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# Carboniferous Miospores of Western Europe: illustration and zonation

## REPORT OF COMMISSION INTERNATIONALE DE MICROFLORE DU PALÉOZOÏQUE WORKING GROUP ON CARBONIFEROUS STRATIGRAPHICAL PALYNOLOGY

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ABSTRACT

This report which is the result of a collective study by members of the Commission Internationale de Microflore du Paleozoïque Working Group on Carboniferous Stratigraphical Palynology synthesises all the data that is available from the Carboniferous deposits of Western Europe in the formulation of a unified zonal scheme for these deposits. A scheme of 24 zones is proposed extending from the uppermost Devonian to the lowermost Permian, each illustrated with a selection of characteristic palynomorphs.

## 1. INTRODUCTION

It is appropriate that the twentieth year of the existence of the Commission Internationale de Microflore du Paléozoïque should be marked by the publication of a report which clearly reflects the organisation's framework of small working groups independently investigating specific palynological problems.

From the inaugural meeting of the C.I.M.P. at the time of the 4th International Congress of Carboniferous Stratigraphy and Geology at Heerlen in 1958, one of the principal aims of the Commission has been to initiate detailed investigations into the taxonomy of Palaeozoic palynomorphs with the objective of establishing a greater standardisation of taxa used in biostratigraphy. Several generic groups have already been studied and the results published in a monographic format in several parts of the C.I.M.P. Atlas, other generic groups have been studied and the detailed conclusions documented in various scientific journals, whilst a third group are still being investigated.

In addition to this primary interest in generic taxonomic revisions, the Commission has always fostered advancement of knowledge in stratigraphic palynology by the establishment of working groups dealing with particular stratigraphic intervals. The activities of these stratigraphic working groups have been cumulative over the years leading to the formulation of internationally acceptable zonal schemes for particular parts of the stratigraphical column. This is especially true in the case of the Carboniferous where members of the working group have had considerable success through the organisation of special symposia, in reaching agreement and acceptance of individually researched zonal schemes for particular series on a wider international basis.

During the last ten years, the members of the working group on Carboniferous stratigraphical palynology have, sometimes working independently and sometimes collectively in small groups, produced a number of zonal schemes for particular stages which now enable a composite scheme to be proposed which would appear to be applicable over much of western Europe. The scheme which is summarised diagrammatically on Enclosure 2 proposes a system of zonation which extends from the uppermost Devonian to the lowermost Permian. It is the result of two years' intensive cooperation between the authors and palynological colleagues in both western and central Europe and the U.S.S.R. An indication of the extent of this cooperation is given on Enclosure 1 where the stratigraphic range and geographical location of the data incorporated in this report is documented.

It is accepted that the formulation of this extensive zonal scheme may be subject to minor revision as more detailed information becomes available for particular parts of the system but it is hoped these revisions will be possible within the proposed framework.

The purpose of this report is to provide a guide for palynologists to the more diagnostic and characteristic components of the assemblages of each of the zones. Whilst it will provide an initial aid to establishing biostratigraphical conclusions, it is in no way designed to replace the detailed publications on the individual schemes of zonation mentioned in the text to which reference must ultimately be made.

The commonly diverse nature of all Carboniferous miospore assemblages clearly presents certain limiting factors in the selection of forms illustrated in this report. It has therefore been necessary in the illustrations to choose the more characteristic species. In some cases, species which are also components of adjacent zones have not been included in one particular plate in order to avoid repetition. Reference should therefore be constantly made to the descriptive text and the chart showing the stratigraphic distribution of the miospore species when using this report.

## 2. ACKNOWLEDGEMENTS

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"Mededelingen Rijks Geologische Dienst". In this context we would like to memorize that it is this year fifty years ago, that the Geological Survey of the Netherlands organized the first international congress on Carboniferous Geology and Stratigraphy at Heerlen.

## 3. PALYNOLOGICAL BIOSTRATIGRAPHY OF THE CARBONIFEROUS OF WESTERN EUROPE

The Carboniferous rocks of western Europe are widespread in their distribution and are divisible on lithological criteria into two groups which correspond with the two subsystems Dinantian and Silesian. The Dinantian subsystem being largely marine in character is divisible into two series, the Tournaisian and Visean. The overlying Silesian is, on the other hand, largely paralic or continental in character and is divisible into four series. The lower two, the Namurian and Westphalian are largely subcontinental (deltaic and paralic) whilst the upper two, the Stephanian and Autunian are more typically continental with occasional limnic developments. This classification is now widely accepted and is the result of decisions originally taken at the 2nd International Congress of Carboniferous Stratigraphy and Geology (Heerlen, 1935) and subsequent emendations ratified by the Subcommission on Carboniferous Stratigraphy which was established in Sheffield in 1965.

The definition and subdivision of the various stages of both the Dinantian and Silesian subsystems of the Carboniferous is based on biostratigraphical criteria. The nature of these criteria varies according to the series involved, foraminifera, coral-brachiopods and conodonts being applied in the Tournaisian and Visean, goniatites and conodonts in the Namurian, goniatites and non-marine bivalves in the Westphalian and plants in the Stephanian and Autunian. The only exception to this situation is the utilisation of certain lithological criteria, i.e. tonsteins, in the upper part of the Westphalian. It is against this framework that attempts towards a palynological zonation of the Carboniferous have been established.

The basic stratigraphic framework of each series is outlined below and the distribution of the proposed palynological zonation is briefly summarised.

### *3.1. DINANTIAN*

This subsystem is divisible into two series, namely the Tournaisian and the Visean which are each in turn divisible mainly on biostratigraphic criteria into three parts referred to in ascending stratigraphical order as Tn1, Tn2, Tn3, V1, V2, V3.

The lower boundary of the Tournaisian has been traditionally defined in the Dinant Basin of Belgium and northern France and not in type area around Tournai in the Namur Basin where palynological studies have demonstrated that the lowermost part of the Tournaisian is not present (STREEL 1966, pp. 90-91; AUSTIN, CONIL *et al.* 1971, text fig. 2). As a result of palaeontological investigations, two possible interpretations have emerged for the base of the Carboniferous denpending on the significance accorded to the "Etroeungt zone" (GOSSELET 1857). The oldest interpretation which was utilised on the nineteenth century geological map of Belgium was to place the base of the Carboniferous in the lower part of the Calcaire d'Hastiere in the Dinant area and to subdivide the Tournaisian sequence into two; T1 and T2. Since the work of MAILLEUX & DEMANET (1928) however, the "Zone d'Etroeungt" has been incorporated in the Tournaisian as the lowest division of Tn1 (i.e. Tn1a, sometimes informally referred to as the "Strunian"). Studies carried out in recent years suggest that the lower limit of Tn1a is generally marked by the first appearance of the foraminifera *Quasiendothyra kobeitusana* (RAUSER-TCHERN) despite the fact that this widely accepted guide fossil occurs some 25 metres below the lowest accepted limit of the Calcaire d'Etroeungt in the parastratotype section at Avesnelles in northern France (see AUSTIN, CONIL *et al.* 1971, text fig. 3). Alternatively since the 2nd International Congress of Carboniferous Stratigraphy and Geology (Heerlen, 1935), stratigraphers working with pelagic faunas have placed the base of the Carboniferous at the base of the Hangenberg Kalk in the type section of Oberrödinghausen in Western Germany which coincides with the first appearance of the goniatite *Gattendorfia subinvoluta* MÜNSTER. This boundary would appear, following comparative studies of conodont and spore assemblages (PAPROTH & STREEL 1971), to have been placed very near to the base of the originally defined Tournaisian (T1), that is within the lower part of Tn1b (the lower part of the Calcaire d'Hastiere in the Dinant Basin). Most stratigraphers now accept this boundary as the base of the Carboniferous although it implies that the lowest part of the Tournaisian Series (Tn1a) occurs below the base of the system.

Re-examination and reappraisal of Dinantian successions on a regional basis during the last ten years has led to proposals for schemes of regional stages. Since some confusion still exists in the interrelationships of these different stage names in the lower part of the Tournaisian (i.e. Courceyan in the British Isles (GEORGE *et al.* 1976), Balvian or CuI in Germany (H. SCHMIDT 1972) and Hastarian or TI in the Franco-Belgian area (CONIL, GROESSENS & PIRLET 1977)) they are not utilised in this report.

The base of the middle Tournaisian has been traditionally taken at the base of a ten metres' thick shale horizon (the so-called *Spiriferellina peracuta* Schistes) which is widespread throughout the Dinant and Namur Basins where it has been formally named Formation de Pont d'Arcole (GROESSENS

1974). These shales are generally considered to be a lateral equivalent of the "Liegende Alaunschiefer" which in Western Germany yields a conodont fauna containing "advanced" *Siphonodella* (*S. crenulata* (COOPER)).

The lower limit of Tn2 has so far yielded little diagnostic micro-palaeontological data, a fact that has led CONIL, GROESSENS & PIRLET (1977) to move the base of their second new Tournaisian regional stage in Belgium (the Ivorian, TII) to the base of the former Tn3. The limit to this new stage is accuralety defined by conodont evidence, coinciding with the base of the *carina* Zone (Cc2).

The development of a carbonate facies in the upper part of the Tournaisian and throughout the Visean in Belgium prevents the extraction of miospores from that part of the Dinantian and necessitates total reliance on conodont and foraminiferal evidence for establishing the biostratigraphy.

In Britain during late Tournaisian and Visean times, two main areas of deposition were represented. A persistent calcareous facies was developed over much of England and Wales whereas in the Midland Valley of Scotland and the Northumberland Through during the same period a non-marine sequence with only periodic marine horizons was developed. The successions in the calcareous facies proved unsuitable for palynological study but their rich macrofaunas and microfaunas have provided a means for biostratigraphical subdivision. The original coral-brachiopod zonation scheme proposed by VAUGHAN (1905-1906) for the classic Avon Gorge succession has now been replaced by GEORGE *et al.* (1976) with a series of regional stages, the Courceyan for the Tournaisian, and the uppermost Courceyan, Chadian, Arundian, Holkerian, Asbian and Brigantian for the Visean. The non-marine sequence developed in the Midland Valley of Scotland which proved less satisfactory for macrofaunal and microfaunal studies than the English and Welsh calcareous successions, has been successfully investigated from the palynological point of view. NEVES *et al.* (1972, 1973) have established a series of six concurrent miospore assemblage zones in this Scottish sequence. The precise relationships between this series of concurrent miospore assemblage range zones and the regional stages proposed by GEORGE *et al.* have been provisionally inferred but await detailed substantiation.

### *3.1.1. MIOSPORE ZONES OF UPPERMOST FAMENNIAN AND LOWER-MIDDLE TOURNAISIAN AGE*

These zones have been defined by BOUCKAERT, STREEL & THOREZ (1968, 1969) [B.S.T.]* in the type area of the upper Famennian in the east of Belgium (Dinant Basin). The principal diagnostic species are illustrated in BOUCKAERT, STREEL, THOREZ & MOUND (1969) [B.S.T.M.]*, PAPROTH & STREEL (1971) and more particularly in BECKER, BLESS, STREEL & THOREZ (1974) [B.B.S.T.]*. The microfaunas which are the best known components present in this sedimentary interval are listed by THOREZ, STREEL, BOUCKAERT & BLESS (1977) [T.S. B.B.]* (see their text fig. 2).

#### *3.1.1.1. Grandisporia gracilis — Endosporites minutus* (GM) Zone

This zone corresponds to the upper part of Fa2a and Fa2b and may be equated with the *marginifera* and *velifera* zones of the independent conodont zonation. The base of Fa2b may be recognised by the appearance of *Grandispora microseta* (KEDO) STREEL in B.B.S.T. (1974) and *Hymenozonotriletes cassiculus* HIGGS (*Spelaeotriletes* sp. A in B.B.S.T., 1974). These two species are normally poorly represented in the assemblages which are dominated by *Aneurospora greggsii* (MCGREGOR) STREEL in B.B.S.T. (1974), a small form which is abundant throughout the Famennian, and to a lesser extent by *Auroraspora hyalina* (NAUMOVA) STREEL in B.B.S.T. (1974) (*Endosporites* gr. *minutus* in B.S.T. 1968) and *Grandispora gracilis* (KEDO) STREEL in B.B.S.T. (1974).

#### *3.1.1.2. Rugospora versabilis — Grandispora uncata* (VU) Zone

This zone is equivalent to Fa2c in the type region. The upper part of Fa2c is characterised by the appearance of conodonts of the *costatus* Zone, the base of which is however not known with certainty in this region. The base of this zone is defined by the appearance of *Grandispora cornuta* HIGGS (*G. uncata* in B.B.S.T. 1974) and *Rugospora flexuosa* (JUSCH) STREEL in B.B.S.T. (1974) (*Hymenozonotriletes famenensis* KEDO 1957a in PAPROTH & STREEL 1971). The appearance of *Raistrickia variabilis* DOLBY & NEVES is a little later than that of the two previously mentioned species. Whilst the species which are dominant components of the preceeding GM Zone are also abundant in the VU Zone they are frequently accompanied in this zone by an abundance of *Rugospora versabilis* (KEDO) STREEL in B.B.S.T. (1974).

*Endosporites* sp. A. in BALME & HASSELL (1962, pl. 5, fig. 5), a species characteristic of the Devonian-Carboniferous transition beds, appears infrequently in this zone. *Retusotriletes* sp. A in B.B.S.T. (1974) likewise appears in the VU Zone where it is a rare but very characteristic component of the

* For convenience the names of the following authors have been consistently abbreviated in this section as follows:— BOUCKAERT, STREEL & THOREZ 1968, 1969 (B.S.T.); BECKER, BLESS, STREEL & THOREZ 1974 (B.B.S.T.); BOUCKAERT, STREEL, THOREZ & MOUND 1969 (B.S.T.M); THOREZ, STREEL, BOUCKAERT & BLESS 1977 (T.S.B.B.).

assemblages. Representatives of *Hystricosporites* sp. aff. *H. multifurcatus* (WINSLOW) MORTIMER & CHALONER, a form distinguished by possessing a larger number of processes with squatter multifurcate terminations than *H. multifurcatus*, are also recorded in this zone (but not figured here).

### *3.1.1.3. Vallatisporites pusillites — Spelaeotriletes lepidophytus* (PL) Zone

This zone is equivalent to Fa2d and Tn1a in the type areas of these chronostratigraphic units i.e. the central and eastern parts of the Dinant Syncline in eastern Belgium and the Avesnois in that part of the Dinant syncline lying in the northern part of France respectively. It is also found in sediments equivalent to the lower part of Tn1b in other regions (Namur Basin and Sauerland).

This stratigraphical interval is characterised by conodonts of the *costatus* Zone and in the uppermost part by faunas containing *Protognathodus*. The foraminifera *Quasiendothyra kobeitusana* makes its appearance in the middle part of this interval whilst the cephalopod *Cymaclymenia euryomphyla* SCHINDEWOLF has been found in the upper part, straddling the boundary between Tn1a and Tn1b.

The base of the PL Zone is defined by the simultaneous appearance of *Spelaeotriletes lepidophytus* (KEDO) STREEL in B.B.S.T. (1974) and of *Vallatisporites pusillites* (KEDO) DOLBY & NEVES. *S. lepidophytus* becomes very abundant several metres above the point of its first appearance in the type section of Fa2d in eastern Belgium. It remains abundant in the Comblain au Pont beds as well as in the Hangenberg Shales in Sauerland. It however becomes less abundant in the Hangenberg Sandstones and in their probable lateral equivalent in Tournaisis (Namur Basin). In contrast *Vallatisporites pusillites* is only abundant in part of the Hangenberg Shales.

Deposits of Fa2d age are characterised by large representatives of *S. lepidophytus* with large lacunae on the distal surface which may often overlap the equator when folded in polar compression (STREEL 1966). *Grandispora echinata* HACQUEBARD appears in deposits of Tn1a age whilst *Corbulispora cancellata* (WALTZ) BHARADWAJ & VENKATACHALA is present in the Hangenberg Shales, the Hangenberg Sandstones and their probable lateral equivalents of basal Tn1b age.

Large numbers of reticulate spores, frequently in a poor state of preservation, appear in the Hangenberg Sandstones at a similar horizon as isolated examples of *Hymenozonotriletes explanatus* (LUBER) KEDO. The horizon of their appearance is approximately the same as that of the boundary between the lower and upper *Protognathodus* conodont faunas (ALBERTI *et al.* 1974).

The upper *Protognathodus* fauna contains *P. kuehni* ZIEGLER & LEUTERITZ which together with *Siphonodella sulcata* (HUDDLE) (absent in the Hangenberg Sandstones) is considered to mark the base of the Carboniferous (*sensu* Heerlen 1935).

The appearance of the numerous reticulate spores together with the isolated examples of *Hymenozonotriletes explanatus* is utilised to define the base of the *Dictyotriletes trivialis - Hymenozonotriletes explanatus* (TE) Zone. Poorly preserved assemblages of this zone are known in Sauerland (lowermost Tn1b: Devonian) whilst assemblages of good preservation are known in stratigraphically younger beds of definite Carboniferous age in Tournaisian (uppermost Tn1b and Tn2a). Figure 2 on Enclosure 1 shows the relationship between these zones in the different basins.

The TE Zone is however not adopted in the present work and the alternative *Verrucosisporites nitidus — Vallatisporites vallatus* (NV) Zone which was established in Britain, has been applied. CLAYTON *et al.* (1976) working in Eire have recognised two divisions to this zone which were established as subzones of the NV Zone. The lowest of these subzones, the *Spelaeotriletes lepidophytus — Verrucosisporites nitidus* (LN) Subzone has a clearly defined base but is established in a facies which does not allow accurate dating of the sediments to be achieved. Since the horizon at which the diagnostic species of the LN Subzone appear has not been recognised in Sauerland, it results in a situation where the base of the subzone cannot be fixed with precision with respect to the Devonian — Carboniferous boundary. It is however probable that it is situated in the uppermost Devonian, a position which is adopted in this report.

### *3.1.1.4. Verrucosisporites nitidus — Vallatisporites vallatus* (NV) Zone

Only the upper part of the preceeding PL Zone of the Franco-Belgian succession has been recognised in the British Isles with *Hymenozonotriletes explanatus* being noted in the uppermost part. The base of the NV Zone is defined by the first appearance of *Verrucosisporites nitidus* together with *Vallatisporites verrucosus* HACQUEBARD* and *Lophozonotriletes malevkensis* NAUMOVA in KEDO (1963).

In the South Munster Basin of southern Eire, CLAYTON *et al.* (1974) have distinguished the two subzones of the NV Zone, the lower LN Subzone and the upper *Vallatisporites vallatus — Retusotriletes incohatus* (VI) Subzone based on the dis-

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* *Vallatisporites vallatus*, one of the index species of the NV Zone was considered by NEVES *et al.* (1972) to be synonymous with *V. verrucosus*. The two taxa can however be distinguished by detailed examination of the ornament and have different stratigraphic ranges with *V. vallatus* occurring only in the highest strata assigned to the VI Subzone.

appearance of *Spelaeotriletes lepidophytus, Vallatisporites pusillites* and *Rugospora flexuosa* at the base of the VI Subzone. The greatly expanded succession in the South Munster Basin includes more than 2,000 metres of lower and middle Tournaisian sediments and the strata assigned to the LN Subzone would appear to be drastically reduced in thickness or absent elsewhere.

#### *3.1.1.4.1. Spelaeotriletes lepidophytus — Verrucosisporites nitidus* (LN) Subzone

Assemblages assigned to the LN Subzone are characteristically dominated by *S. lepidophytus* which often constitutes up to 30 per cent or more of the assemblages. Other taxa which typically occur in assemblages from this subzone include:— *Retusotriletes incohatus* SULLIVAN, *Verrucosisporites nitidus, Raistrickia macrura* (LUBER) DOLBY & NEVES, *R. variabilis, Dictyotriletes submarginatus* PLAYFORD, *Hymenozonotriletes commutatus* NAUMOVA, *Lophozonotriletes malevkensis, Vallatisporites pusillites, V. verrucosus, Auroraspora macra* SULLIVAN, *A. poljessica* (KEDO) STREEL, in B.B.S.T., *Discernisporites micromanifestus* (HACQUEBARD) SABRY & NEVES and *Rugospora flexuosa*. The upper part of the Old Head Sandstone Formation in the South Munster Basin is assigned to the LN Subzone.

#### *3.1.1.4.2. Vallatisporites vallatus — Retusotriletes incohatus* (VI) Subzone

The base of the VI Subzone is defined by the disappearance of *Spelaeotriletes lepidophytus* together with *Vallatisporites pusillites* and *Rugospora flexuosa*. The lowermost assemblages of the subzone are typically dominated by smooth acamerate spores such as *Punctatisporites irrasus* HACQUEBARD and *Retusotriletes incohatus. Lophozonotriletes cristifer* (LUBER) KEDO first appears immediately above the base of the subzone although it has been recorded from much older strata in Canada and the U.S.S.R.

VI Subzone assemblages are extremely varied in composition and are characterised by the presence of *Retusotriletes incohatus, R. triangulatus* (STREEL) STREEL, *Pulvinispora quasilabrata* HIGGS, *Verrucosisporites nitidus, Raistrickia corynoges* SULLIVAN, *Convolutispora* sp., *Corbulispora cancellata, Dictyotriletes submarginatus, Hymenozonotriletes explanatus, Knoxisporites literatus* (WALTZ) PLAYFORD, *Lophozonotriletes cristifer, L. malevkensis, L. raritubercularus* (LUBER) KEDO and *Latosporites* sp. *Dibolisporites distinctus* (CLAYTON) PLAYFORD appears first midway through the VI Subzone but is not common. *Spelaeotriletes balteatus* (PLAYFORD) HIGGS first appears near to the top of the subzone and is frequently abundant.

In the South Munster Basin, the Kinsale Formation is assigned to the VI Subzone, as are the upper part of the "Old Red Sandstone" and the lower part of the Porter's Gate Formation at Hook Head, Co. Wexford, and the lower part of the Lower Limestone Shales in the Mendips, S.W. Britain.

#### *3.1.1.5. Spelaeotriletes pretiosus — Raistrickia clavata* (PC) Zone

The PC Zone was first described by DOLBY (1971) from S.W. Britain as the *Vallatisporites vallatus* Zone and later by HIGGS (1975) from Hook Head, Co. Wexford, Eire as the "*Vallatisporites vallatus — Spelaeotriletes pretiosus* Assemblage" The base of the PC Zone is defined by the first appearance of *Spelaeotriletes pretiosus* (PLAYFORD) NEVES & BELT. *Granulatisporites microgranifer* IBRAHIM and *Raistrickia clavata* PLAYFORD also appear for the first time at this level, but do not occur frequently. Assemblages assigned to the PC Zone are characterised by:— *Punctatisporites irrasus, Retusotriletes incohatus, R.* sp. A. HIGGS 1975, *Apiculatisporis* sp., *Baculatisporites fusticulus* SULLIVAN, *Verrucosisporites nitidus, Dictyotriletes trivialis, Densosporites spitzbergensis* PLAYFORD, *Vallatisporites vallatus, V. verrucosus, Auroraspora macra, Discernisporites* sp. A SULLIVAN 1964, *Grandispora echinata, Rugospora polyptycha* NEVES & IOANNIDES.

The Courtmacsherry Formation, the upper part of the Porter's Gate Formation, and the upper part of the "Lower Limestone Shales" are assigned to the PC Zone in the South Munster Basin, at Hook Head, and in the Mendips respectively.

### *3.1.2. MIOSPORE ZONES OF THE UPPER TOURNAISIAN AND VISEAN*

#### *3.1.2.1. Schopfites claviger — Auroraspora macra* (CM) Zone

The miospore assemblages assigned to the CM Zone are characterised by containing representatives of the following association: *Pulvinispora scolecophora* NEVES & IOANNIDES, *Baculatisporites fusticulus, Verrucosisporites nitidus, Apiculiretusispora multiseta* (LUBER) BUTTERWORTH & SPINNER, *Dibolisporites distinctus, Raistrickia corynoges, Schopfites claviger* SULLIVAN, *Colatisporites decorus* (BHARADWAJ & VENKATACHALA) WILLIAMS, *Crassispora trychera* NEVES & IOANNIDES, *Auroraspora macra, Spelaeotriletes microspinosus* NEVES & IOANNIDES.

This zone and the succeeding zones of the Visean were established by NEVES *et al.* (1972, 1973) from successions in the Midland Valley of Scotland. The precise relationships between the CM Zone and the preceeding PC Zone of the South Munster Basin, Eire and south-western Britain still await detailed elucidation but many of the forms present in the CM Zone are also known in the PC Zone. The base of the CM Zone is marked by the appearance of

*Schopfites claviger*. Establishment of the relationship between the age of the CM Zone and the other schemes of biostratigraphical zonation is difficult in the Midland Valley of Scotland. There is however limited evidence of the occurrence of the late Tournaisian conodont faunas (AUSTIN *et al.* 1969) from sections containing CM Zone miospore assemblages in Northumberland, England. In southern Eire there is evidence from conodont studies to suggest that PC Zone miospore assemblages occur in sections which yield Tn2 - Tn3a-b conodont faunas, thus implying that the CM Zone is at least of Tn3c age.

### *3.1.2.2. Lycospora pusilla* (Pu) Zone

The lower limit of this zone is marked by the base of the biozone of *Lycospora pusilla* (IBRAHIM) SOMERS which also coincides with the base of the biozone of the genus *Lycospora*. All of the species listed previously as being characteristic of the CM Zone extend up into the Pu Zone. The assemblages from the two zones being distinguished only by the presence of *Lycospora pusilla* in the Pu Zone.

Continuous sections through the CM and Pu Zone haves been reported from the Cementstones Group in the Midland Valley of Scotland by NEVES *et al.* (1973) and NEVES & IOANNIDES (1974). These continuous sections are however commonly interrupted by a thick series of volcanic sediments and the boundary between the Pu Zone and the overlying *Perotrilites tesselatus — Schulzospora campyloptera* (TC) Zone is provisionally placed at the base of the volcanic sediments until a completely productive continuous section can be examined. In the Northumberland Trough, northern England, the Bewcastle Formation, Main Algal Formation and Cambeck Formation of the Lower Border Group and the lower part of the Middle Border Group are assigned to the Pu Zone. Several species including *Tholisporites? biannulatus* NEVES, *Knoxisporites stephanephorus* LOVE and *Vallatisporites ciliaris* (LUBER) SULLIVAN have been recorded from the Northumberland Trough assemblages which are absent in the Midland Valley of Scotland and may therefore imply these assemblages to be younger than those in Scotland.

The Pu Zone, as currently defined, encompasses the uppermost part of the Courceyan, Chadian, Arundian and at least part of the Holkerian regional stages in Britain as proposed by GEORGE *et al.* (1976).

BERTELSEN (1972) recorded assemblages from borehole material from the Island of Falster, Denmark which contained many elements in common with assemblages from the Pu Zone in Scotland and northern England. The Danish material was obtained from sections previously dated by MICHELSEN (1971) on foraminiferal evidence as being of V1 age.

### *3.1.2.3. Perotrilites tessellatus — Schulzospora campyloptera* (TC) Zone

The lower limit of the TC Zone is marked by the appearance of the genus *Schulzospora*. Other distinctive species which make their appearance in the lower part of the zone include *Chaetosphaerites pollenisimilis* (HORST) BUTTERWORTH & WILLIAMS, *Waltzispora planiangulata* SULLIVAN, *Verrucosisporites baccatus* STAPLIN, *Crassispora aculeata* NEVILLE and *Perotrilites tessellatus* (STAPLIN) NEVILLE. Spores of the genus *Densosporites* also become numerically important components of the assemblages for the first time.

The upper part of the TC Zone is marked by the incoming of several relatively short ranging species including *Apiculatisporis? porosus* WILLIAMS, *Tripartites distinctus* WILLIAMS, *Cribrosporites cribellatus* SULLIVAN, and *Potoniespores delicatus* PLAYFORD. The assemblage recorded by SMITH & BUTTERWORTH (1967, text fig. 24) from the Oakshaw Ford Coal at the base of the Upper Border Group and assigned by them to their *Grumosisporites verrucosus* Assemblage 1 falls within the lower part of the TC Zone.

The precise relationship between the TC Zone and the regional stages for the Dinanthian in Britain proposed by GEORGE *et al.* (1976) remains in some doubt but it is probably equivalent to the uppermost part of the Holkerian and the lower Asbian.

### *3.1.2.4. Raistrickia nigra — Triquitrites marginatus* (NM) Zone

Several species including *Raistrickia nigra* LOVE, *Densosporites* cf. *velatus* FELIX & BURBRIDGE, *Murospora parthenopia* NEVES & IOANNIDES, *Monilospora mutabilis* (STAPLIN) CLAYTON and *Kraeuselisporites echinatus* OWENS, MISHELL & MARSHALL appear at the base of the NM Zone whilst a group of species including *Tripartites distinctus, Ahrensisporites duplicatus* NEVILLE and *Potoniespores delicatus* which appeared in the upper part of the preceeding TC Zone are not above the lower part of the NM Zone, *Densosporites* cf. *velatus, Murospora parthenopia* and *Monilospora mutabilis* are likewise not known above the middle of this zone (i.e. the level of the Fourlaws Coal in Northumberland).

The upper part of the *Grumosisporites verrucosus* Assemblage I of SMITH & BUTTERWORTH (1967) i.e. from the Fourlaws Coal to the Wood End Coal (see text fig. 24) could be assigned to the NM Zone which is also equivalent to the upper part of the Asbian regional stage of GEORGE *et al.* (1976).

### *3.1.2.5. Tripartites vetustus — Rotaspora fracta* (VF) Zone

The base of the VF Zone is defined by the first appearance of a group of new species which include

*Tripartites vetustus* SCHEMEL, *Tripartites nongerickei* (HORST) BUTTERWORTH & WILLIAMS, *Triquitrites trivalvis* (WALTZ) POTONIÉ & KREMP, *Rotaspora fracta* (SCHEMEL) SMITH & BUTTERWORTH, *R. knoxi* BUTTERWORTH & WILLIAMS, *Savitrisporites nux* (BUTTERWORTH & WILLIAMS) SMITH & BUTTERWORTH, *Crassispora maculosa* (KNOX) SULLIVAN, *Spencerisporites radiatus* (IBRAHIM) FELIX & PARKS, *Grandispora spinosa* HOFFMEISTER, STAPLIN & MALLOY. All of these species extend into the succeeding *Bellispores nitidus — Reticulatisporites carnosus* (NC) Zone.

Within the VF Zone several species have the upper limit of their ranges, these include *Verrucosisporites baccatus, Crassispora aculeata, Cribrosporites cribellatus* and *Perotrilites tessellatus*. The distinct qualitative change in the composition of the assemblages from this zone compared with those of the preceeding NM Zone, can be traced throughout the Northumberland Trough and the Midland Valley of Scotland (see NEVES *et al.* 1973, text fig. 15).

The *Diatomozonotriletes saetosus*. Assemblage II of SMITH & BUTTERWORTH (1967) is the approximate equivalent of the VF Zone. The base of the VF Zone coincides with the base of the Brigantian regional stage of GEORGE *et al.* (1976) and the zone extends through the major part of this stage.

