

## ASPECTS OF LATE DEVONIAN AND EARLY CARBONIFEROUS PALYNOLOGY OF SOUTHERN IRELAND. III. PALYNOLOGY OF DEVONIAN—CARBONIFEROUS TRANSITION SEQUENCES WITH SPECIAL REFERENCE TO THE BANTRY BAY AREA, CO. CORK

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### ABSTRACT

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The present paper provides: (1) an analysis of the qualitative and quantitative compositional development of Late Devonian—Early Carboniferous palynological assemblages from the Bantry Bay and other sections of southern Ireland; (2) a scheme of successive phases, (inter) regionally recognizable in the gradual compositional development of Late Devonian—Early Carboniferous palynological assemblages; (3) a palynological zonation based on three successive assemblage zones (*Retispora lepidophyta* Assemblage Zone, *Verrucosiporites nitidus* Assemblage Zone, *Spelaeotriletes pretiosus* Assemblage Zone); and (4) two palaeogeographically related local phases, within the scheme of regional phases.

It is concluded that: (1) the scheme of regional phases, in combination with the assemblage zones recognized, provides a more realistic tool for long-range palynostratigraphical correlation than the earlier proposed schemes of concurrent range zones; (2) the assemblage zones may be used for chronostratigraphical purposes, the boundary between the *Retispora lepidophyta* Assemblage Zone and the *Verrucosiporites nitidus* Assemblage Zone approximates the conventional Devonian—Carboniferous boundary; (3) the palaeogeographically related local phases may be considered to reflect floras of the coastal and alluvial plain, and the coastal-deltaic area, respectively; (4) within southern Ireland, the palynologically determined Devonian—Carboniferous boundary lithostratigraphically correlates with a thin mudstone unit (Claystone Member, Castle Slate Member).

The taxonomical part includes: (1) an emended diagnosis of *Lophozonotriletes*; (2) formal proposals of new combinations of *Ceratosporites delicatus*, *Asperispora acuta*, *Asperispora perlota* and *Diaphanospora scolecophora*; and (3) the establishment of the *Verrucosiporites nitidus* morphon and the *Dictyotriletes submarginatus* morphon.

### INTRODUCTION

Late Palaeozoic rocks dominate the south of Ireland, usually resting with marked unconformity on underlying successions, and thinning dramatically when traced to the north and to the east. Since the earliest work in the

nineteenth century, the sequence has been known to be one in which "Old Red Sandstone" facies passed conformably into marine Carboniferous. Structurally the region is dominated by large-amplitude folds, resulting in the widespread repetition of stratigraphical levels. Coastal exposure is excellent, so that there are numerous good sections available for study.

Until recently biostratigraphical research has been effected by macrofossils, but the thick redbed sequences have remained an enigma. Although a rich continental fauna and flora has been obtained from several localities near the top of the "Old Red Sandstone" (e.g., from the famous locality of Kiltorcan), none can be used for the establishment of a biostratigraphical zonation. Marine macrofossils (compare e.g., Naylor et al., 1969) have also proved disappointing for detailed correlative purposes and doubts have been cast on the usefulness of Vaughan's (1905) coral-brachiopod zonation as applied in Ireland (cf. George, 1953).

In contrast, micropalaeontological studies initiated in the past decade have proved fruitful. In the Early Carboniferous carbonates, notably conodonts may have a potential in regional correlations (Matthews and Naylor, 1973; Naylor et al., 1974; Sleeman et al., 1974; Clayton et al., 1977b; Naylor et al., 1978).

The use of palynology for biostratigraphical purpose was initiated by Dr. G. Dolby, some of his results being presented in Dolby (1970) and Austin et al. (1970). Subsequently Doran (1970) recorded palynological assemblages from an inland exposure of "Old Red Sandstone" in Co. Tipperary. This was followed by regional palynostratigraphical correlation for transition sequences in southern Ireland by Clayton et al. (1974), and a report on a Middle-Late Devonian assemblage by Clayton and Graham (1974). A mainly taxonomic paper on assemblages from Hook Head, Co. Wexford, by Higgs (1975) has also been published amplifying data presented in Clayton et al. (1974). Subsequently the following papers with palynological data have been published: Gardiner (1975), Gardiner and Horne (1976), Naylor (1975), Naylor et al. (1974, 1977), Keegan (1977), Clayton et al. (1977a, b, 1978), Keegan and Penney (1978), Sleeman et al. (1978), MacCarthy et al. (1978). A paper with Namurian data from the Bantry Bay area has been published by Naylor et al. (1978).

In 1971 a stratigraphical research project in the Devonian-Lower Carboniferous was initiated by P.R.R. Gardiner and H. Visscher, based on the mutual collaboration of the Geological Survey of Ireland and the Laboratory of Palaeobotany and Palynology of the State University of Utrecht. This project is aimed at the study of all lines of evidence bearing on the integration of the lithostratigraphical work within a suitable palynologically supported biostratigraphical and chronostratigraphical framework.

At present palynological investigations within the project are concentrated on the Late Devonian-Early Carboniferous transition sequence; results have been published by Van der Zwan and Van Veen (1978), Van der Zwan (1979, 1980b) and by Van Veen (1980). Limited work lower in the sequence has led to the discovery of a late Early Devonian assemblage in the Dingle Peninsula (Van der Zwan, 1980a).

Late Devonian—Early Carboniferous sections in southwest Ireland between Kerry Head and Black Ball Head are presently under investigation by P.M. van Veen. More easterly sections between Bantry Bay and Hook Head have been studied by the present author, with emphasis on a detailed analysis of the succession and the development of palynological assemblages from the Bantry Bay section with the following objectives:

- (1) A comparison of the assemblages from Bantry Bay with those from the more easterly sections in order to test the applicability of the palynological zonation scheme developed by Clayton et al. (1974).
- (2) A modification of this zonation in terms of the recognition of successive assemblage zones rather than concurrent range zones.
- (3) The integration of lithostratigraphical and biostratigraphical data in order to establish a practical framework for further palaeogeographical and palynological analysis.
- (4) A comparison of proposed Irish zonation with zonation concepts based on successions in North America and the European mainland.
- (5) A chronostratigraphical interpretation of the palynological data in terms of standard classification units.
- (6) A morphological/taxonomic study of morphologically interesting palynological taxa.
- (7) The further establishment of informal classification units (morphons; cf. Van der Zwan, 1979, 1980b) in order to unite palynological taxa, showing continuous morphological variation.

#### LITHOSTRATIGRAPHY

The Late Devonian—Early Carboniferous transition sequence in southern Ireland (“Cork Beds” of Naylor, 1966) approximates the grey clastic sediments which link the underlying redbeds with the overlying limestone formations.

The present study is principally based on an evaluation of the Bantry Bay section, East of Glengariff (Co. Cork). For comparative purposes additional sections have been studied east of this section (see fig.1).

#### *Bantry Bay and Coomhola River*

The Bantry Bay section (Table I) has been lithologically studied by the author in collaboration with P.R.R. Gardiner. For relevant information on location, sedimentology and lithostratigraphy, one is referred to Coe and Selwood (1968), Gardiner (1970), Jones (1974) and Gardiner et al. (in prep.). According to the new lithostratigraphical classification proposed by Gardiner et al. (in prep.), the following subdivisions can be recognized:

*West Cork Sandstone Formation* — a predominantly arenaceous unit defined by the incoming of “fining upwards cycles” (sensu Allen, 1965), which includes the upper boundary (“top redbed”) of the classic “Old Red Sandstone”.

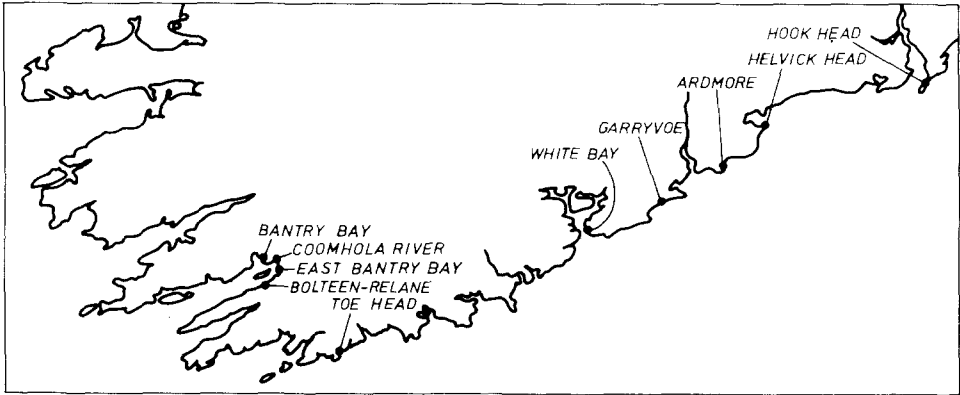


Fig.1. Map of southern Ireland, showing sample localities.

*Coomhola Formation* — a clastic unit of variable and discontinuous lithological composition, defined by the incoming of “heterolithic bed” (sensu De Raaf and Boersma, 1971).

*Kinsale Formation* — a clastic unit of variable lithological composition, defined by the incoming of the first significant mudstone unit. The following members are recognized:

*Claystone member* — a fully pelitic unit.

*Ardaturrish Member* — a clastic unit of variable and discontinuous lithological composition and having heterolithic intervals.

*Reenagough Member* — a predominantly arenaceous unit with heterolithic intervals.

*Ardnamanagh Member* — a predominantly pelitic unit with “coarsening upwards cycles” (compare Selley, 1970, p.80).

*Courtmacsherry Formation* — an essentially calcareous formation, composed of alternating mudstones and limestones; the base of the unit is taken at the first calcareous intercalation.

It should be noted that in the Bantry Bay section, the contact between the Reenagough Member and the Ardnamanagh Member is fault-controlled. A gradual sedimentary development, however, has recently been found in the nearby Coomhola River section (Table II). Here one may recognize an additional clastic unit: the *Trawnamaddref Member* of Gardiner et al. (in prep.), characterized by a variable lithological composition.

#### *Additional sections*

Apart from the Bantry Bay and Coomhola River sections, the following sections have been sampled for palynological investigation (see Tables III–VIII; relevant references to location, sedimentology, lithostratigraphy, etc. are given in brackets).

