum* Stockmans and Williere f. *ancorastrum* Wall, n. f.
8, type specimen, Blue Lias, Lyme Regis (Prep. K2/2/2); 9, paratype.

10–11 *Veryhachium reductum* (Deunff) Jekhowsky
10, f. *trispinoides* Jekhowsky, Junction Bed, Watton Cliff; 11, f. *breve* Jekhowsky, Green Ammonite Beds, Golden Cap.

12–13 *Veryhachium* sp. cf. *V. trispinosum* Eisenack
12, Three Tiers, Golden Cap, Dorset; 13, Eype Clay, Eypemouth, Dorset.

14–20 *Cantulodinium protuberatum* Wall, n. sp.
15, holotype, Three Tiers, Golden Cap, Dorset (Prep. C9/1/4); 14, 17–20, paratypes; 16, Green Ammonite Beds, Golden Cap, Dorset.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Assemblages from the lower Sinemurian section of the Frodingham Ironstone at Scunthorpe were intermediate in composition between populations observed in equivalent and younger Pliensbachian strata in Dorset. That is, the Ironstone population showed a tendency toward domination by acanthomorphitids (70 percent of the cells) but also included smaller numbers of species believed to be more typical of open-sea conditions. This is in agreement with the environmental interpretation of an offshore, marine shoal suggested by Hallam (1963*b*).

The relationship between fossil and living dinoflagellates in more recent times is certainly complex. But again, dinoflagellates were found to be restricted to dark shale facies in the British Rhaetic (*Dapcodinium priscum*, *Gonyaulax rhaetica*) and lower Toarcian (*Nannoceratopsis gracilis*), and the two species of *Hystrichosphaeridium* recorded here were found only in bituminous strata of the Dorset Hettangian and lower Sinemurian. Also, *Tasmanites* species, although not restricted to black shale facies, were certainly most abundant in them. Clearly the distribution of these dinoflagellates and leiospheres was facies-controlled.

CONCLUSIONS

The British Liassic microplankton comprises a large number of small acritarchs and a few species of leiospheres and dinoflagellates. Abundant pollen grains and spores occur together with the plankton, predominantly *Classopollis*, araucarian and bisaccate pollen, inaperturate palynomorphs, and a variety of trilete spores including *Calamospora*. Almost all of these resemble palynomorphs previously described from elsewhere in the Lias.

The stratigraphic distribution of both microplankton and pollen-spore associations is ecologically determined. Major stratigraphic changes are coincident with the Pliensbachian transgression and a marked facies change in the lower Toarcian. Pronounced domination of both microplankton populations and pollen-spore associations is encountered and is believed to be significant palaeoecologically, reduction in diversity of species being related to accumulation in an inshore, basinal environment. In the case of land-derived pollen, this phenomenon is due to close proximity to an almost homogeneous coastal vegetation, whereas in the case of microplankton populations, reduction in the diver-

PLATE 5

1–3 *Domasia liassica* Wall, n. sp.
1, Eype Clay, Eypemouth, Dorset; 2, paratype, Green Ammonite Beds, Golden Cap; 3, holotype, Green Ammonite Beds (Prep. O1/3/4).