The uppermost part of the Visean is palynologically identical with the lowermost portion of the Namurian, no boundary being recognisable by palynological criteria at the series boundary. For convenience therefore the assemblages from the succeeding NC Zone are described in the Namurian section.

## 3.2. SILESIAN

The Silesian subsystem is divisible into four series, namely the Namurian, Westphalian, Stephanian and Autunian which may each in turn be subdivided into either formal stages or less formal divisions on the basis of their floral or faunal content.

### *3.2.1. NAMURIAN*

The Namurian deposits of the British Isles which are the most extensively studied palynologically, consist predominantly of cyclic sandstone and shale units with minor but persistent marine horizons. The development of limestones within the cycles is limited in occurrence, particularly to the lower part of the series. The lower limit of the series is defined by the appearance of the goniatite genus *Cravenoceras* and its upper limit is located at the *Gastrioceras subcrenatum* Marine Band. The series is therefore equivalent to part of the Bashkirian Series of Soviet stratigraphers and the late Mississippian and early Pennsylvanian deposits of North America.

At the 3rd International Congress of Carboniferous Stratigraphy and Geology (Heerlen 1937) proposals were adopted to subdivide the series into three stages designated from the base to the top by the letters A, B and C. This convention has over the years progressively fallen into disuse and subdivision of the series into its component stages is now based on evidence from the rapidly evolving goniatite faunas. The pioneer work of BISAT (1928) on the stratigraphic distribution of the goniatites in the Namurian deposits in northern England forms the basis for this subdivision although significant detail has been subsequently added by HODSON (1957), HUDSON (1945), HUDSON & COTTON (1943), MOORE (1930), WRIGHT (1926) and YATES (1962). The distinctive goniatite faunas which are recognisable over large areas of Europe, Central Asia, U.S.S.R. and North America allow subdivision of the series into the following stages:

| *Stage* | *Goniatite Index* | *Heerlen Stage* |
|---|---|---|
| Yeadonian | $G_1$ | Namurian C |
| Marsdenian | $R_2$ | Namurian B |
| Kinderscoutian | $R_1$ | |
| Alportian | $H_2$ | Namurian A |
| Chokierian | $H_1$ | |
| Arnsbergian | $E_2$ | |
| Pendleian | $E_1$ | |

RAMSBOTTOM (1969, 1977) has provided detailed summaries of Namurian chrono- and biostratigraphy in Great Britain and has clarified many of the difficulties in correlations between the lithostratigraphies and the scheme of goniatite zonation. The broad scheme of palynological zonation proposed by OWENS *et al.* (1977) can now also be integrated into these correlations and will be particularly useful in establishing biostratigraphical relationships in those areas where goniatite faunas are poorly developed. Similar possibilities of confirmatory evidence may be obtained from studies of conodont faunas. HIGGINS (1975) has proposed a comprehensive set of conodont zones for the Namurian sediments of northern England which can be accurately equated with the established goniatite zonation.

### *3.2.2. WESTPHALIAN*

The Westphalian Series has, since the International Congresses of Carboniferous Stratigraphy and Geology (Heerlen, 1927, 1935, been divided into four stages, designated from the base to the top by the letters A, B, C and D.

The lower limit coincides with the *Gastrioceras subcrenatum* Marine Band which has been positively identified in the Ruhr, Limburg in the Netherlands, le Placard Basse Sambre or Spy Basin in Belgium and also in several basins in Great Britain including the Pennine Basin and South Wales. The upper limit to the series is placed at the base of the Holz Conglomerate in the Saar-Lorraine Basin which is a

widespread lithological marker.

The boundaries between Westphalian A and B and Westphalian B and C are marked by marine horizons i.e. the Katharina, Poissonnière, Clay Cross between Westphalian A and B and the Aegir, Petit Buisson, Rimbert, Mansfield between Westphalian B and C. These marine horizons are well known in most of the paralic coal basins of Western Europe and provide easily recognisable and accurate means of correlation. In contrast the boundary between Westphalian C and D has traditionally been recognised by a change in the macroflora. Agreement was reached at the 5th International Congress of Carboniferous Stratigraphy and Geology (Paris 1963) that the base of Westphalian D should be recognised at the base of the biozone of *Neuropteris ovata* Hoffman (cf. 2nd Resolution t.1. pp. xxxviii-xxxix, Paris 1963). Its appearance in the Saar-Lorraine Basin at the base of "la veine Wohlwert" or its equivalents, that is to say between Tonsteins 200 and 100 (LAVEINE, COQUEL & LOBOZIAK in press) implies that the major part of the "Zone" de Forbach originally assigned to Westphalian D (PRUVOST 1934), belongs in reality to Westphalian C.

These proposals concerning the boundaries still remain valid despite several attempts at revisions by the working groups of the Subcommission on Carboniferous Stratigraphy. One of these attempts using fossil plants and palynomorphs to fix the base of Westphalian C in the upper part of the "faisceau de Six-Sillons" in the Nord-Pas-de-Calais Basin, France, in which the possible stratotype section for Westphalian C had been proposed (CORSIN *et al.* 1971, LAVIENE, 1967, LOBOZIAK, 1971).

Several authors including ALPERN, LACHKAR & LIABEUF (1966), ALPERN & LIABEUF (1967), CORSIN, P., CORSIN, P. M., & GUERRIER (1968). ALPERN, CORSIN, P., CORSIN, P. M. & MERRY (1971) and CORSIN, P. & CORSIN, P. M. (1971) have suggested various proposals, sometimes contradictory to the lower and upper limits of Westphalian D.

Following the detailed examination of material from more than fifty recent boreholes and the re-examination of all samples held by the Laboratoire de Paléobotanique, Université des Sciences et Techniques de Lille, LAVEINE (1974) has clarified much of the information concerning the fossil plants by presenting a table documenting the stratigraphical distribution of the principle species in the Saar-Lorraine Basin. LAVEINE has also specified in view of the proposed revisions of the stratotype of Westphalian D, those palaeobotanical features which should be taken into account and emphasised. Examination of the lower part of the table shows the presence of a large number of plant species both above and below the level of the base of the *Neuropteris ovata* biozone. The palaeobotanical composition of these sediments appears to vary only slightly and thus emphasises that this horizon is an excellent stratigraphical marker. As far as it concerns the upper limit of the Westphalian, the table shows the existence of two possibilities. The first is located at the level of the Holz Conglomerate and corresponds therefore to the originally proposed limit. This limit is very clear but can only be applied in the Lorraine Basin since it corresponds to a break of some importance hitherto ignored elsewhere. The second which is located at the horizon of Tonstein 60, is marked in particular by the appearance of *Pecopteris* cyathéoides. This horizon whose palaeontological significance has been recently emphasised in a comparative study of the macroflora and palynomorphs in boreholes from Marienau and Cocheren (LOBOZIAK *et al.* 1976), has already been proposed on the basis of palynological data (ALPERN & LIABEUF 1967) as the lower limit of the Stephanian.

As a result of research on the Carboniferous floras of the Cantabrian Mountains, Spain, WAGNER (1966) demonstrated the existence of an intermediary flora between that from the "faisceau de Steinbesch" in the Lorraine Basin and that from the "Assise de Rive de Gier" from the St Etienne Basin and proposed the introduction of the term Cantabrian*, a stage which would be the basal unit of the Stephanian.

These different prepositions are still under discussion. For the purpose of this report, the Carboniferous is defined in its original sense with the exception however of accepting the resolution passed as the 5th International Congress of Carboniferous Stratigraphy and Geology to place the base of Westphalian D at the horizon of the first appearance of *Neuropteris ovata.*

### *3.2.3. STEPHANIAN*

The term Stephanian was first introduced by MUNIER-CHALMAS & DE LAPPARENT (1893, p. 451) for beds containing coal swamp floras which extend from the Assise de Rive de Gier up to and including those of the Bois d'Avaize. This definition is based on a number of large works, in particular those of GRAND EURY, ZEILLER and BERTRAND. On the basis of these former works, BERTRAND (2nd International Congress of Carboniferous Stratigraphy & Geology, Heerlen 1935) distinguished three succes-

* The creation of the Cantabrian Stage is based on the presence in the floras from Terejina and from the Penecorba Beds of a typically upper Westphalian flora, together with certain elements diagnostic of the Stephanian which were unknown in the "faisceau de Steinbesch" of Lorraine. Included within this flora were *Alethopteris bohemica* FRANKE, *Callipteridium jongmansi* (BERTRAND), *Pecopteris hemitelioides* BRONGNIART, *P. rarinervosa* CORSIN, *Lepidodendron scutatum* LESQUEREUX, *Sigillaria brardi* BRONGNIART.

sive floral units which were from the base to the top:

a. flora from Rive de Gier (lower Stephanian) observable at Rive de Gier and in Le Gard,
b. flora from Saint-Etienne (middle Stephanian) observable at Saint-Etienne and in Le Gard,
c. upper Stephanian flora seen by ZEILLER in the Commentry and Blanzy-Le Creusot Basins.

To these three subdivisions, subsequently called Stephanian A, B and C by JONGMANS & PRUVOST (1950), DOUBINGER (1956) added Stephanian D based on the doubtful Stephano-Autunian formation of Saint-Etienne and the Assise d'Igornay of Autun until then attributed to the Autunian**. More recently BOUROZ & DOUBINGER (1974) have confirmed this proposal as the result of the discovery of several *Callipteris* amongst the typically Stephanian floras in the upper part of the Assise d'Avaize (Stephanian C of JONGMANS & PRUVOST 1950). The upper limit of the Stephanian was placed by these authors at the Lally Conglomerate = base of the Assise de Muse at Autun.

The following subdivisions have been adopted here:

- Stephanian A = Assise de Rive de Gier,
- Stephanian B = Assise de Saint-Etienne,
- Stephanian C = Assise d'Avaize (*sensu stricto*)
- Stephanian D = Assise d'Avaize (uppermost part), the ambiguous formation of the Loire Basin and the Assise d'Igornay of the Autun Basin.

### 3.2.4. *AUTUNIAN*

The Autunian was defined to accommodate the bituminous shales of Autun which comprise the following subdivisions: Schistes d'Igornay, Schistes de Muse and Schistes de Millery. The Schistes d'Igornay have already been assigned to the uppermost part of the Stephanian, and there remains therefore in the Autunian only the two upper lithological units, the base of which sees a massive influx of *Callipteris****.

This transitional series, originally included in the Permian, was reassigned by JONGMANS & PRUVOST (1950, p. 342) to the top of the Carboniferous, the limit of the latter corresponding in western and central Europe to STILLE's terminal orogenic phase of the Hercynian.

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** The resemblance between the floras from the upper part of the Assise d'Avaize and that from the Assise d'Igornay had been previously remarked upon by JONGMANS & PRUVOST (1950, p. 340).

*** Lower Autunian equivalent to the Assise de Muse and Upper Autunian equivalent to the Assise de Surmoulin and Assise de Millery are retained in this report.

### 3.1.5. *MIOSPORE ZONES OF THE NAMURIAN*

These zones have been defined in the Namurian deposits of northern England and the Midland Valley of Scotland by OWENS *et al.* (1977). Broadly similar palynological subdivisions have been recognised in Poland by JACHOWICZ (1972) and in the Donetz Basin, U.S.S.R. by TETERIUK (1976).

#### 3.2.5.1. *Bellispores nitidus — Reticulatisporites carnosus* (NC) Zone

This zone is the youngest of the Dinantian zones proposed by NEVES *et al.* (1972) and contains many elements which are also common to the preceeding VF Zone, i.e. *Leiotriletes tumidus* BUTTERWORTH & WILLIAMS, *Raistrickia nigra, Microreticulatisporites concavus* BUTTERWORTH & WILLIAMS, *M. punctatus* KNOX *Tripartites vetustus, T. trilinguis* (HORST) POTONIÉ & KREMP, *Rotaspora fracta, R. knoxi, Crassispora maculosa* (KNOX) SULLIVAN, *Kraeuselisporites echinatus, Grandispora spinosa, Spelaeotriletes arenaceus* NEVES & OWENS *Rugospora corporara* NEVES & OWENS and *Remysporites magnificus* (HORST) BUTTERWORTH & WILLIAMS. The base of the zone is located in the middle of the $P_2$ goniatite zone and its upper limit is placed close to the boundary between the $E_1$ - $E_2$ goniatite zones or the Pendleian - Arnsbergian stages. No recognisable palynological break has been identified at the base of the Namurian series and the zone is therefore of both uppermost Visean and lowermost Namurian age.

Several distinctive species have been noted as making their appearance at the base of the $E_1$ goniatite zone (Great or Main Limestone and Upper Bowland Shales of Northern England), these include *Verrucosisporites morulatus* (KNOX) SMITH & BUTTERWORTH, *Secarisporites lobatus* NEVES, *Ahrensisporites guerickei* var. *ornatus* NEVES, *Crassispora kosankei* (POTONIÉ & KREMP) BHARADWAY, *Proprisporites laevigatus* NEVES and *Potonieisporites elegans* (WILSON & KOSANKE) WILSON & VENKATACHALA.

#### 3.2.5.2. *Stenozonotriletes triangulus — Rotaspora knoxi* (TK) Zone

The base of the TK Zone is marked by the first appearance of *Punctatisporites giganteus* NEVES, *P. pseudopunctatus* NEVES and *Stenozonotriletes triangulus* NEVES. Some distance above the base of the zone, close to the boundary between $E_2a$ - $E_2b$, other species including *Mooreisporites fustis* NEVES and *Reinschospora speciosa* (LOOSE) SCHOPF, WILSON & BENTALL appear and at the same time *Tripartites trilinguis* and *Rotaspora ergonulii* (AGRALI) SULLIVAN & MARSHALL disappear. *Tripartites vetustus, Triquitrites marginatus, Rotaspora knoxi* and *Spinozonotriletes uncatus* HACQUEBARD disappear at the top of the zone.

The base of the TK Zone is placed at the base of the Arnsbergian stage at the boundary between the $E_1$ and $E_2$ goniatite zones and its upper limit is located in the High Wood Marine Beds in the Stainmore Outlier, Cumbria, England which on goniatite evidence are suggested to be of $E_2b$ age (OWENS & BURGESS 1965).

#### 3.2.5.3. *Lycospora subtriquetra — kraeuselisporites ornatus* (SO) Zone

Assemblages from the SO Zone contain several species which persist from the preceeding NC and TK Zones but are distinguished by the presence of *Apiculatisporis variocorneus* SULLIVAN, *Camptotriletes superbus* NEVES, *Kraeuselisporites ornatus* (NEVES) OWENS, MISHELL & MARSHALL and *Lycospora subtriquetra* (LUBER) POTONIÉ & KREMP which appear at the base of the zone and *Cirratriradites rarus* (IBRAHIM) SCHOPF, WILSON & BENTALL which appears slightly above the base.

The upper limit of the zone is placed at the top of Alportian stage which is equivalent to the boundary between the $H_2$ and $R_1$ goniatite zones. The upper limit of the zone marks the end of a gradual period of change in the miospore assemblages during which the forms typical of the late Visean and early Namurian have been replaced by species which will become more characteristic of the late Namurian. This change can be suggested as being comparable to the changes between Mississippian and Pennsylvanian miospore assemblages in North America.

#### 3.2.5.4. *Crassispora kosankei — Grumosisporites varioreticulatus* (KV) Zone

Previous records of *Crassispora kosankei* indicate that it makes its first appearance within $E_1$ zone sediments but it is not until the base of the Kinderscoutian ($R_1a$) that it becomes a quantitatively significant component in the assemblages. In northern England this significant increase in its frequency occurs in beds containing diagnostic $R_1a$ goniatites and is a feature which is utilised as being of zonal significance. Other species which appear at the base of the zone include *Ibrahimispores magnificus* NEVES, *Raistrickia fulva* ARTUZ, *Triquitrites bransonii* WILSON & HOFFMEISTER and *Grumosisporites varioreticulatus* (NEVES) SMITH & BUTTERWORTH. The precise age of the upper limit of this zone remains, in the absence of confirmatory goniatite evidence, uncertain but is provisionally placed within the Marsdenian Stage ($R_2$). The following species are not recorded above the top of this zone: — *Ibrahimisporites magnificus, Kraeuselisporites echinatus, Proprisporites laevigatus* and *Rugospora corporata.*

#### 3.2.5.5. *Raistrickia fulva — Reticulatisporites reticulatus* (FR) Zone

Miospore assemblages from the FR Zone are transitional in character between those of the remainder of the Namurian below and the Westphalian above. The lower part of the zone is marked by the appearance of *Ahrensisporites beeleyensis* NEVES, *Dictyotriletes muricatus* (KOSANKE) SMITH & BUTTERWORTH, *Cristatisporites indignabundus* (LOOSE) STAPLIN & JANSONIUS, *Reticulatisporites reticulatus* (IBRAHIM) IBRAHIM and *Bellispores nitidus* (the latter after an apparent absence during $R_1$ and early $R_2$ times). Towards the top of the zone in the lower part of the Yeadonian ($G_1$) the distinctive reticulate spore *Dictyotriletes bireticulatus* (IBRAHIM) SMITH & BUTTERWORTH is recorded for the first time. *Punctatisporites pseudopunctatus, Microreticulatisporites punctatus* and *Cirratriradites rarus* are not known above the top of this zone which is located at the *Gastrioceras subcrenatum* Marine Band and therefore coincides with the boundary between the Namurian and Westphalian series. A further group of characteristic species from this zone including *Mooreisporites fustis, Bellispores nitidus, Stenozonotriletes triangulus* and *Spelaeotriletes arenaceus* are not known above the lowermost part of the succeeding *Triquitrites sinani — Cirratriradites saturni* (SS) Zone.

### 3.2.6. *MIOSPORE ZONES OF THE WESTPHALIAN*

The economic importance of the Westphalian deposits in Western Europe has led to several attempts at palynological zonation for these deposits. For the purpose of this report the scheme adopted is one based on the original scheme proposed by LOBOZIAK (1974). Attempts are made where possible to equate this zonation with that proposed by SMITH & BUTTERWORTH (1967) for the coal seams of Great Britain. The latter scheme is not adopted here because it is based on data obtained only from coal seam assemblages.

#### 3.2.6.1. *Triquitrites sinani — Cirratriradites saturni* (SS) Zone

Assemblages from the SS Zone are characterised by containing numerous representatives of a complex group of miospore which show complete morphological intergradation between the genera *Triquitrites* and *Ahrensisporites.* Representatives of the monolete genus *Laevigatosporites* become quantitatively significant components in the assemblages from the middle part of the zone. *Cirratriradites saturni* which has been infrequently recorded in the Namurian is a more frequent component in the assemblages. The upper boundary of the SS Zone is placed at the same horizon as the boundary between the *lenisulcata* and *communis* non-marine bivalve zone.

#### 3.2.6.2. *Radiizonates aligerens* (RA) Zone

This is the first of the zones defined by LOBOZIAK (1974) and was originally referred to as Zone I of

the Westphalian of Western Europe. Its lower limit is placed some distance above the *Gastrioceras subcrenatum* Marine Band. The precise relationship of the lower boundary of this zone to the upper boundary of the preceeding SS Zone recently recognised by OWENS *et al.* (1977) in northern England still awaits final elucidation. The lower limit of the zone is marked by the appearance of *Radiizonates aligerens* (KNOX) STAPLIN & JANSONIUS, a species with a very limited stratigraphical distribution which in some regions may not even extend to the top of this zone. The lower limit of the zone is also marked by the appearance of *Punctatosporites* spp., particularly *P. minutus* IBRAHIM, the base of the epibole of *Laevigatosporites* spp. and *Florinites* spp., the disappearance of *Spelaeotriletes triangulus* NEVES & OWENS and *S. arenaceus* and the more frequent occurrence of *Reticulatisporites reticulatus*. The middle part of the zone marks the top of the biozone of *Kraeuselisporites ornatus*, of which the youngest representatives have been recorded by NEVES (1964) in the uppermost beds of the *Dictyotriletes bireticulatus* Zone from the La Camocha Mine in the Gijon region of northern Spain.

In the uppermost part of this zone, the first isolated representatives of *Westphalensisporites irregularis* ALPERN have been noted in the Nord-Pas-de-Calais Basin and the first *Disaccites* non *striatiti* in the Campine Basin, Belgium.

The palynological characteristics of this zone can be summarised as follows:

(i) abundance of *Lycospora* spp., *Densosporites* spp., *Laevigatosporites* spp. and *Florinites* spp. and to a lesser degree of *Crassispora kosankei* and *Cingulizonates loricatus* (LOOSE) BUTTERWORTH *et al.*,
(ii) more or less constant occurrence of *Radiizonates aligerens* (particularly in the middle part of the zone), *Cirratriradites saturni*, *Reticulatisporites reticulatus* and occasionally of *Triquitrites* spp.,
(iii) infrequent occurrence of *Schulzospora* spp., *Punctatisporites sinuatus* (ARTUZ) NEVES, *Bellispores* spp. recognized by VAN WIJHE & BLESS (1974) up to the base of the Maurits Formation of Limburg (Netherlands) (= middle Westphalian B) and by GREBE (1971) by several doubtful representatives up to the lowermost part of the Essener Schichten of the Ruhr (= Lower Westphalian B), *Savitrisporites nux* and *Grumosisporites varioreticulatus* – *G. maculatus*,
(iv) appearance of the first punctate monolete spores of the genus *Punctatosporites*.

In addition to these diagnostic forms for this zone there are several accessory species which are not recorded on the distribution chart on Enclosure 2. In particular it is worth noting the occurrence of *Chaetosphaerites pollenisimilis* (HORST) BUTTERWORTH & WILLIAMS a form which normally occurs infrequently in Visean and Namurian deposits but which in the Nord-Pas-de-Calais Basin had been recorded up to about the horizon of the Poissonnière Marine Band which marks the boundary between Westphalian A and B, and *Endosporites globiformis* (IBRAHIM) SCHOPF, WILSON & BENTALL, a species which becomes more frequent in the younger deposits.

This zone corresponds to the middle and upper parts of the Lower Coal Measures of Great Britain (*Radiizonates aligerens* and *Schulzospora rara* Assemblage Zones of the scheme proposed by SMITH & BUTTERWORTH 1967), to the "faisceaux de Modeste et Chandeleur" in the Nord-Pas-de-Calais, to the Genk Zone of the Campine, Belgium, to the Wilhelmina Formation of Limburg, the Netherlands, and the Bochumer Schichten of the Ruhr. In the Camocha Mine sequence in Spain where several of the guide taxa, including *Radiizonates aligerens* have not been recorded, the zone has not been recorded with certainty.

### *3.2.6.3. Microreticulatisporites nobilis — Florinites junior* (NJ) Zone

The lower limit of this zone is marked by the appearance of *Microreticulatisporites nobilis* (WICHER) KNOX and *Florinites junior* POTONIÉ & KREMP, the more consistent appearance of *Dictyotriletes bireticulatus*, *Punctatosporites* spp. and *Vestispora costata* (BALME) SPODE — *V. cancellata* (DYBOVA & JACHOWICZ) as well as by the end of the biozones of *Punctatisporites sinuatus* and *Schulzospora rara*. It coincides with the Poissonnière Marine Band in the Nord-Pas-de-Calais, the Katharina in the Ruhr and Limburg, the Quaregnon in the Campine, Belgium and the Clay Cross in Great Britain, which define the boundary between Westphalian A and B. The lower part of the zone marks the end of the biozone of *Bellispores* spp. which has been recorded from this level only in the Limburg and Ruhr Basins.

The principal palynological characteristics of this zone may be summarised as follows:

(i) abundance of *Lycospora* spp., *Densosporites* spp., *Laevigatosporites* spp. and *Florinites* spp. in addition to *Crassispora kosankei* and *Cingulizonates loricatus*,
(ii) development of the maximum frequency of *Dictyotriletes bireticulatus* and *Cirratriradites saturni*,
(iii) weak development of *Punctatosporites* spp. and particularly *Vestispora costata* and *V. cancellata*,
(iv) the appearance of *Microreticulatisporites nobilis* and *Florinites junior* which occur regularly from the middle part of the zone and the continuation in the same frequencies of *Triquitrites* spp., *Savitrisporites nux* and *Reticulatisporites* as in the underlying zone.

This zone corresponds to the Middle Coal Measures of Great Britain, to the faisceaux de Meunière et Pouilleuse in the Nord-Pas-de-Calais Basin, France, to the Asch, Eikenberg and Meuwen zones of the Campine Basin, Belgium, to the Hendrik, Maurits and lower part of the Jabeek Formations in Limburg, Netherlands, to the Essener and Horster Schichten and the lower part of the Dorstener Schichten of the Ruhr. The upper beds from La Camocha Mine, Spain as well as the Assise de St-Ingbert and the lower part of the Assise de Sulzbach

of the Saar-Lorraine are likewise allocated to this zone.

### *3.2.6.4. Torispora securis - Torispora laevigata* (SL) Zone

The base of this zone coincides with the appearance of the first monolete spores at the genus *Torispora* which quickly become quantitatively very significant and also of *Vestispora fenestrata* (Kosanke & Brokaw) Spode. The boundary also marks the top of the epibole of *Cingulizonates loricatus* and the level where *Grumosisporites varioreticulatus — G. maculatus* and *Raistrickia fulva* disappear after occurring infrequently from the Upper Namurian. The position of the lower boundary of the SL Zone is slightly above the following marine horizons: Rimbert in the Nord-Pas-de-Calais, the Aëgir in the Ruhr and Limburg, the Maurage in the Campine and the Mansfield in Great Britain all of which coincide with the boundary between Westphalian B and C.

Just above the lowermost part of the zone a sharp increase in the numbers of *Punctatosporites* spp. (appearance of *P. granifer* Potonié & Kremp) and *Triquitrites* spp. is noted together with a perceptible reduction in the number of spores of the "Densospore Group" Staplin & Jansonius 1964 as well as the disappearance of *Savitrisporites nux. Westphalensisporites irregularis* and *Vestispora fenestrata* become a little more frequent in the upper part of this zone but it is in the succeeding zone that they reach their maximum development. Finally it is possible in this zone to recognise the beginning by the presence of rare isolated specimens of the biozones of the *Disaccites striatiti and Lundbladispora gigantea* (Alpern) Doubinger, species which become more significant later. A relatively large number of striate bisaccate specimens has been recorded from several horizons attributed to Upper Westphalian C in a borehole at Haaksbergen in the Netherlands. These same horizons have also yielded specimens of *Potonieisporites gelrianensis* Bless, Loboziak & Streel (1977) and *Latensina trileta* Alpern.

The assemblages from the zone can therefore be summarised by the following:

(i) abundance of *Lycospora* spp., *Laevigatosporites* spp., *Punctatosporites* spp., *Torispora* spp., *Florinites* spp. and by less frequent *Triquitrites* spp., *Densosporites* spp., and *Crassispora kosankei*,

(ii) representation at the same frequency as in the preceeding zone of *Microreticulatisporites nobilis, Reticulatisporites reticulatus, Florinites junior* and *Vestispora costata – V. cancellata* with a slightly increased frequency for *Westphalensisporites irregularis* particularly in the upper part of the zone,

(iii) marked reduction in the frequency of *Dictyotriletes bireticulatus, Cirratriradites saturni* and particularly of *Cingulizonates loricatus* which is recorded only very occasionally,

(iv) appearance at the base of the zone of rare *Vestispora fenestrata* which becomes quite common particularly in the upper part of the zone.

This zone corresponds to the lower part of the Upper Coal Measures in Great Britain (= *Torispora securis* Assemblage Zone of Smith & Butterworth 1967), to the "faisceau de Six-Sillons" (except the base) and the lower part of the "faisceau d'Ernestine" in the Nord-Pas-de-Calais, to the lower and middle parts of the Neeroeteren Zone of the Campine, Belgium, to the Jabeek Formation (except the bottom and top) in Limburg, to the Dorstener Schichten (except the base and uppermost portion) in the Ruhr and the Assise de Sulzbach (except the base) and the lower part of the Forbach zone in the Saar-Lorraine. In the central Asturias, Spain, Zone 1 (*Vestispora* cf. *laevigata*) of the zonation proposed by Chateauneuf (1973) is thought to be equivalent to this zone despite the fact that it contains significant numbers of monolete species with prominent verrucose ornament.

### *3.2.6.5. Thymospora obscura — T. thiessenii* (OT) Zone

The lower limit of this zone coincides with the appearance of monolete verrucose spores of the genus *Thymospora* which becomes quantitatively significant very quickly, with the appearance of rare monolete spinose spores of the genus *Spinosporites* as well as with the tops of the epiboles of *Reticulatisporites reticulatus* and *Vestispora costata — V. cancellata*. It is situated a little below the horizon of the appearance of *Neuropteris ovata*.

In the lower part of this zone a new but poorly represented microflora is introduced which develops later in the zone. It includes *Polymorphisporites* spp., *Savitrisporites camptotus* (Alpern) Doubinger and *Candidispora* spp. The lower part of the zone also marks the final occurrence of *Dictyotriletes bireticulatus* and *Cingulizonates loricatus*.

The middle part of the zone marks the top of the epiboles of *Crassispora kosankei* and *Cirratriradites saturni* (already absent in the upper part of the Upper Coal Measures in Great Britain but still reported, although rarely, in several of the younger basins in France). *Microreticulatisporites nobilis* which is a more characteristic Westphalian species but which several authors have noted still in the lower Stephanian (Saar-Lorraine) and upper Stephanian (Loire) and *Florinites junior*, likewise more typically Westphalian but which may be recorded into the upper Stephanian, are both present but begin to become less frequent.

*Lundbladispora gigantea, Westphalensisporites irregularis* and *Vestispora fenestrata* (particularly in the upper part of the zone in the case of the last named species) are normally relatively more frequent, whilst the *Densosporites* spp. except at a few horizons, show a significant reduction (mainly in the lower part of the zone).

The characteristics of this zone can therefore be summarised as follows:

(i) abundance of *Lycospora* ssp., *Triquitrites* spp., *Laevigatosporites* spp., *Punctatosporites* spp. (appearance of *P. rotundus* BHARADWAJ), *Torispora* spp., *Thymospora* spp. (starting in the middle part of the zone) and *Florinites* spp.,
(ii) presence in more or less constant but sometimes slightly increased frequency of *Lundbladispora gigantea, Westphalensisporites irregularis* and *Vestispora fenestrata,*
(iii) occurrence of rare spinose monolete spores (*Spinosporites spinosus* ALPERN and of *Polymorphisporites* spp., *Savitrisporites camptotus* and *Candidispora* spp.,
(iv) sharp decline in the frequency of *Densosporites* spp. in the lower part of the zone and *Microreticulatisporites nobilis, Crassispora kosankei, Cirratriradites saturni* and *Florinites junior* in the middle part of the zone.

It is only in the Saar-Lorraine Basin in Western Europe that this zone is represented in full. It extends from the upper part of the Forbach Zone to the Göttelborn Zone. Although a degree of evolution towards the Stephanian microflora is already manifest, the basic palynological composition does not vary much in this zone on either side of the Holz Conglomerate.