- (1) East Bantry Bay (Gardiner et al., in prep.) (Table VIII)
- (2) Bolteen—Relane (Gardiner et al., in prep.) (Table III)

TABLE I

Quantitative/qualitative distribution of palynomorphs,

LITHOSTRATIGRAPHY		SAMPLES	PHASES		PALYNOFORMS
			REGIONAL	LOCAL	
		BAN 11	PV		GRANDISPORA CORNUTA
		CZ 39			?ANCYROSPORA CAPILLATA
		BAN 10			DIDUCITES POLJESSICUS
		CZ 36	NH		DIDUCITES MUCRONATUS
		CZ 35			RUGOSPORA FLEXUOSA
					PEROTRILITES CAPERATUS
					RAISTRICKIA MACRURA
					VALLATISPORITES SP. = C-HYSTRICOSUS
					LOPHOZONOTRILETES CURVATUS
					VERRUCOSISPORITES SP. A
					<i>see also table II</i>
		BAN 9	NDi	TCr	
		BAN 8			
	BAN 7				
	BAN 6	NR			
	BAN 5				
	BAN 4				
	BAN 20				
	BAN 21				
	BAN 19	LCr		. . . o o o . . .	
	CZ 22			o . . . . 0 . . .	
	BAN 2			o . . . o . . 0 . . .	
	BAN 1	LN		o . . . . + . . .	
	CZ 15				
	CZ 13	?		? . . . . 0 . . . 0	
	CZ 7	LE	RaLo	. . . 0 . . .	
	BAN 15	LM		. . . o o o . . . 0 o	





CYCLOGRANISPORITES CF. LEOPOLDII ASPERISPOA PERLOTA							
DIAPHANOSPORA CF. DEPRESSA	.	.	.	.	.	.	.
RETUSOTRILETES PLANUS	.	.	.	.	.	.	.
SPELAOTRILETES RESOLUTUS	.	.	.	.	.	.	.
CORYTISPORITES SP.	.	.	.	.	.	.	.
?DICTYOTRILETES TRIVIALIS	.	.	.	.	.	.	.
DICTYOTRILETES SP.A	.	.	.	.	.	.	.
SPELAEOTRILETES CRUSTATUS	.	.	.	.	.	.	.
LOPHOZONOTRILETES EXCISUS	.	.	.	.	.	.	.
LATOSPORITES SP.B	.	.	.	.	.	.	.
PUSTULATISPORITES SP.A OF HIGGS (1975)	.	.	.	.	.	.	.
?RETICULATISPORITES FIMBRIATUS	.	.	.	.	.	.	.
ENDOCULEOSPORA GRADZINSKII VARIANT A	.	.	.	.	.	.	.
DIBOLISPORITES ABSTRUSUS	.	.	.	.	.	.	.
?CRISTATISPORITES COLLICULUS	.	.	.	.	.	.	.
ANEUROSPORA CF. GREGGSLI	.	.	.	.	.	.	.
GRANDISPOA SP.B	.	.	.	.	.	.	.
CYTOSPOA CRISTIFER VARIANT B	.	.	.	.	.	.	.
MICRHYSTRIDIUM SP.	.	.	.	.	.	.	.
RAISTRICKIA SPATHULATA	.	.	.	.	.	.	.
BACULATISPORITES FUSTICULUS	.	.	.	.	.	.	.
DIBOLISPORITES DISTINCTUS	.	.	.	.	.	.	.
KNOXISPORITES RUHLANDII	.	.	.	.	.	.	.
CERATOSPORITES SP.A	.	.	.	.	.	.	.
KRAEUSELISPORITES FIBERNICUS	.	.	.	.	.	.	.
SPELAEOTRILETES PRETIOSUS	.	.	.	.	.	.	.
SPELAEOTRILETES BALTEATUS	.	.	.	.	.	.	.
MUOSPOA DUBITATA	.	.	.	.	.	.	.
MOOREISPORITES SP.A	.	.	.	.	.	.	.
CRASSISPOA TRYCHERA	.	.	.	.	.	.	.
GRANULATISPORITES MICROGRANIFER	.	.	.	.	.	.	.

♣ plant fragments  
 F fossils  
 quantitative record  
 • 0 - 1.9%  
 ○ 2 - 4.9%  
 ○ 5 - 14.9%  
 ○ 15 - 24.9%  
 X > 25%  
 quantitative record  
 + present

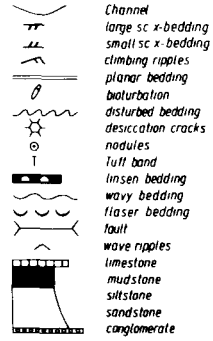




TABLE II

Quantitative/qualitative distribution of palynomorphs, Coomhola River

COOMHOLA RIVER		LITHOSTRATIGRAPHY		SAMPLES	REGIONAL PHASES		LOCAL
TRAWNA-MADDE REF	MEMBER	NH	TCr				
	COO 11B						SPELAOTRILETES SP.
	COO 11C						CERATOSPORITES DELICATUS
	COO 11D						AURORASPOA ASPERELLA VARIANT A
	COO 11A						AURORASPOA ASPERELLA VARIANT C
	COO 9A						CORBULISPOA SUBALVEOLARIS
	COO 9D						TYPE A
	COO 9C						ENDOCULEOSPOA GRADZINSKII VARIANT B
	COO 9E						RETUSOTRILETES SP.A OF HIGGS(1975)
							COLATISPORITES DECORUS VARIANT B
							TUMULISPOA RARITUBERCULATA VARIANT A
							AURORASPOA HYALINA
							?CRISTATISPORITES COLLICULUS
							SPELAOTRILETES BALTEATUS
							ENDOCULEOSPOA GRADZINSKII VARIANT A
							PUSTULATISPORITES SP.A OF HIGGS(1975)
							PLANISPORITES SP.A
							LOPHOTRILETES LINGUAEFORMIS
							PUNCTATISPORITES SOLIDUS
							ANEUROSPOA CF. SEMIZONALIS
							AURORASPOA MACRA
							KRAEUSELISPORITES HIBERNICUS

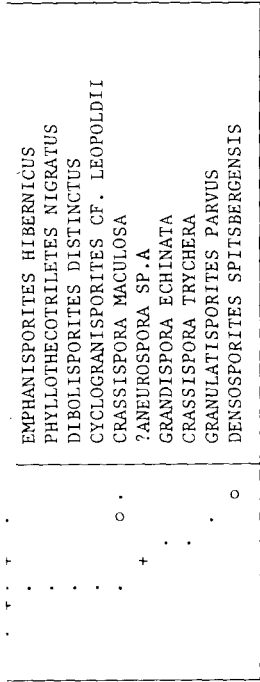
TABLE III

Quantitative/qualitative distribution of palynomorphs, Bolteen—Relane

BOLTEEN - RELANE		LITHOSTRATIGRAPHY		SAMPLES	REGIONAL		LOCAL
COOM - HOLA FORMATION		LN					
	REL 4						DIBOLISPORITES ABSTRUSUS
	REL 2						GRANDISPOA ECHINATA
	BOLT 1						CONVOLUTISPOA VERMIFORMIS
	BOLT 2						PLANISPORITES SP.A
							DENSOSPORITES SPITSBERGENSIS
							ASPERISPOA PERLOTA
							ENDOCULEOSPOA GRADZINSKII VARIANT B
							AURORASPOA ASPERELLA
							?ANEUROSPOA SP.A
							DIDUCITES MUCRONATUS
							VERRUCOSISPORITES DEPRESSUS
							RETUSOTRILETES INCOHATUS
							VERRUCOSISPORITES CONGESTUS
							RETISPOA LEPIDOPHYTA
							LOPHOZONOTRILETES CURVATUS
							VALLATISPORITES SP.=C.HYSTRICOSUS
							DISCERNISPORITES MICROMANIFESTUS
							COLATISPORITES DECORUS VARIANT A
							KNOXISPORITES HEDERATUS
							TYPE A
							PUNCTATISPORITES DEBILIS

.	RAISTRICKIA BACULOSA
.	HYTRICOSPORITES SP.
.	PUNCTATISPORITES SOLIDUS
.	DIDUCITES POLJESSICUS
.	LOPHOZONOTRILETES BELLUS
.	ASPERISPORIA ACUTA
.	AURORASPORIA MACRA
0	PEROTRILETES CAPERATUS
0	ANEUROSPORA CF. GREGGSII
0	CORBULISPORIA SUBALVEOLARIS
.	VALLATISPORITES VERRUCOSUS
.	RUGOSPORIA FLEXUOSA
.	VERRUCOSISPORITES NITIDUS
.	KNOXISPORITES LITERATUS
.	GRANDISPORIA SP.A
.	VERRUCOSISPORITES SP.A
.	RAISTRICKIA VARIABILIS
.	DIDUCITES VERSABILIS
0	VALLATISPORITES VALLATUS
.	DENTATISPORIA SP.
0	RAISTRICKIA MACRURA
.	RUGOSPORIA CF. MINUTA
.	CYCLOGRANISPORITES COMMODUS
.	RETUSOTRILETES SP.A OF HIGGS (1975)

0	DICTYOTRILETES SUBMARGINATUS
0	VERRUCOSISPORITES DEPRESSUS
0	VERRUCOSISPORITES NITIDUS
0	VERRUCOSISPORITES CONGESTUS
.	TUMULISPORIA VARIIVERRUCATA
.	TUMULISPORIA RARITUBERCULATA VARIANT B
.	PUNCTATISPORITES DEBILIS
.	CYRTOSPORIA CRISTIFER VARIANT B
0	CYRTOSPORIA CRISTIFER VARIANT A
0	ANEUROSPORA CF. GREGGSII
0	AURORASPORIA ASPERELLA VARIANT B
0	COLATISPORITES DECORUS VARIANT A
0	STENOZONOTRILETES CLARUS
.	LOPHOZONOTRILETES BELLUS
.	CERATOSPORITES SP.A
.	RETUSOTRILETES INCOHATUS
.	DIBOLISPORITES ABSTRUSUS
.	DICTYOTRILETES SP.A
.	RETUSOTRILETES PLANUS
.	LATOSPORITES SP.A
.	BACULATISPORITES FUSTICULUS
.	SPELAEOTRILETES RESOLUTUS
0	DIAPHANOSPORITES CF. DEPRESSA
.	ASPERISPORIA ACUTA
.	GRANDISPORIA SP.B
.	KNOXISPORITES LITERATUS
0	DIAPHANOSPORIA SCOLECOPHORA
.	RUGOSPORIA CF. MINUTA



TABI

Quant

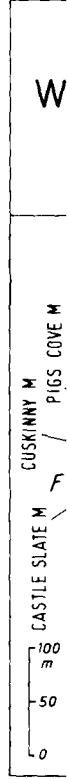
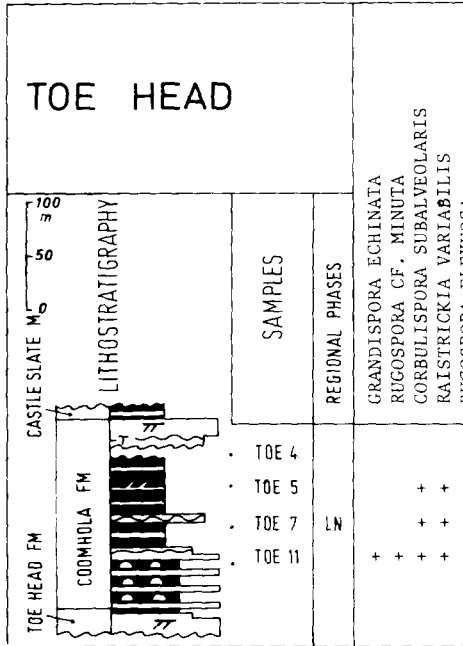
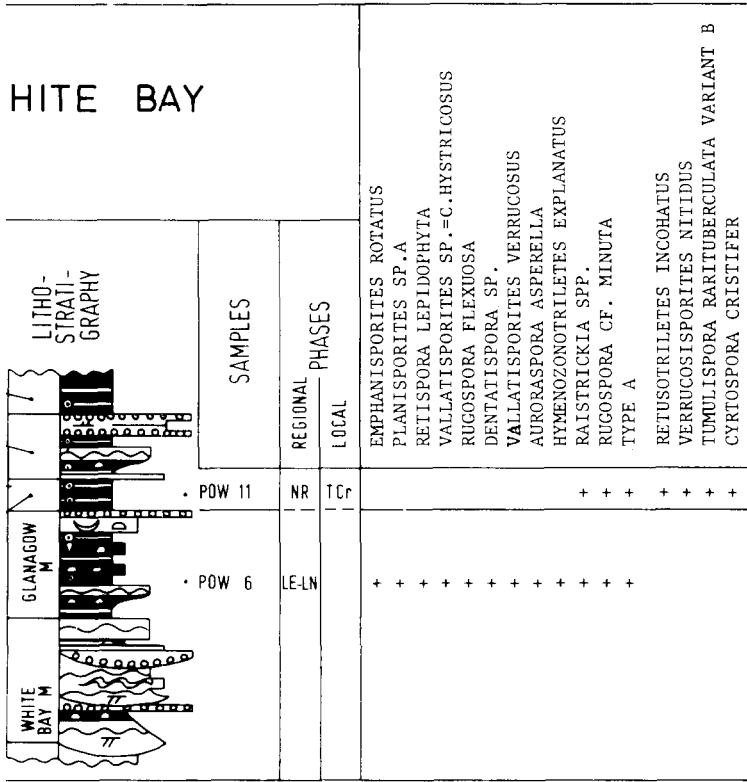