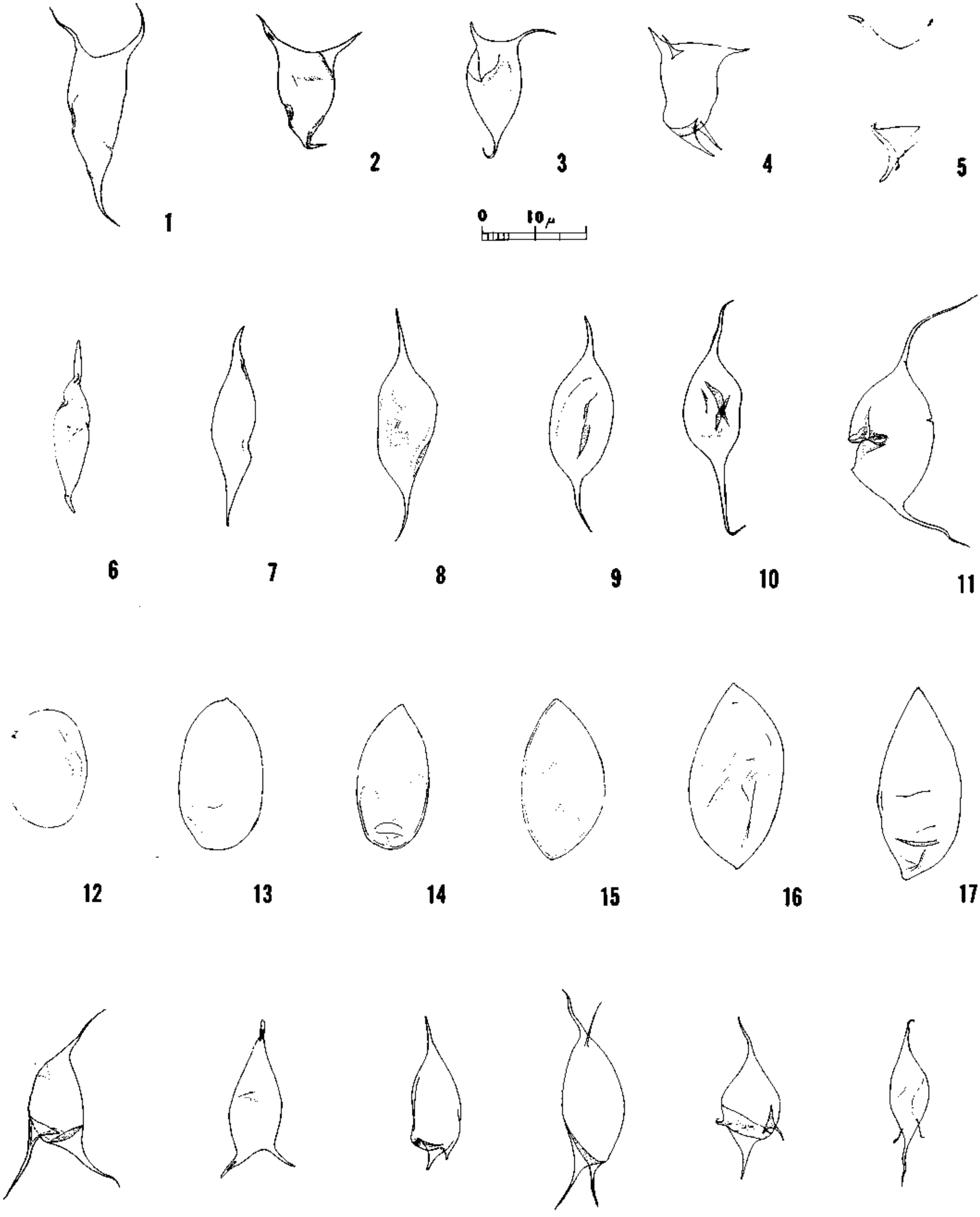
4–5 *Veryhachium?* sp.
4, Eype Clay, Eypemouth; 5, Three Tiers, Golden Cap, Dorset.

6–11 *Leiofusa jurassica* Cookson and Eisenack
6–7, 9–10, Green Ammonite Beds, Golden Cap; 8, Eype Clay, Eypemouth; 11, Three Tiers, Golden Cap, Dorset.

12–17 *Leiofusa spicata* Wall, n. sp.
15, holotype, Green Ammonite Beds, Dorset (Prep. O1/3/3); 12–14, 16–17, paratypes.

18–20 *Metaleiofusa arcuata* Wall, n. gen., n. sp.
18, holotype, Three Tiers, Golden Cap (Prep. C9/1/2); 19, form transitional to *Domasia liassica*, Appleby-Frodingham Bore M. 103, depth 150 ft.; 20, Eype Clay, Eypemouth.