The upper part of the Upper Coal Measures (*Thymospora obscura* Assemblage zone of SMITH & BUTTERWORTH 1967), the upper part of Ernestine and the Dusouich and Edouard successions in the Nord-Pas-de-Calais, the upper part of Neeroeteren Zone of the Campine, Belgium, the top of the Jabeek Formation of Limburg, Netherlands, and the Dorstener Schichten of the Ruhr and the almost complete section of productive measures in Asturias are all equivalent to the lower part of this zone. The lower parts of Carmaux and Figeac St-Perdoux Basins successions and the Assise des Girondons and without doubt the base of the Verneuil Conglomerate of Decize (complex Decize 1 of the zonation proposed by LIABEUF & ALPERN 1970) are equivalent to the upper part of this zone.

### *3.2.7. MIOSPORE ZONES OF THE STEPHANIAN AND AUTUNIAN*

#### *3.2.7.1. Angulisporites splendidus — Latensina trileta* (ST) Zone

The base of this zone is marked by the appearance of *Angulisporites splendidus* BHARADWAJ and *Cheiledonites* spp. as well as a more constant occurrence of *Latensina trileta*. The *Disaccites* non *striatiti* pollen together with *Candidispora* spp., *Polymorphisporites* spp. and *Spinosporites spinosus* become more abundant in this zone (the latter two from the upper and middle parts respectively) whilst *Vestispora fenestrata* becomes relatively less frequent and the first examples of *Vittatina* spp. are recorded.

The assemblages recorded from this zone are recognised by the following characteristics:

(i) abundance of *Lycospora* spp., *Densosporites* spp., *Laevigatosporites* spp., *Torispora* spp., *Thymospora* spp. and *Florinites* spp.,
(ii) presence of more or less constant numbers of *Disaccites* non *striatiti, Westphalensisporites irregularis, Lundbladispora gigantea, Latensina trileta, Savitrisporites camptotus* and *Angulisporites splendida* and in the upper part of the zone of *Spinosporites spinosus* and *Candidispora* spp.,
(iii) reduction in the numbers of *Triquitrites* spp.,
(iv) presence of rare examples of *Crassispora kosankei, Cirratriradites saturni, Vestispora fenestrata* and *Florinites junior,*
(v) appearance of isolated examples of *Cheiledonites* spp. and *Vittatina* spp.

The Dilsburg and Heusweiler Beds of the Saar-Lorraine Basin are assigned to this zone as well as several other sequences in the limnic basins of Central France including the upper parts of the successions in the Carmaux and Figeac-St-Perdoux Basins, the bottom of the Assise de la Machine in the Decize Basin (complex Decize 2 of the zonation of LIABEUF & ALPERN 1970), the Assise d'Auzits and Assise du Banel of Decazeville, samples from the Rive de Gier and the Serie du Treuil from the Loire (zone 1 and the lower part of zone 2 of the zonation proposed by LIABEUF & ALPERN 1969) the Assise d'Epinac-Mt. Pele of the Autun Basin and the majority of the coal-bearing series of Blanzy.

The zone therefore corresponds to the upper part of the Assise de Rive de Gier (upper Stephanian A) and almost all of the Assise de Saint-Etienne (Stephanian B).

#### *3.2.7.2. Potonieisporites novicus-bhardwajii — Cheiledonites major* (NBM) Zone

The lower limit of this zone coincides with the expansion in the frequency of *Cheiledonites* spp., *Potonieisporites* spp. and *Spinosporites spinosus,* the top of the epibole of *Densosporites* spp. and *Savitrisporites camptotus* and that of the biozone of *Vestispora fenestrata.*

*Torispora* spp. and *Polymorphisporites* spp. become rarer towards the middle of the zone at the same time as *Crassispora kosankei, Westphalensisporites irregularis* and *Florinites junior* disappear.

The assemblages from this zone are characterised by the following features:

(i) abundance of *Lycospora* spp. (which show nevertheless a slight drop in frequency), *Laevigatosporites* spp., *Punctatosporites* spp., *Thymospora* spp., *Spinosporites spinosus* and *Florinites* spp.
(ii) presence of *Triquitrites* spp., *Lundbladispora gigantea, Latensina trileta, Angulisporites splendidus, Candidispora* spp., *Cheiledonites* spp., *Potonieisporites* spp., *Disaccites* non *striatiti* (except in the lower part) and *Polymorphisporites* spp. (except in the upper part)
(iii) presence of several *Vittatina* spp. and *Disaccites striatiti*
(iv) distinct drop in the frequency of *Densosporites* spp. and *Triquitrites* spp.

Assemblages from this zone have been recognised in the upper part of the Assise de la Machine and in the Assise des Varioux at Decize (Complex Decize 3 of the zonation of LIABEUF & ALPERN 1970), in

the "faisceau de Buxieres de l'Aumance", in the Assise de Villeneuve of the Jura, in the Assise de Campagnac and Assise de Bourran from Decazeville, in Epinac, Aubigny-la-Ronce, and the Schistes d'Igornay in the Autunois, in the Serie de Ricamarie and the "faisceau de Bellevue" in the Loire (upper part of Zone 2 and Zone 3 in the zonation proposed by LIABEUF & ALPERN 1969), at the top of the Assise de Breitenbach and the lower part of the Assise du Kusel from Palatinat as well as in the Guadalcanal Basin near Seville, Southern Spain.

This zone corresponds to the Assise d'Avaize the doubtful formation of the Loire Basin and the Assise d'Igornay (Autun Basin) and is equivalent to Stephanian C and D.

### *3.2.7.3. Vittatina costabilis* (VC) Zone

The lower limit of this zone is defined by the maximum development of *Potonieisporites*, the continued persistent occurrence of *Vittatina* spp., a marked reduction in the number of *Lycospora* spp., *Laevigatosporites* spp., *Punctatosporites* and *Spinosporites spinosus* and by the disappearance of *Densosporites* spp., *Angulisporites splendidus* and *Savitrisporites camptotus*. In the middle part of the zone it is possible to delimit the tops of the biozones of *Polymorphisporites* spp. and *Candidispora* spp. and towards the top of the zone that of *Torispora* sp.

The assemblages known from this zone contain few spores but may be distinguished by the following characteristics:

(i) predominance of monosaccate pollen (*Potonieisporites* spp. and *Florinites* spp.),
(ii) relative abundance of *Disaccites* non *striatiti, Cheiledonites* spp. and *Vittatina* spp.,
(iii) continuation of *Lundbladispora gigantea* and *Latensina trileta*,
(iv) continued occurrence but only as rare examples, of *Laevigatosporites* spp., *Punctatosporites* spp. and *Thymospora* spp. (sometimes locally still frequent),
(v) very rare occurrences of *Lycospora* spp., *Triquitrites* spp., *Spinosporites spinosus* and *Candispora* spp.

The assemblages from this zone have been recognised in the Schistes de Lallyet de Muse from Autun, in the Schistes de Clairvaux du Détroit de Rodez en La Tuiliere and Usclas in the Lodève Basin, in the middle part of the Assise du Kusel from Palatinat as well as in levels at the edge of the Central System to the north of Madrid, Spain. This zone corresponds therefore to the lower Autunian.

### *3.2.7.4. Disaccites striatiti* (DS) Zone

This zone sees the important development where the monosaccate pollens are exclusively represented by *Potonieisporites* spp., *Vittatina* spp. and *Disaccites striatiti*. The lower limit is marked by the disappearance of *Lycospora* spp. and a marked reduction in the frequency of *Laevigatosporites* spp., *Punctatosporites* spp., *Thymospora* sp., *Florinites* spp., *Lundbladispora gigantea*, *Latensina trileta* and *Cheiledonites* spp.

The principal characteristics which distinguish the assemblages from this zone are:

(i) predominance of representatives of *Potonieisporites* spp.,
(ii) strong representation of *Disaccites striatiti*,
(iii) continuation of the presence of representatives of *Disaccites* non *striatiti* and of *Vittatina* spp.
(iv) rare occurrence of spores, with in particular a marked decline in the presence of monolete spores.

This association has been recorded from the Schistes du Charmoy from the Blanzy Basin, in the Gourd du Diable in the Brive Basin, in the Assise de Surmoulin and the Assise de Millery in the Autun Basin, in the uppermost part of the Assise du Kusel from Palatinat and in the Guadalcanal Basin. It corresponds therefore to the upper Autunian.

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# Plates 1-25

All figures x 500, unless otherwise stated

# PLATE 1

*Grandispora gracilis - Endosporites minutus* (GM) Zone

Fig. 1 *Retusotriletes planus* DOLBY & NEVES
Belgium, Chera quarry, A, in the Amblève valley;
Montfort Fm. L: 3656/1413.

Fig. 2 *Retusotriletes incohatus* SULLIVAN
Belgium, La Gombe quarry, 2 in the Ourthe valley;
Montfort Fm. L: 2381/2201.

Fig. 3 *Pulvinispora* sp. A. in B.B.S.T.
Belgium, La Gombe quarry, 19/1 in the Ourthe valley;
Montfort Fm. L: 2369/1169.
3a: idem, x 1000.

Fig. 4 *Aneurospora greggsii* (MCGREGOR) STREEL in B.B.S.T.
Belgium, Bon Mariage quarry, 35 in the Ourthe valley;
Montfort Fm. L: 2816/3013.
4a: idem, x 1000.

Fig. 5 *Auroraspora solisorta* HOFF., ST. & MALLOY
Belgium, Booischot borehole 743 m in the Campine basin.
L: 3059/03.

Fig. 6 *Auroraspora macra* SULLIVAN
Belgium, Chera quarry, A, in the Amblève valley;
Montfort Fm. L: 3656/3067.

Fig. 7 *Hymenozonotriletes cassiculus* HIGGS
Belgium, Chera quarry, B, in the Amblève valley.
L: 3542/1895.

Fig. 8 *Auroraspora* sp. cf. *P. perinatus* HUGHES & PLAYFORD
Belgium, Booischot borehole, 743 m in the Campine basin.
L: 3059/05.
8a: idem, x 1000.

Fig. 9 *Rugospora versabilis* (KEDO) STREEL in B.B.S.T.
Belgium, Chera quarry, A, in the Amblève valley;
Montfort Fm. L: 3656/2249.

Fig. 10 *Grandispora* sp. A. in B.B.S.T.
Belgium. Modave quarry, h, in the Hoyoux valley;
Montfort Fm. L: 3422/1375.
10a: idem, x 1000.
10b: idem, x 1000 (phase contrast.).

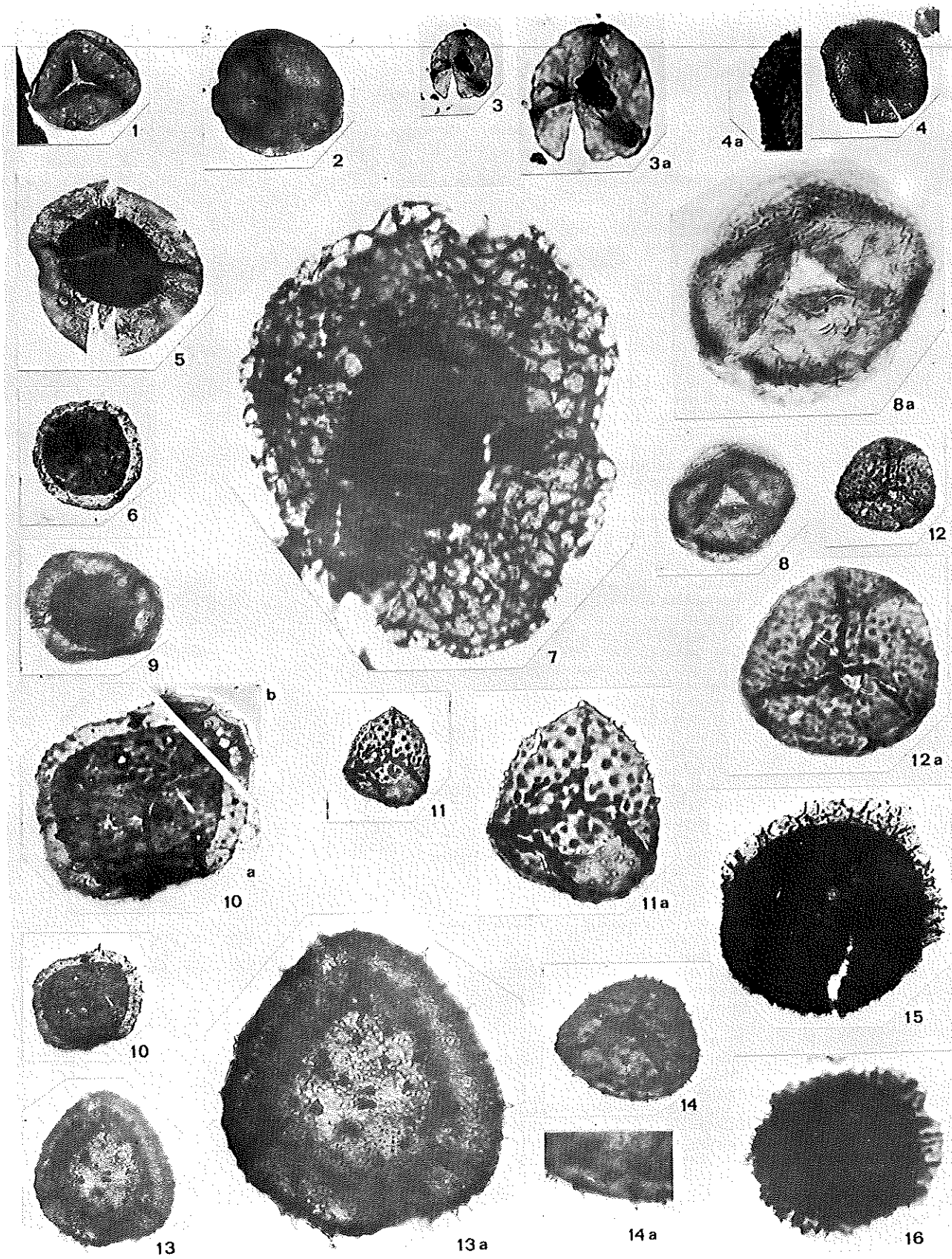
Fig. 11 *Dibolisporites* sp. cf. *Lophotriletes atratus* NAUMOVA
Belgium, Chera quarry, A, in the Amblève valley;
Montfort Fm. L: 3656/2487.
11a: idem, x 1000.

Fig. 12 *Grandispora gracilis* (KEDO) STREEL in B.B.S.T.
Belgium, La Gombe quarry, 19/1 in the Ourthe valley;
Montfort Fm. L: 2369/2093.
12a: idem, x 1000.

Fig. 13 *Grandispora* cf. *tenuispina* (HACQ.) PLAYFORD var. *punctata* STREEL in B.B.S.T.
Belgium, La Gombe quarry, 19/1 in the Ourthe valley;
Montfort Fm. L: 2369/2189.
13a: idem, x 1000.

Fig. 14 *Grandispora microseta* (KEDO) STREEL in B.B.S.T.
Belgium, Chera quarry, B, in the Amblève valley.
L: 3542/2039.
14a: idem, x 1000.

Figs. 15-16 *Samarisporites* sp. cf. *Acanthotriletes hirtus* NAUM. in B.B.S.T.
Belgium, Chera quarry, A, in the Amblève valley;
Montfort Fm. L: 3656/3085; fig. 16/3108; fig. 15.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## PLATE 2

*Rugospora versabilis - Grandispora uncata* (VU) Zone

Fig. 1 *Retusotriletes* sp. A. in B.B.S.T.
Belgium, Beverire quarry, 55. in the Ourthe valley;
Beverire Fm. L: 2444/2985.
1a: idem, x 1000.

Fig. 2 *Aneurospora greggsii* (McGregor) Streel
Belgium, Beverire quarry, 55. in the Ourthe valley;
Beverire Fm. L: 2444/2041.
2a: idem, x 1000.

Fig. 3 *Auroraspora* sp. cf. *P. perinatus* Hughes & Playford
Belgium, Beverire quarry, 46/3 in the Ourthe valley;
Beverire Fm. L: 2454/0782.

Fig. 4 *Auroraspora solisorta* Hoff., St. & Malloy
Belgium, Beverire quarry, 49/10 in the Ourthe valley;
Beverire Fm. L: 2457/3207.

Fig. 5 *Auroraspora* sp. cf. *D. perplexa* Balme & Hassell
Belgium, Beverire quarry, 57/14 in the Ourthe valley;
Beverire Fm. L.: 2466/1693
5a: idem, x 1000.

Fig. 6 *Auroraspora hyalina* (Naum.) Streel in B.B.S.T.
Belgium, Beverire quarry, 55. in the Ourthe valley;
Beverire Fm. L: 2444/2842.

Fig. 7 *Auroraspora poljessica* (Kedo) Streel in B.B.S.T.
Belgium, Chera quarry, E. in the Amblève valley.
L: 3549/1255.

Fig. 8 *Lagenicula* sp. A. in B.B.S.T. 1974
Belgium, Beverire quarry, in the Ourthe valley;
Beverire Fm. L: 2475/2222 x 250.

Fig. 9 *Hymenozonotriletes cassiculus* Higgs (immature specimen?)
Belgium, Beverire quarry, 45/10 in the Ourthe valley;
Beverire Fm. L: 2440/1222.

Fig. 10 *Rugospora versabilis* (Kedo) Streel in B.B.S.T.
Belgium Beverire quarry, seq. 62-64/1 in the Ourthe valley;
Beverire Fm. L: 15385/1384.

Fig. 11 *Rugospora flexuosa* (Jusch.) Streel in B.B.S.T.
Belgium, Beverire quarry, 55/4 in the Ourthe valley;
Beverire Fm. L: 2460/1665.

Fig. 12 *Grandispora cornuta* Higgs
Belgium, Beverire quarry, 45/10 in the Ourthe valley;
Beverire Fm. L: 2440/1354.
12a: idem, x 1000.

Fig. 13 *Grandispora microseta* (Kedo) Streel in B.B.S.T.
Belgium, Chera quarry, E. in the Amblève valley.
L: 3549/1479.
13a: idem, x 1000.

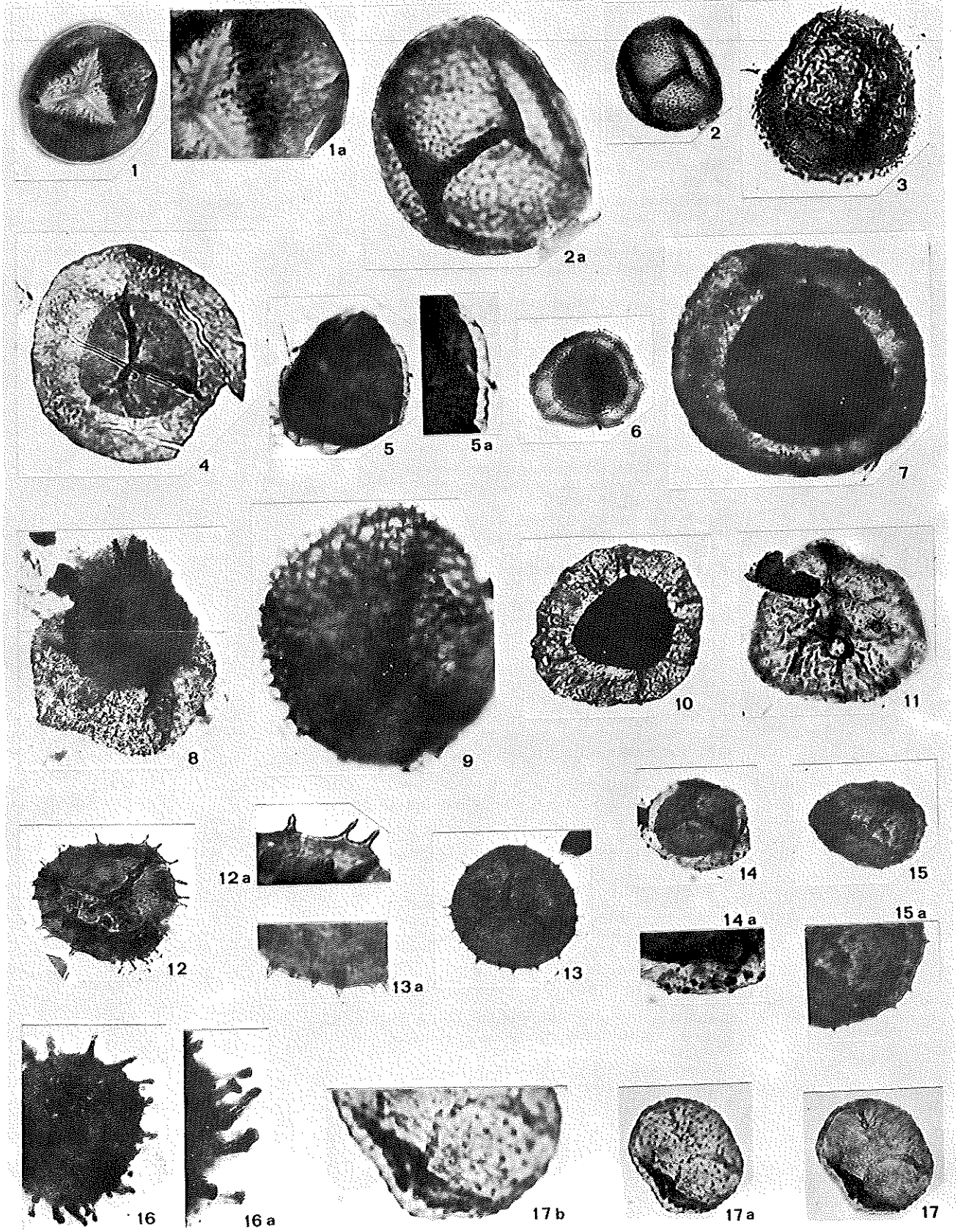
Fig. 14 *Grandispora* sp. A. in B.B.S.T.
Belgium, Chera quarry, E. in the Amblève valley.
L: 3549/1615.
14a: idem, x 1000.

Fig. 15 *Grandispora* cf. *tenuispina* (Hacq.) Playford
Belgium, Beverire quarry, seq. 62-64/1 in the Ourthe valley;
Beverire Fm. L: 15385/1368.
15a: idem, x 1000.

Fig. 16 *Raistrickia variabilis* Dolby & Neves
Belgium, Poulseur Ch. quarry, 9. in the Ourthe valley;
Evieux Fm. L: 2596/1167.
16a: idem, x 1000

Fig. 17 *Grandispora gracilis* (Kedo) Streel in B.B.S.T.
Belgium, Beverire quarry, seq. 45/10 in the Ourthe valley;
Beverire Fm. L: 15518/1240.
17a: idem, other focus.
17b: idem, x 1000.

p. retusoidea philippsi



# PLATE 3

*Vallatisporites pusillites - Spelaeotriletes lepidophytus* (PL) Zone

Fig. 1 *Retusotriletes incohatus* SULLIVAN
Belgium, Wepion borehole, 1741 m in the Namur basin.
L: 10584/2196.

Fig. 2 *Retusotriletes planus* DOLBY & NEVES
Belgium, Tournai borehole, 316 m in the Namur basin.
L: 3017/01.

Fig. 3 *Aneurospora greggsii* (McGREGOR) STREEL in B.B.S.T.
Belgium, Wepion borehole, 1741 m in the Namur basin.
L: 10584/2147.

Fig. 4 *Auroraspora* sp. cf. *P. perinatus* HUGHES & PLAYFORD
Belgium, Tournai borehole, 316 m in the Namur basin.
L: 3014/04.

Fig. 5 *Auroraspora hyalina* (NAUM.) STREEL in B.B.S.T.
Belgium, Tournai borehole, 316 m in the Namur basin.
L: 3012/01.

Fig. 6 *Spelaeotriletes lepidophytus* (KEDO) STREEL in B.B.S.T.
Belgium, Chanxhe road section, 112 (= 3) in the Ourthe valley;
Comblain au Pont beds.
L: 1615/1555.

Fig. 7 *Spelaeotriletes lepidophytus* (KEDO) STREEL in B.B.S.T.
Eire, East Seven Heads, Old Head Sandstone Fm;
distal surface, S.E.M. x 2000.

Fig. 8 *Spelaeotriletes lepidophytus* (KEDO) STREEL in B.B.S.T.
Belgium, Tournai borehole, 316 m in the Namur basin.
L: 3019/01.

Fig. 9 *Hymenozonotriletes cassiculus* HIGGS
Eire, Hook Head, Co. Wexford, Old Red Sandstone, ML 1119.

Fig. 10 *Cristatisporites echinatus* PLAYFORD
Belgium, Tournai borehole, 316 m in the Namur basin.
L: 1207/2617.
10a: idem, x 1000.

Fig. 11 *Vallatisporites pusillites* (KEDO) DOLBY & NEVES
Eire, Hook Head, Co. Wexford, Old Red Sandstone, ML 1408.

Fig. 12 *Vallatisporites pusillites* (KEDO) DOLBY & NEVES
Eire, Hook Head, Co. Wexford, Old Red Sandstone, ML 1409.

Fig. 13 *Raistrickia* cf. *variabilis* DOLBY & NEVES
Belgium, Tournai borehole, 316 m in the Namur basin.
L: 3028/02.

Fig. 14 *Grandispora echinata* HACQ.
W. Germany, Oese road section, 1. in the Honnetal.
L: 2958/1212.

Fig. 15 *Grandispora cornuta* HIGGS
Belgium, Tournai borehole, 316 m in the Namur basin.
L: 3010/01.

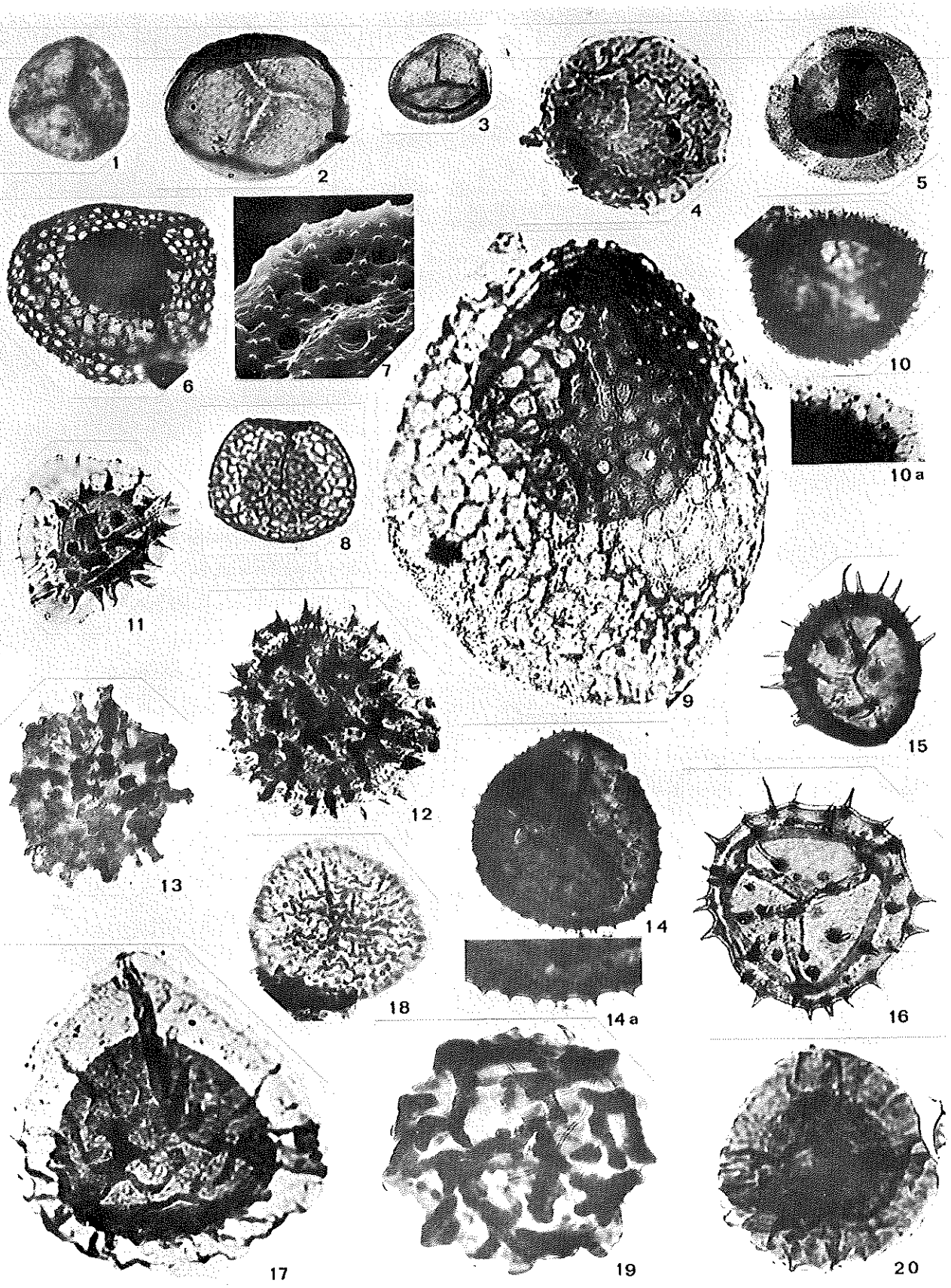
Fig. 16 *Grandispora cornuta* HIGGS (holotype)
Eire, Hook Head, Co. Wexford, Old Red Sandstone, ML 1104.

Fig. 17 *Endosporites* sp. in BALME & HASSELL
Belgium, Tournai borehole, 316 m in the Namur basin.
L; 3012/03.

Fig. 18 *Rugospora flexuosa* (JUSCH.) STREEL in B.B.S.T.
Belgium, Wepion borehole, 1741 m in the Namur basin.
L: 10584/1270.

Fig. 19 *Corbulispora* cf. *cancellata* (WALTZ) BHARADWAJ & VENKATACHALA
Belgium, Tournai borehole, 316 m in the Namur basin.
L: 3028/01.

Fig. 20 *Rugospora versabilis* (KEDO) STREEL in B.B.S.T.
Belgium, Tournai borehole, 316 m in the Namur basin.
L: 3007/01.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# PLATE 4

*Spelaeotriletes lepidophytus* - *Verrucosisporites nitidus* (LN) Subzone

Fig. 1 *Retusotriletes incohatus* SULLIVAN
Eire, North Ringabella, Co. Cork, 58 m below top Old Head Sandstone Formation, ML 1059.

Fig. 2 *Discernisporites micromanifestus* (HACQUEBARD) SABRY & NEVES
Eire, North Ringabella, Co. Cork, 100 m below top Old Head Sandstone Formation, ML. 1410.

Fig. 3 *Auroraspora macra* SULLIVAN
Eire, North Ringabella, Co. Cork, 100 m below top Old Head Sandstone Formation, ML 1411.

Fig. 4 *Auroraspora hyalina* (NAUMOVA) STREEL in B.B.S.T.
Eire, South Ringabella, Co. Cork, 300 m below top Old Head Sandstone Formation, ML 1412.

Fig. 5 *Rugospora versabilis* (KEDO) STREEL in B.B.S.T.
Eire, Galley Head, Co. Cork, 40 m below top Old Head Sandstone Formation, PC 1.

Fig. 6 *Rugospora flexuosa* (JUSCH.) STREEL in B.B.S.T.
Eire, Galley Head, Co. Cork, 50 m below top Old Head Sandstone Formation, PC 2.