TABLE IV

Quantitative/qualitative distribution of palyn



itative/qualitative distribution of palynomorphs, White Bay



omorphs, Toe Head

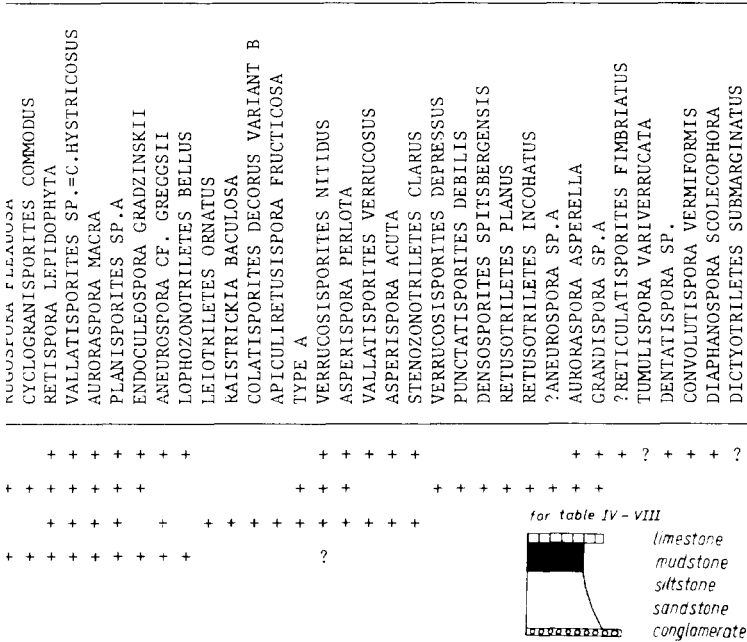
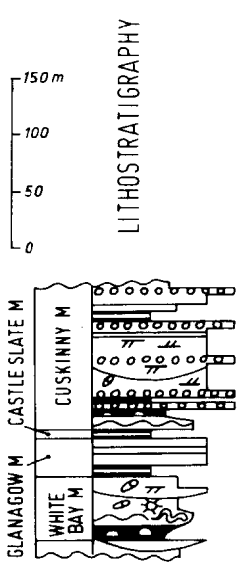


TABLE VI

Quantitative/qualitative distribution of palynomorphs, Garryvoe

GARRYVOE		LITHOSTRATIGRAPHY 	SAMPLES		REGIONAL PHASES		PALYNOFORMS
			REGIONAL	LOCAL	REGIONAL	LOCAL	
		GAR 14	NH				CERATOSPORITES DELICATUS
		GAR 12,16					RETUSOTRILETES PLANUS
		GAR 20,17	NR	Tcr			VERRUCOSISPORITES SP.A
		GAR 19					LOPHOZONOTRILETES CURVATUS
		GAR 9					?ANCYROSPOA CAPILLATA
		GAR 8					ANEUROSPOA CF. GREGGSII
		GAR 18	LCr				DIDUCITES MUCRONATUS
		GAR 6					RAISTRICKIA MACRURA
		GAR 5					RUGOSPOA FLEXUOSA
		GAR 3	LE-LN	RaLo			LEIOTRILETES ORNATUS
		GAR 2					VALLATISPORITES SP.=C.HYSTRICOSUS
							RETISPOA LEPIDOPHYTA
							ASPERISPOA PERLOTA
							RUGOSPOA CF. MINUTA
							VALLATISPORITES VERRUCOSUS
							DENTATISPOA SP.
							CYCLOGRANISPORITES COMMODUS
							PUNCTATISPORITES SOLIDUS
							RETUSOTRILETES INCOHATUS
							RAISTRICKIA VARIABILIS
							DENSOSPORITES SPLITSBERGENSIS
							AURORASPOA MACRA

+	+	+	+	+	+	ASPERISPOA ACUTA
+	+	+	+	+	+	COLATISPORITES DECORUS VARIANT B
+	+	+	+	+	+	PLANISPORITES SP.A
						CORBULISPOA SUBALVEOLARIS
+	+	+	+	+	+	?ACINOSPORITES SP.A
+	+	+	+	+	+	HYSTRIGOSPORITES SP.
+	+	+	+	+	+	KNOXISPORITES LITERATUS
+	+	+	+	+	+	ENDOCULEOSPOA GRADZINSKIL VARIANT B
						DICTYOTRILETES SUBMARGINATUS
						DIDUCITES VERSABILIS
						DIAPHANOSPOA SCOLEOPHORA
						DISCERNISPORITES MICROMANIFESTUS
						PUNCTATISPORITES DEBILIS
						HYMENOZONOTRILETES EXPLANATUS
						COLATISPORITES DECORUS VARIANT A
						VERRUCOSISPORITES DEPRESSUS
						AURORASPOA ASPERELLA
						PHYLLOTHECOTRILETES NIGRATUS
						CYTOSPOA CRISTIFER
						TUMULISPOA VARIVERRUCATA
						CAMPOTRILETES SP.A
						TUMULISPOA RARITUBERCULATA VARIANT B
						LOPHOZONOTRILETES BELLUS
						VERRUCOSISPORITES NITIDUS
						LOPHOZONOTRILETES EXCISUS
						TYPE A
						SPELAEOTRILETES RESOLUTUS
						VERRUCOSISPORITES CONGESTUS
						ANEUROSPORA CF. SEMIZONALIS
						CONVOLUTISPOA VERMIFORMIS
						CRASSISPOA MACULOSA
						RETUSOTRILETES LEPTOCENTRUM
						TUMULISPOA RARITUBERCULATA VARIANT A
						RETUSOTRILETES SP.A OF HIGGS(1975)

				KRAUSELISPORITES HIBERNICUS BACULATISPORITES FUSTICULUS DIBOLISPORITES ABSTRUSUS
			+ .2 +	

TABLE VII

Quantitative/qualitative distribution of palynomorphs, Hook Head

HOOK HEAD		LITHOSTRATIGRAPHY	SAMPLES	REGIONAL PHASES	PALYNOFORMS
TEMPLETOWN CONGLOMERATE FM.	SCOUT'S HIDING PLACE M.				
			G 66	NH	
			G 63 T 7	NR	
			T 3 G 55	LE	
			G 50 G 45	LM	
					PHYLLOTHECOTRILETES NIGRATUS ?ANCYROSPORA CAPILLATA AURORASPORA TORQUATA PEROTRILITES CAPERATUS RUGOSPORA FLEXUOSA DIDUCITES VERSABILIS RETISPORA LEPIDOPHYTA DIDUCITES MUCRONATUS VALLATISPORITES SP. = C. HYSTRICOSUS PEROTRILITES SPP. GRANDISPORA SP. A ACANTHOTRILETES SPP. DIDUCITES POLJESSICUS ASPERISPORA ACUTA DISCERNISPORITES MICROMANIFESTUS LEIOTRILETES SPP. ENDOCULEOSPORA GRADZINSKII VARIANT B AURORASPORA HYALINA





LATOSPORITES SP. B			
SPELAOTRILETES CRUSTATUS			
COLATISPORITES DECORUS VARIANT A	.		
DIBOLISPORITES ABSTRUSUS	.		
COLATISPORITES DECORUS VARIANT B	o		
CYTOSPORA CRISTIFER VARIANT A	o		
BACULATISPORITES FUSTICULUS	o		
SPELAOTRILETES OBTUSUS	o		
SPELAOTRILETES RESOLUTUS	o	.	
RETUSOTRILETES SP. A OF HIGGS (1975)	o	.	
VERRUCOSISPORITES NITIDUS	.	.	
MUROSPORA DUBITATA	.	.	
ENDOCULEOSPORA GRADZINSKII VARIANT A	.	o	
CYTOSPORA CRISTIFER VARIANT B	.	.	
DENTATISPORA SP.	.	.	
CRASSISPORA MACULOSA	.	.	
VERRUCOSISPORITES SP. A	.	.	
DIAPHANOSPORA CF. DEPRESSA	.	.	
LEIOTRILETES ORNATUS	.	.	
VERRUCOSISPORITES CONGESTUS	o	.	
VERRUCOSISPORITES DEPRESSUS	.	.	
TUMULISPORA RARITUBERCULATA VARIANT A	.	.	
PUSTULATISPORITES SP. A OF HIGGS (1975)	.	.	
CRASSISPORA TRYCHERA	.	.	
KRAEUSELISPORITES HIBERNICUS	o	.	
RUGOSPORA POLYPTYCHA	o	.	
VALLATISPORITES VERRUCOSUS	o	.	
LOPHOTRILETES LINGUAIFORMIS	o	.	
DIBOLISPORITES DISTINCTUS	o	.	
TUMULISPORA RARITUBERCULATUS VARIANT B	o	.	
SPELAOTRILETES BALTEATUS	o	.	
?CRISTATISPORITES COLLICULUS	o	.	

TABLE VIII

Quantitative/qualitative distribution of palynomorphs, Ardmore, Helvick Head and East Bantry Bay