21–23 *Metaleiofusa diagonalis* Wall, n. gen., n. sp.
21, paratype, Eype Clay; 22, holotype, Eype Clay, Eypemouth (Prep. P1/2/2); 23, Three Tiers, Golden Cap, Dorset.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sity of the assemblage is probably related to the partly unfavourable physical conditions existing in a partly enclosed, inshore basin of deposition.

ACKNOWLEDGMENTS

The author expresses his gratitude to Dr. Charles Downie for proposing and supervising the original research. Thanks are also due to Professor L. R. Moore and the Technical Staff of the Department of Geology, The University, Sheffield, for the use of facilities and to Professor P. C. Sylvester-Bradley and Mr. D. A. E. Spalding for supplying samples and data. The research was conducted at Sheffield under tenure of a Shell International Oil Company Grant.

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PLATE 6

1 *Cymatiosphaera eupeplos* Valensi
Down Cliff Clay, Watton Cliff, Dorset; overall size 18μ.

2–3 *Cymatiosphaera bleawykensis* Wall, n. sp.
2, holotype, Down Cliff Clay, Watton Cliff (Prep. DC/8/4); central body 8μ; 3, Yellow Sands with *Dumortiera* sp., Blea Wyke, Yorkshire; central body 9μ.

4–5 *Cymatiosphaera* sp. cf. *C. stigmata* Cookson and Eisenack
4, Down Cliff Clay, Watton Cliff, overall size 64μ; 5, enlarged drawing of polygonal areas, each *ca.* 8μ across.

6 *Cymatiosphaera* sp. cf. *C. areolatum* Deflandre
Blue Lias, Lyme Regis; optical view of specimen with "cell contents"; the surface has a reticulum with areas 3μ across; overall size 29μ.

7 *Cymatiosphaera* sp. A
Down Cliff Clay, Watton Cliff; central body 26μ.

8 *Cymatiosphaera* sp. D
Blue Lias, Lyme Regis; overall size *ca.* 100μ.

9–11 *Hystrichosphaeridium langi* Wall, n. sp.
9, holotype, Blue Lias, Lyme Regis (Prep. K1/2/3); test 24μ; 10–11, Blue Lias, Lyme Regis, sample K2/2; same magnification.

12–13 *Nannoceratopsis gracilis* (Alberti) Evitt
12, Appleby-Frodingham Bore M. 103, depth 95 ft.; size 86μ; 13, Hard Shales (*H. falcifer* Zone), Ravenscar, Yorkshire; size 46μ.

14 *Pterospermopsis* sp. cf. *P. helios* Sarjeant
Bituminous Shales, Ravenscar, Yorkshire; size 24μ.