Fig. 7 *Rugospora flexuosa* (JUSCH.) STREEL in B.B.S.T.
Eire, Old Head of Kinsale, Co. Cork, 150 m below top Old Head Sandstone Formation, PC 3.,

Fig. 8 *Rugospora flexuosa* (JUSCH.) STREEL in B.B.S.T.
Eire, Galley Head, Co. Cork, 50 m below top Old Head Sandstone Formation, PC 4.

Fig. 9 *Hymenozonotriletes explanatus* (LUBER) KEDO
Eire, South Ringabella, Co. Cork, 300 m below top Old Head Sandstone Formation, ML 1051.

Fig. 10 *Hymenozonotriletes explanatus* (LUBER) KEDO
Eire, South Ringabella, Co. Cork, 300 m below top Old Head Sandstone Formation, ML 1413.

Fig. 11 *Vallatisporites pusillites* (KEDO) DOLBY & NEVES
Eire, Old Head of Kinsale, Co. Cork, 150 m below top Old Head Sandstone Formation, PC 5.

Fig. 12 *Vallatisporites pusillites* (KEDO) DOLBY & NEVES
Eire, Galley Head, Co. Cork, 40 m below top Old Head Sandstone Formation, PC 6.

Fig. 13 *Vallatisporites verrucosus* HACQUEBARD
Eire, North Ringabella, Co. Cork, 100 m below top Old Head Sandstone Formation, ML 1056.

Fig. 14 *Spelaeotriletes lepidophytus* (KEDO) STREEL in B.B.S.T.
Eire, West Seven Heads, Co. Cork, 20 m below top Old Head Sandstone Formation, PC 7.

Fig. 15 *Spelaeotriletes lepidophytus* (KEDO) STREEL in B.B.S.T.
Eire, Old Head of Kinsale, Co. Cork, 150 m below top Old Head Sandstone Formation, PC 8.

Fig. 16 *Spelaeotriletes lepidophytus* (KEDO) STREEL in B.B.S.T.
Eire, Old Head of Kinsale, Co. Cork, 150 m below top Old Head Sandstone Formation, PC 9.

Fig. 17 *Lophozonotriletes malevkensis* NAUMOVA in KEDO 1963
Eire, Old Head of Kinsale, Co. Cork, 150 m below top Old Head Sandstone Formation, PC 10.

Fig. 18 *Lophozonotriletes malevkensis* NAUMOVA in KEDO 1963
Eire, Old Head of Kinsale, Co. Cork, 150 m below top Old Head Sandstone Formation, PC 11.

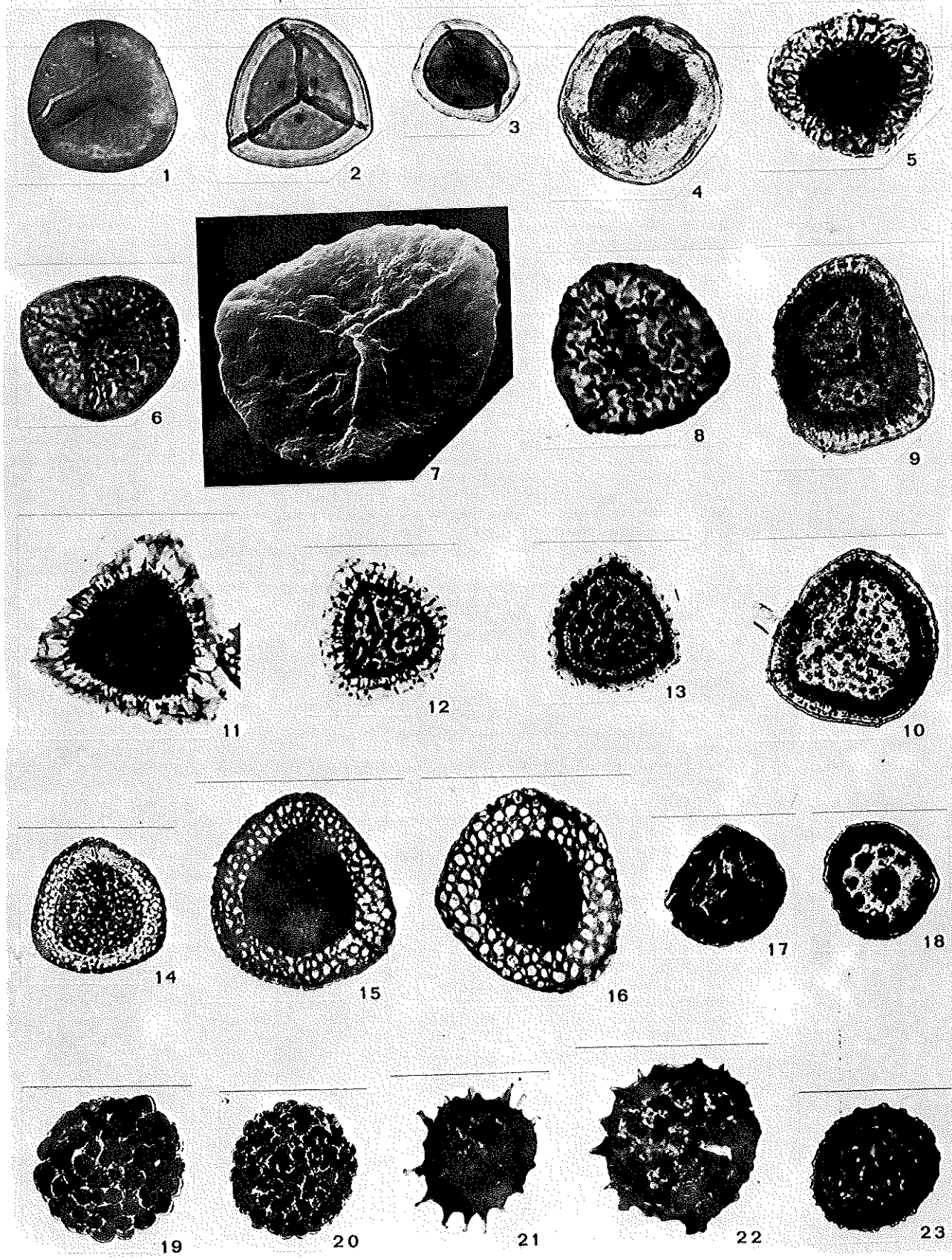
Fig. 19 *Verrucosisporites nitidus* (NAUMOVA) PLAYFORD
Eire, South Ringabella, Co. Cork, 1 m above base Kinsale Formation, ML 1056.

Fig. 20 *Verrucosisporites nitidus* (NAUMOVA) PLAYFORD
Eire, South Ringabella, Co. Cork, 1 m above base Kinsale Formation, ML 1414.

Fig. 21 *Raistrickia variabilis* DOLBY & NEVES
Eire, Galley Head, Co. Cork, 50 m below top Old Head Sandstone Formation, PC 12.

Fig. 22 *Raistrickia macrura* (LUBER) DOLBY & NEVES
Eire, West Seven Heads, Co. Cork, 20 m below top Old Head Sandstone Formation, PC 13.

Fig. 23 *Dictyotriletes submarginatus* PLAYFORD
Eire, Galley Head, Co. Cork, 40 m below top Old Head Sandstone Formation, PC 14.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# PLATE 5

*Vallatisporites vallatus* - *Retusotriletes incohatus* (VI) Subzone

Fig. 1 *Retusotriletes triangulatus* (STREEL) STREEL
Eire, Galley Head, Co. Cork, 30 m above base of Kinsale Formation, PC 15.

Fig. 2 *Pulvinispora quasilabrata* HIGGS
Eire, Old Head of Kinsale, Co. Cork, 40 m above base Member 2, Kinsale Formation, PC 16.

Fig. 3 *Retusotriletes incohatus* SULLIVAN
Eire, Old Head of Kinsale, Co. Cork, 40 m above base Member 2, Kinsale formation, PC 17.

Fig. 4 *Raistrickia corynoges* SULLIVAN
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC 18.

Fig. 5 *Latosporites* sp.
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC 19.

Fig. 6 *Verrucosisporites nitidus* (NAUMOVA) PLAYFORD
Eire, Leap Harbour, Co. Cork, 5 m above base Member 2, Kinsale Formation, PC 20.

Fig. 7 *Lophozonotriletes malevkensis* NAUMOVA in KEDO 1963.
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC 21.

Fig. 8 *Lophozonotriletes rarituberculatus* (LUBER) KEDO
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC 22.

Fig. 9 *Dibolisporites distinctus* (CLAYTON) PLAYFORD
Eire, Hook Head, Co. Wexford, 1 m above base Lyraun Cove Member, Porter's Gate Fm., MI. 1146.

Fig. 10 *Lophozonotriletes cristifer* (LUBER) KEDO
Lateral compression, S.E.M. x 1000.
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC 23.

Fig 11 *Lophozonotriletes cristifer* (LUBER) KEDO
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC 24.

Fig. 12 *Lophozonotriletes cristifer* (LUBER) KEDO
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC 25.

Fig. 13 *Hymenozonotriletes explanatus* (LUBER) KEDO
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC 26.

Fig. 14 *Knoxisporites literatus* (WALTZ) PLAYFORD
Distal surface, S.E.M. x 750.
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC 27.

Fig. 15 *Knoxisporites literatus* (WALTZ) PLAYFORD
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC 28.

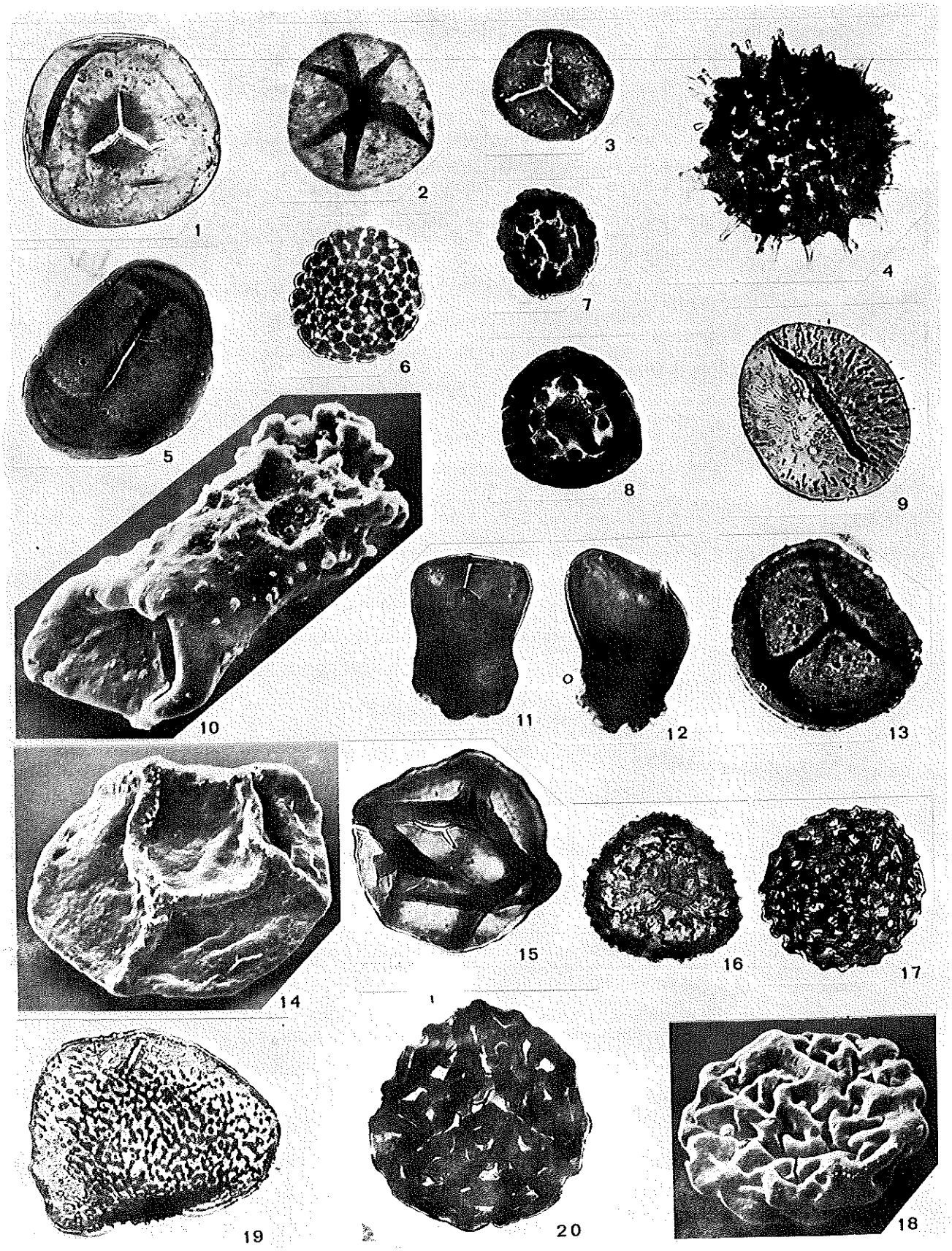
Fig. 16 *Dictyotriletes submarginatus* PLAYFORD
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC. 29.

Fig. 17 *Convolutispora* sp.
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC 30.

Fig. 18 *Convolutispora* sp.
Distal surface, S.E.M. x 750
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC 31.

Fig. 19 *Spelaeotriletes balteatus* (PLAYFORD) HIGGS
Eire, Coolaghmore Quarry (S423 392), 4 km S.W. of Callan, Co. Kilkenny, c. 20 m above base of "Lower Limestone Shale", PC 32.

Fig. 20 *Corbulispora cancellata* (WALTZ) BHARADWAJ & VENKATACHALA
Eire, Old Head of Kinsale, Co. Cork, 40 m above base of Member 2, Kinsale Formation, PC 33.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# PLATE 6

*Spelaeotriletes pretiosus - Raistrickia clavata* (PC) Zone

Fig. 1 *Granulatisporites microgranifer* (IBRAHIM) POTONIÉ & KREMP
Eire, Hook Head, Co. Wexford, 1 m above base of Lyraun Cove Member, Porter's Gate Formation, ML 1414.

Fig. 2 *Granulatisporites microgranifer* (IBRAHIM) POTONIÉ & KREMP
Eire, Hook Head, Co. Wexford, 1 m above base of Lyraun Cove Member, Porter's Gate Formation, ML 1141.

Fig. 3 *Retusotriletes incohatus* SULLIVAN
Eire, 12 km N.W. of Ennis, Co. Clare, Depth c. 105 m, Ballyvergin bore, PC 34.

Fig. 4 *Retusotriletes sp.* A. HIGGS
Eire, Leap Harbour, Co. Cork, 15 m above base Lispatrick Formation, PC 35.

Fig. 5 *Punctatisporites irrasus* HACQUEBARD
Eire, 12 km N.W. of Ennis, Co. Clare, Depht c. 105 m, Ballyvergin bore, PC. 36.

Fig. 6 *Raistrickia clavata* (HACQUEBARD) PLAYFORD
Eire, Hook Head, Co. Wexford, 1 m above base of Lyraun Cove Member, Porter's Gate Formation, ML 1146.

Fig. 7 *Apiculatisporis* sp.
Eire, 12 km N.W. of Ennis, Co. Clare, Depth c. 65 m, Ballyvergin bore, PC 37.

Fig. 8 *Baculatisporites fusticulus* SULLIVAN
Eire, 12 km N.W. of Ennis, Co. Clare, Depth c. 110 m, Ballyvergin bore, PC 38.

Fig. 9 *Rugospora polyptycha* NEVES & IOANNIDES
Eire, 4 km S.W. of Callan, Co. Kilkenny, Coolaghmore Quarry (S 423 392) c. 20 m above base of "Lower Limestone Shale", PC 39.

Fig. 10 *Dictyotriletes trivialis* NAUMOVA in KEDO 1963
Eire, 4 km S.W. of Callan, Co. Kilkenny, c. 20 m above base of "Lower Limestone Shale", PC 40.

Fig. 11 *Vallatisporites vallatus* HACQUEBARD
Eire, Leap Harbour, Co. Cork, 15 m above base of Lispatrick Formation, PC 41.

Fig. 12 *Vallatisporites vallatus* HACQUEBARD
Eire, Leap Harbour, Co. Cork, 15 m above base of Lispatrick Formation, PC 42.

Fig. 13 *Vallatisporites verrucosus* HACQUEBARD
Eire, 12 km N.W. of Ennis, Co. Clare, Depth c. 67 m, Ballyvergin bore, PC 43.

Fig. 14 *Auroraspora macra* SULLIVAN
Eire, 4 km S.W. of Callan, Co. Kilkenny, Coolaghmore Quarry (S423 392) c. 20 m above base of "Lower Limestone Shale", PC 44.

Fig. 15 *Verrucosisporites nitidus* (NAUMOVA) PLAYFORD
Eire, 4 km S.W. of Callan, Co. Kilkenny, Coolaghmore Quarry (S423 392), c. 20 m above base of "Lower Limestone Shale", PC 45.

Fig. 16 *Densosporites spitsbergensis* PLAYFORD
Eire, 4 km S.W. of Callan, Co. Kilkenny, Coolaghmore Quarry (S423 392), c. 20 m above base of "Lower Limestone Shale", PC 46.

Fig. 17 *Grandispora echinata* HACQUEBARD
Eire, 4 km S.W. of Callan, Co. Kilkenny, Coolaghmore Quarry (S423 392), c. 20 m above base of "Lower Limestone Shale", PC 47.

Fig. 18 *Spelaeotriletes pretiosus* (PLAYFORD) NEVES & BELT
Eire, Hook Head, Co. Wexford, 1 m above base of Lyraun Cove Member, Porter's Gate Formation, ML 1147.

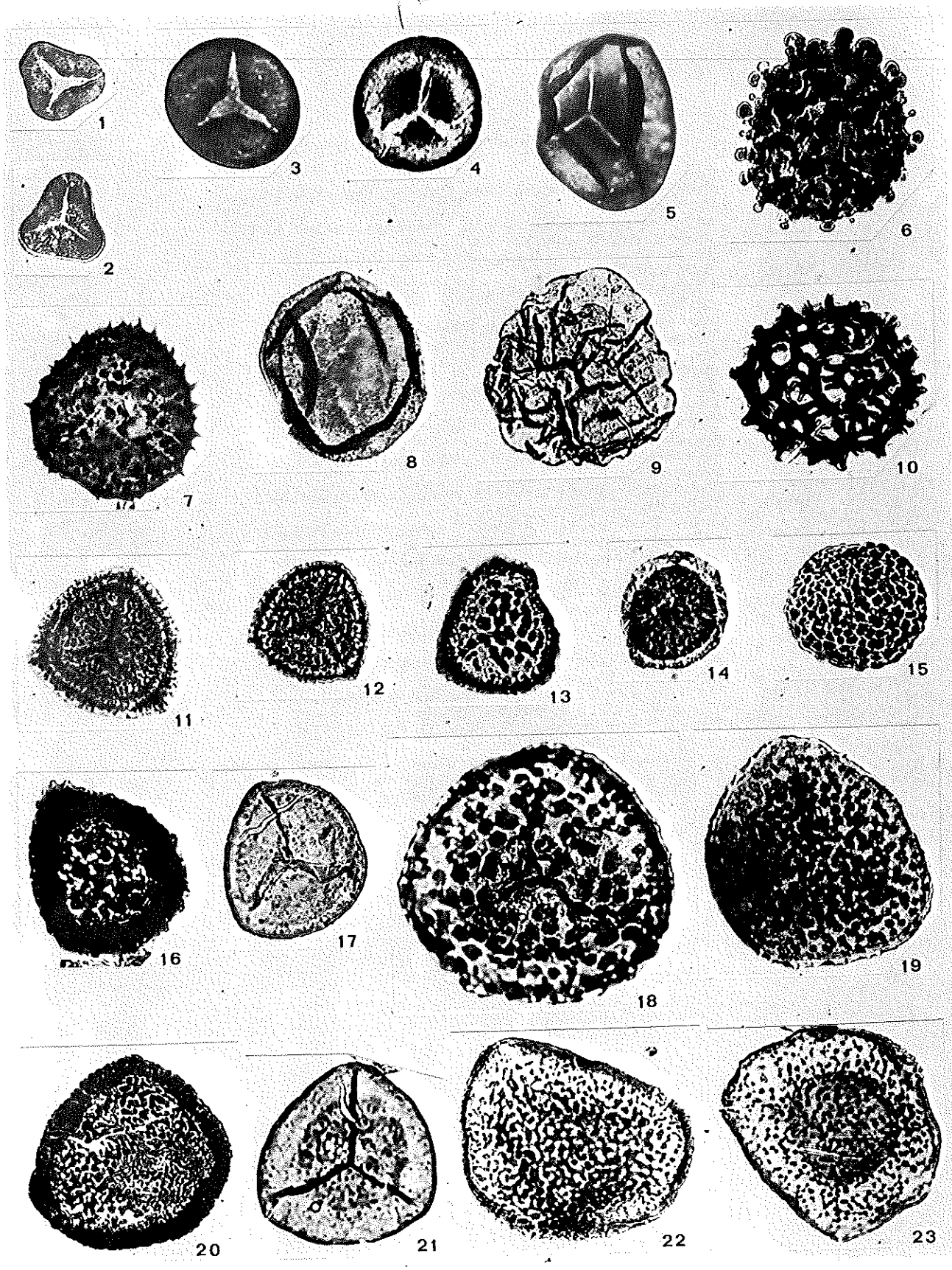
Fig. 19 *Spelaeotriletes pretiosus* (PLAYFORD) NEVES & BELT
Eire, Leap Harbour, Co. Cork, 15 m above base of Lispatrick Formation, PC 48.

Fig. 20 *Verruciretusispora magnifica* var. *magnifica* (MCGREGOR) OWENS
Eire, 4 km S.W. of Callan, Co. Kilkenny, Coolaghmore Quarry (S423 392) c. 20 m above base of "Lower Limestone Shale", PC 49.

Fig. 21 *Discernisporites* sp. A. SULLIVAN 1964
Eire, 12 km N.W. of Ennis, Co. Clare, Depth c. 105 m, Ballyvergin bore, PC 50.

Fig. 22 *Spelaeotriletes balteatus* (PLAYFORD) HIGGS
Eire, 4 km S.W. of Callan, Co. Kilkenny, Coolaghmore Quarry (S423 392) c. 20 m above base of "Lower Limestone Shale", PC 51.

Fig. 23 *Spelaeotriletes balteatus* (PLAYFORD) HIGGS
Eire, 4 km S.W. of Callan, Co. Kilkenny, Coolaghmore Quarry (S423 392) c. 20 m above base of "Lower Limestone Shale", PC 52.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# PLATE 7

*Schopfites claviger - Auroraspora macra* (CM) Zone

Fig. 1 *Calamospora sp.*
Scotland, Edinburgh I.R.R. Borehole 60, Cementstone Group, MPK 1793.

Fig. 2 *Punctatisporites sp.*
Scotland, Edinburgh I.R.R. Borehole 60, Cementstone Group, MPK 1471.

Fig. 3 *Discernisporites crenulatus* (PLAYFORD) CLAYTON
Cumbria, Woyegarth Gill 1 Borehole, Pinskey Gill Beds, MPK 1472.

Fig. 4 *Schopfites claviger* SULLIVAN
Cumbria, Woyegarth Gill 1 Borehole, Pinskey Gill Beds, MPK 1474.

Fig. 5 *Crassispora trychera* NEVES & IOANNIDES
Cumbria, Woyegarth Gill 1 Borehole, Pinskey Gill Beds, MPK 1799.

Fig. 6 *Dibolisporites distinctus* (CLAYTON) PLAYFORD
Cumbria, Woyegarth Gill 1 Borehole, Pinskey Gill Beds, MPK 1475.

Fig. 7 *Raistrickia corynoges* SULLIVAN
Cumbria, Woyegarth Gill 1 Borehole, Pinskey Gill Beds, MPK 1480.

Fig. 8 *Convolutispora circumvallata* CLAYTON
Cumbria, Woyegarth Gill 1 Borehole, Pinskey Gill Beds, MPK 1479.

Fig. 9 *Rugospora minuta* NEVES & IOANNIDES
Scotland, Edinburgh I.R.R. Borehole 60, Cementstone Group, MPK 1794.

Fig. 10 *Auroraspora* sp.
Scotland, Edinburgh I.R.R. Borehole 60, Cementstone Group, MPK 1473.

Fig. 11 *Dictyotriletes* cf. *cheveriensis*
Scotland, Edinburgh I.R.R. Borehole 60, Cementstone Group, MPK 1795.

Fig. 12 *Convolutispora flexuosa* forma *minor* HACQUEBARD
Scotland, Edinburgh I.R.R. Borehole 60, Cementstone Group, MPK 1477.

Fig. 13 *Stenozonotriletes* sp.
Cumbria, Woyegarth Gill 1 Borehole, Pinskey Gill Beds, MPK 1798.

Fig. 14 *Rugospora polyptycha* NEVES & IOANNIDES
Scotland, Edinburgh I.R.R. Borehole 60, Cementstone Group, MPK 1486.

Fig. 15 *Dictyotriletes* cf. *cheveriensis*
Scotland, Edinburgh I.R.R. Borehole 60, Cementstone Group, MPK 1483.

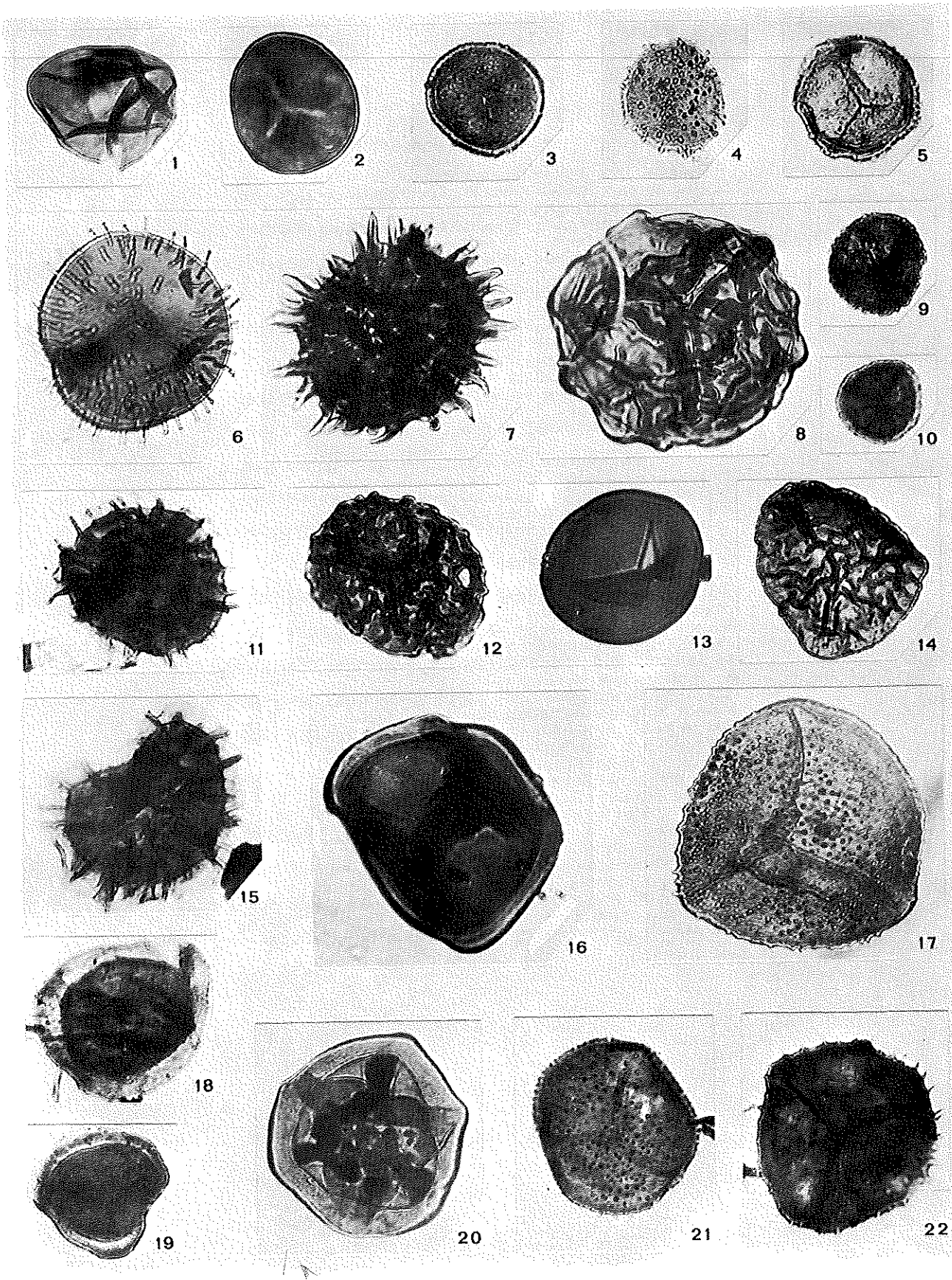
Fig. 16 *Knoxisporites pristinus* SULLIVAN
Cumbria, Woyegarth Gill 1 Borehole, Pinskey Gill Beds, MPK 1482.

Fig. 17 *Spelaeotriletes pretiosus* (PLAYFORD) NEVES & BELT
Cumbria, Woyegarth Gill 1 borehole, Pinskey Gill Beds, MPK 1484.

Figs. 18-19 *Auroraspora macra* SULLIVAN
Scotland, Edinburgh I.R.R. Borehole 60, Cementstone Group, MPK 1796, MPK 1487.

Fig. 20 *Knoxisporites literatus* var. *triangularis* (KEDO) CLAYTON
Cumbria, Woyegarth Gill 1 Borehole, Pinskey Gill Beds, MPK 1481.

Figs. 21-22 *Grandispora echinata* HACQUEBARD
Scotland, Edinburgh I.R.R. Borehole 60, Cementstone Group, MPK 1485, MPK 1797.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## PLATE 8

*Lycospora pusilla* (Pu) Zone

Fig. 1 — *Punctatisporites aerarius* BUTTERWORTH & WILLIAMS
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1496.

Fig. 2 — *Crassispora trychera* NEVES & IOANNIDES
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1491.

Figs. 3-4 — *Schopfites claviger* SULLIVAN
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1492, MPK 1493.

Fig. 5 — *Neoraistrickia* sp.
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1489.

Fig. 6 — *Acanthotriletes* sp.
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1490.

Fig. 7 — *Apiculiretusispora multiseta* (LUBER) BUTTERWORTH & SPINNER
North-West England, Bewcastle, Main Algal Formation, MPK 1494.

Fig. 8 — *Pustulatisporites multicapitis* BERTELSEN
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1490.

Fig. 9 — *Convolutispora* cf. *mellita*
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1495.

Fig. 10 — *Auroraspora* sp.
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1800.

Fig. 11 — *Lycospora pusilla* (IBRAHIM) SOMERS
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1499.

Fig. 12 — *Convolutispora ampla* HOFFMEISTER, STAPLIN & MALLOY
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1498.

Fig. 13 — *Convolutispora* cf. *circumvallata*
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1503.

Fig. 14 — *Knoxisporites* cf. *cinctus*
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1497.

Fig. 15 — *Dictyotriletes* sp.
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1502.

Figs. 16-17 — *Vallatisporites ciliaris* (LUBER) SULLIVAN
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1501-MPK 1505.

Fig. 18 — *Knoxisporites stephanophorus* LOVE
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1500.