LITHO-STRATIGRAPHY	SAMPLES	PHASES		
		REGIONAL	LOCAL	
<p><b>ARDMORE</b></p> <p>100m 50 0</p> <p>USKINNY M CROWS POINT FM F CASTLE SLATE M DYSSERT M</p>	ARDM 12	NR	TCr	<p>VERRUCOSISPORITES NITIDUS, V. CONGESTUS, V. DEPRESSUS, SPELAEOTRILETES RESOLUTUS, CYRTOSPOA CRISTIFER, TUMULISPOA VARIVERRUCATA, T. RARITUBERCULATA VARIANT A, LOPHOZONOTRILETES BELLUS, ASPERISPOA ACUTA, DICTYOTRILETES SUBMARGINATUS, RAISTRICKIA VARIABILIS, R. MACRURA, CONVOLUTISPOA VERMIFORMIS, ANEUROSPORA CF. SEMIZONALIS, A. CF. GREGGSII, RETUSOTRILETES INCOHATUS, RUGOSPOA CF. MINUTA, RETISPOA LEPIDOPHYTA.</p>
<p><b>HELVICK HEAD</b></p> <p>CROWS POINT FM ARDMORE M</p>	HELV 7	NDi		<p>VERRUCOSISPORITES NITIDUS, V. CONGESTUS, V. DEPRESSUS, BACULATISPORITES FUSTICULUS, DIBOLISPORITES ABSTRUSUS, SPELAEOTRILETES BALTEATUS, HYMENAZONOTRILETES EXPLANATUS, LOPHOZONOTRILETES BELLUS, ASPERISPOA ACUTA, RAISTRICKIA SPATHULATA, ANEUROSPORA CF. SEMIZONALIS, CONVOLUTISPOA VERMIFORMIS, CYCLOGRANISPORITES COMMODUS, AURORASPOA ASPERELLA, ENDOCULEOSPOA GRADZINSKII, RUGOSPOA CF. MINUTA, PEROTRILITES SPP., RETISPOA LEPIDOPHYTA.</p>
<p><b>EAST BANTRY BAY</b></p> <p>COURTMACSHERRY FORMATION</p>	BAN 26	PV	TCr	<p>SPELAEOTRILETES PRETIOSUS, S. BALTEATUS, S. RESOLUTUS, VALLATISPORITES VALLATUS, V. VERRUCOSUS, CYRTOSPOA CRISTIFER VARIANT A AND B, KRAEUSELISPORITES HIBERNICUS, DENSOSPORITES SPITSBERGENSIS, CRASSISPOA TRYCHERA, VERRUCOSISPORITES NITIDUS, V. CONGESTUS, V. DEPRESSUS, V. TUBERCULATUS, TUMULISPOA RARITUBERCULATA VARIANT A, CERATOSPORITES SP. A, AURORASPOA ASPERELLA, A. MACRA, ENDOCULEOSPOA GRADZINSKII VARIANT A AND B, COLATISPORITES DECORUS, ASPERISPOA ACUTA, GRANDISPOA SP. B, G. ECHINATA, DIBOLISPORITES ABSTRUSUS, GRANULATISPORITES PARVUS, CORBULISPOA SUBALVEOLARIS, ?DICTYOTRILETES TRIVIALIS, CONVOLUTISPOA VERMIFORMIS, ANEUROSPORA CF. GREGGSII, PUSTULATISPORITES SP. A OF HIGGS (1975), PUNCTATISPORITES DEBILIS, P. SOLIDUS, STENOZONOTRILETES CLARUS, CF. STAUROCEPHALITES SP.</p>

- (3) Toe Head (Graham, 1975, and pers. comm.) (Table IV)
- (4) White Bay (MacCarthy, 1974; MacCarthy et al., 1978) (Table V)
- (5) Garryvoe (MacCarthy et al., 1971, 1978) (Table VI)
- (6) Ardmore (MacCarthy et al., 1978) (Table VIII)
- (7) Helvick Head (MacCarthy et al., 1978) (Table VIII)
- (8) Hook Head (Gardiner and Horne, in press; Sleeman et al., 1974) (Table VII)

*Problems of regional classification*

Considerable diversity exists with regard to a detailed regional classification and correlation of the sequences (Table IX). In their correlation scheme Gardiner and Horne (1972) proposed a unified sequence of formally named formations for the whole of southern Ireland. Some aspects of Gardiner and Horne's (1972) scheme have proved controversial, and these parts have been recently re-evaluated in an effort at rationalisation (Gardiner and Horne, 1976).

In regional classification the main problems are constituted by positioning the boundaries between (a) the West Cork Sandstone Formation and the Coomhola Formation, and (b) between the Coomhola Formation and the Kinsale Formation (see also Table IX).

TABLE IX

The lithostratigraphy of the Devonian—Carboniferous strata in southwestern Ireland; comparison of the various schemes and terms applied

Coe and Selwood 1968	Gardiner 1970	Gardiner and Horne 1972	Jones 1974	Gardiner et al. in prep. present paper	Naylor 1975	Graham 1975		
Black Slate Formation		Courtmacsherry Formation	Reenydonagan Formation	Courtmacsherry Formation	Courtmacsherry Formation	Courtmacsherry Formation		
	Ardnamanagh Formation	Kinsale Formation	Ardnamanagh Formation	Ardnamanagh Member	Member 3	Member 3		
	Coomhola Group	Coomhola Formation	Reenagough Formation	Trawnaadriet Member	Kinsale Formation	Kinsale Formation		
				Reenagough Member			Member 2	Member 2
				Ardaturrish Member			Member 1	Member 1
				Claystone Member				
Coomhola Formation				Coomhola Formation	Old Head Sandstone Formation	Old Head Sandstone Formation		
	Yellow Rocks Formation		Glengarriff Formation		Toe Head Formation	Toe Head Formation		
West Cork Sandstone Formation		West Cork Sandstone Formation	Old Red Sandstone	West Cork Sandstone Formation				

The problems with regard to the first boundary (a) are related to the indistinctness in the Bantry Bay area of the "top redbed", which is a well-traceable layer in more easterly sections. Because of this indistinctness Gardiner and Horne (1972) proposed to use the first heterolithic bed as the arbitrary boundary between the West Cork Sandstone Formation and the Coomhola Formation. This boundary has been accepted by Graham (1975) as boundary between his Toe Head Formation and the Old Head Sandstone Formation. Naylor (1975) applied the "first significant" heterolithic intercalation for demarcating the latter boundary.

The problems on the second boundary (b) have resulted from the proposal of Gardiner and Horne (1972), who considered the two formations to be linked by the Garryvoe Conglomerate Formation of MacCarthy et al. (1971), as present in the Cork area. Since the first recognition of this formation, however, it has been demonstrated that the characteristic intercalations of quartz pebbles may occur at different levels. Consequently, the Garryvoe Conglomerate Formation has been discarded. Parts of this unit have been included in the Glanagow Member and in the Cuskinny Member (Table V, VI). It is now considered that the base of the Kinsale Formation should be defined by the first thick mudstone development (Gardiner and Horne, 1976; Naylor et al., 1974). This basal mudstone ("Castle Slate Formation" as defined at Old Head of Kinsale by Naylor, 1966) has been traced all over southern Ireland in coastal sections, and certainly has correlative value, in spite of its diminishing thickness in sections east and west of the Cork Harbour area. It should be realized, however, that in some cases the recognition of a "first thick mudstone development" is highly subjective, because of the gradual appearance of mudstone intercalations. From a practical point of view, it could be argued whether such an important lithostratigraphical boundary should be based on a mudstone unit, which is almost untraceable in inland outcrops.

## TECHNIQUES

The samples studied have been prepared according to the usual procedures, using HCl, HF, ZnCl<sub>2</sub> and a sieve. After this treatment the residue has been oxidized in dry Schulze reagents.

Originally preparations were made in glycerine jelly, this mounting medium, however, proved unsatisfactory, as the mounted palynomorphs could only be examined for a week, before darkening again (compare Marshall, 1980). The heating applied in mounting appeared to be the main agent in this reversal process. At present preparations are made in "Elvacite" cold mounting medium. By using this medium, the observability of the palynomorphs could be extended to several weeks. However, still no permanent slides could be prepared.

## SPORES AND OTHER ACID-RESISTANT MICROFOSSILS

Of the assemblages investigated 109 miospore taxa, 1 acritarch and 1 scolecodont have been included in the species list.

Since many of the taxa recognized are very rare, the possibility of additional taxa of palynomorphs is not completely ruled out.

In the following species list only short remarks, concerning the classification and/or the distribution of stratigraphically important species are given. More extensive remarks with regard to morphologically and/or taxonomically problematic species are included in the section "Selected Systematics" (pp. 212–237).

From a taxonomic point of view not all problems related to the forms listed could be solved satisfactorily. One of the difficulties hampering such a solution was the impossibility of establishing new species, as holotypes could not be kept in a permanently transparent condition. Yet many of the forms studied occur in great numbers and it has been possible to formulate an emended diagnosis for the form genus *Lophozonotriletes* Naumova 1953. In addition the following new combinations are proposed: (1) *Ceratosporites delicatus* (Higgs 1975) nov. comb. Van der Zwan; (2) *Asperispora acuta* (Kedo 1963) nov. comb. Van der Zwan; (3) *Asperispora perlota* (Naumova 1953) nov. comb. Van der Zwan; (4) *Diaphanospora scolecophora* (Neves et Ioannides 1974) nov. comb. Van der Zwan.

Apart from these formal taxonomic decisions, the morphon-concept (Van der Zwan, 1979) has been applied to unite: (1) *Verrucosisorites nitidus* Playford 1964, *V. congestus* Playford 1964, *V. depressus* Winslow 1962 and *Cyclogranisporites* cf. *leopoldii* (Kremp) Potonié et Kremp 1954 into the *Verrucosisorites nitidus* morphon; and (2) *Dictyotriletes submarginatus* Playford 1964, *Dictyotriletes* sp. A (present paper), *Asperispora perlota* (Naumova 1953) nov. comb. Van der Zwan and *Cristatisporites colliculus* Playford 1971 into the *Dictyotriletes submarginatus* morphon.

## Annotated species list

## Laevigati

- Leiotriletes ornatus* Ischenko 1956 (Plate I, 5)  
*Punctatisporites debilis* Hacquebard 1957 (Plate I, 1)  
*Punctatisporites solidus* Hacquebard 1957 (Plate I, 2)  
*Phyllothecotriletes nigratus* (Naumova) De Jersey 1966 (Plate I, 3)  
 Identifying characters: p.212

## Retusotrileti

- Retusotriletes incohatatus* Sullivan 1964 (Plate I, 4)  
*Retusotriletes leptocentrum* Higgs 1975 (Plate I, 6)  
*Retusotriletes planus* Dolby et Neves 1970 (Plate I, 7)  
*Retusotriletes* sp. A of Higgs 1975 (Plate I, 8)  
*Apiculiretuispora fructicosa* Higgs 1975 (Plate I, 9)  
*?Pulvinispora quasilabrata* Higgs 1975 (not figured)

*Aneurospora* cf. *semizonalis* (McGregor) Lele et Strel 1969 (Plate I, 10)

Identifying characters: p.214

*Aneurospora* cf. *greggsii* (McGregor) Strel in Becker et al. 1974 (Plate II, 1, 2)

Identifying characters: p.214

?*Aneurospora* sp. A (present paper) (Plate II, 3, 4)

Identifying characters: p.214

#### Granulati

*Granulatisporites parvus* (Ibrahim) Potonié et Kremp 1954 (Plate II, 8)

*Granulatisporites microgranifer* Ibrahim 1933 (Plate II, 5, 9)

*Remarks:* Spores with concave—subtriangular outline form a conspicuous compositional element of post-Tournaisian, Carboniferous assemblages, therefore the appearance of the present species may constitute a stratigraphical applicable event.

*Cyclogranisporites commodus* Playford 1964 (Plate II, 7)

*Cyclogranisporites* cf. *leopoldii* (Kremp) Potonié et Kremp 1954 (Plate XXIII, 1)

Identifying characters: p.215

#### Verrucati

*Verrucosisporites nitidus* Playford 1964 (Plate XXIV, 1—5)

Identifying characters: p.216

*Verrucosisporites congestus* Playford 1964 (Plate XXV, 1—5)

Identifying characters: p.215

*Verrucosisporites depressus* Winslow 1962 (Plate XXIII, 2—7)

Identifying characters: p.216

*Verrucosisporites tuberculatus* (Kedo) Turnau 1978 (Plate II, 6)

Identifying characters: p.217

*Verrucosisporites* sp. A (present paper) (Plate III, 3)

Identifying characters: p.217

#### Nodati

*Lophotriletes linguaeformis* Bertelsen 1972 (Plate III, 1)

*Planisporites* sp. A (present paper) (Plate III, 4, 5)

Identifying characters: p.218

*Pustulatisporites* sp. A of Higgs 1975 (Plate III, 2)

*Lophozonotriletes* cf. *lebedianensis* Naumova 1953 (Plate IV, 1)

Identifying characters: p.219

*Lophozonotriletes bellus* Kedo 1963 (Plate IV, 2—7; V, 2)

Identifying characters: p.219

*Lophozonotriletes excisus* Naumova 1953 (Plate IV, 8; V, 1)

Identifying characters: p.220

*Lophozonotriletes curvatus* Naumova 1953 (Plate V, 3—6)

*Distribution elsewhere:* The present species has been recorded from the Frasnian up to the Middle Tournaisian of North America (e.g., McGregor and Owens, 1966), perhaps of Belgium (Strel in Becker et al., 1974), of Poland (Turnau, 1975) and of the U.S.S.R. (e.g., Naumova, 1953; Kedo, 1974; Byvsheva, 1976).