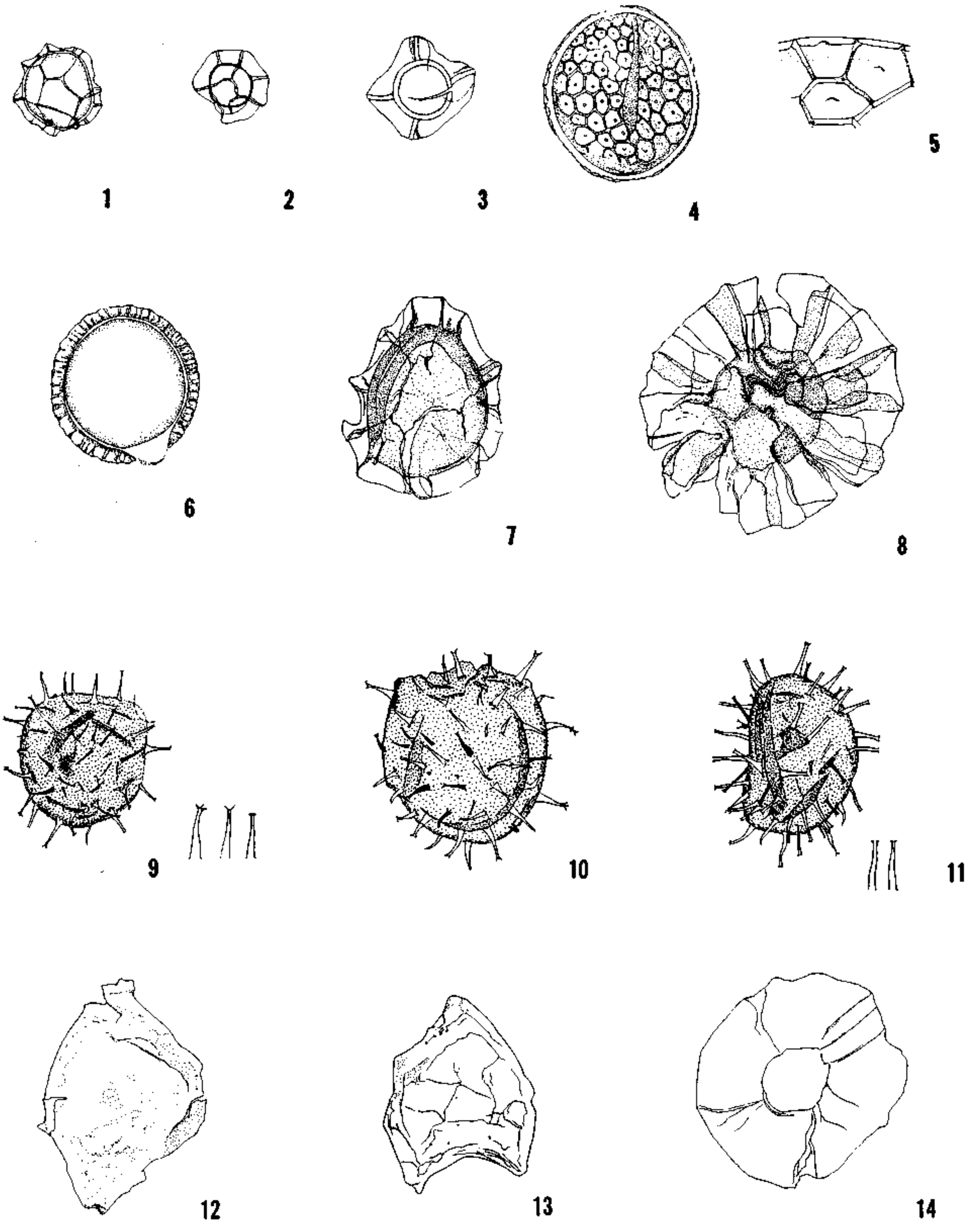
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PLATE 7

All figures × 1000, oil immersion; figures 2, 5, 12, 14, bright field; other phase contrast.

1 *Baltisphaeridium diversispinosum* Wall, n. sp.
Holotype, Green Ammonite Beds, Dorset (Prep. O1/3/3).

2 *Baltisphaeridium micropunctatum* Wall, n. sp.
Paratype, Junction Bed, Watton Cliff, Dorset.

3 *Baltisphaeridium infulatum* var. *infulatum* Wall, n. sp., n. var.
Holotype, Three Tiers, Dorset (Prep. C9/1/2).

4 *Baltisphaeridium debilispinum* Wall and Downie
Belemnite Marls, Dorset.

5 *Baltisphaeridium debilispinum* var. *brevispinosum* (Sarjeant) Wall, n. comb.
Type specimen, Blue Lias, Lyme Regis, Dorset.

6 *Baltisphaeridium delicatum* Wall, n. sp.
Paratype, Blue Lias, Lyme Regis, Dorset.

7 *Micrhystridium clavatispinum* Wall, n. sp.
Holotype, Three Tiers, Dorset (Prep. C9/1/4).

8 *Baltisphaeridium eypensis* Wall, n. sp.
Holotype, Down Cliff Sands, Seatown, Dorset (Prep. P1/5/2).

9 *Micrhystridium intromittum* var. *intromittum* Wall, n. sp., n. var.
Holotype, Three Tiers, Dorset (Prep. C9/1/4).

10 *Micrhystridium intromittum* var. *transitorium* Wall, n. sp., n. var.
Type specimen, Blue Lias, Lyme Regis (Prep. K1/3/2).