Fig. 19 — *Knoxisporites literatus* (WALTZ) PLAYFORD
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1506.

Fig. 20 — *Pulvinispora scolecophora* NEVES & IOANNIDES
Cumbria, Lower Border Group, ML 1387.

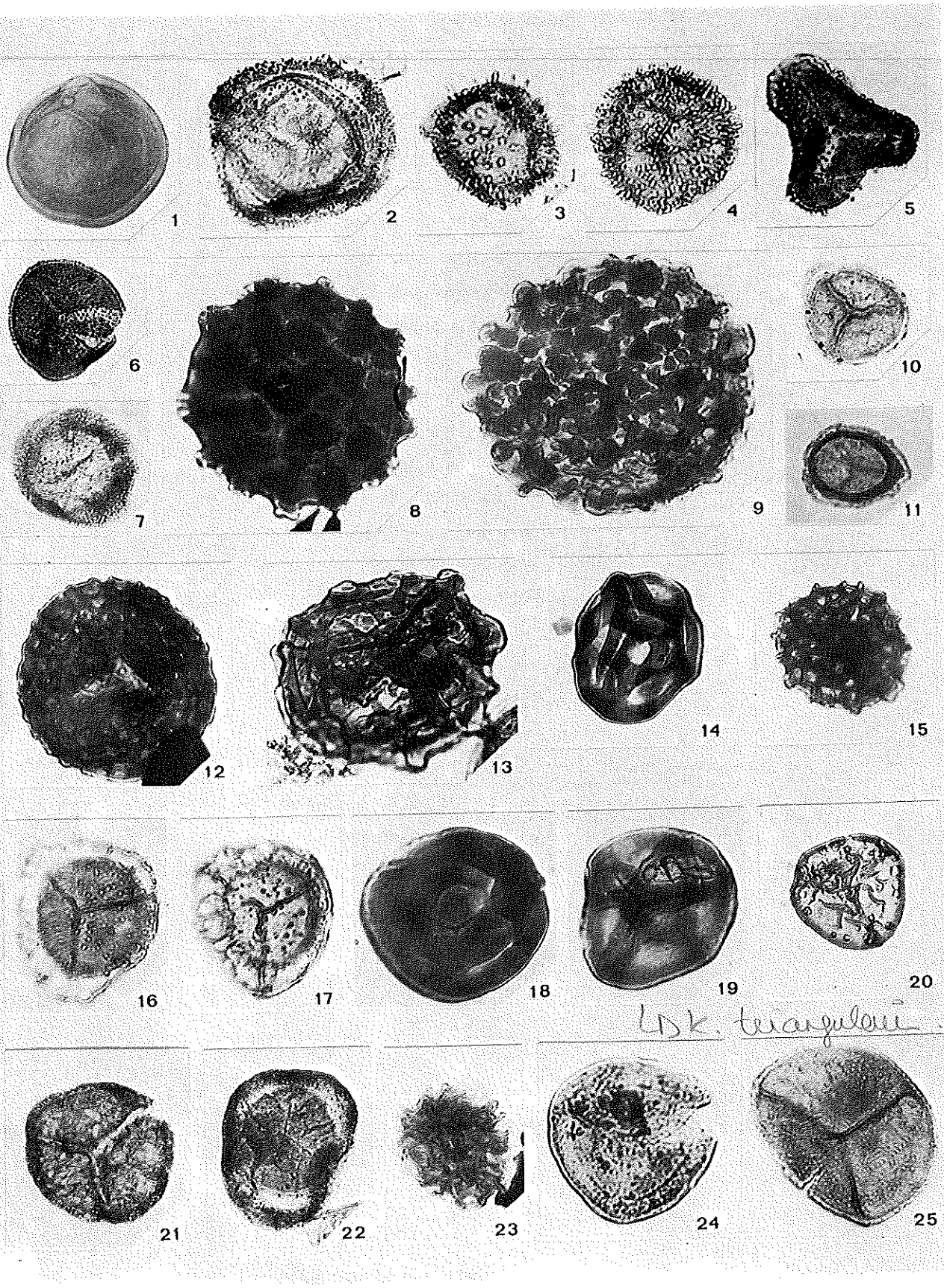
Fig. 21 — *Colatisporites decorus* (BHARADWAJ & VENKATACHALA) WILLIAMS
Cumbria, Lower Border Group, ML 1385.

Fig. 22 — *Auroraspora macra* SULLIVAN
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1508.

Fig. 23 — *Rugospora minuta* NEVES & IOANNIDES
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1801.

Fig. 24 — *Discernisporites micromanifestus* (HACQUEBARD) SABRY & NEVES
Scotland, Newburgh Borehole, Firth of Tay, Cementstone Group, MPK 1802.

Fig. 25 — *Grandispora* cf. *echinata*
Scotland, Newburgh Borehole, Firth of Tay Cementstone Group, MPK 1507.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Lisk. triangulatus
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# PLATE 9

*Perotrilites tessellatus - Schulzospora campyloptera* (TC) Zone

Fig. 1 *Punctatisporites glaber* (NAUMOVA) PLAYFORD
Scotland, Cousland Borehole, Lower Oil Shale Group, MPK 1509.

Fig. 2 *Calamospora* cf. *microrugosa*
Scotland, Cousland Borehole, Lower Oil Shale Group, MPK 1803.

Fig. 3 *Waltzispora planiangulata* SULLIVAN
Scotland, Cousland Borehole, Lower Oil Shale Group, MPK 1513.

Fig. 4 *Anaplanisporites* cf. *atheticus*
Scotland, Cousland Borehole, Lower Oil Shale Group, MPK 1517.

Fig. 5 *Convolutispora* sp.
Scotland, Cousland Borehole, Lower Oil Shale Group, MPK 1804.

Fig. 6 *Punctatisporites* sp.
Northumberland, Bewcastle, Middle Border Group,MPK 1510.

Fig. 7 *Cyclogranisporites palaeophytus* NEVES & IOANNIDES
Scotland, Cousland Borehole, Lower Oil Shale Group, MPK 1516.

Fig. 8 *Acanthotriletes hacquebardi* PLAYFORD
Northumberland, Bewcastle, Middle Border Group, MPK 1512.

Fig. 9 *Lycospora noctuina* BUTTERWORTH & WILLIAMS
Northumberland, Bewcastle, Middle Border Group, ML 1396.

Fig. 10 *Lycospora pusilla* (IBRAHIM) SOMERS
Northumberland, Bewcastle, Middle Border Group, ML 1394.

Fig. 11 *Apiculatisporis* sp.
Northumberland, Bewcastle, Middle Border Group, MPK 1519.

Fig. 12 *Dictyotriletes* cf. *submarginatus*
Northumberland, Bewcastle, Middle Border Group, MPK 1522.

Fig. 13 *Dictyotriletes plumosus* BUTTERWORTH & SPINNER
Northumberland, Bewcastle, Middle Border Group, MPK 1515.

Fig. 14 *Crassispora aculeata* NEVILLE
Scotland, Cousland Borehole, Lower Oil Shale Group, MPK 1523.

Fig. 15 *Vallatisporites* cf. *ciliaris*
Northumberland, Bewcastle, Middle Border Group, MPK 1521.

Fig. 16 *Convolutispora planimuricata* BUTTERWORTH & SPINNER
Northumberland, Bewcastle, Middle Border Group, MPK 1514.

Fig. 17 *Convolutispora* sp.
Northumberland, Bewcastle, Middle Border Group, MPK 1518.

Fig. 18 *Colatisporites decorus* (BHARADWAJ & VENKATACHALA) WILLIAMS
Scotland, Cousland Borehole, Lower Oil Shale Group, MPK 1511.

Fig. 19 *Anaplanisporites delicatus* NEVES & IOANNIDES
Scotland, Cousland Borehole, Lower Oil Shale Group, MPK 1901.

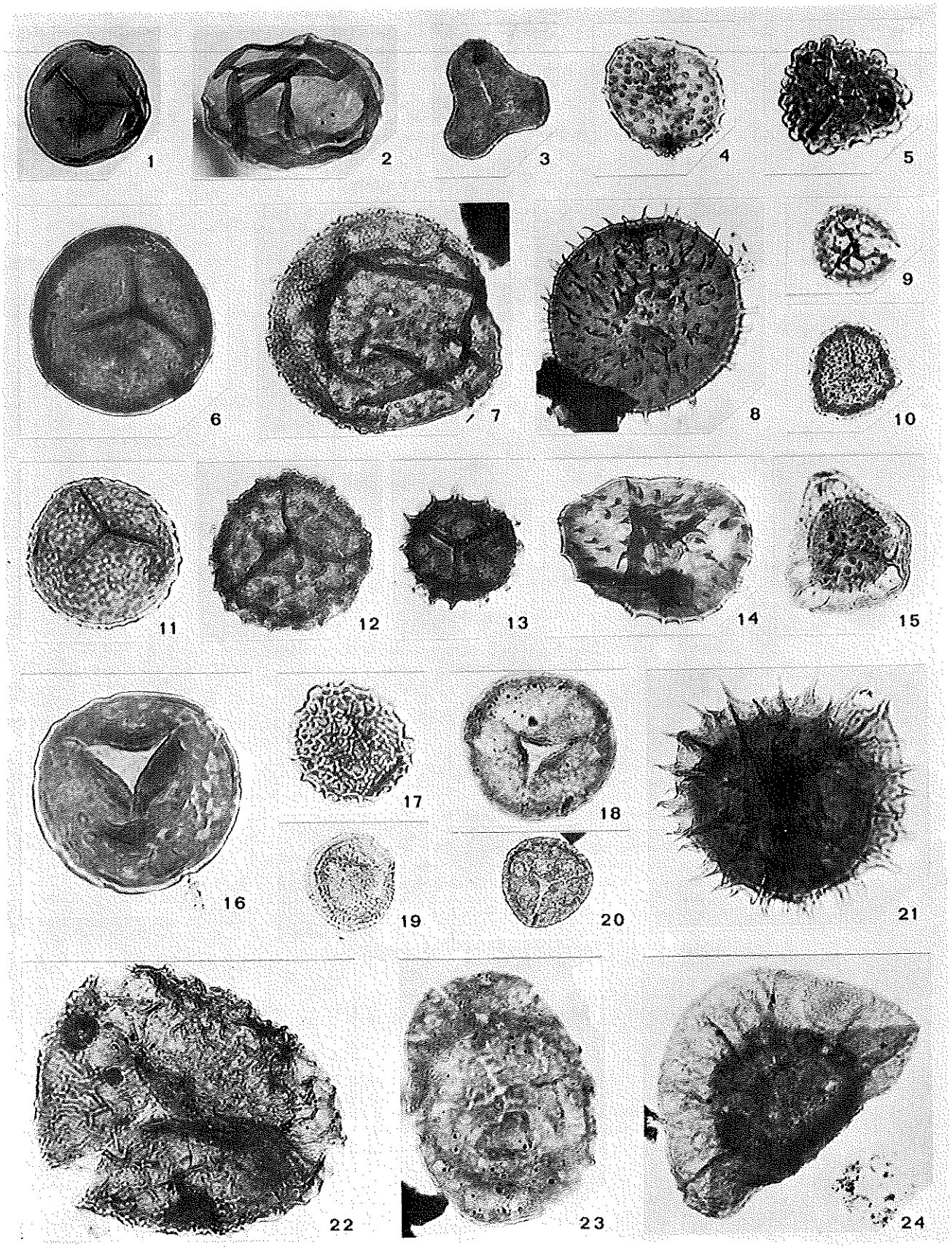
Fig. 20 *Lycospora rugulosa* BUTTERWORTH & SPINNER
Northumberland, Bewcastle, Middle Border Group, ML 1388.

Fig. 21 *Spinozonotriletes uncatus* HACQUEBARD
Northumberland, Bewcastle, Middle Border Group, MPK 1519.

Fig. 22 *Perotrilites tessellatus* (STAPLIN)NEVILLE
Northumberland, Bewcastle, Middle Border Group, MPK 1524.

Fig. 23 *Schulzospora rara* KOSANKE
Northumberland, Bewcastle, Middle Border Group, MPK 1525.

Fig. 24 *Auroraspora solisortus* HOFFMEISTER, STAPLIN & MALLOY
Northumberland, Bewcastle, Middle Border Group, MPK 1526.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## PLATE 10

*Raistrickia nigra - Triquitrites marginatus (NM) Zone*

Fig. 1 *Waltzispora polita* (LOVE) SULLIVAN
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1527.

Fig. 2 *Lophotriletes densus* LOVE
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1529.

Fig. 3 *Tricidarisporites fasciculatus* LOVE
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1805.

Fig. 4 *Punctatisporites* sp.
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1531.

Fig. 5 *Waltzispora polita* (LOVE) SULLIVAN
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1806.

Fig. 6 *Apiculatisporis* cf. *porosus*
Northumberland, Lower Limestone Group, ML 1390.

Fig. 7 *Dictyotriletes* sp.
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1807.

Fig. 8 *Raistrickia nigra* LOVE
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1532.

Fig. 9 *Corbulispora* cf. *cancellata*
Northumberland, Fourlaws Coal, MPK 1812.

Figs. 10-11 *Tripartites distinctus* WILLIAMS
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1535, MPK 1533.

Fig. 12 *Ahrensisporites duplicatus* NEVILLE
Northumberland, Fourlaws Coal, MPK 1534.

Fig. 13 *Murospora margodentata* BÉJU
Northumberland, Lower Limestone Group, ML 1383.

Fig. 14 *Cribrosporites cribellatus* SULLIVAN
Northumberland, Lower Limestone Group, ML 1391.

Fig. 15 *Orbisporites* cf. *convolutus*
Northumberland, Fourlaws Coal, MPK 1539.

Figs. 16-17 *Lycospora pusilla* (IBRAHIM) SOMERS
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1530, MPK 1808.

Fig. 18 *Monilospora mutabilis* (PLAYFORD) CLAYTON
Northumberland, Lower Limestone Group, ML 1386.

Fig. 19 *Knoxisporites stephanophorus* LOVE
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1809.

Fig. 20 *Dictyotriletes sagenoformis* SULLIVAN
Northumberland, Fourlaws Coal, MPK 1813.

Fig. 21 *Apiculiretusispora multiseta* (LUBER) BUTTERWORTH & SPINNER
Scotland, Cousland 1 Borehole Lower Oil Shale Group, MPK 1810.

Fig. 22 *Potoniespores delicatus* PLAYFORD
Northumberland, Lower Limestone Group, ML 1384.

Fig. 23 *Murospora parthenopia* NEVES & IOANNIDES
Northumberland, Lower Limestone Group, ML 1385.

Fig. 24 *Densosporites anulatus* (LOOSE) SMITH & BUTTERWORTH
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1540.

Fig. 25 *Cingulizonates* sp.
Northumberland, Fourlaws Coal, MPK 1541.

Fig. 26 *Cristatisporites* cf. *bellus*
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1542.

Fig. 27 *Diatomozonotriletes* cf. *rarus*
Northumberland, Fourlaws Coal, MPK 1814.

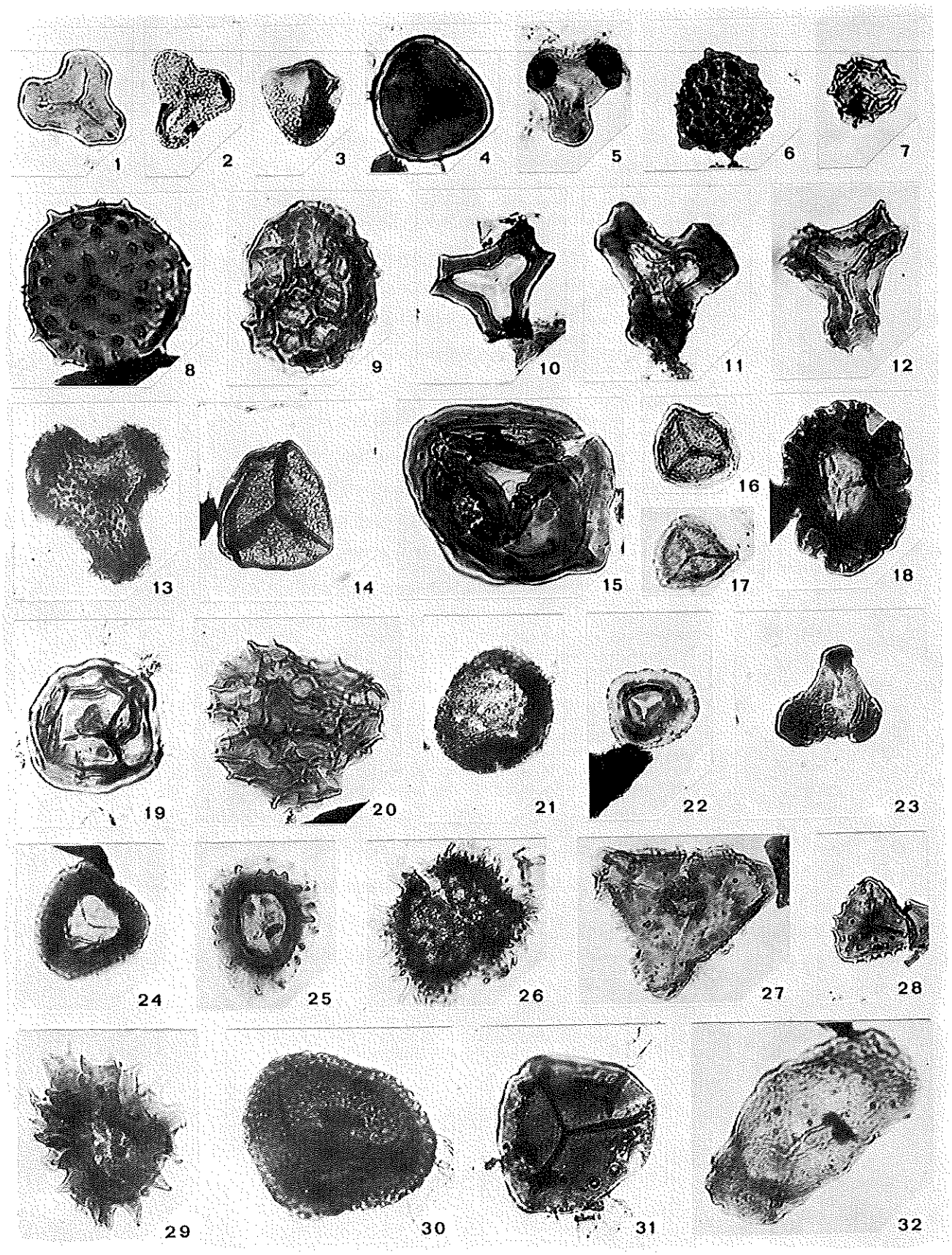
Fig. 28 *Rotaspora ergonulii* (AGRALI) SULLIVAN & MARSHALL
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1528.

Fig. 29 *Cristatisporites* sp.
Northumberland, Fourlaws Coal, MPK 1543.

Fig. 30 *Convolutispora* sp.
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1544.

Fig. 31 *Discernisporites micromanifestus* (HACQUEBARD) NEVES & BELT
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1545.

Fig. 32 *Schulzospora campyloptera* (WALTZ) HOFFMEISTER, STAPLIN & MALLOY
Scotland, Cousland 1 Borehole, Lower Oil Shale Group, MPK 1546.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## PLATE 11

*Tripartites vetustus* - *Rotaspora fracta* (VF) Zone

Fig. 1 *Punctatisporites* sp.
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1815.

Fig. 2 *Leiotriletes tumidus* BUTTERWORTH & WILLIAMS
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1547.

Fig. 3 *Verrucosisporites baccatus* STAPLIN
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1550.

Fig. 4 *Lophotriletes* sp.
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1549.

Fig. 5 *Lophotriletes tribulosus* SULLIVAN
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1549.

Fig. 6 *Verrucosisporites* cf. *nodosus*
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1816.

Fig. 7 *Waltzispora planiangulata* SULLIVAN
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1819.

Fig. 8 *Dictyotriletes* sp.
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1820.

Fig. 9 *Densosporites* sp.
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1821.

Fig. 10 *Densosporites brevispinosus* SULLIVAN & MARSHALL
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1818.

Fig. 11 *Tripartites vetustus* SCHEMEL
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1557.

Fig. 12 *Raistrickia nigra* LOVE
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1552.

Fig. 13 *Pilosisporites venustus* SULLIVAN & MARSHALL
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1551.

Fig. 14 *Triquitrites comptus* WILLIAMS
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1555.

Fig. 15 *Triquitrites marginatus* HOFFMEISTER, STAPLIN & MALLOY
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1554.

Fig. 16 *Lycospora* cf. *noctuina*
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1825.

*Fig. 17* *Lycospora pusilla* (IBRAHIM) SOMERS
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1558.

Figs. 18-19 *Stenozonotriletes coronatus* SULLIVAN & MARSHALL
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1560, MPK 1556.

Fig. 20 *Knoxisporites triradiatus* HOFFMEISTER, STAPLIN & MALLOY
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1900.

Fig. 21 *Tholisporites ? biannulatus* NEVES
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1559.

Fig. 22 *Kraeuselisporites* sp., cf. *K. ornatus* (NEVES) OWENS, MISHELL & MARSHALL
Scotland Cousland 1 Borehole, Upper Oil Shale Group, MPK 1561.

Fig. 23 *Kraeuselisporites* sp.
Scotland, Cousland 1 Borehole. Upper Oil Shale Group, MPK 1562.

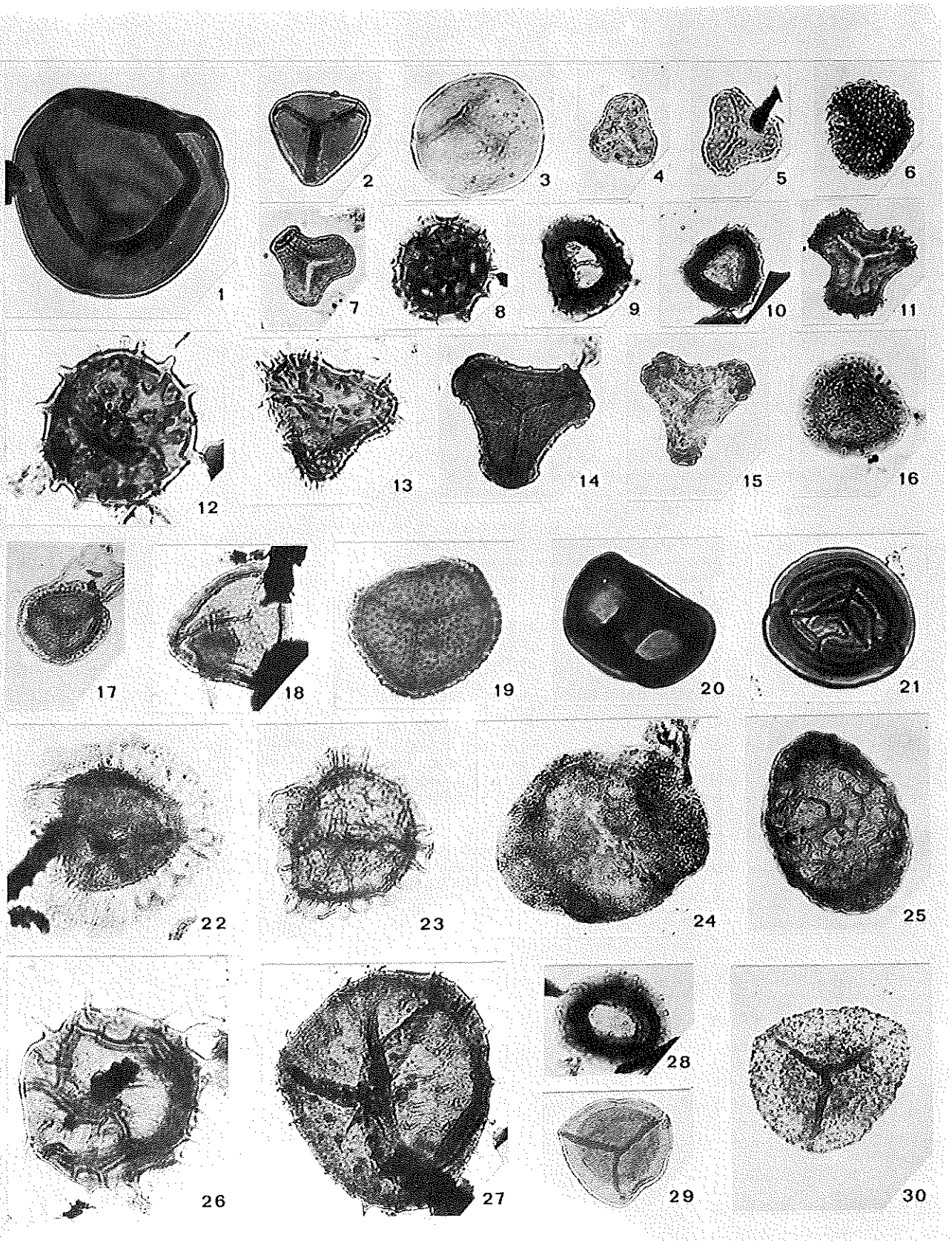
Figs. 24-25 *Schulzospora rara* KOSANKE
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 986, MPK 1563.

Figs. 26-27 *Crassispora aculeata* NEVILLE
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1564, MPK 1565.

Fig. 28 *Cingulizonates bialatus* (WALTZ) SMITH & BUTTERWORTH
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1824.

Fig. 29 *Discernisporites* cf. *micromanifestus*
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1825.

Fig. 30 *Discernisporites micromanifestus* (HACQUEBARD) SABRY & NEVES
Scotland, Cousland 1 Borehole, Upper Oil Shale Group, MPK 1817.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## PLATE 12

*Bellispores nitidus - Reticulatisporites carnosus* (NC) Zone

Fig. 1 *Acanthotriletes* sp.
Stainmore, Shale above Little Limestone, MPK 1361.

Fig. 2 *Raistrickia nigra* LOVE
Stainmore, Shale above Little Limestone, MPK 1360.

Fig. 3 *Rotaspora knoxi* BUTTERWORTH & WILLIAMS
Stainmore, Shale above Little Limestone, MPK 1371.

Fig. 4 *Cingulizonates bialatus* (WALTZ) SMITH & BUTTERWORTH
Cumbria, Moota 2 Borehole, MPK 1372.

Fig. 5 *Ibrahimispores* cf. *brevispinosus*
Stainmore, Shale above Little Limestone, MPK 1363.

Fig. 6 *Dictyotriletes* cf. *aquabilis*
Stainmore, Shale above Little Limestone, MPK 1365.

Fig. 7 *Triquitrites marginatus* HOFFMEISTER, STAPLIN & MALLOY
Cumbria, Moota 2 Borehole, MPK 1366.

Fig. 8 *Ahrensisporites guerickei* var. *ornatus* NEVES
Stainmore, Shale above Little Limestone, MPK 1380.

Fig. 9 *Rotaspora fracta* SCHEMEL
Stainmore, Shale above Little Limestone, MPK 1375.

Fig. 10 *Rotaspora knoxi* BUTTERWORTH & WILLIAMS
Stainmore, Shale above Upper Stonesdale Limestone, MPK 1316.

Fig. 11 *Tripartites vetustus* SCHEMEL
Stainmore, Shale above Upper Stonesdale Limestone, MPK 1367.

Fig. 12 *Tripartites trilinguis* (HORST) POTONIÉ & KREMP
Stainmore, Shale above Crow Limestone, MPK 1370.

Fig. 13 *Bellispores nitidus* (HORST) SULLIVAN
Stainmore, Shale above Little Limestone, MPK 1377.

Fig. 14 *Densosporites* cf. *spinifer*
Cumbria, Moota 2 Borehole, MPK 1372.

Fig. 15 *Schulzospora ocellata* (HORST) POTONIÉ & KREMP
Stainmore, Shale above Little Limestone, MPK 1389

Fig. 16 *Schulzospora campyloptera* (WALTZ) HOFFMEISTER, STAPLIN & MALLOY
Stainmore, Shale above Crow Limestone, MPK 1388.

Fig. 17 *Crassispora maculosa* (KNOX) SULLIVAN
Stainmore, Shale above Little Limestone, MPK 1379.

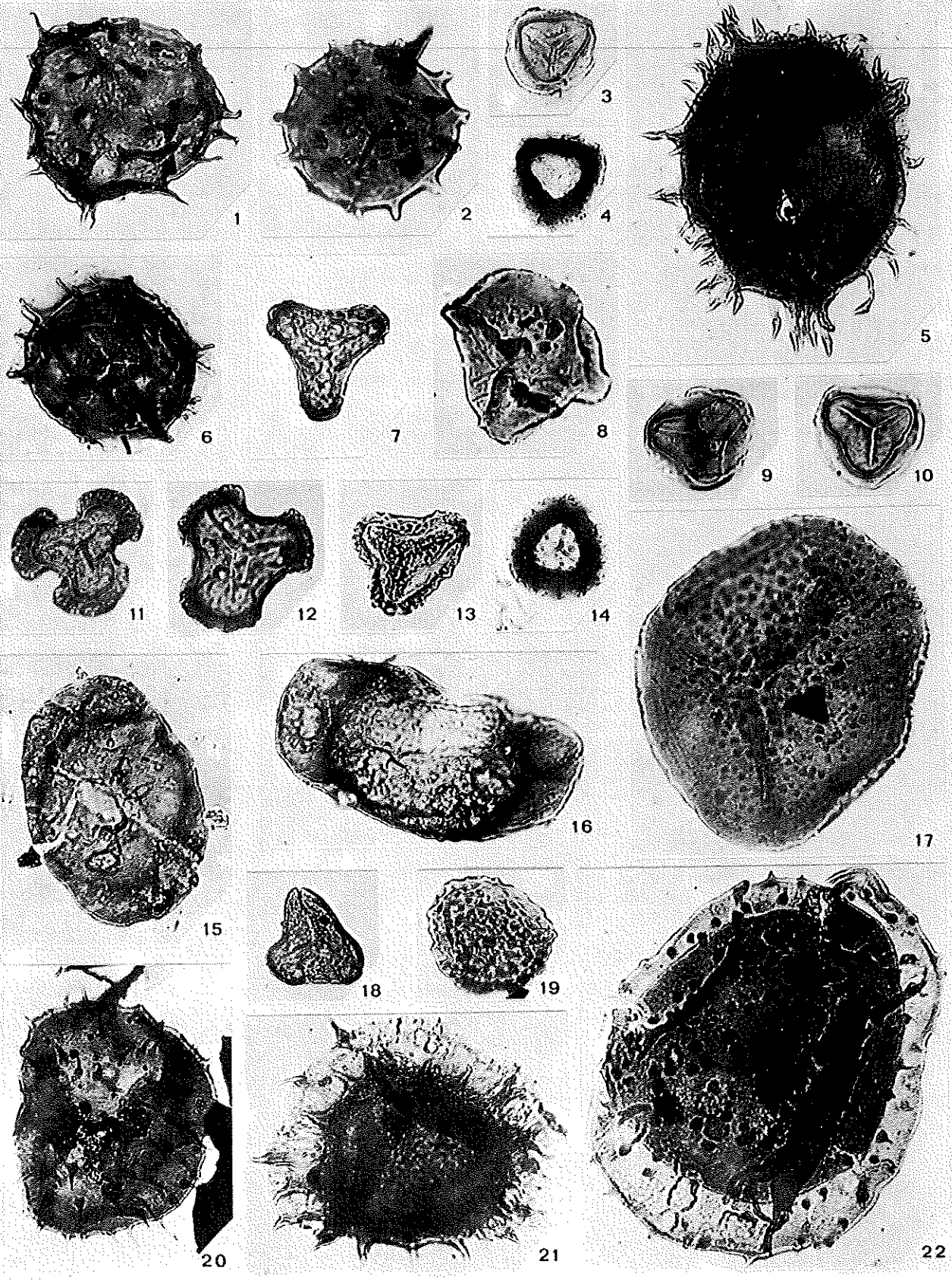
Fig. 18 *Microreticulatisporites concavus* BUTTERWORTH & WILLIAMS
Stainmore, Shale above Little Limestone, MPK 1370.