*Lophozonotriletes tuberosus* Sullivan 1964 (Plate VI, 1)

#### Baculati

*Baculatisporites fusticulus* Sullivan 1968 (Plate VI, 2, 3)

*Distribution elsewhere:* The present species is a characteristic element of Middle Tournaisian up to Early Viséan assemblages of Western Europe (e.g., Sullivan, 1968; Bertelsen, 1972; Burmann, 1975).

*Dibolisporites distinctus* (Clayton) Playford 1976 (Plate VI, 4, 5)

Distribution elsewhere: The present species is a characteristic element of Middle Tournaisian up to Middle Visean assemblages of Western Europe (e.g., Clayton et al., 1977c), Poland (Turnau, 1978) and it occurs up to the Late Visean of Australia (Playford, 1971, 1976, 1978).

*Dibolisporites abstrusus* (Playford) Playford 1976 (Plate VI, 6)

*Raistrickia variabilis* Dolby et Neves 1970 (Plate VI, 10)

*Raistrickia macrura* (Luber) Dolby et Neves 1970 (Plate VI, 8)

*Raistrickia baculosa* Hacquebard 1957 (Plate VI, 9)

*Raistrickia spathulata* (Winslow) Higgs 1975 (Plate VII, 1)

*Ceratospirites delicatus* (Higgs 1975) nov. comb. Van der Zwan (Plate VI, 7)

Remarks: p.220

*Ceratospirites* sp. A of Van der Zwan 1979 (Plate XXII, 2–5)

### Murornati

*Convolutispora vermiformis* Hughes et Playford 1961 (Plate VII, 2)

*Convolutispora* cf. *usitata* Playford 1962 (Plate VII, 3, 4)

Identifying characters: p.221

*Camptotriletes* sp. A (present paper) (Plate VII, 5, 6; VIII, 1)

Identifying characters: p.221

?*Acinosporites* sp. A (present paper) (Plate VIII, 2)

Identifying characters: p.222

?*Dictyotriletes trivialis* Naumova in Kedo 1963 (Plate VIII, 3)

Remarks: The assignment of the present species to *Dictyotriletes* remains questionable, since this genus lacks proximal ornamentation. Distribution elsewhere: The present species has been recorded from the latest Devonian and Early Carboniferous of Belgium (e.g., Paproth and Streel, 1970), of Poland (Turnau, 1978) and of the U.S.S.R. (e.g., Kedo, 1963; Byvsheva, 1976).

*Dictyotriletes submarginatus* Playford 1964 (Plate XXVII, 2, 3; XXVIII, 1–5; XXIX, 4)

Identifying characters: p.223

*Dictyotriletes* cf. *minor* Naumova 1953 (Plate VIII, 4)

Identifying characters: p.223

*Dictyotriletes* sp. A (present paper) (Plate XXIX, 1–3)

Identifying characters: p.224

?*Reticulatisporites fimbriatus* Winslow 1962 (Plate VIII, 6)

Remarks: Reticulate ornamentation with surmounted apiculate elements is a morphological feature, worth classification on generic level. However, since such a genus is so far not established, the present species has been classified, according to its originally assigned genus. Distribution elsewhere: The present species has been recorded from latest Devonian and Early Carboniferous strata of North America (e.g., Winslow, 1962; McGregor, 1970), of Western Europe (Combaz and Streel, 1970), of Bear Island (Kaiser, 1970), of Iran (Coquel et al., 1977) and perhaps of Algeria (Lanzoni and Magloire, 1969).

*Corbulispora subalveolaris* (Luber) Sullivan 1964 (Plate VIII, 5)

Distribution elsewhere: The present species has been recorded from the latest Devonian and Early Carboniferous of North America (e.g., McGregor, 1970), of Western Europe (e.g., Clayton et al., 1977c) and of Poland (Turnau, 1975).

*Emphanisporites rotatus* McGregor 1961 (Plate VIII, 8)

*Emphanisporites hibernicus* Clayton, Higgs et Keegan 1977 (Plate VIII, 7)

### Auriculati

*Mooreisporites* sp. A of Van der Zwan 1979 (Plate XXII, 1)



## Cingulati

*Stenozonotriletes clarus* Ischenko 1956 (Plate VIII, 9)

*Murospora dubitata* Higgs 1975 (Plate IX, 1)

*Knoxisporites literatus* (Waltz) Playford 1963 (Plate IX, 2, 3)

Distribution elsewhere: The present species has been recorded from the latest Devonian and Early Carboniferous of North America (e.g., Streel and Traverse, 1978), Western Europe (e.g., Clayton et al., 1977c), Poland (Turnau, 1978), Spitsbergen (Playford, 1963), the U.S.S.R. (e.g., Kedo and Golubtsov, 1971), Iran (Coquel et al., 1977) and Australia (Playford, 1976, 1977, 1978).

*Knoxisporites hederatus* (Ischenko) Playford 1963 (Plate IX, 4)

*Knoxisporites ruhlandii* Doubinger et Rauscher 1966 (Plate IX, 5)

Distribution elsewhere: The present species has been recorded from the Viséan of Western Europe (e.g., Doubinger and Rauscher, 1966), of Bear Island (Kaiser, 1970) and of Australia (Playford, 1971, 1978).

## Patinati

*Cyrtospora cristifer* (Luber) Van der Zwan 1979 (Plate XXII, 6–8)

## Tuberculornati

*Hystricosporites* sp. (present paper) (Plate X, 1)

Identifying characters: p.224

*Corystisporites* sp. of Van Veen (in prep.) (Plate X, 2)

## Crassiti

*Crassispora maculosa* (Knox) Sullivan 1964 (Plate IX, 6, 7; X, 3)

Distribution elsewhere: The present species is a characteristic element of Late Viséan assemblages. It has also been recorded from Tournaisian deposits of southeast Ireland (Keegan and Penney, 1978).

*Crassispora trychera* Neves et Ioannides 1974 (Plate XI, 1)

Distribution elsewhere: The species is a characteristic element of Middle Tournaisian up to Middle Viséan assemblages of Western Europe (e.g., Clayton et al., 1977c) and of Poland (Turnau, 1978).

## Cingulicavati

*Densosporites spitsbergensis* Playford 1963 (Plate XI, 2, 3)

*Tumulispora variverrucata* (Playford) Staplin et Jansonius 1964 (Plate XI, 7, 8; XII, 1–3)

Identifying characters: p.224

*Tumulispora rarituberculata* (Luber) Potonié 1966 (Plate XI, 4–6, 9; XII, 4–8)

Identifying characters: p.225

*Asperispora acuta* (Kedo 1963) nov. comb. Van der Zwan (Plate XIII, 1–5)

Identifying characters: p.226

*Asperispora perlota* (Naumova 1953) nov. comb. Van der Zwan (Plate XXVI, 1, 2)

Identifying characters: p.228

?*Cristatisporites colliculus* Playford 1971 (Plate XXX, 1–5)

Identifying characters: p.228

*Vallatisporites vallatus* Hacquebard 1957 (Plate XIV, 1, 2)

*Vallatisporites verrucosus* Hacquebard 1957 (Plate XIV, 3–6)

*Vallatisporites* sp. = *Cirratiradites hystricosus* Winslow 1962 (Plate XIV, 7, 8)

*Hymenozonotriletes explanatus* (Luber) Kedo 1963 (Plate XV, 1, 2)

Distribution elsewhere: The present species is a characteristic element of the Early and

Middle Tournaisian of North America (e.g., McGregor, 1970; Streel and Traverse, 1978), Western Europe (e.g., Clayton et al., 1977c), Bear Island (Kaiser, 1970), Poland (Turnau, 1978), the U.S.S.R. (e.g., Kedo, 1963) and of the Tournaisian and Visean of Australia (Playford, 1976, 1978).

*Kraeuselisporites hibernicus* Higgs 1975 (Plate XV, 4, 5)

Distribution elsewhere: The present species has been recorded from the Middle and Upper Tournaisian of Poland (*Hymenozonotriletes explanatus* type I sensu Turnau, 1978).

#### Pseudosacciti

*Auroraspora macra* Sullivan 1968 (Plate XV, 10)

*Auroraspora hyalina* (Naumova) Streel in Becker et al. 1974 (Plate XVI, 3)

*Auroraspora rectiformis* (Naumova) Van der Zwan 1980b (Plate XV, 6)

*Auroraspora asperella* (Kedo) Van der Zwan 1980b (Plate XV, 3, 9)

*Auroraspora torquata* Higgs 1975 (not figured)

*Colatisporites decorus* (Bharadwaj et Venkatachala) Williams in Neves et al. 1973 (Plate XV, 7)

*Endoculeospora gradzinskii* Turnau 1975 (Plate XV, 8)

*Calyptosporites triangulatus* Higgs 1975 (Plate XVI, 2)

*Grandispora echinata* Hacquebard 1957 (Plate XVI, 1)

Distribution elsewhere: The present species has been recorded from Tournaisian up to Namurian strata of North America (e.g., Playford, 1964; McGregor, 1970), Western Europe (e.g., Clayton et al., 1977c; Bertelsen, 1972) and perhaps of Iran (Coquel et al., 1977).

*Grandispora cornuta* Higgs 1975 (Plate XVI, 5)

?*Grandispora conspicua* (Playford) Playford 1971 (Plate XVI, 6)

Remarks: The assignment to *Grandispora* remains questionable, since the species has not the pseudosaccate habitus of the type species.

*Grandispora* cf. *notensis* Playford 1971 (Plate XVI, 4)

Identifying characters: p.229

*Grandispora* sp. A (present paper) (Plate XVII, 1)

Identifying characters: p.229

*Grandispora* sp. B (present paper) (Plate XVII, 2, 3)

Identifying characters: p.230

Apiculate pseudosaccate spore type A (Plate XVIII, 4)

Identifying characters: p.230

*Retispora lepidophyta* (Kedo) Playford 1976 (Plate XVII, 4–9)

Identifying characters: p.231

*Discernisporites micromanifestus* (Hacquebard) Sabry et Neves 1971 (Plate XVIII, 2)

*Spelaeotriletes pretiosus* (Playford) Neves et Belt 1970 (Plate XVIII, 7)

Distribution elsewhere: The present species has been recorded from the Middle Tournaisian up to the Middle Visean of Canada (Playford, 1964), Western Europe (e.g., Clayton et al., 1977), Poland (Turnau, 1978), Iran (Coquel et al., 1977), and perhaps of Algeria (Lanzoni and Magloire, 1969). A doubtful record is known from the Late Visean of Scotland (Neves et Ioannides, 1974).

*Spelaeotriletes balteatus* (Playford) Higgs 1975 (Plate XVIII, 8)

Distribution elsewhere: The species has been recorded from the Tournaisian and Visean of Great Britain (Sullivan, 1964) and of Spitsbergen (Playford, 1963).