11 *Micrhystridium wattonensis* Wall, n. sp.
Holotype, Watton Cliff, Dorset (Prep. DC/8/3).

12 *Micrhystridium minutispinum* Wall, n. sp.
Holotype, Three Tiers, Dorset (Prep. C9/1/2).

13 *Micrhystridium deflandrei* Valensi
Three Tiers, Golden Cap, Dorset.

14 *Veryhachium? irregulare* Jekhowsky f. *quadratum* Wall, n. f.
Type specimen, Three Tiers, Dorset (Prep. C9/1/2).

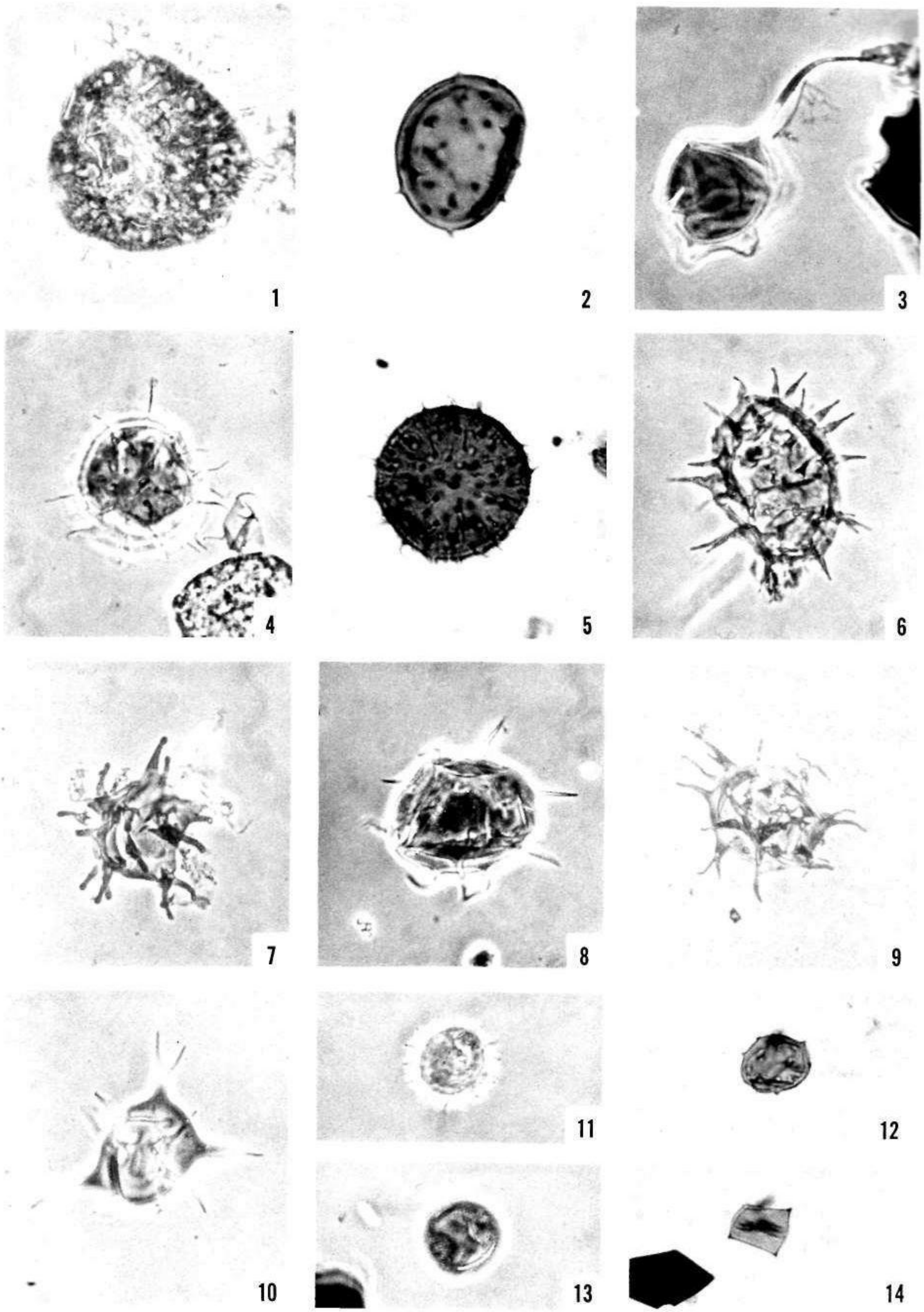
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PLATE 8

All figures × 1000, oil immersion; figure 7, bright field; others phase contrast.