Fig. 19 *Convolutispora venusta* HOFFMEISTER, STAPLIN & MALLOY
Stainmore, Shale above Little Limestone, MPK 1385.

Fig. 20 *Spinozonotriletes uncatus* HACQUEBARD
Cumbria, Moota 2 Borehole, MPK 1386.

Fig. 21 *Kraeuselisporites echinatus* OWENS, MISHELL & MARSHALL
Stainmore, Shale above Little Limestone, MPK 1384.

Fig. 22 *Grandispora spinosa* HOFFMEISTER, STAPLIN & MALLOY
Stainmore, Shale above Little Limestone, MPK 1387.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## PLATE 13

*Stenozonotriletes triangulus* - *Rotaspora knoxi* (TK) Zone

Fig. 1 *Punctatisporites pseudopunctatus* NEVES
Stainmore, Shales below High Wood Marine Beds, MPK 1390.

Fig. 2 *Acanthotriletes castanea* BUTTERWORTH & WILLIAMS
Stainmore, Shales below Stricegill Grit, MPK 1391.

Fig. 3 *Dictyotriletes* cf. *peltatus*
Stainmore, Shales below High Wood Marine Beds, MPK 1393.

Fig. 4 *Dictyotriletes aequalis* STAPLIN
Stainmore, Shales below High Wood Marine Beds, MPK 1392.

Fig. 5 *Knoxisporites dissidius* NEVES
Stainmore, Shales below High Wood Marine Beds, MPK 1400.

Fig. 6 *Convolutispora* cf. *varicosa*
Stainmore, Shale above Stricegill Grit, MPK 1397.

Fig. 7 *Knoxisporites stephanophorus* LOVE
Stainmore, Shales below High Wood Marine Beds, MPK 1406.

Fig. 8 *Lycospora pusilla* (IBRAHIM) SOMERS
Stainmore, Stricegill Limestone, St. Gt. Pal. 21.

Fig. 9 *Cingulizonates loricatus* (LOOSE) BUTTERWORTH et al.
Stainmore, Stricegill Limestone, St. Gt. Pal. 21.

Fig. 10 *Rotaspora fracta* SCHEMEL
Stainmore, Holme Wood Coal, MPK 1785.

Fig. 11 *Rotaspora knoxi* BUTTERWORTH & WILLIAMS
Stainmore, Holme Wood Coal, MPK 1371.

Fig. 12 *Lycospora pusilla* (IBRAHIM) SOMERS
Stainmore, Stricegill Limestone, St. Gt. Pal. 21.

Fig. 13 *Densosporites* cf. *intermedius*
Stainmore, Stricegill Limestone, St. Gt. Pal. 21.

Fig. 14 *Tripartites vetustus* SCHEMEL
Stainmore, Shale below Stricegill grit, MPK 1396.

Fig. 15 *Alatisporites rudus* NEVES
Stainmore, Shale below Stricegill Grit, MPK 1403.

Fig. 16 *Schulzospora campyloptera* (WALTZ) HOFFMEISTER, STAPLIN & MALLOY
Stainmore, Shales below High Wood Marine Beds, MPK 1402.

Fig. 17 *Knoxisporites seniradiatus* NEVES
Stainmore, Shales below High Wood Marine Beds, MPK 1401.

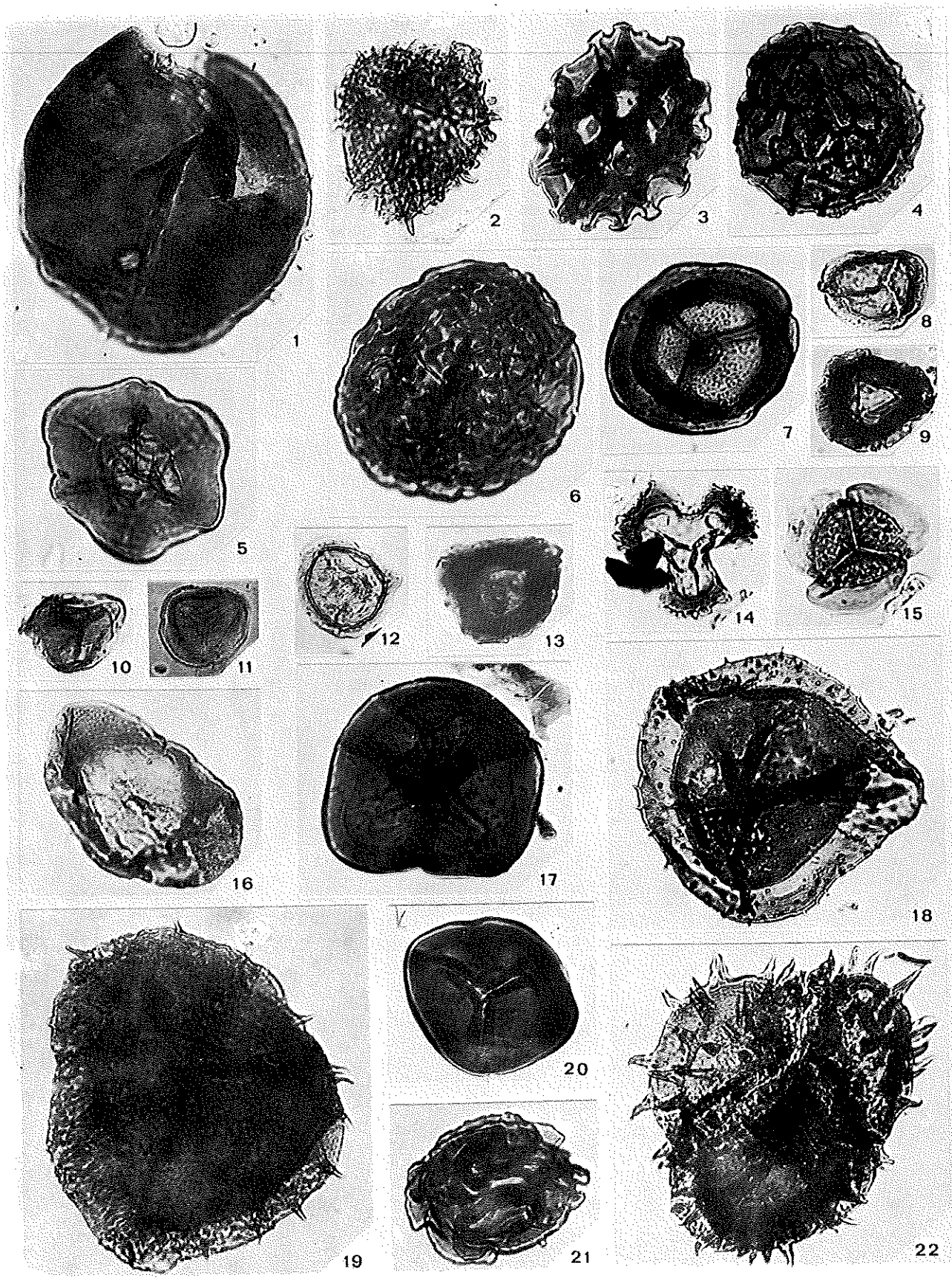
Fig. 18 *Grandispora spinosa* HOFFMEISTER, STAPLIN & MALLOY
Stainmore, Shales above Little Limestone, MPK 1408.

Fig. 19 *Kraeuselisporites echinatus* OWENS, MISHELL & MARSHALL
Stainmore, Shales above Little Limestone, MPK 1106.

Fig. 20 *Stenozonotriletes triangulus* NEVES
Stainmore, Shales below High Wood Marine Beds, MPK 990.

Fig. 21 *Proprisporites laevigatus* NEVES
Stainmore, Shale below Stricegill Grit, MPK 1404.

Fig. 22 *Spinozonotriletes uncatus* HACQUEBARD
Stainmore, Shales above Little Limestone, MPK 1409.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# PLATE 14

*Lycospora subtriquetra - Kraeuselisporites ornatus* (SO) Zone

Fig. 1 *Ibrahimispores brevispinosus* NEVES
Stainmore, Shales below Mousegill Marine Beds, MPK 1410.

Fig. 2 *Verrucosisporites cerosus* (HOFFMEISTER, STAPLIN & BUTTERWORTH) BUTTERWORTH & WILLIAMS
Stainmore, Coal below High Wood Marine Beds, MPK 1411.

Fig. 3 *Convolutispora cerebra* BUTTERWORTH & WILLIAMS
Stainmore, Coal below High Wood Marine Beds, MPK 1417.

Fig. 4 *Raistrickia* cf. *microhorrida*
Stainmore, Shale below Peasah Wood Limestone, MPK 1841.

Fig. 5 *Acanthotriletes aculeolatus* KOSANKE
Stainmore, Shale above Peasah Wood Limestone, MPK 1840.

Fig. 6 *Bellispores nitidus* (HORST) SULLIVAN
Stainmore, Coal below High Wood Marine Beds, MPK 995.

Fig. 7 *Dictyotriletes* cf. *peltatus*
Stainmore, Shales below Mousegill Marine Beds, MPK 1415.

Fig. 8 *Proprisporites laevigatus* NEVES
Stainmore, Shale above Peasah Wood Limestone, MPK 1421.

Fig. 9 *Kraeuselisporites ornatus* (NEVES) OWENS, MISHELL & MARSHALL
Stainmore, Shale below Swinstone Bottom Marine Band, ML 1187.

Fig. 10 *Lycospora pusilla* (IBRAHIM) SOMERS
Stainmore, Shale above Little Limestone, MPK 1830.

Fig. 11 *Lycospora subtriquetra* (LUBER) POTONIÉ & KREMP
Stainmore, Shales below Mousegill Marine Beds, MPK 1414.

Fig. 12 *Knoxisporites hageni* POTONIÉ & KREMP
Stainmore, Shale above Peasah Wood Limestone, MPK 1420.

Fig. 13 *Knoxisporites stephanophorus* LOVE
Stainmore, Shale above Peasah Wood Limestone, MPK 1835.

Fig. 14 *Crassispora kosankei* (POTONIÉ & KREMP) BHARADWAJ
Stainmore, Shales below Mousegill Marine Beds, MPK 1416.

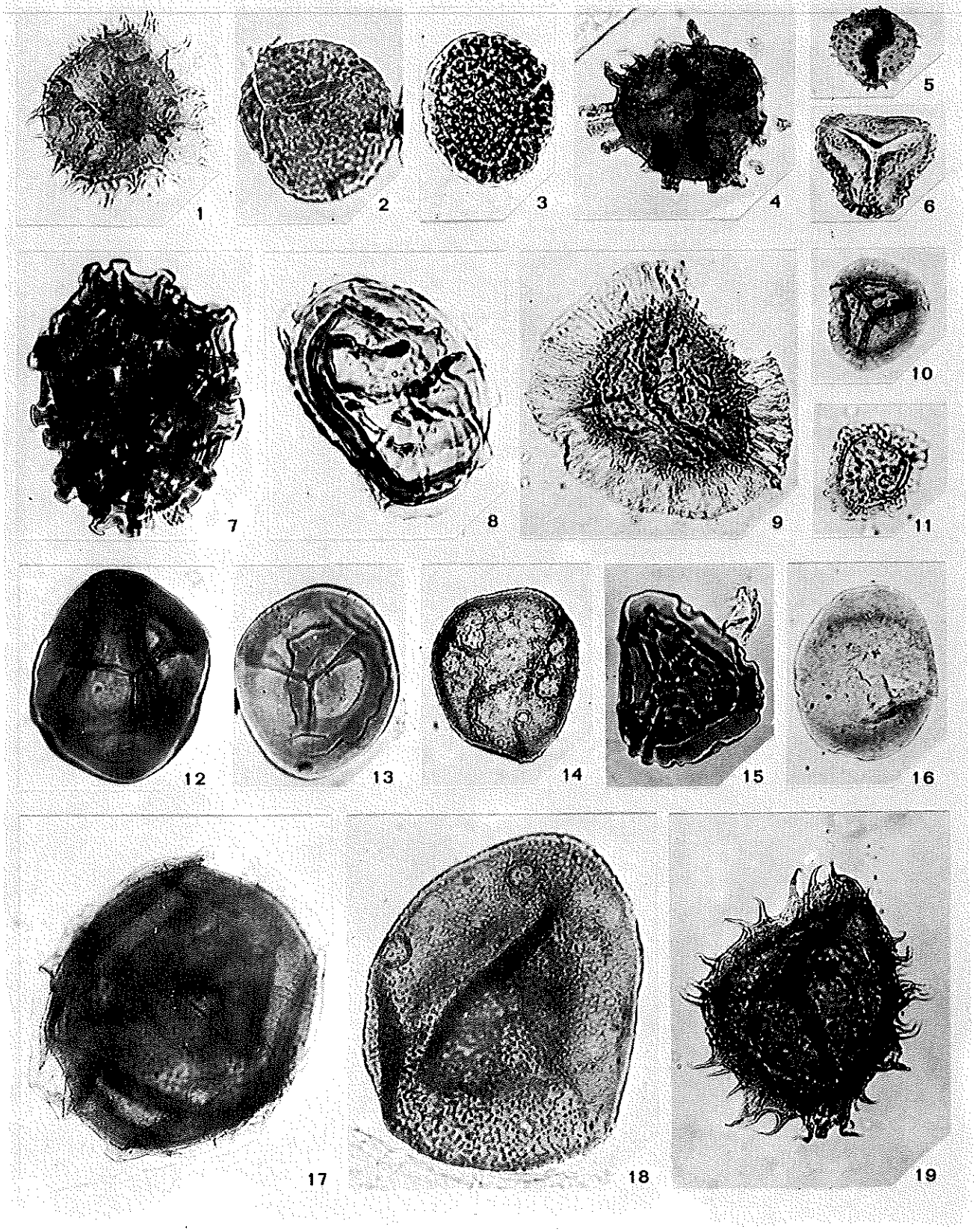
Fig. 15 *Savitrisporites nux* (BUTTERWORTH & WILLIAMS) SMITH & BUTTERWORTH
England, Shropshire, Cornbrook Sandstone, MPK 931.

Fig. 16 *Shulzospora* cf. *ocellata*
Stainmore, Shale below Peasah Wood Limestone, MPK 1839.

Fig. 17 *Remysporites magnificus* (HORST) BUTTERWORTH & WILLIAMS
Stainmore, Shale above High Wood Coal, MPK 1832.

Fig. 18 *Spelaeotriletes arenaceus* NEVES & OWENS
Stainmore, Shale above Peasah Wood Limestone, MPK 1836.

Fig. 19 *Spinozonotriletes uncatus* HACQUEBARD
Stainmore, Shales below High Wood Marine Beds, MPK 1422.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# PLATE 15

*Crassispora kosankei - Grumosisporites varioreticulatus* (KV) Zone

Fig. 1 *Punctatisporites aerarius* BUTTERWORTH & WILLIAMS.
Stainmore, Mousegill Marine Beds, MPK 1423.

Figs. 2-3 *Mooreisporites trigallerus* NEVES
Stainmore, Shales above Mousegill Marine Beds, MPK 1428, MPK 1425.

Fig. 4 *Mooreisporites* cf. *fustis*
Stainmore, Shales above Mousegill Marine Beds, MPK 1424.

Fig. 5 *Ibrahimispores magnificus* NEVES
Stainmore, Shales above Mousegill Marine Beds, MPK 1427.

Fig. 6 *Ibrahimispores brevispinosus* NEVES
Stainmore, Mousegill Marine Beds, MPK 1426.

Fig. 7 *Dictyotriletes karadenizensis* ARTUZ
Stainmore, Shales above Mousegill Marine Beds, MPK 1430.

Fig. 8 *Lycospora pusilla* (IBRAHIM) SOMERS
Stainmore, Shales above Mousegill Marine Beds, A 27/Che.

Fig. 9 *Lycospora noctuina* BUTTERWORTH & WILLIAMS
Stainmore, Shales above Mousegill Marine Beds, A 27/Che.

Fig. 10 *Grumosisporites varioreticulatus* (NEVES) SMITH & BUTTERWORTH
Stainmore, Shales above Mousegill Marine Beds, MPK 1431.

Fig. 11 *Crassispora kosankei* (POTONIÉ & KREMP) BHARADWAJ
Stainmore, Shales above Mousegill Marine Beds, MPK 993.

Fig. 12 *Secarisporites remotus* NEVES
Stainmore, Shales above Mousegill Marine Beds, MPK 1437.

Fig. 13 *Kraeuselisporites ornatus* (NEVES) OWENS, MISHELL & MARSHALL
Stainmore, Shales above Mousegill Marine Beds, MPK 1108.

Fig. 14 *Densosporites pannosus* ARTUZ
Stainmore, Shales above Mousegill Marine Beds, MPK 1438.

Fig. 15 *Vallatisporites* cf. *vallatus*
Stainmore, Shales above Mousegill Marine Beds, MPK 1441.

Fig. 16 *Cirratriradites rarus* (IBRAHIM) SCHOPF, WILSON & BENTALL
Stainmore, Mousegill Marine Beds, MPK 1435.

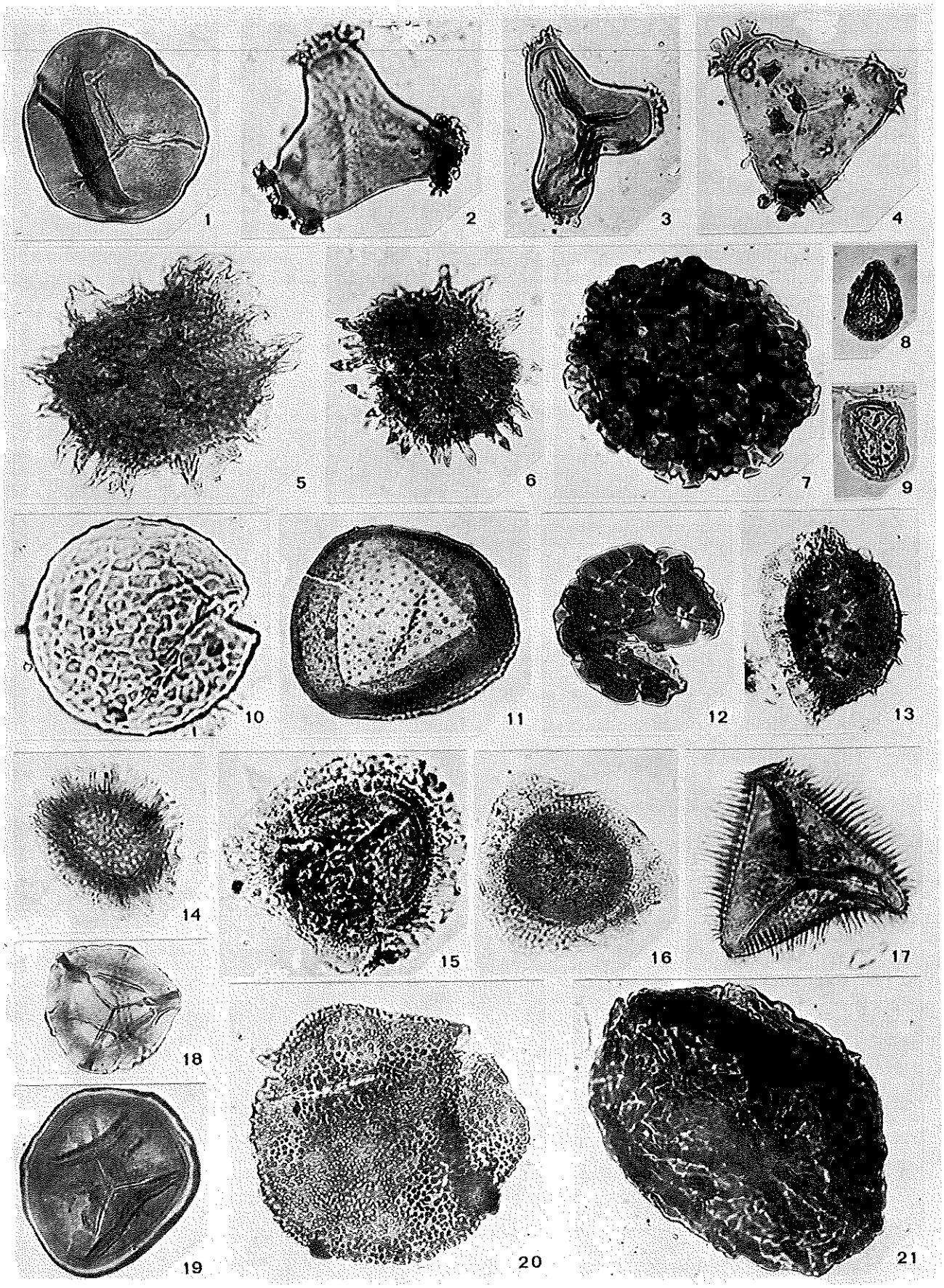
Fig. 17 *Reinschospora triangularis* KOSANKE
Stainmore, Mousegill Marine Beds, MPK 1432.

Fig. 18 *Knoxisporites dissidius* NEVES
Stainmore, Shales above Mousegill Marine Beds, MPK 1436.

Fig. 19 *Knoxisporites seniradiatus* NEVES
Stainmore, Shales above Mousegill Marine Beds, MPK 1434.

Fig. 20 *Spelaeotriletes arenaceus* NEVES & OWENS
Stainmore, Mousegill Marine Beds, MPK 1440.

Fig. 21 *Rugospora corporata* NEVES & OWENS
Stainmore, Shales above Mousegill Marine Beds, MPK 1443.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# PLATE 16

*Raistrickia fulva - Reticulatisporites reticulatus* (FR) Zone

Fig. 1 *Punctatisporites punctatus* IBRAHIM
Stainmore, Shales below Lower Swinstone House Marine Band, MPK 2091.

Fig. 2 *Apiculatisporis varicorneus* SULLIVAN
Stainmore, Shales below Swinstone Bottom Marine Band, MPK 1444.

Fig. 3 *Raistrickia fulva* ARTUZ
Stainmore, Shales below Swinstone Bottom Marine Band, MPK 1445.

Fig. 4 *Ibrahimispores brevispinosus* NEVES
Stainmore, Shales below Lower Swinstone House Marine Band, MPK 2092.

Fig. 5 *Dictyotriletes muricatus* (KOSANKE) SMITH & BUTTERWORTH
Shropshire, Upper part Cornbrook Sandstone, MPK 1447.

Fig. 6 *Knoxisporites rotatus* HOFFMEISTER, STAPLIN & MALLOY
Stainmore, Shales below Swinstone Bottom Marine Band, MPK 1456.

Fig. 7 *Crassispora kosankei* (POTONIÉ & KREMP) BHARADWAJ
Stainmore, Shales above Mousegill Marine Beds, MPK 1453.

Fig. 8 *Vallatisporites* sp.
Stainmore, Shales below Lower Swinstone House Band, MPK 2093.

Fig. 9 *Cirratriradites rarus* (IBRAHIM) SCHOPF, WILSON & BENTALL
Stainmore, Shales below Swinstone Bottom Marine Band, MPK 1458.

Fig. 10 *Cristatisporites indignabundus* (LOOSE) STAPLIN & JANSONIUS
Stainmore, Shales below Swinstone Bottom Marine Band, MPK 1451.

Fig. 11 *Cingulizonates loricatus* (LOOSE) BUTTERWORTH *et al.*
Stainmore, Swinstone Bottom Marine Band, Ml 2b.

Figs. 12-13 *Lycospora pusilla* (IBRAHIM) SOMERS
Stainmore, Swinstone Bottom Marine Band, Ml 2b

Fig. 14 *Savitrisporites nux* (BUTTERWORTH & WILLIAMS) SMITH & BUTTERWORTH
Stainmore, Shales below Swinstone Bottom Marine Band, MPK 1450.

Fig. 15 *Densosporites crassigranifer* ARTUZ
Stainmore, Shales below Swinstone Bottom Marine Band, MPK 1452.

Fig. 16 *Secarisporites remotus* NEVES
Stainmore, Coal below *Carbonicola pseudorobusta* Band, MPK 1465.

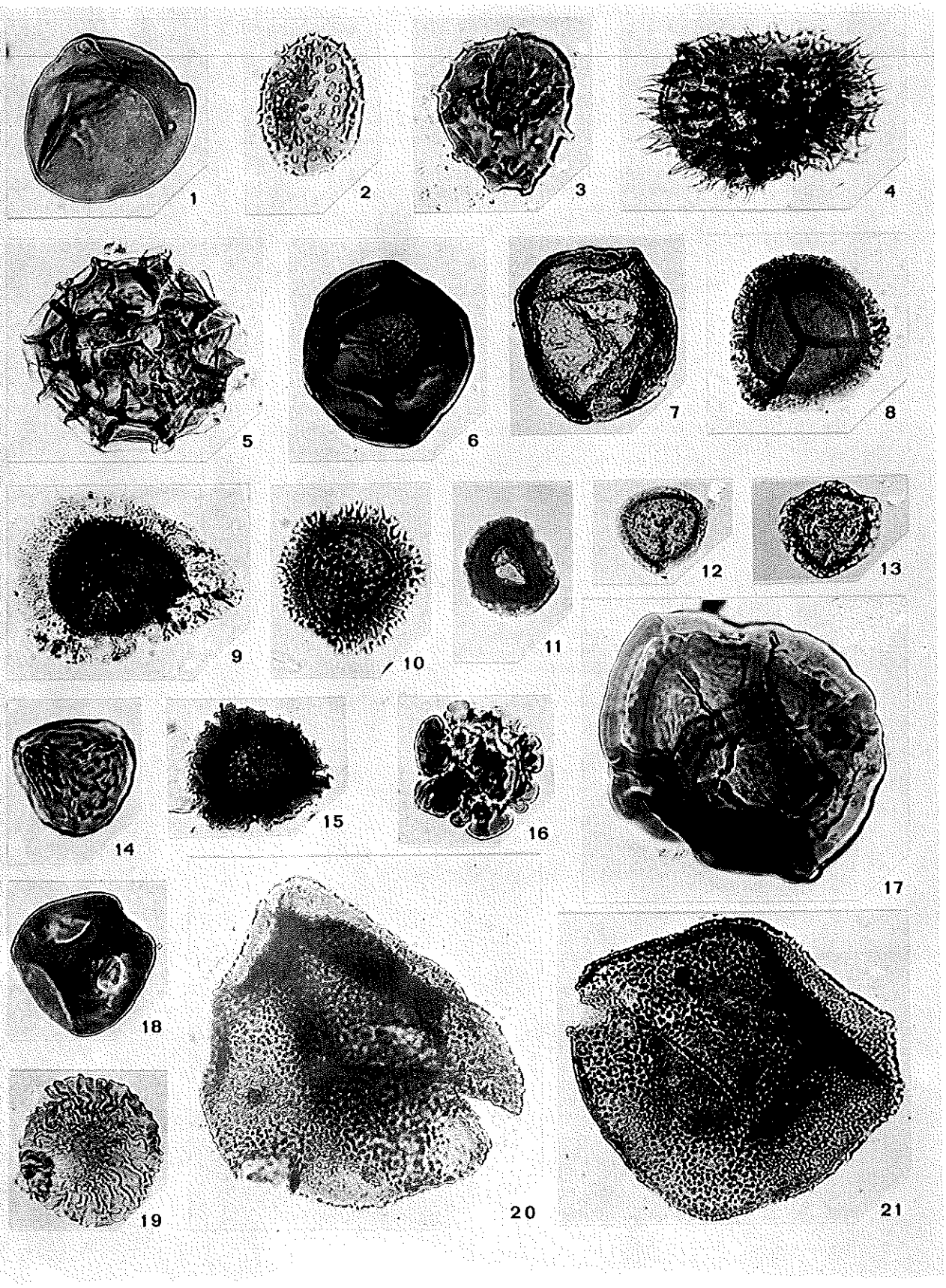
Fig. 17 *Reticulatisporites polygonalis* (IBRAHIM) SMITH & BUTTERWORTH
Stainmore, Shales below Lower Swinstone House Marine Band, MPK 2094.

Fig. 18 *Trinidulus diamphidios* FELIX & PADEN
Stainmore, Shales below Swinstone House Marine Band, MPK 1787.

Fig. 19 *Radialetes* sp.
Stainmore, Shales below Swinstone Bottom Marine Band, MPK 1455.

Fig. 20 *Spelaeotriletes* cf. *triangulus*
Stainmore, Shales below Lower Swinstone House Marine Band, MPK 2095.

Fig. 21 *Spelaeotriletes arenaceus* NEVES & OWENS
Stainmore, Shales below Swinstone Bottom Marine Band, MPK 1454.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# PLATE 17

*Triquitrites sinani - Cirratriradites saturni* (SS) Zone

Fig. 1 *Calamospora pallida* (LOOSE) SCHOPF, WILSON & BENTALL
Shropshire, Shales above Cornbrook Sandstone, MPK 935.

Fig. 2 *Apiculatisporis* sp.
Scotland, West field Borehole, Bogside Thick Group, ML 1416.

Fig. 3 *Raistrickia fulva* ARTUZ
Stainmore, *Carbonicola pseudorobusta* Band, MPK 1460.

Fig. 4 *Camptotriletes superbus* NEVES
Stainmore Coal below *Carbonicola pseudorobusta* Band, MPK 1461.

Fig. 5 *Camptotriletes bucculentus* (LOOSE) POTONIÉ & KREMP
Stainmore, *Carbonicola pseudorobusta* Band, MPK 1462.

Fig. 6 *Crassispora kosankei* (POTONIÉ & KREMP) BHARADWAJ
Scotland, West field Borehole, Bogside Thick Group, ML 1417.

Fig. 7 *Triquitrites bransonii* WILSON &4 HOFFMEISTER
Stainmore, Shales below Argill Shell Bed, MPK 1463.

Fig. 8 *Triquitrites* cf. *sinani*
Stainmore, Shales above Swinstone Bottom Marine Band, MPK 1464.

Fig. 9 *Triquitrites* sp.
Scotland, West field Borehole, Bogside Thick Group, ML 1418.

Fig. 10 *Convolutispora* sp.
Stainmore, Argill Marine Band, MPK 1789.

Fig. 11 *Triquitrites tribullatus* (IBRAHIM) SCHOPF, WILSON & BENTALL
Scotland, West field Borehole, Bogside Thick Group, ML 1419.

Fig. 12 *Mooreisporites fustis* NEVES
Scotland, West field Borehole, Bogside Thick Group, ML 1420.

Fig. 13 *Cirratriradites saturni* (WILSON & COE) SCHOPF, WILSON & BENTALL
Stainmore, Argill Shell Bed, MPK 996.