*Spelaeotriletes crustatus* Higgs 1975 (Plate XVIII, 3)

*Spelaeotriletes resolutus* Higgs 1975 (Plate XVIII, 5)

*Spelaeotriletes obtusus* Higgs 1975 (Plate XVIII, 1)

*Spelaeotriletes* sp. (present paper) (Plate XVIII, 6)

Identifying characters: p.233

*Dentatispora* sp. (present paper) (Plate XIX, 1)

Identifying characters: p.233

?*Ancyrospora capillata* Dolby et Neves 1970 (Plate XIX, 7)

*Rugospora flexuosa* (Juschko) Streel in Becker et al. 1974 (Plate XIX, 6; XX, 1)

Distribution elsewhere: The present species is a characteristic element of the latest Devonian of North America (e.g., Streel and Traverse, 1978; identified as *Hymenozonotriletes famenensis* in McGregor, 1970), of Western Europe (e.g., Clayton et al., 1977c), of the U.S.S.R. (identified as *Trachytriletes radiatus* in Kedo, 1974, and in Byvsheva, 1976) and of Iran (identified as *T. radiatus* in Coquel et al., 1977).

*Rugospora polyptycha* Neves et Ioannides 1974 (not figured)

*Rugospora* cf. *minuta* Neves et Ioannides 1974 (Plate XIX, 2, 3)

Identifying characters: p.234

*Rugospora* sp. A (present paper) (Plate XIX, 4, 5)

Identifying characters: p.234

#### Perinotrilites

*Peroitrilites caperatus* Higgs 1975 (Plate XX, 4, 5)

*Diaphanospora scoleophora* (Neves et Ioannides 1974) nov. comb. Van der Zwan, (Plate XX, 2)

Remarks: p.235

*Diaphanospora* cf. *depressa* (Balme et Hassel) Evans 1970 (Plate XX, 3)

Identifying characters: p.235

*Diducites mucronatus* (Kedo) Van Veen (in press) (Plate XX, 6; XXI, 1)

*Diducites versabilis* (Kedo) Van Veen (in press) (Plate XXI, 3)

*Diducites poljessicus* (Kedo) Van Veen (in press) (Plate XXI, 2)

*Diducites plicabilis* Van Veen (in press) (Plate XXI, 5)

#### Laevigatomonoletes

*Latosporites* sp. A (present paper) (Plate XXI, 6, 7)

Identifying characters: p.236

*Latosporites* sp. B (present paper) (Plate XXI, 8)

Identifying characters: p.236

#### Acritarcha

*Micrhystridium* sp. (present paper) (Plate XXI, 4)

Identifying characters: p.236

#### Scolecodonts

cf. *Staurocephalites* sp. (present paper) (Plate XXI, 9)

Characteristic features: p.236

It should be noted that the above species list shows some differences with the provisional list previously published by the present author (in Van der Zwan and Van Veen, 1978): (1) *Verrucosisorites* cf. *variotuberculatus* is now identified as *V. tuberculatus*; (2) *Pustulatisporites* sp. B is now identified as *Verrucosisorites* sp. A; (3) *Pustulatisporites* sp. E together with *Dibolisporites* sp. A are now included in *Lophozonotriletes curvatus*; (4) *Convolutispora* sp. G is now identified as *C. cf. usitata*; (5) *Biornatisporites* sp. A is now identified as ?*Acinosporites* sp. A; (6) *Auroraspora granulati-punctata* is now subdivided into *A. asperella* variant A, B and C, and *Colatisporites decorus* variant A; and (7) *Vallatisporites pusillites* is now identified as *Vallatisporites* sp. =*C. hystricosus*.

## DIFFERENTIAL ANALYSIS OF THE PALYNOLOGICAL ASSEMBLAGES: PHASES

The distribution and relative frequencies of the palynomorphs found in the sections studied are given in Tables I—VIII.

Comparison of the composition of the successive assemblages shows that: (1) all assemblages have a number of species in common, e.g., *Auroraspora macra*, *A. asperella*, *A. hyalina*, *Endoculeospora gradzinskii* variant B, *Retusotriletes incohatus*, *Corbulispora subalveolaris* and *Rugospora* cf. *minuta*, (2) long-ranging species may be quantitatively important in a short part of their range; and (3) the compositional development of the palynological assemblages is gradual.

In order to facilitate regional correlation, we may recognise a series of arbitrarily chosen steps in the gradually developing composition of the palynological assemblages. Following Schuurman's (1977, 1979) principle of classifying the development of palynological assemblages in the Late Triassic, such steps may be termed "phases". Schuurman did not provide an explicit definition of his phases. It is here considered, however, that a phase could well be defined as "any recognizable step in the (local, regional or interregional) gradual compositional development of successive (palynological) assemblages". Phases may be named after characteristic species. Similarly to the procedure in Devonian and Carboniferous zonation, these species names may be abbreviated.

*Regional phases*

Evaluation of the assemblages studied has led to the recognition of the following regional phases (see also Van der Zwan and Van Veen, 1978): LM (*Retispora lepidophyta*—*Diducites mucronatus*) phase, LE (*Retispora lepidophyta*—*Hymenozonotriletes explanatus*) phase, LN (*Retispora lepidophyta*—*Verrucosisporites nitidus*) phase, LCr (*Retispora lepidophyta*—*Cyrtoispora cristifer*) phase, NR (*Verrucosisporites nitidus*—*Spelaeotriletes resolutus*) phase, NDi (*Verrucosisporites nitidus*—*Dibolisporites distinctus*) phase, NH (*Verrucosisporites nitidus*—*Kraeuselisporites hibernicus*) phase, PV (*Spelaeotriletes pretiosus*—*Vallatisporites vallatus*) phase.

In the following paragraphs the characteristics of these phases are briefly discussed.

**LM phase.** This phase is reflected by the composition of sample BAN 15 of Bantry Bay and samples G 45 and G 50 of Hook Head.

The following species may be considered characteristic: *Retispora lepidophyta*, *Diducites mucronatus*, *Rugospora flexuosa*, *Perotriletes caperatus*, *Vallatisporites* sp. = *C. hystricosus*, *Endoculeospora gradzinskii* variant B, *Auroraspora macra* and additionally the presence of *Diducites poljessicus*, *D. versabilis*, *Knoxisporites literatus*, *Grandispora echinata* and the presence of large reticulate spores such as *Corbulispora subalveolaris*.

**LE phase.** This phase is reflected by the composition of sample CZ 7 of Bantry Bay and samples G 55 and H 3 of Hook Head.

Apart from the characteristic appearance of *Hymenozonotriletes explanatus*, and, at a higher level, of *Vallatisporites verrucosus*, the characteristic species of this phase are generally the same as those of the preceding LM phase. Of additional significance, at a higher level, is the presence of *Denso-sporites spitsbergensis* and *Asperispora perlota*.

**LN phase.** This phase is reflected by the composition of samples CZ 13—BAN 2 of Bantry Bay, of samples BOLT 2, 1, REL 2, 4 of Bolteen—Relane and of samples TOE 11-4 of Toe Head.

Apart from the characteristic appearance of *Verrucosisporites nitidus* and *V. congestus*, the characteristic species are generally the same as those of the preceding LE phase. Additionally significant is the presence of *Asperispora acuta*, *A. perlota*, *Vallatisporites verrucosus*, *Planisporites* sp. A and ?*Aneurospora* sp. A.

**LCr phase.** This phase is reflected by the composition of samples CZ 22—BAN 21 of Bantry Bay and sample GAR 18 of Garryvoe.

The phase is characterized by the last occurrence of *Retispora lepidophyta* and the first appearance of *Cyrtospora cristifer* variant A. The composition of this phase is distinctly transitional between that of the preceding LN phase and the succeeding NR phase.

**NR phase.** This phase is reflected by the composition of samples BAN 20—BAN 7 of Bantry Bay, sample H 7 and G 63 of Hook Head, samples GAR 8—GAR 16 of Garryvoe, sample ARDM 12 of the Ardmore and sample POW 11 of White Bay.

Apart from the characteristic absence of *Retispora lepidophyta*, *Vallatisporites* sp. = *C. hystricosus* and *Diducites mucronatus*, the phase is characterized by the presence of *Verrucosisporites nitidus*, *V. congestus*, *V. depressus*, *Spelaotriletes resolutus*, *Rugospora* cf. *minuta* and *Auroraspora asperella* variant A. Additionally significant is the presence of *Tumulispora rarituberculata*, *T. variverrucata*, *Lophozonotriletes bellus*, *Hymenozonotriletes explanatus* and *Convolutispora* spp.

**NDi phase.** This phase is reflected by the composition of samples BAN 8, 9 of Bantry Bay and sample HELV 7 of Helvick Head.

The following species may be regarded as characteristic for this phase: *Verrucosisporites nitidus*, *Aneurospora* cf. *greggsii*, *Baculatisporites fusticulus*, *Endoculeospora gradzinskii* and, additionally, the appearance of *Dibolisporites distinctus* and ?*Cristatisporites colliculus*.

The nature and relevance of this phase and its relationship to the preceding NR phase and the succeeding NH phase will be clarified by Van Veen (in prep.).

**NH phase.** This phase is reflected by the composition of samples CZ 35—BAN 10 of Bantry Bay, sample G 66 of Hook Head, sample GAR 14 of Garryvoe and samples COO 9A—D, COO 11A—D of Coomhola River.

The following species are regarded as characteristic: *Verrucosporites nitidus*, *Kraeuselisporites hibernicus*, *Auroraspora asperella*, *Aneurospora* cf. *greggsii*, *?Cristatisporites colliculus* and *Densosporites spitsbergensis*. Additionally significant is the presence of *Dibolisporites distinctus*, *Cyrtospora cristifer* variant B and *Ceratosporites* sp. A.

**PV phase.** This phase is reflected by the composition of samples CZ 39 and BAN 11 of Bantry Bay and sample BAN 26 of East Bantry Bay.

The following species are considered characteristic: *Spelaeotriletes pretiosus*, *Vallatisporites vallatus*, *V. verrucosus*, *Granulatisporites microgranifer*, *Crassispora trychera*, *Kraeuselisporites hibernicus* and additionally most of the species of the preceding NH phase.

#### *Lateral variation*

Inherent in any scheme of arbitrarily chosen phases within a gradually changing composition of successive palynological assemblages is the occurrence of transitional assemblages. In the Bantry Bay section, for example, sample BAN 7 is clearly transitional in composition between assemblages characteristic for the NR and NDi phases: presence of *?Cristatisporites colliculus* and *Cyrtospora cristifer* variant B; absence of *Baculatisporites fusticulus*. A comparable situation may be found in the Hook Head section (samples H 7 and G 63).

On a regional scale the transition between successive phases is not necessarily a uniform process. When comparing different sections, individual compositional elements may show mutual differences in first and/or last occurrences. Especially when the principal characterizing elements are involved, the regional recognition of phases may become somewhat obscured.

This is particularly true with regard to the first occurrence of *Verrucosporites nitidus*. This species, which is regarded as the principally characterizing element of the LN phase, can be readily applied for the recognition of this phase at Bantry Bay (CZ 13), Bolteen—Relane (BOLT 1) and Toe Head (TOE 11?, 7). At Garryvoe, however, the first occurrence of *V. nitidus* takes place in an assemblage (GAR 8), which, according to the absence of *R. lepidophyta* and the presence of *Tumulispora variverrucata* ought to be regarded as representing the NR phase.

Consequently, at Garryvoe, the appearance of *V. nitidus* cannot be applied for recognizing the transition between the LE and LN phases. Since other characterizing criteria are also lacking, the LE and LN phases can not yet be adequately distinguished from each other (Table VI).