1 *Micrhystridium lymensis* var. *rigidum* Wall, n. sp., n. var.
Type specimen, Blue Lias, Lyme Regis (Prep. K1/3/2).

2 *Micrhystridium lymensis* var. *gliscum* Wall, n. sp., n. var.
Paratype.

3 *Micrhystridium lymensis* var. *lymensis* Wall, n. sp., n. var.
Holotype, Blue Lias, Lyme Regis (Prep. K1/3/2).

4 *Micrhystridium exilium* Wall, n. sp.
Junction Bed, Watton Cliff, Dorset.

5 *Veryhachium formosum* Stockmans and Williere f. *ancorastrum* Wall, n. f.
Type specimen, Blue Lias, Lyme Regis (Prep. K2/2/2).

6 *Veryhachium collectum* Wall, n. sp.
Holotype, Green Ammonite Beds, Golden Cap (Prep. O1/3/4).

7 *Veryhachium dualispinum* Wall, n. sp.
Holotype, Three Tiers, Golden Cap (Prep. C9/1/2).

8 *Cantulodinium protuberatum* Wall, n. sp.
Holotype, Three Tiers, Golden Cap (Prep. C9/1/4).

9 *Domasia liassica* Wall, n. sp.
Holotype, Green Ammonite Beds, Golden Cap (Prep. O1/3/4).

10 *Leiofusa jurassica* Cookson and Eisenack
Green Ammonite Beds, Golden Cap, Dorset.

11–14 *Leiofusa spicata* Wall, n. sp.
12, holotype, Green Ammonite Beds, Dorset (Prep. O1/3/3); 11, 13–14, paratypes.