Fig. 14 *Ahrensisporites* cf. *beeleyensis*
Stainmore, Shale below *Carbonicola pseudorobusta* Band, MPK 1449.

Fig. 15 *Lycospora rotunda* (BHARADWAJ) SOMERS
Scotland, West field Borehole, Bogside Thick Group, ML 1421.

Fig. 16 *Reticulatisporites polygonalis* (IBRAHIM) SMITH & BUTTERWORTH
Shropshire, Shales above Cornbrook Sandstone, MPK 1468.

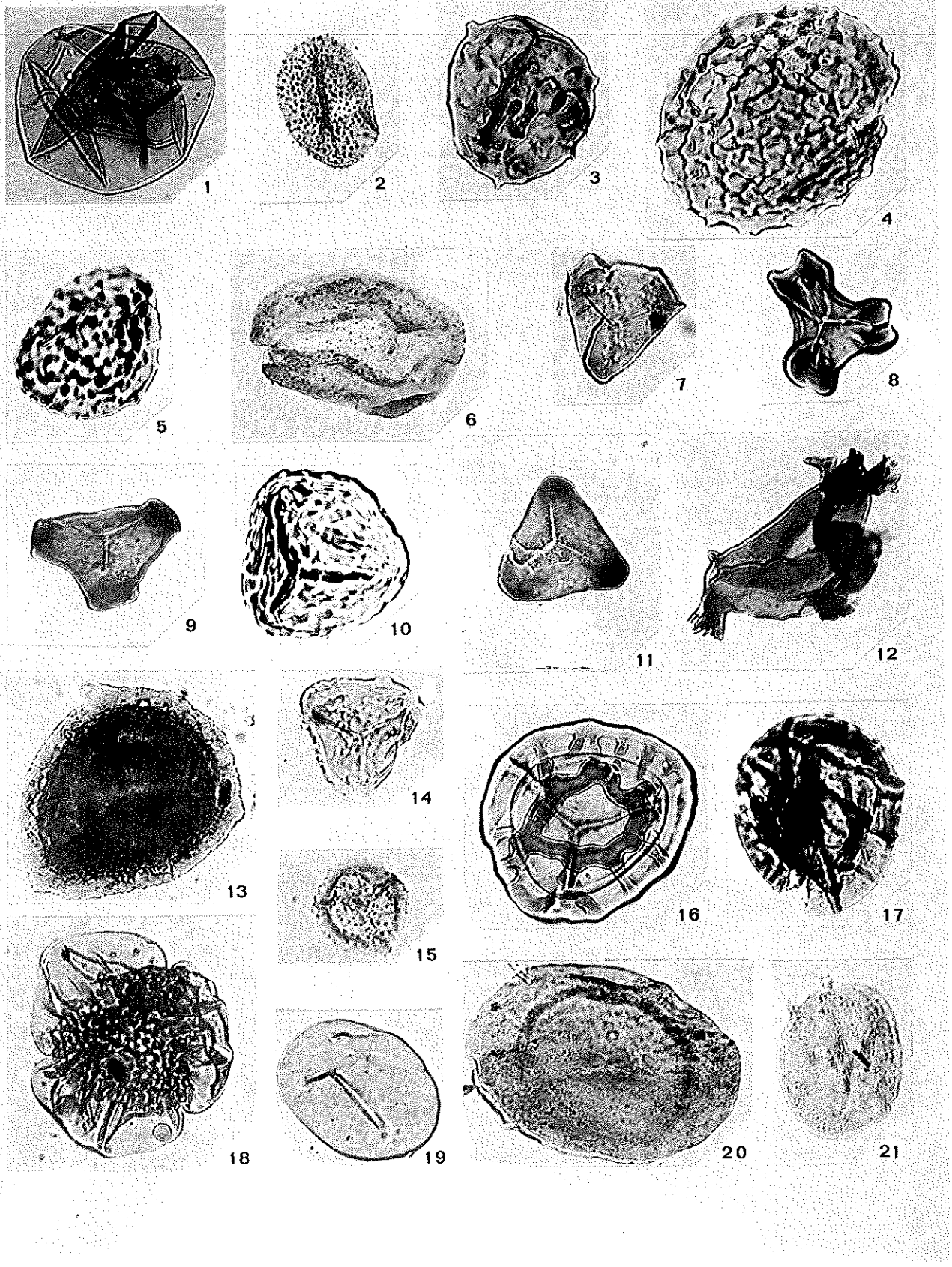
Fig. 17 *Vestispora costata* (BALME) SPODE
Stainmore, Argill Shell Bed, MPK 1467.

Fig. 18 *Alatisporites pustulatus* IBRAHIM
Shropshire, Shales above Cornbrook Sandstone, MPK 1469.

Fig. 19 *Laevigatosporites vulgaris* (IBRAHIM) ALPNER & DOUBINGER
Stainmore, Coal below Argill Plant Beds, MPK 997.

Fig. 20 *Schulzospora rara* KOSANKE
Stainmore, Argill Shell Bed, MPK 1790.

Fig. 21 *Florinites* sp.
Stainmore, Coal below Argill Plant Beds, MPK 1791.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## PLATE 18

*Radiizonates aligerens* (RA) Zone

Fig. 1 — *Calamospora mutabilis* (LOOSE) SCHOPF, WILSON & BENTALL
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 11.

Fig. 2 — *Punctatisporites sinuatus* (ARTUZ) NEVES
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 1.

Fig. 3 — *Calamospora parva* GUENNEL
Campine, Voort, Coal-seam 20, Genk, L 194/2/2.

Fig. 4 — *Cyclogranisporites leopoldi* (KREMP) POTONIÉ & KREMP
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 25.

Fig. 5 — *Leiotriletes adnatus* KOSANKE
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 15.

Fig. 6 — *Granulatisporites piroformis* LOOSE
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 20.

Fig. 7 — *Verrucosisporites microtuberosus* LOOSE) SMITH & BUTTERWORTH
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 26.

Fig. 8 — *Raistrickia fulva* ARTUZ
Campine, Houthalen, Coal-seam 10, Genk, L 240/9/1.

Figs. 9-10 — *Lycospora pusilla* (IBRAHIM) SOMERS
Campine, Voort, Coal-seam 20, Genk, Ech. 30.
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 10.

Fig. 11 — *Densosporites anulatus* (LOOSE) SCHOPF, WILSON & BENTALL
Boulonnais, Napoléon, Fmb 1 b l.

Fig. 12 — *Cingulizonates loricatus* (LOOSE) BUTTERWORTH et al.
Durham, victoria Coal-seam, L DCVS 1.

Fig. 13 — *Reticulatisporites reticulatus* IBRAHIM
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 115.

Fig. 14 — *Crassispora kosankei* (POTONIÉ & KREMP) BHARADWAJ
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 130.

Figs. 15-16 — *Radiizonates aligerens* (KNOX) STAPLIN & JANSONIUS
Campine, Voort, Coal-seam 20, Genk, L 194/2/2.
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 34.

Fig. 17 — *Savitrisporites nux* (BUTTERWORTH & WILLIAMS) SMITH & BUTTERWORTH
Campine, Kleine-Heide, Coal-seam 61, Genk, L 69/1/1.

Fig. 18 — *Bellispores nitidus* (HORST) SULLIVAN
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 1.

Fig. 19 — *Ahrensisporites guerickei* (HORST) POTONIÉ & KREMP
Campine, Voort, Coal-seam 20, Genk, L. 194/2/3.

Fig. 20 — *Triquitrites* cf. *triturgidus*
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 133.

Fig. 21 — *Endosporites ornatus* WILSON & COE
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 160.

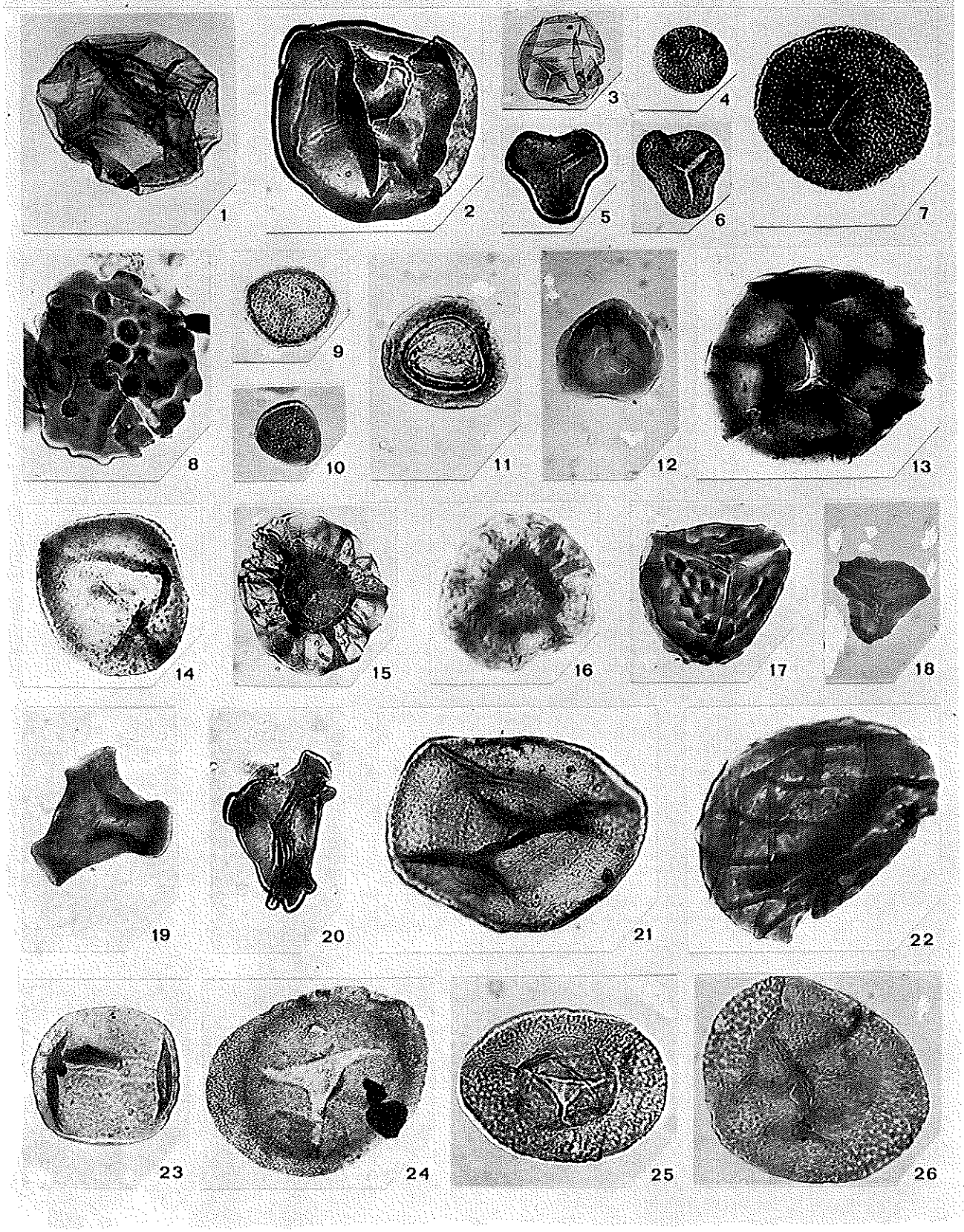
Fig. 22 — *Vestispora cancellata* (DYBOVA & JACHOWICZ) WILSON & VENKATACHALA
Nord-pas-de-Calais, Saint-Mark, Vicoigne, L 156.

Fig. 23 — *Laevigatosporites vulgaris* (IBRAHIM) ALPERN & DOUBINGER
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 1.

Fig. 24 — *Schulzospora rara* KOSANKE
Campine, Voort, Coal-seam 20, Genk, L 194/2/3.

Fig. 25 — *Florinites triletus* KOSANKE
Nord-Pas-de-Calais, Saint-Mark, Vicoigne, L 171.

Fig. 26 — *Florinites pellucidus* (WILSON & COE) WILSON
Durham, Victoria Coal-seam, L. DCVS 2.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# PLATE 19

*Microreticulatisporites nobilis* - *Florinites junior* (NJ) Zone

Fig. 1 *Calamospora breviradiata* KOSANKE
Nord-Pas-de-Calais, Borehole 233, Coal-seam no. 28, Lower Bruay, L 788 Cl.

Fig. 2 *Planisporites spinulistratus* (LOOSE) POTONIÉ & KREMP
Nord-Pas-de-Calais, Borehole 233, Coal-seam no. 29, Lower Bruay, L 789-02.

Fig. 3 *Dictyotriletes bireticulatus* (IBRAHIM) POTONIÉ & KREMP
Campine, Eisden, Coal-seam 33, Eikenberg, L 39/1/2.

Fig. 4 *Microreticulatisporites* cf. *nobilis*
Nord-Pas-de-Calais, Borehole 233, Coal-seam St-Jules, Lower Bruay, Sp 802 Ml.

Fig. 5 *Grumosisporites varioreticulatus* (NEVES) SMITH & BUTTERWORTH
Nord-Pas-de-Calais, Saint-Mark, Poissonnière, L 141.

Figs. 6-7 *Lycospora pusilla* (IBRAHIM) SOMERS
Nord-Pas-de-Calais, Borehole 233, Upper Anzin, L 823 T2, L 823 Cl.

Fig. 8 *Densosporites anulatus* (LOOSE) SMITH & BUTTERWORTH
Campine, Zwartberg, Coal-seam 17, Eikenberg, L 212/1/2.

Fig. 9 *Densosporites sphaerotriangularis* KOSANKE
Nord-Pas-de-Calais, Saint-Mark, Lower Anzin, L 98.

Fig. 10 *Densosporites duriti* POTONIÉ & KREMP
Ruhr, Friedrich Heinrich, Coal-seam Zollverein, Essener Schichten, 524/1.

Fig. 11 *Cingulizonates loricatus* (LOOSE) BUTTERWORTH *et al.*
Nord-Pas-de-Calais, Saint-Mark, Lower Anzin, L 110.

Fig. 12 *Cristatisporites indignabundus* (LOOSE) STAPLIN & JANSONIUS
Campine, Zwartberg, Coal-seam 26, Asch, L 215/1/2.

Fig. 13 *Savitrisporites nux* (BUTTERWORTH & WILLIAMS) SMITH & BUTTERWORTH
Nord-Pas-de-Calais, Saint-Mark, Lower Anzin, L 125.

Fig. 14 *Radiizonates tenuis* (LOOSE) BUTTERWORTH *et al.*
Campine, Eisden, Coal-seam 28, Eikenberg, L 44/1/2.

Fig. 15 *Crassispora konsankei* (POTONIÉ & KREMP) BHARADWAJ
South Limburg, Upper West. B, G.B. 196 A.

Fig. 16 *Reticulatisporites reticulatus* IBRAHIM
Nord-Pas-de-Calais, Saint-Mark, Lower Anzin, L 115.

Fig. 17 *Triquitrites* cf. *triturgidus*
Ruhr, Adolf von Hansemann, Coal-seam Zollverein 8, Esener Schichten, 15230/1.

Fig. 18. *Cirratriradites saturni* (IBRAHIM) SCHOPF, WILSON & BENTALL
Campine, Zwartberg, Coal-seam 16, Eikenberg, L 211/1/2.

Fig. 19 *Endosporites globiformis* (IBRAHIM) SCHOPF, WILSON & BENTALL
Nord-Pas-de-Calais, Borehole 233, Lower Bruay, L 786 El.

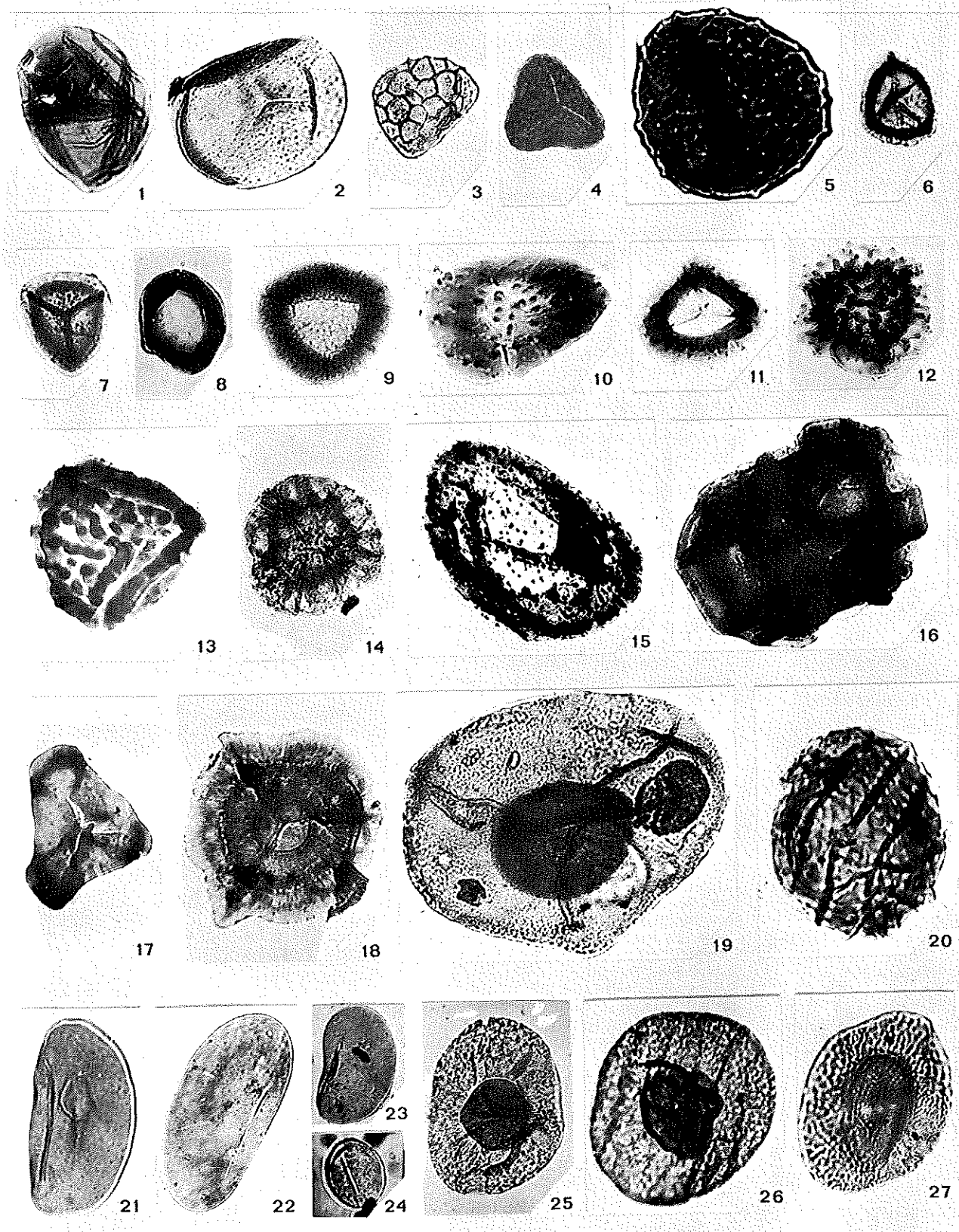
Fig. 20 *Vestispora pseudoreticulata* SPODE
Le Plessis. Ech. 3, L 313.

Figs. 21-23 *Laevigatosporites vulgaris* (IBRAHIM) ALPERN & DOUBINGER
Nord-Pas-de-Calais, Borehole 233, Lower Bruay L 786 L2, L 825 L1.
Ruhr, Hugo-Ost, Coal-seam Bismarck, Horster Schichten, 609/2.

Fig. 24 *Punctatosporites minutus* (IBRAHIM) ALPERN & DOUBINGER
Ruhr, Hugo-Ost, Coal-seam Bismarck, Horster Schichten, 614 Bl.

Figs. 25-26 *Florinites junior* POTONIÉ & KREMP
Campine, Eisden, Coal-seam 33, Asch, L 39/1/2.
Nord-Pas-de-Calais, Borehole 233, Upper Anzin, L 825 F6.

Fig. 27 *Florinites mediapudens* (LOOSE) POTONIÉ & KREMP
Nord-Pas-de-Calais, Borehole 233, Upper Anzin, L 823 F2.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# PLATE 20

*Torispora securis* - *Torispora laevigata* (SL) Zone

Fig. 1 — *Calamospora breviradiata* KOSANKE
Campine, Zwartberg, Coal-seam M, Lower Neeroeteren, L 218/1/4.

Fig. 2 — *Leiotriletes adnatoïdes* POTONIÉ & KREMP
Nord-Pas-de-Calais, 6 Bruay, Coal-seam no 15, Lower Bruay, L wc 45.

Fig. 3 — *Granulatisporites microgranifer* IBRAHIM
Nord-Pas-de-Calais, 4 Bruay, Coal-seam no. 21, Lower Bruay, Lc 1.

Fig. 4 — *Lophotriletes pseudaculeatus* POTONIÉ & KREMP
Nord-Pas-de-Calais, 7 Noeux, Coal-seam Robert, Lower Bruay, L 109.

Fig. 5 — *Apiculatisporis aculeatus* (IBRAHIM) POTONIÉ & KREMP
Nord-Pas-de-Calais, 7 Noeux, Coal-seam Elisabeth, Lower Bruay, L wc 82.

Fig. 6 — *Microreticulatisporites nobilis* (WICHER) KNOX
Ruhr, Borehole Fürst Leopold-Baldur, Coal-seam 12 b, Dorstener Schichten, 29270/2.

Fig. 7 — *Verrucosisporites verrucosus* IBRAHIM
Nord-Pas-de-Calais, 3 Bruay, Coal-seam no. 19 ter, Lower Bruay, L 62.

Figs. 8-9 — *Lycospora pusilla* (IBRAHIM)SOMERS
Nord-Pas-de-Calais, 6 Bruay, Coal-seam no. 16, Lower Bruay, Lwc 168, Lwc 162.

Fig. 10 — *Densosporites anulatus* (LOOSE) SMITH & BUTTERWORTH
Nord-Pas-de-Calais, 4 Vermelles, Coal-seam 0,70 m, Lower Bruay, L 4.

Fig. 11 — *Cristatisporites solaris* (BALME) BUTTERWORTH *et al.*
Nord-Pas-de-Calais, 4 Bruay, Coal-seam no. 20, Lower Bruay, L 112.

Fig. 12 — *Crassispora kosankei* (POTONIÉ & KREMP) BHARADWAJ
Nord-Pas-de-Calais, 4 Bruay, Coal-seam no 21, Lower Bruay, L 18.

Fig. 13 — *Reticulatisporites reticulatus* IBRAHIM
Nord-Pas-de-Calais, 6 Bruay, Coal-seam no 15, Lower Bruay, Lwc 146.

Fig. 14 — *Cirratriradites saturni* (IBRAHIM) SCHOPF, WILSON & BENTALL
Nord-Pas-de-Calais, 6 bruay, Coal-seam no. 15, Lower Bruay, L 221.

Fig. 15 — *Triquitrites triturgidus* (LOOSE) SCHOPF, WILSON & BENTALL
Nord-Pas-de-Calais, 7 Noeux, Coal-seam Jeanne d'Arc, Lower Bruay, L wc 240.

Figs. 16-17 — *Triquitrites sculptilis* BALME
Nord-Pas-de-Calais, 4 Bruay, Coal-seam no 20, Lower Bruay, Sc 23.
Campine, Borehole 117, Coal-seam 11, Lower Neeroeteren, S 117/11/1.

Fig. 18 — *Westphalensisporites irregularis* ALPERN
Nord-Pas-de-Calais, 4 Bruay, Coal-seam no. 20, Lower Bruay, L 65.

Fig. 19 — *Vestispora pseudoreticulata* SPODE
Campine, Zwartberg, Coal-seam M, Lower Neeroeteren, L 218/1/3.

Fig. 20 — *Vestispora fenestrata* (KOSANKE & BROKAW) WILSON & VENKATACHALA
Netherlands, Haaksbergen 1 Borehole, GB 372.

Fig. 21 — *Endosporites globiformis* (IBRAHIM) SCHOPF, WILSON & BENTALL
Ruhr, Borehole Fürst Leopold-Baldur, Coal-seam 22, Dorstener Schichten, 29314/2.

Fig. 22 — *Laevigatosporites vulgaris* (IBRAHIM) ALPERN & DOUBINGER
Nord-Pas-de-Calais, 6 Bruay, Coal-seam no. 15, Lower Bruay, Lwc 107.

Fig. 23 — *Laevigatosporites* cf. *latus*
Nord-Pas-de-Calais, 6 Bruay, Coal-seam no 17, Lower Bruay, Lwc 10.

Fig. 24 — *Punctatosporites granifer* POTONIÉ & KREMP
Campine, Borehole 117, Coal-seam 13bis, Lower Neeroeteren, S 117/13bis/3.

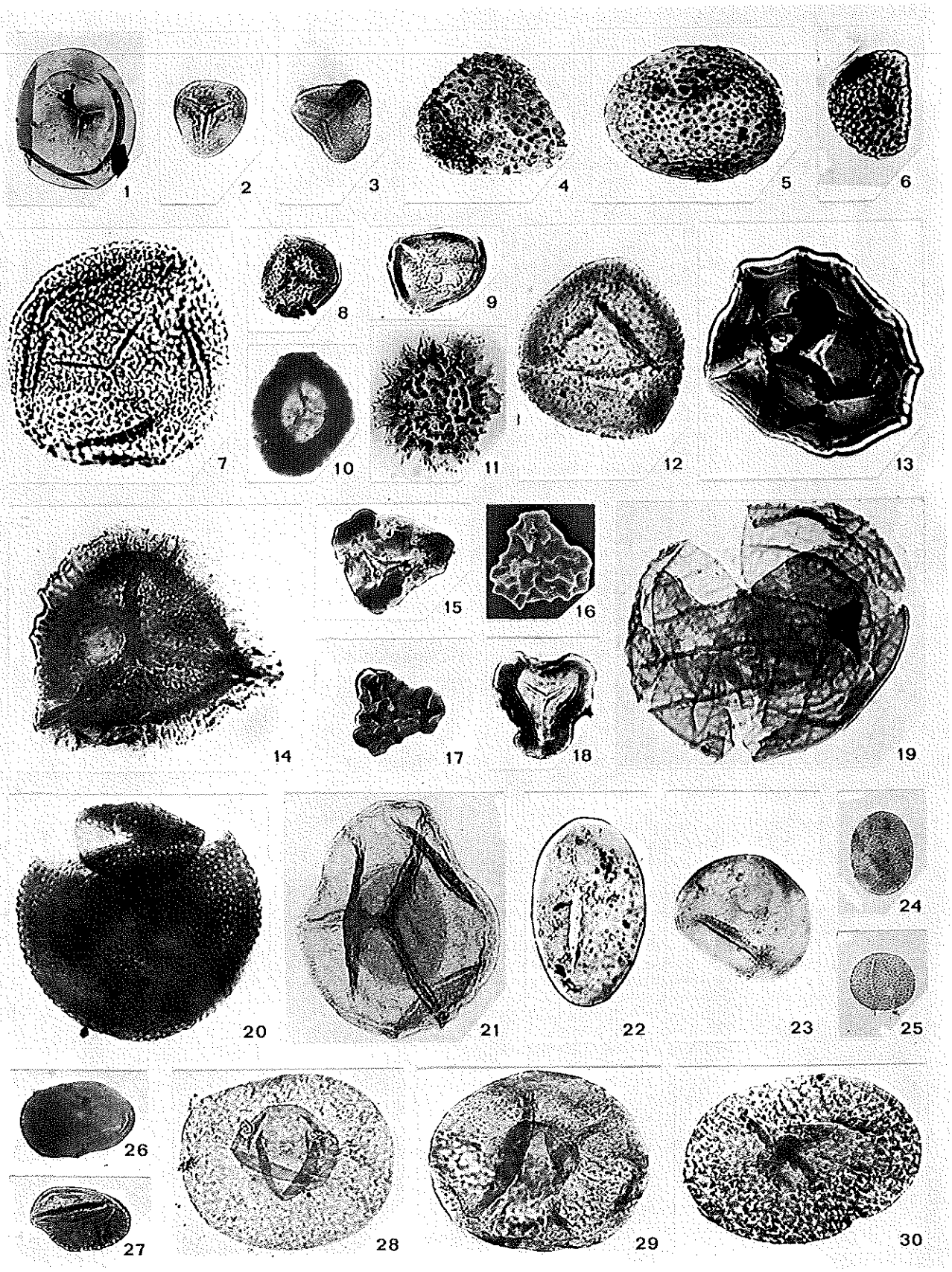
Fig. 25 — *Punctatosporites* cf. *rotundus*
Campine, Zwartberg, Coal-seam M, Lower Neeroeteren, L 218/1/3.

Figs. 26-27 — *Torispora securis* (BALME) ALPERN, DOUBINGER & HORST
Campine, Borehole 117, Coal-seam no 11, Lower Neeroeteren, S 117/11/2.
Ruhr, Borehole Nordlich-Ost, Coal-seam 4, Dorstener Schichten, 28210/1.

Fig. 28 — *Florinites mediapudens* (LOOSE) POTONIÉ & KREMP
Campine, Zwartberg, Coal-seam M, Lower Neeroeteren, L 218/1/3.

Fig. 29 — *Florinites junior* POTONIÉ & KREMP
Ruhr, Borehole Lippermulde 1, Coal-seam 4, Dorstener Schichten.

Fig. 30 — *Florinites* sp.
Nord-Pas-de-Calais, 7 Noeux, Coal-seam Robert, Lower Bruay, L 322.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## PLATE 21

*Thymospora obscura - T. thiessenii* (OT) Zone

Fig. 1 — *Calamospora mutabilis* (Loose) Schopf, Wilson & Bentall
Nord-Pas-de-Calais, 6 Bruay, Coal-seam no 12 bis, Bruay, Lwc 29.

Fig. 2 — *Lophotriletes mosaicus* Potonié & Kremp
Campine, Borehole 117, Coal-seam 4, Neeroeteren, S 117/4/1.

Fig. 3 — *Microreticulatisporites nobilis* (Wicher) Knox
Lorraine, Marienau 3 Borehole, LC 1.

Fig. 4 — *Microreticulatisporites* cf. *nobilis*
Lorraine, Bisten 5 Borehole, L 120.

Fig. 5 — *Densosporites faunus* (Ibrahim) Potonié & Kremp
Nord-Pas-de-Calais, 6 Bruay, Coal-seam no 10, Bruay. Lwc 187.

Fig. 6 — *Crassispora kosankei* (Potonié & Kremp) Bharadwaj
Nord-Pas-de-Calais, 6 Bruay, Coal-seam no 10, Bruay. Lwc 205.

Fig. 7 — *Schopfites* cf. *dimorphus*
Lorraine, Cocheren 7 Borehole, L 80.

Figs. 8, 10 — *Lycospora pusilla* (Ibrahim) Somers
Nord-Pas-deCalais, 6 Bruay, Coal-seam no 12 bis, Bruay, L 159.
Lorraine, Marienau 3 Borehole, L 90.

Figs. 9, 11 — *Westphalensisporites irregularis* Alpern
Lorraine, Marienau 3 Borehole, LC 1.