A similar situation occurs at White Bay (see Table V).

### Local phases

Apart from the lateral variation resulting from differences in first appearance of individual compositional elements, a more conspicuous type of variation between assemblages from Bantry Bay and Hook Head has already been described earlier (Van der Zwan and Van Veen, 1978). For the present considerations it is sufficient to briefly summarize the main observations within the regional LM—LE phases and NR—NH phases, respectively:

(1) **LM—LE phases.** Characteristic species for Bantry Bay are (for quantitative data see Table I): ?*Acinosporites* sp. A, *Verrucosisporites* sp. A and *Lophozonotriletes curvatus*, together with the relative abundance of *Lophozonotriletes* spp. and *Raistrickia* spp. Characteristic species for Hook Head are (for quantitative data see Table VII): *Calyptosporites triangulatus*, *Auroraspora torquata* and *Lophozonotriletes tuberosus*, together with the relative abundance of *Auroraspora asperella* and *Rugospora* cf. *minuta*.

The qualitative data from Garryvoe (Table VI) seem most comparable with those from Bantry Bay (occurrence of ?*Acinosporites* sp. A, *Lophozonotriletes curvatus*, *Raistrickia variabilis* and *R. macrura*).

(2) **NR—NH phases.** Characteristic species for Bantry Bay are (Table I): *Verrucosisporites tuberculatus*, *Convolutispora* cf. *usitata*, *Camptotriletes* sp. A and the relative abundance of *Cyrtoispora cristifer*, *Tumulispora rari-tuberculata*, *T. variverrucata*, *Lophozonotriletes bellus*, *Asperispora acuta* and *Crassispora maculosa*. Characteristic for Hook Head are (Table VII): *Spelaeotriletes obtusus* and the relative abundance of *S. resolutus* and *Dibolisporites abstrusus*.

The assemblages from Coomhola River, White Bay, Garryvoe and Ardmore may be compared with those of Bantry Bay, on the basis of the frequent occurrence of *Tumulispora* spp. and *Cyrtoispora cristifer*. (see Tables II, V, VI and VIII).

The assemblage from Helvick Head is intermediate in composition between those of Bantry Bay and Hook Head and shows the greatest resemblance with the assemblage from Kerry Head (compare Van der Zwan and Van Veen, 1978) (as both are characterized by the abundance of *Verrucosisporites* spp. and the absence of *Cyrtoispora cristifer* and *Tumulispora* spp., Table VIII).

From the above given information it follows that, mainly on the basis of comparable frequency of groups of species, we may correlate assemblages from various other localities, either with Bantry Bay, with Hook Head or with Kerry Head. Therefore, the frequent occurrence of such a group of species may well be considered to represent a local compositional characteristic within a regional phase. These local compositional characteristics may be taken as the basis for the recognition of local phases.

In this way, supplementary to the scheme of regional phases, we may recognize in the lower part of the sequence the RaLo (*Raistrickia*—*Lophozonotriletes*) local phase, and in the upper part of the sequence the TCr (*Tumulispora*—*Cyrtoispora cristifer*) local phase:

**RaLo phase.** This phase is reflected by the composition of samples BAN 15, CZ 7 from Bantry Bay and of samples GAR 2—GAR 6 from Garryvoe.

The frequent occurrence of *Raistrickia* spp. and *Lophozonotriletes* spp. is considered to be characteristic for this phase. Additionally significant is the presence of ?*Acinosporites* sp. A.

**TCr phase.** This phase is reflected by the composition of samples CZ 22—BAN 11 from Bantry Bay, of samples COO 9A—D, COO 11A—D from Coomhola River, of sample BAN 26 from East Bantry Bay, of sample POW 11 from White Bay, of samples GAR 18—GAR 14 from Garryvoe and of sample ARDM 12 from Ardmore.

The frequent occurrence of *Tumulispora* spp., *Cyrtospora cristifer* and *Lophozonotriletes bellus* is considered to be characteristic for this phase.

As no compositional distinction in LN phase assemblages has so far been made, no attribution to either local phase has been attempted.

Because of the rareness of elements that could be interpreted in terms of local compositional characterization, the assemblages from Hook Head have not been attributed to one or another local phase.

#### REGIONAL AND INTERREGIONAL COMPARISON

In order to assess the geographical extend of the present phases in compositional development of palynological assemblages, an attempt is made in the following paragraphs, after a general comparison with existing schemes of concurrent range zones in Ireland, to trace the characteristics of the phases in assemblages from Devonian—Carboniferous transition sequences of Canada, U.S.A., Bear Island, Ardenno-Rhine Basin, Poland, U.S.S.R., Iran and Australia (Table X).

##### *Ireland*

In the last decade a wealth of palynological data has been published from the Devonian and Lower Carboniferous sequences of Ireland (Dolby, 1970; Doran, 1970; Clayton et al., 1974, 1977b, 1978; Higgs, 1975; Naylor, 1975; Naylor et al., 1977; Keegan, 1977; Keegan and Penney, 1978, and Sleeman et al., 1978). A summary of these data has been published by Clayton et al. (1978). Comparison of the present scheme of phases with these data is hampered by the fundamentally different approach to stratigraphy of Clayton and collaborators, who use the concurrent range zone as basis for their zonation scheme. Generally speaking, however, the following comparisons may be readily made: (1) LM phase correlates with the LL subzone of the PL zone, (2) LE phase correlates with the LE subzone of the PL zone, (3) LN+LCr phases correlate with the LN subzone of the NV zone, (4) NR—NH phases correlate with the VI subzone of the NV zone, and (5) PV phase correlates with the PC zone.



Correlation problems may notably arise when a characterizing species has its first local appearance before it becomes characteristic: e.g., *Spelaeotriletes pretiosus* has its first appearance in the Bantry Bay section in sample CZ 35 (NH phase), but it becomes characteristic in sample CZ 39 (PV phase). According to the principles of the concurrent range zone, sample CZ 35 should form the first sample of the PC zone, while in the phase concept, sample CZ 39 would be the first sample of the PV phase.

### Canada

A survey of the Upper Devonian miospore assemblages from Yukon, Ontario and Nova Scotia has been given by McGregor (1970).

*Yukon.* From the Imperial Formation an assemblage is recorded characterized by the presence of *Retispora lepidophyta* and *Grandispora echinata*, justifying an assignment to the LM phase. Noteworthy is the presence of *Tumulispora rarituberculata* and *Cyrtospora cristifer*, indicating a relatively early appearance of these species in Canada.

*Ontario.* From the Bedford Formation, Berea Formation and Sunbury Formation assemblages have been described, characterized by e.g., *Retispora lepidophyta*, *Hymenozonotriletes explanatus* and ?*Corbulispora subalveolaris*. These elements indicate an assignment to the LE phase. Again *Cyrtospora cristifer* is already present. In an assemblage from the underlying Kettle Point Formation *Hymenozonotriletes explanatus* is lacking, therefore this assemblage may be attributed to the LM phase.

*Nova Scotia.* From the Horton Group an assemblage was described, characterized by the presence of *Retispora lepidophyta*, but lacking characteristic species of the LM and succeeding phases. Therefore, this assemblage is here considered to represent a preceding phase. Noticeable in this assemblage is the presence of *Verrucosisporites congestus*.

Playford (1964) described from Nova Scotia, from the upper part of the Horton Group, an assemblage characterized by the presence of *Vallatisporites vallatus* and *V. verrucosus*, which could be attributed to the late NH or early PV phase. From the succeeding Cheverie Formation an assemblage was recorded characterized by the presence of *Spelaeotriletes pretiosus*, which indicates an assignment to the PV phase.

### U.S.A.

In spite of the many areas of the U.S.A. where Devonian—Carboniferous transition sequences occur, detailed palynological information is still rare.

*Pennsylvania.* Recently, miospore assemblages have been described by Streehl and Traverse (1978) from the Pocono Formation. They recorded assem-

blages lacking *Retispora lepidophyta* (samples 1, 2), which are succeeded by an assemblage (sample 3) characterized by the presence of *R. lepidophyta*, *Knoxisporites literatus*, *Vallatisporites* sp. = *C. hystricosus* and *Vallatisporites vallatus*. The latter assemblage clearly represents the LM phase. The following assemblage (sample 4) is characterized by the same species together with *Hymenozonotriletes explanatus* and *Vallatisporites verrucosus*. This assemblage is assignable to the LE or LN phase. Finally, they recorded an assemblage (sample 5) characterized by the presence of *Hymenozonotriletes explanatus*, *Vallatisporites vallatus* and *V. verrucosus*; these elements may justify an assignment to the NH phase.

*Ohio.* Winslow (1962) published data on the Devonian—Carboniferous transition sequence of Ohio. One may recognize a lower assemblage, characterized by the presence of *Retispora lepidophyta*, *Vallatisporites* sp. = *C. hystricosus*, *Diducites mucronatus*, *Cyrtospora cristifer* and numerous large reticulate spores, making an assignment to the LM phase plausible. The upper part of the sequence yielded an assemblage containing such species as *?Reticulatisporites fimbriatus*, *Verrucosisporites depressus*, *Cyrtospora cristifer* and occasionally *Vallatisporites vallatus*; this assemblage is likely to represent the NH phase.

#### *Bear Island*

Within the assemblages recorded by Kaiser (1970) from the Skredneset section of Bear Island, one may recognize two types of assemblages: (1) a lower assemblage, characterized by the presence of *Retispora lepidophyta* var. *minor* and *Tumulispora rarituberculata*, but lacking *Hymenozonotriletes explanatus*, thus indicating a correlation with the LM phase, or perhaps with a preceding phase; and (2) an upper assemblage, characterized by the presence of *R. lepidophyta* and *H. explanatus*, which may be correlated with the LE phase.

From the Kapp Harry section Kaiser (1970) recorded an assemblage characterized by the presence of *Apiculiretusispora multiseta* (Luber) Butterworth et Spinner 1967 and forms identified as *Hymenozonotriletes explanatus*. If the latter identification is correct, an assignment to the NR—NDi phases should be made. However, it is here considered that the forms could also include the species *Kraeuselisporites hibernicus*, implying the possibility of an assignment to the NH or following phases. Such an assignment would be in agreement with the occurrence of *A. multiseta* (=synonym of *Colatisporites denticulatus* Neville 1973) in the assemblage.