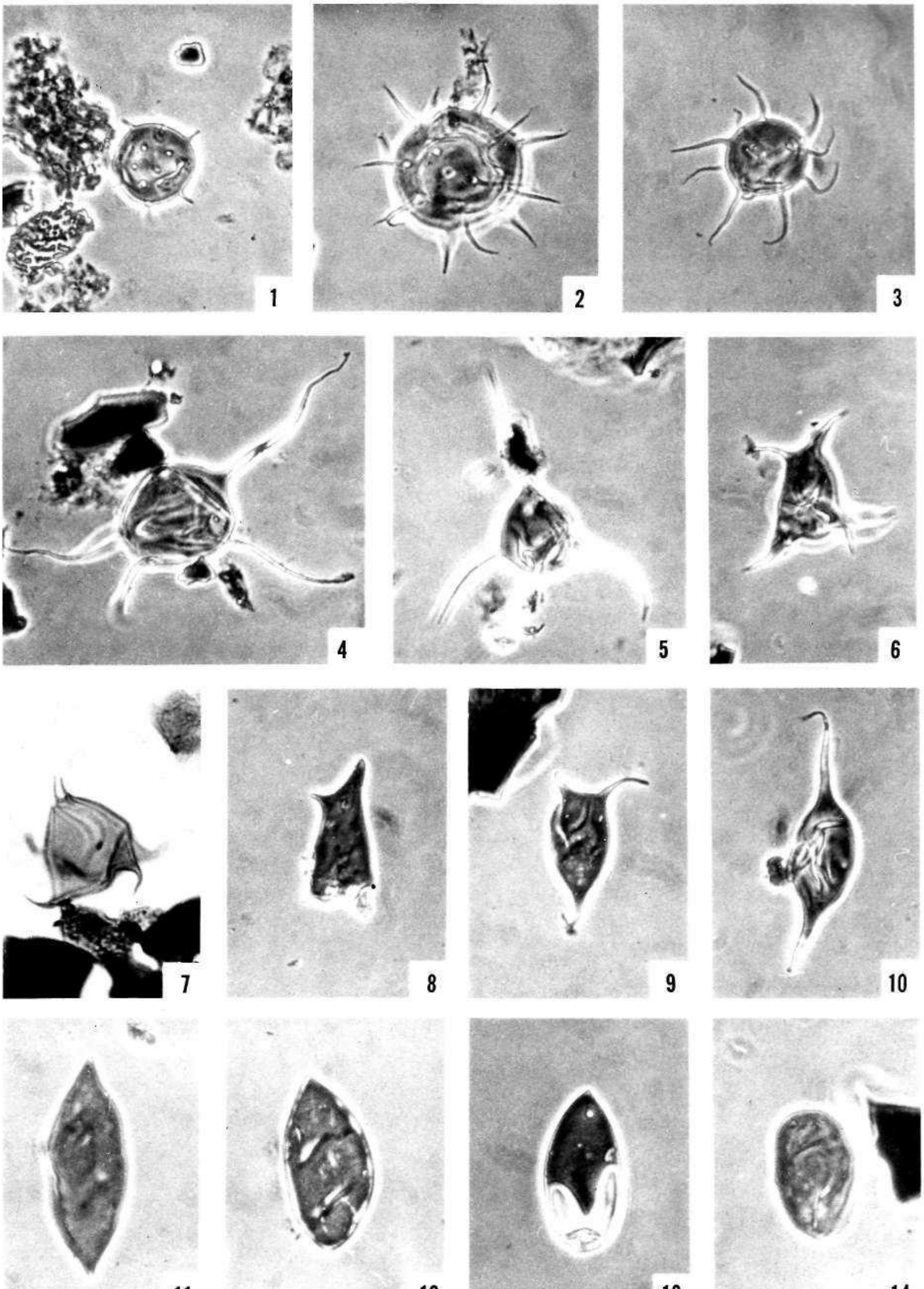
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PLATE 9

All figures × 1000 unless otherwise stated; figures 5, 8, and 11–13, bright field; others phase contrast.

1–2 *Metaleiofusa arcuata* Wall, n. gen., n. sp.
1, holotype, Three Tiers, Golden Cap (Prep. C9/1/2); 2, Green Ammonite Beds, Golden Cap, Dorset.

3 *Metaleiofusa diagonalis* Wall, n. gen., n. sp.
Holotype, Eype Clay, Eypemouth (Prep. P1/2/2).

4 *Hystrichosphaeridium caminuspinum* Wall, n. sp.
Holotype, Shales-with-Beef, Charmouth, Dorset (Prep. L1/6/2).

5 *Cymatiosphaera* sp. A
Type specimen, Down Cliff Clay, Watton Cliff, Dorset.

6 *Cymatiosphaera* sp. C
Type specimen, Black Ven Marls, Charmouth (Prep. M1/2/2).

7 *Cymatiosphaera* sp. D
Type specimen, Blue Lias, Lyme Regis, × 250.

8 *Cymatiosphaera* sp. B
Type specimen, Down Cliff Clay, Watton Cliff (Prep. DC/8/4), × 675.

9 *Hystrichosphaeridium langi* Wall, n. sp.
Holotype, Blue Lias, Lyme Regis (Prep. K1/2/3).