Fig. 12 — *Lundbladispora gigantea* (Alpern) Doubinger
Lorraine, Bisten 5 Borehole, LC 1, x 650.

Fig. 13 — *Savitrisporites camptotus* (Alpern) Doubinger
Lorraine, Cocheren 7 Borehole, LC 1.

Fig. 14 — *Cirratriradites annuliformis* Kosanke & Brokaw
Lorraine, Cocheren 7 Borehole, LC 1.

Fig. 15 — *Cirratriradites saturni* (Ibrahim) Schopf, Wilson & Bentall
Nord-Pas-de-Calais, 3 Lens, Coal-seam Pouilleuse, Bruay, LC 1.

Fig. 16 — *Triquitrites* cf. *triturgidus*
Lorraine, Marienau 3 Borehole. L 110.

Fig. 17 — *Vestispora velensis* (Bharadwaj) Wilson & Venkatachala
Lorraine, Bisten 4 Borehole, L 140.

Fig. 18 — *Vestispora fenestrata* (Kosanke & Brokaw) Wilson & Venkatachala
Lorraine, Marienau 3 Borehole, LC 1.

Fig. 19 — *Endosporites* cf. *globiformis*
Lorraine, Cocheren 7 Borehole, L 110.

Fig. 20 — *Laevigatosporites maximus* (Loose) Potonié & Kremp
Nord-Pas-de-Calais, 6 Bruay, Coal-seam no. 10, Bruay, Lwc 2.

Fig. 21 — *Laevigatosporites perminutes* Alpern
Nord-de-Calais, 10 bis Béhune, Coal-seam Emilie, Upper Bruay, LC 1.

Fig. 22 — *Laevigatosporites latus* Kosanke
Nord-Pas-de-Calais, 3 Lens, Bruay, L 12.

Figs. 23-24 — *Punctatosporites minutus* (Ibrahim) Alpern & Doubinger
Nord-Pas-de-Calais, 6 Bruay, Coal seam no 12 bis, Bruay, Lwc 13.
Nord-Pas-de-Calais, 6 Liévin, Coal-seam Arago, Bruay, LC 1.

Figs. 25-26 — *Punctatosporites rotundus* Bharadwaj
Nord-Pas-de-Calais, 10 bis Béthune, Coal-seam Marie-Louise, Upper Bruay, L 179.
Lorraine, Cocheren 7 Borehole, LC 1.

Fig. 27 — *Thymospora thiessenii* (Kosanke) Wilson & Venkatachala
Lorraine, Marienau 3 Borehole, L 10.

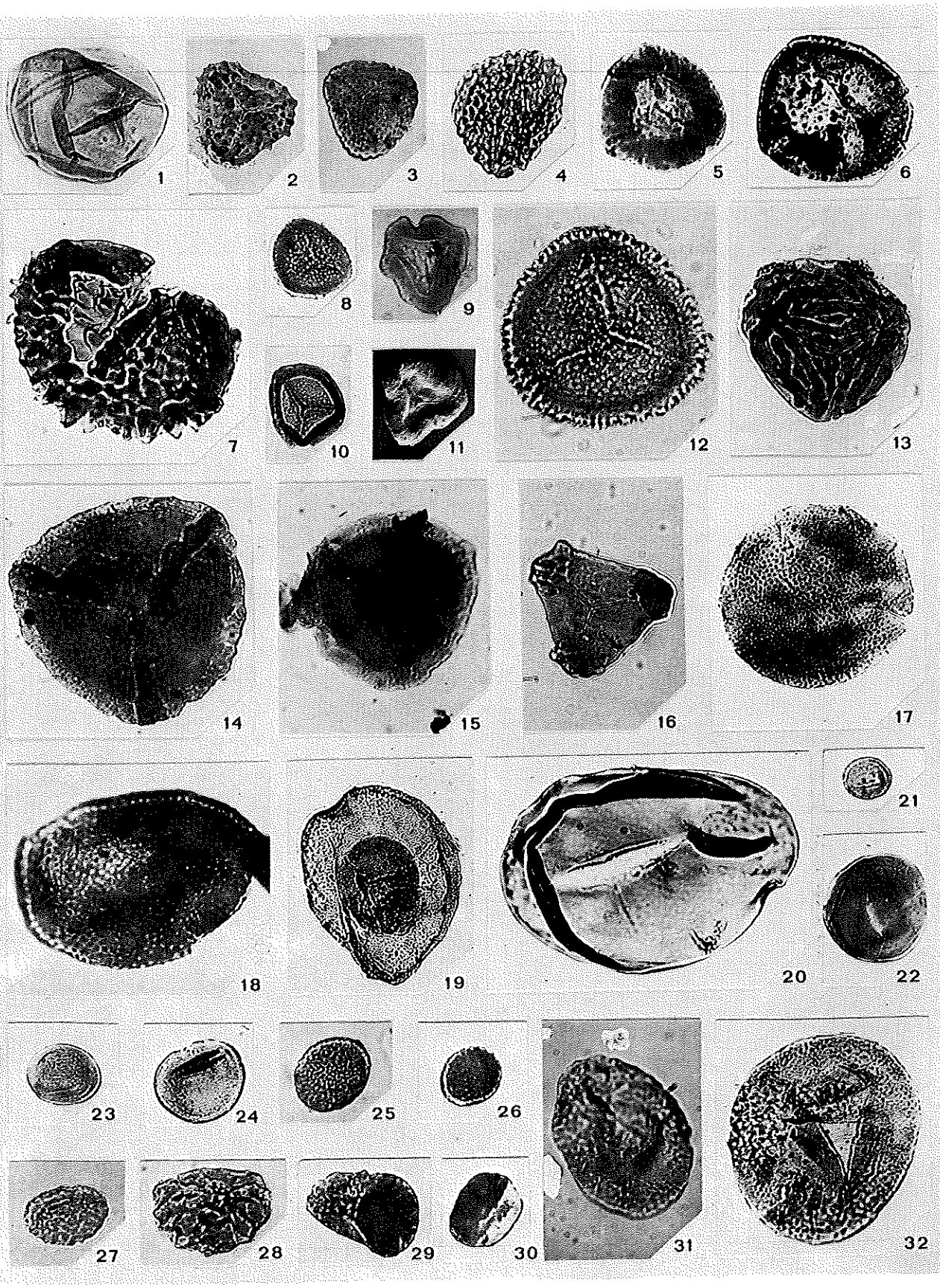
Fig. 28 — *Thymospora pseudothiessenii* (Kosanke) Alpern & Doubinger
Lorraine, Cocheren 7 Borehole, L 10.

Fig. 29 — *Torispora verrucosa* Alpern
Lorraine, Marienau 3 Borehole, L 11.

Fig. 30 — *Torispora securis* (Balme) Alpern, Doubinger & Horst
Nord-Pas-de-Calais, 7 Noeux, Coal-seam 2, Bruay, Lwc 22.

Fig. 31 — *Florinites* cf. *ovalis*
Lorraine, Cocheren 7 Borehole, LC 1.

Fig. 32 — *Florinites pellucidus* (Wilson & Coe) Wilson
Nord-Pas-de-Calais, 6 Bruay, Coal-seam no 12 bis, Bruay, L wc 324.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# PLATE 22

*Angulisporites splendidus - Latensina trileta* (ST) Zone

Fig. 1 — *Verrucosisporites pergranulus* (ALPERN) SMITH
Carmaux, Marmottan, L 8011.

Fig. 2 — *Lycospora pusilla* (IBRAHIM) SOMERS
Carmaux, Marmottan, L 7221.

Fig. 3 — *Westphalensisporites irregularis* ALPERN
Carmaux, Couche du Mur, L 668.

Fig. 4 — *Lundbladispora gigantea* (ALPERN) DOUBINGER
La-Chapelle-sous-Dun, L 1708-1.

Fig. 5 — *Densosporites* sp.
Carmaux. Marmottan, L 799-1.

Fig. 6 — *Savitrisporites camptotus* (ALPERN) DOUBINGER
Carmaux. Marmottan, L 5551.

Fig. 7 — *Crassispora kosankei* (POTONIÉ & KREMP) BHARADWAJ
Carmaux, Marmottan, L 5551.

Fig. 8 — *Polymorphisporites reticuloïdes* ALPERN
Decazeville, Naukuières VIII, L 1348-1.

Figs. 9-10 — *Angulisporites splendidus* BHARADWAJ
Decazeville, Naukuières VIII, L 1349-1.

Fig. 11 — *Latensina trileta* ALPERN
Carmaux, Marmottan, L 5551.

Fig. 12 — *Latensina* sp.
Rive de Gier, Grande Masse, L 4013-2.

Figs. 13-14 — *Laevigatosporites vulgaris* (IBRAHIM) ALPERN & DOUBINGER
Decazeville, Naukuières VIII, L 1349-1.
Carmaux, Marmottan, L 8011.

Figs. 15-16 — *Punctatosporites rotundus* BHARADWAJ
Decazeville, Firmy VIII, L 1048-4.
La-Chapelle-sous-Dun, L 6085-2.

Figs. 17-18 — *Spinosporites spinosus* ALPERN
La-Chapelle-sous-Dun, L 6085-2.
Decazeville, Firmy VII, L 1042.

Fig. 19 — *Thymospora thiessenii* (KOSANKE) WILSON & VENKATACHALA
Carmaux, Marmottan, L 8011.

Fig. 20 — *Thymospora pseudothiessenii* (KOSANKE) ALPERN & DOUBINGER
La-Chapelle-sous-Dun, L 6085.

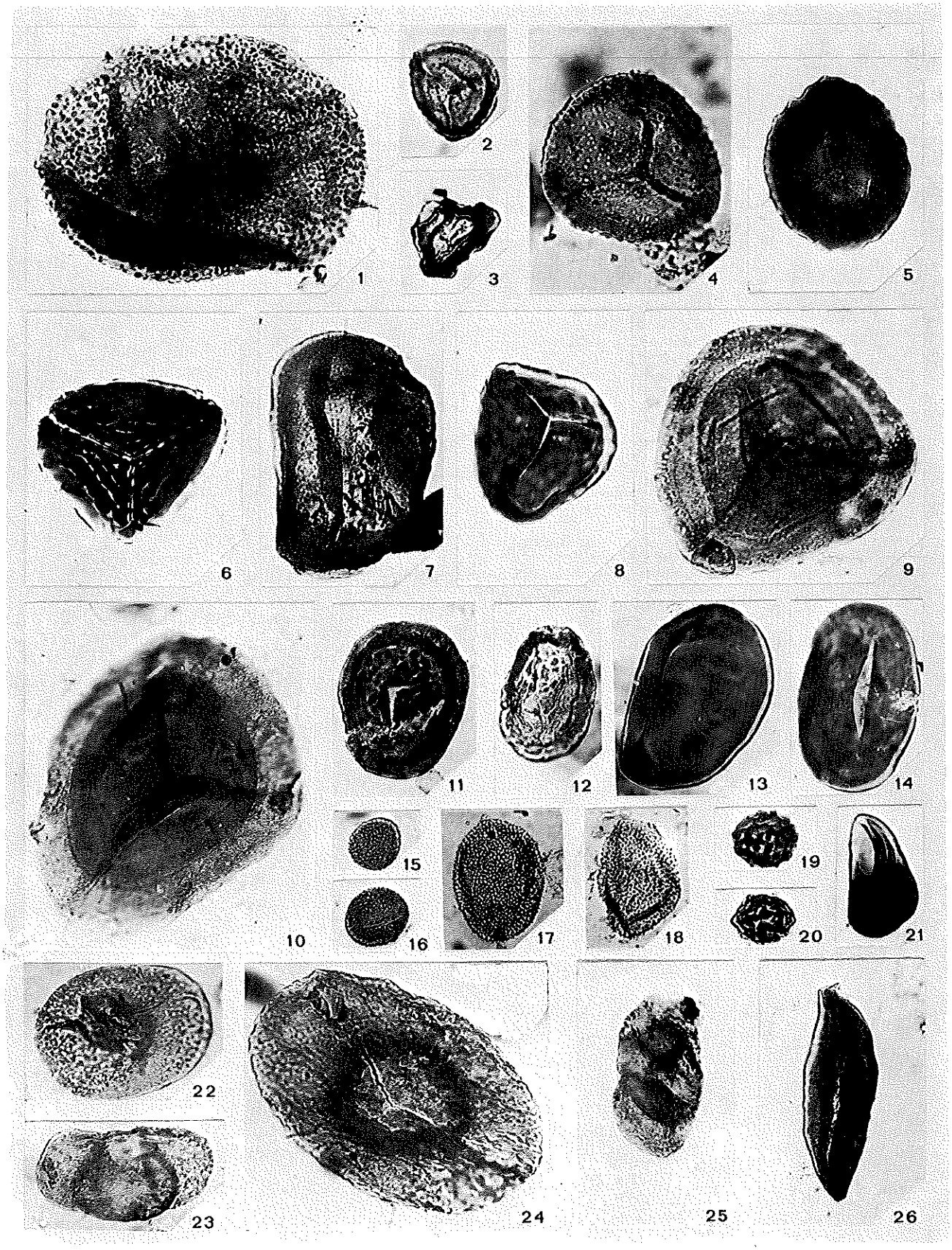
Fig. 21 — *Torispora laevigata* BHARADWAJ
La-Chapelle-sous-Dun, L 6085-2.

Fig. 22 — *Florinites* sp.
Decazeville, Laborde II, L 165.

Figs. 23, 25 — *Pityosporites* sp.
Decazeville, Laborde II, L 2699-1.
Carmaux, Marmottan, L 8011.

Fig. 24 — *Candidispora candida* VENKATACHALA
Rive de Gier, Grande Masse, L 4013-2.

Fig. 26 — *Cheiledonites* sp.
Cruejouls, L 440-2.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## PLATE 23

*Potonieisporites novicus - Cheiledonites major* (NM) Zone

Fig. 1 — *Cyclogranisporites densus* BHARADWAJ
Saint-Eloy-les-Mines, L 19.

Fig. 2 — *Lundbladispora gigantea* (ALPERN) DOUBINGER
Littry, L 46.

Figs. 3-4 — *Lycospora pusilla* (IBRAHIM) SOMERS
Saint-Eloy-les-Mines, LC 8, L 9.

Fig. 5 — *Polymorphisporites reticuloïdes* ALPERN
Saint-Eloy-les Mines, L 27.

Fig. 6 — *Polymorphisporites* sp.
Saint-Eloy-les-Mines, LC 1.

Fig. 7 — *Triquitrites crassus* KOSANKE
Littry, LC B 22.

Fig. 8 — *Angulisporites splendidus* BHARADWAJ
Saint-Eloy-les-Mines, L 17.

Fig. 9 — *Laevigatosporites maximus* (LOOSE) POTONIÉ & KREMP
Saint-Eloy-les-Mines, L 1.

Figs. 10-11 — *Laevigatosporites minimus* (WILSON & COE) SCHOPF, WILSON & BENTALL
Saint-Eloy-les-Mines, L 6, L 7.

Fig. 12 — *Punctatosporites minutus* (IBRAHIM) ALPERN & DOUBINGER
Saint-Eloy-les-mines, L 12.

Fig. 13 — *Punctatosporites* cf. *rotundus*
Littry, LC 1.

Fig. 14 — *Spinosporites spinosus* ALPERN
Saint-Eloy-les-Mines, L 3b.

Fig. 15 — *Thymospora pseudothiessenii* (KOSANKE) WILSON & VENKATACHALA
Saint-Etienne, Dame Blanche, L 870-1.

Fig. 16 — *Latensina trileta* ALPERN
Guadalcanal, Cantera de Ladrillos (loc. 5), L 6564-1.

Fig. 17 — *Wilsonites* sp.
Saint-Etienne-la-Tour, L 1709-2.

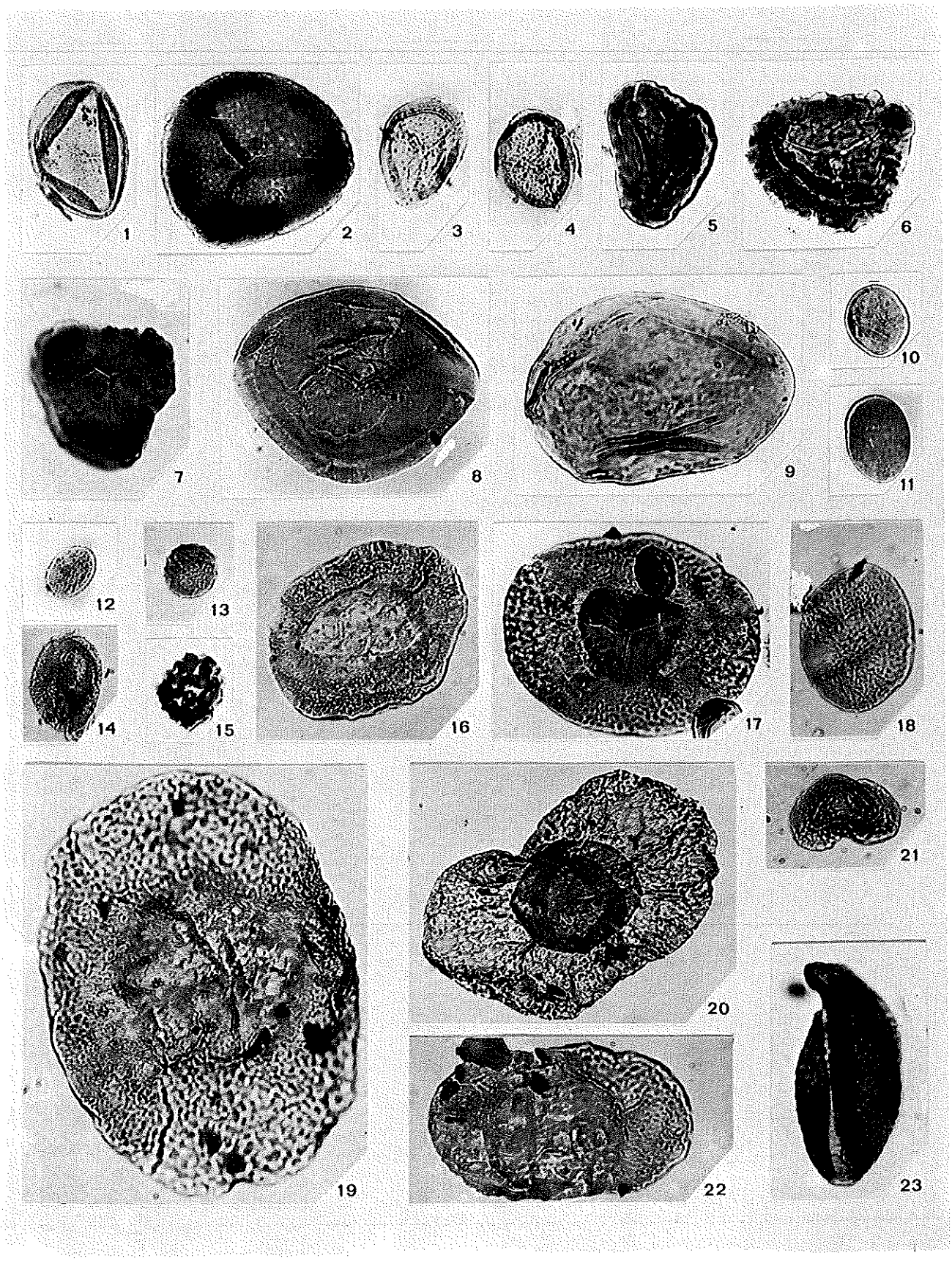
Fig. 18 — *Florinites* sp.
Littry, L 2.

Figs. 19-20 — *Potonieisporites* sp.
Guadalcanal, Cantera de Ladrillos (Loc. 5), L 6540-6, L 6540-8.

Fig. 21 — *Disaccates*
Littry, Lca 21.

Fig. 22 — *Disaccates striatiti*
Guadalcanal, Cantera de Ladrillos (Loc. 5), L 6540-7.

Fig. 23 — *Cheiledonites gigantea* PI-RADONDY & DOUBINGER
Littry, LC 822.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## PLATE 24

*Vittatina costabilis* (VC) Zone

Fig. 1 — *Verrucosisporites pergranulus* (ALPERN) SMITH
Autun, Lally, L 8082-18.

Fig. 2 — *Triquitrites concavus* ALPERN
Autun, Schistes à Poissons de Muse, L 3732-13.

Fig. 3 — *Laevigatosporites vulgaris* (IBRAHIM) ALPERN & DOUBINGER
Autun, Lally, L 8019-1.

Fig. 4 — *Laevigatosporites minimus* (WILSON & COE) SCHOPF, WILSON & BENTALL
Autun, Lally, L 8082-15.

Fig. 5 — *Torispora securis* (BALME) ALPERN, DOUBINGER & HORST
Autun, Schistes à Poissons de Muse, L 3732-12.

Fig. 6 — *Spinosporites exiguus* UPSHAW & HEDLUND
Autun, Lally, L 8019-1.

Fig. 7 — *Thymospora thiessenii* (KOSANKE) WILSON & VENKATACHALA
Autun, Lally, L 8082-2.

Fig. 8 — *Angulisporites splendidus* BHARADWAJ
Autun, Lally, L 8082-16.

Fig. 9 — *Latensina trileta* ALPERN
Autun, Lally, L 8082-3.

Figs. 10, 12 — *Potonieisporites novicus* BHARADWAJ
Autun, Schistes à Poissons de Muse L 3732-3.

Fig. 11 — *Potonieisporites bharadwaji* RÉMY & RÉMY
Autun, Lally, L 8082-24.

Fig. 13 — *Florinites* sp.
Autun, Lally, L 8082-5.

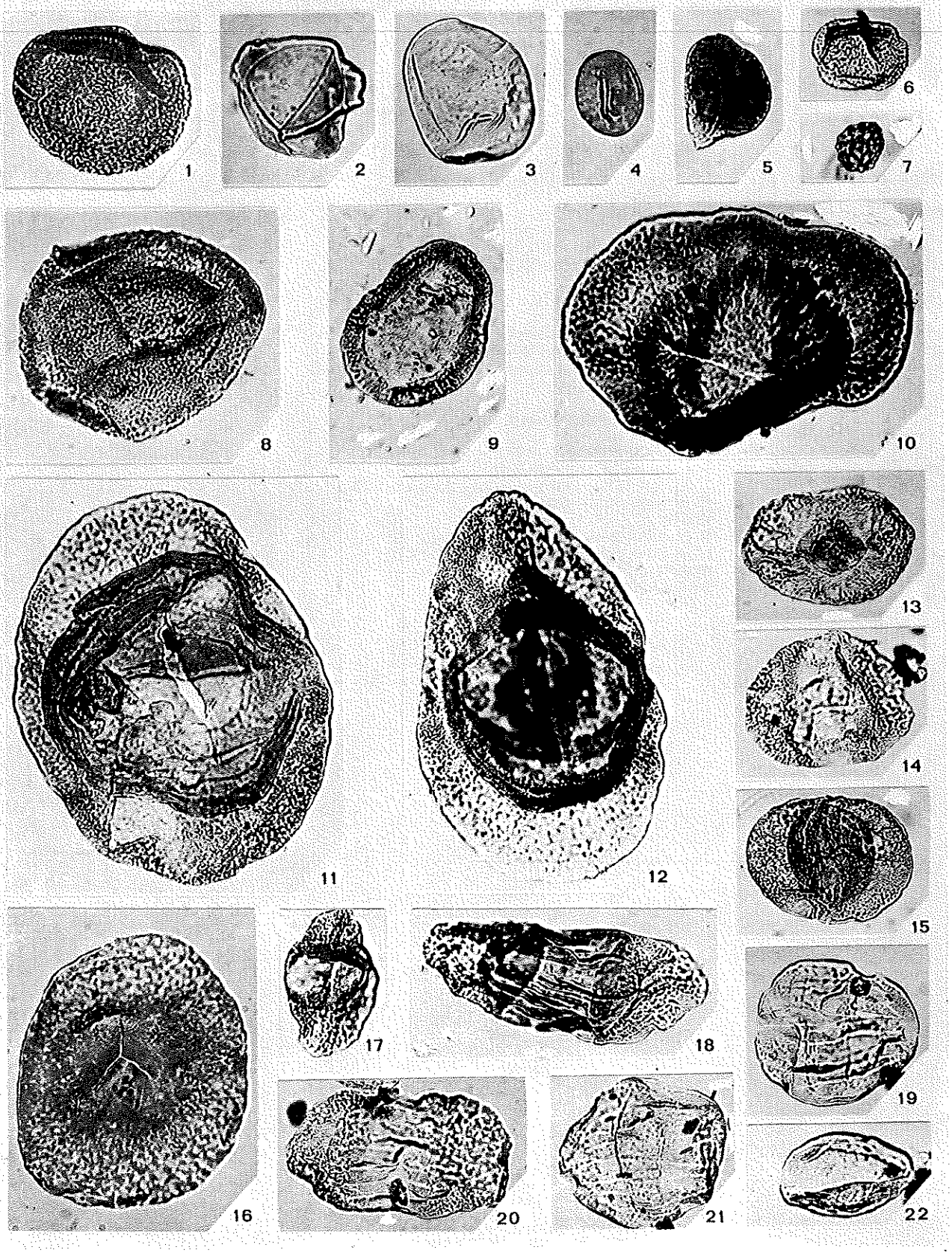
Figs. 14-15, 17 — *Disaccites*
Autun, Lally, L 8019-1.

Fig. 16 — *Wilsonites* sp.
Autun, Schistes à Poissons de Muse, L 3732-14.

Figs. 18, 20 — *Disaccites striatiti*
Autun, Lally, L 8019-1.

Figs. 19, 21 — *Vittatina costabilis* WILSON
Autun, Lally, L 8019-1, L 8019-2.

Fig. 22 — *Cheiledonites major* DOUBINGER
Autun, Lally, L 8019-1.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## PLATE 25

*Disaccites striatiti* (DS) Zone

Fig. 1 — *Polymorphisporites ornatus* ALPERN
Autun, Schistes de Sormoulin, L 8596-10.

Fig. 2 — *Lundbladispora gigantea* (ALPERN) DOUBINGER
Rillo de Gallo (Espagne), L 8511-13.

Fig. 3 — *Knoxisporites glomus* SCHWARTSMAN
Brive, Gourd du Diable, L 4289-1.

Fig. 4 — *Laevigatosporites medius* KOSANKE
Autun, Schistes de Surmoulin, L 8596-12.

Fig. 5 — *Wilsonites* sp.
Autun, Schistes de Surmoulin, L 8596-9.

Fig. 6 — *Cordaitina bractea* INOSSOVA
Autun, Schistes de Surmoulin, L 8596-8.

Figs. 7-9 — *Potonieisporites bharaduaji* RÉMY & RÉMY
Autun, Schistes de Surmoulin, L 8596-11, L 8596-7, L 8596-5.
Fig. 8: x 310.

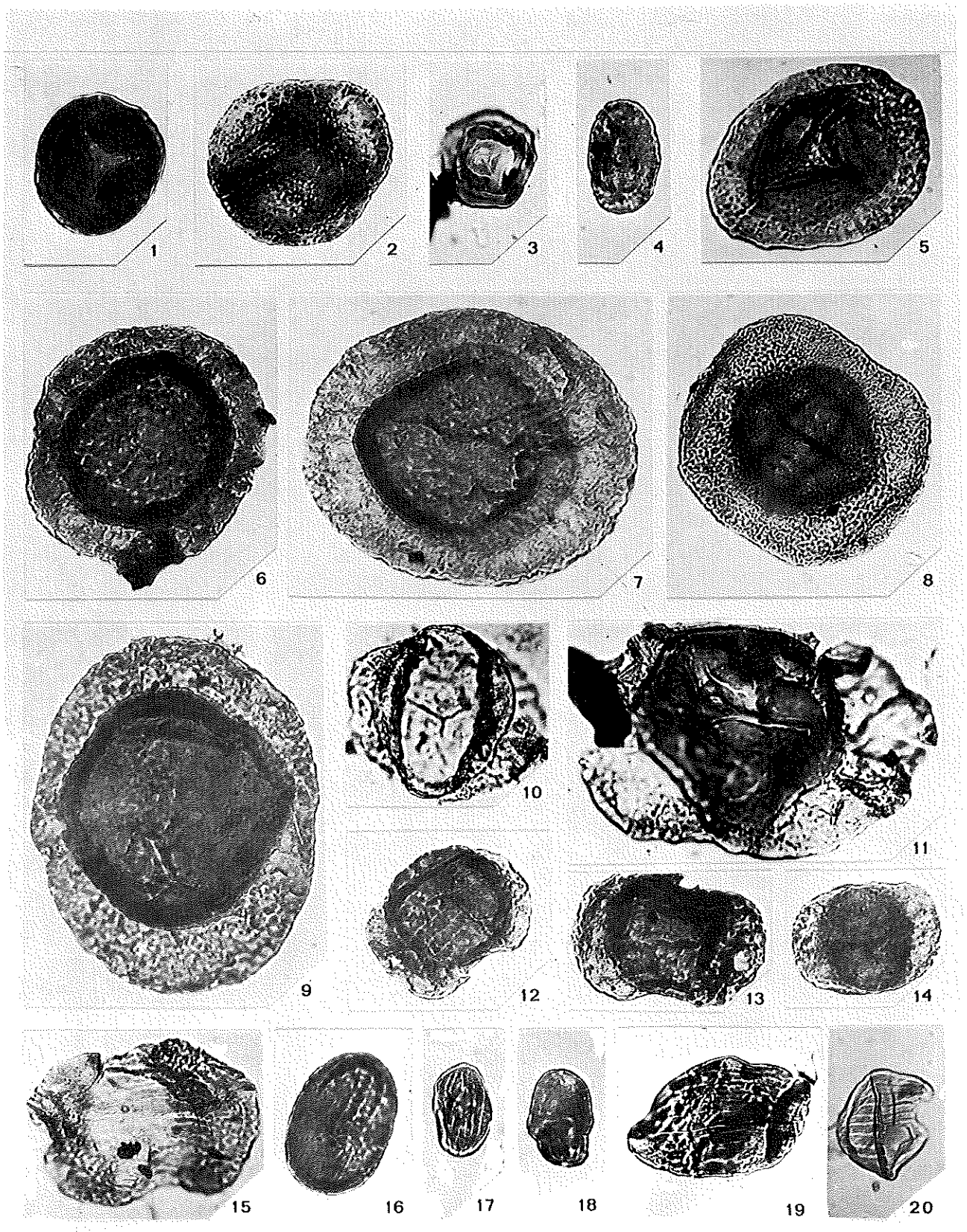
Figs. 10, 14 — *Disaccites*
Autun, Schistes de Surmoulin, L 8016-1, 8596-3.

Fig. 11 — *Sahnites* sp.
Brive, Gourd du Diable, L 4289-2.

Figs. 12-13, 15 *Disaccites striatiti*
12-13: Autun, Schistes de Surmoulin, L 8596-4, L 8596-2.
15: Brive, Gourd du Diable, L 4289-2.

Figs. 16-18 — *Vittatina* sp.
16: Autun, Schistes de Surmoulin, L 8596-6.
17-18: Brive, Gourd du Diable, L 747-13, L 754-21.

Figs. 19-20 — *Vittatina costabilis* WILSON
Brive, Gourd du Diable, L 747-4, L 4289-2.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