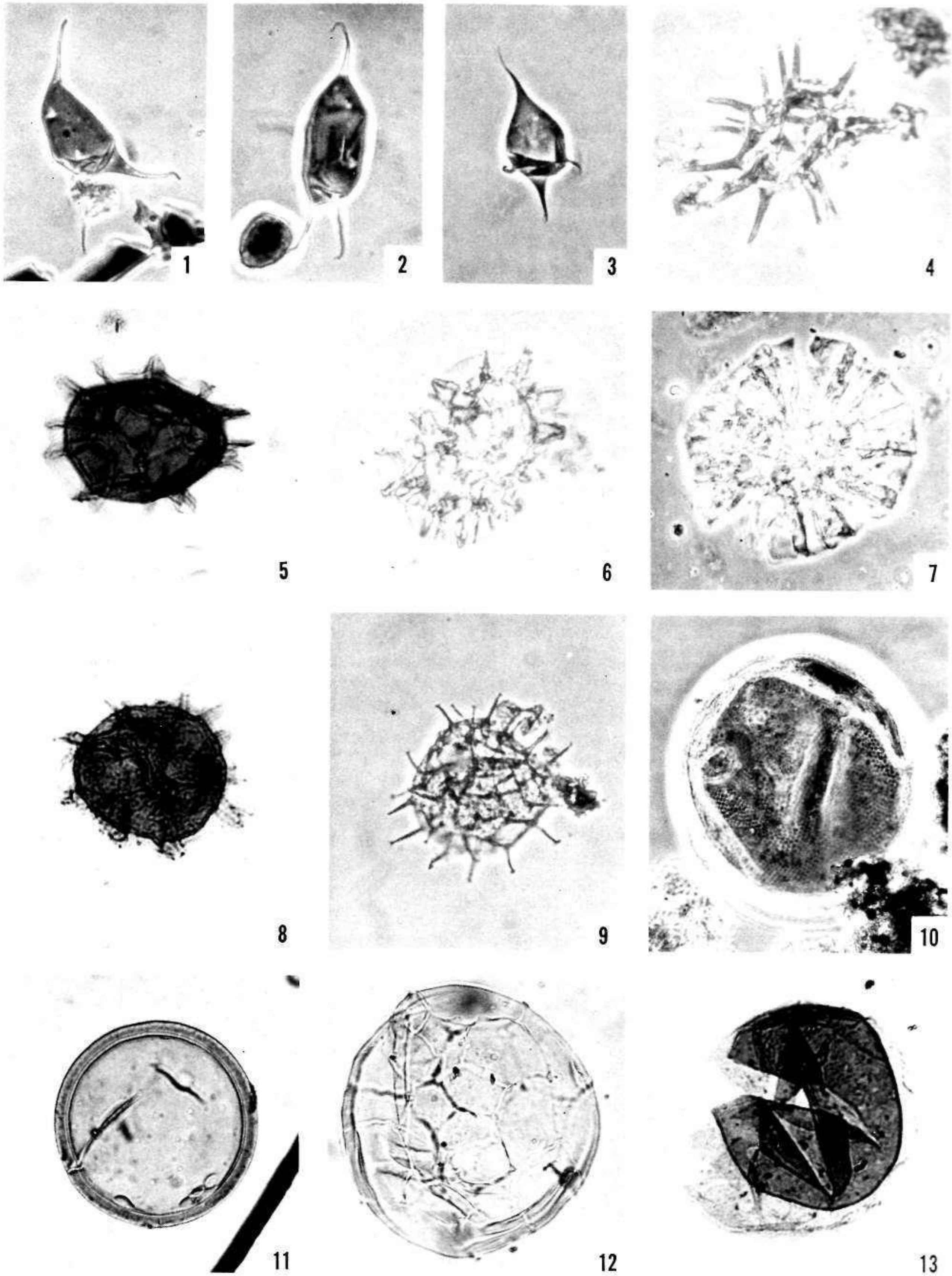
10 *Crassosphaera hexagonalis* Wall, n. sp.
Holotype, Jet Rock, Port Mulgrave, Yorkshire (Prep. W11/1/T1), × *ca.* 325.

11 *Tasmanites newtoni* Wall, n. sp.
Holotype, Blue Lias, Lyme Regis (Prep. K1/4/T3), × *ca.* 235.

12 *Cymatiosphaera* sp. cf. *C. pachytheca* Eisenack
Blue Lias, Lyme Regis, × *ca.* 450.

13 *Concentrisporites hallei* (Nilsson), n. comb.
Frodingham Ironstone, Scunthorpe, Lincolnshire.

PLATE 9



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