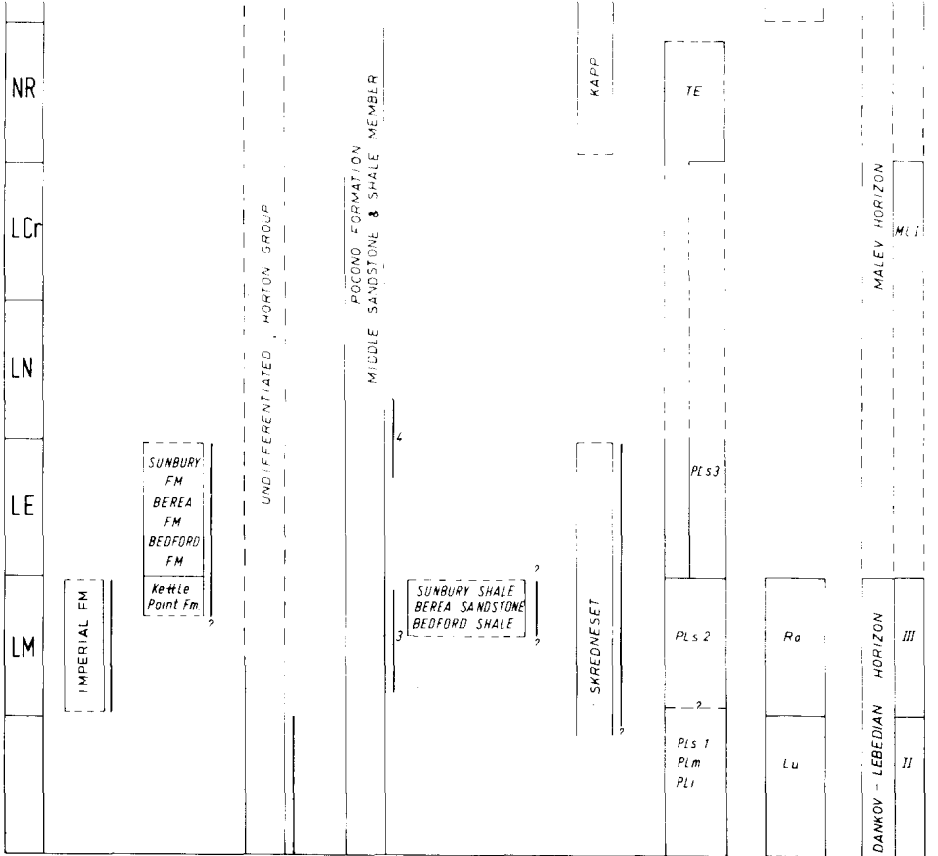
#### *Ardenno—Rhine Basin*

Devonian—Carboniferous transition assemblages from the Ardenno-Rhine Basin have been described by Paproth and Streel (1970), Combaz and Streel (1970) and Streel in Becker et al. (1974). In their zonation schemes

TABLE X

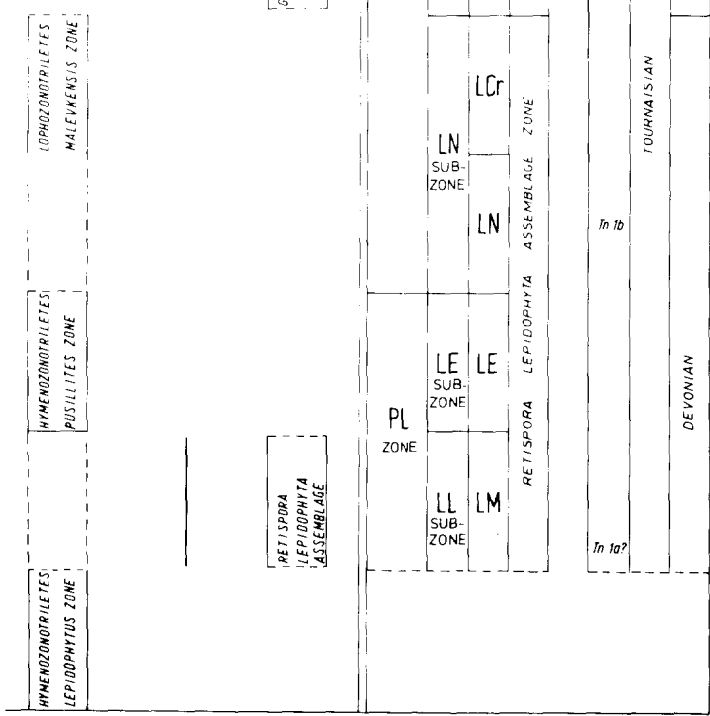
Regional and interregional palynostratigraphical correlation of Late Devonian—Early Carboniferous assemblages and their chronostratigraphical interpretation

PHASES	CANADA			USA			BELGIUM GERMANY	POLAND	US	
	Yukon MCGREGOR 1970	Ontario MCGREGOR 1970	NOVA-SCOTIA MCGREGOR 1970 PLAYFORD 1964	PENN- SYL- VANIA 1978 STREEL & TRAVERSE	OHIO	WINSLOW 1962	BEAR ISLAND KAISER 1970	ARDENNO- RHINE BASIN PAPROTH & STREEL 1970	WESTERN POMERANIA TURNAU 1978	PRIPYAT DEPRESSION KEDO 1963 KEDO & GOUBTSOV 1971
PV			CHERIEVE FM							
NH					BLACKHAND & CUYAHOGA FM				Ma	CHERIEVE HORIZON Kis 1 ?
ND <sub>1</sub>										CHERIEVE HORIZON Ch 1-3 ?
NR				EMBLER						MUB
						KAPP HARRY				
							TE			



SR.	IRAN	AUSTRALIA	IRELAND		CHRONO-STRATIGRAPHY
EAST RUSSIAN PLATFORM BYVSHEVA 1976	GHOSNOVI-TILABAD COQUEL et al 1977	CANNING BASIN PLAYFORD 1976	CLAYTON et al 1978	Present paper PHASES ZONATION	
		GRAND-SPORA SPICULIFERA ASSEMBLAGE LOWER UPPER	PC ZONE	PV SPELAOTRIETES PRETIOSUS ASSEMBLAGE ZONE	
			VI SUB-ZONE	NH VERRICOS (SPORITES) MITIOSUS ASSEMBLAGE ZONE	Tn2
			NV ZONE	NR VERRICOS (SPORITES) MITIOSUS ASSEMBLAGE ZONE	CARBONIFEROUS

□ □ □



these authors established the PL zone (*Retispora lepidophyta*—*Vallatisporites* sp. = *C. hystricosus*), which was subdivided into (1) the PLi zone, (2) the PLm zone (first occurrence of e.g., *Knoxisporites hederatus*) and (3) the PLs zone, subdivided into the PLs1 subzone (first occurrence of e.g., *Tumulispora rarituberculata*, *Grandispora echinata* and *Verrucosisporites nitidus*), the PLs2 subzone (first occurrence of *Verrucosisporites congestus*, *Knoxisporites literatus* and *Corbulispora subalveolaris*) and the PLs3 subzone (first occurrence of *Hymenozonotriletes explanatus* and ?*Dictyotriletes trivialis*). The base of the succeeding TE zone was originally defined by the last occurrence of *Retispora lepidophyta* and *Vallatisporites* sp. = *C. hystricosus*. Subsequently, however, this base was redefined in terms of the first occurrence of *H. explanatus*.

As most of the species, apart from *V. nitidus*, *V. congestus* and *T. rarituberculata* first appearing in the PLs1 and PLs2 subzones are recorded in the LM phase, the assemblages of the PLs2 subzone can be correlated with the LM phase. The first appearance of *H. explanatus* in the PLs3 subzone indicates a correlation with the LE phase.

It should be noted that if the above correlations are correct, the presence of *V. nitidus* and *T. rarituberculata* in the PLs1 subzone and of *V. congestus* in the PLs2 subzone is considerably different from the situation in Ireland.

### Poland

Turnau (1975, 1978) established a zonation scheme for the Upper Devonian and Lower Carboniferous of western Pomerania. In this scheme she recognized two zones with *Retispora lepidophyta*. In the upper zone (Ra zone), *R. lepidophyta* occurs together with e.g., *Tumulispora rarituberculata* and *Knoxisporites literatus*, higher in this zone also *Verrucosisporites nitidus* has its first appearance. Since *Hymenozonotriletes explanatus* is lacking, this zone may be attributed to the LM phase. In the lower zone (Lu zone) *R. lepidophyta* occurs without the above mentioned species, consequently this zone should be attributed to a preceding phase.

After a hiatus the following Ma zone is characterized by *H. explanatus*, *Kraeuselisporites hibernicus* (*H. explanatus* type I of Turnau), *Dibolisporites distinctus* and *Cyrtospora cristifer*. Halfway in this zone *Crassispora trychera* appears, while near the top *Spelaeotriletes pretiosus* and *Schopfites claviger* Sullivan 1968 are present. The lower part of the zone may be compared with the NH phase (possibly NDi-NH), the upper part with the PV or following phases.

It should be noted that, similarly to the situation in the Ardenno-Rhine Basin, *T. rarituberculata* and *V. nitidus* have their first appearance on a level preceding their entrance in the sections from Ireland.

According to Turnau (1978) the zonation for western Pomerania can be well compared with the zonation for the Isle of Rügen, proposed by Burmann (1975).

## U.S.S.R.

*Pripyat Depression.* The spore assemblages derived from the Devonian—Carboniferous transition sequence have been described by Kedo (1963) and by Kedo and Golubtsov (1971). Spore Complex II of the Dankov—Lebedian Horizon lacks, apart from *Retispora lepidophyta*, species characteristic for the LM phase and is therefore attributed to a preceding phase. Since in Spore Complex III of the Dankov—Lebedian Horizon *R. lepidophyta* occurs together with *Knoxisporites literatus*, *Corbulispora subalveolaris* (= ?*Dictyotriletes trivialis* of Kedo and Golubtsov), *Diducites* spp., *Tumulispora rarituberculata* and *Cyrtospora cristifer*, its correlation with the LM phase seems to be justified.

Since the M11 Complex of the Malev Horizon contains *R. lepidophyta* together with *Hymenozonotriletes explanatus*, *Vallatisporites* sp. = *C. hystricosus*, *V. vallatus* and *Archaeozonotriletes malevkensis* Naumova 1963 (forms highly comparable with *Tumulispora variverrucata*), this complex might well be compared with the LCr phase, though an assignment to the LN phase or even to the LE phase could not be excluded.

The following M12, 3; Ch1—3 and Kis 1 Spore Complexes are more or less comparable with the NR—PV phases, though exact correlations are as yet impossible.

*Eastern part of the Russian Platform.* The spore assemblages obtained have been described in detail by Byvsheva (1976). The *Hymenozonotriletes lepidophytus* zone is characterized by, apart from *Retispora lepidophyta*, *Reticulatisporites* aff. *mediareticulatus* (forms resembling *Corbulispora subalveolaris*), which might indicate a position close to the LM phase.

The following *Hymenozonotriletes pusillites* zone is characterized by *R. lepidophyta*, *Vallatisporites* sp. = *C. hystricosus*, *Hymenozonotriletes explanatus*, *Rugospora flexuosa*, *Cyrtospora cristifer*, *Tumulispora rarituberculata* and *Archaeozonotriletes mischkinensis* (? = *Dictyotriletes submarginatus*). Such a composition can be well matched with the LE phase.

This zone is succeeded by the *Lophozonotriletes malevkensis* zone, characterized by *R. lepidophyta*, *Vallatisporites* sp. = *C. hystricosus*, together with *Tumulispora variverrucata*, *T. rarituberculata* and *Asperispora acuta*, and might well be correlated with the LCr phase.

## Iran

The record from the Ghosnavi—Tilabad section given by Coquel et al. (1977) is very scanty, but, nevertheless, provides a possibility for correlation. The authors recognized a lower assemblage characterized by, e.g., *Retispora lepidophyta* together with *Knoxisporites literatus*, *Cyrtospora cristifer* and *Tumulispora rarituberculata*, thus indicating an assignment to the LM phase.

Furthermore they recognized an upper assemblage, characterized by e.g., *Spelaeotriletes pretiosus* and *Vallatisporites vallatus*, which may be assigned to the PV phase.



## Australia

Playford (1976) described miospores from the Devonian–Carboniferous transition sequence of the Canning Basin (Western Australia). He recognized a *Retispora lepidophyta* Assemblage, characterized by the presence of *R. lepidophyta* and *Knoxisporites literatus*, together with *Verrucosisporites nitidus* and *Tumulispora* spp.. From this composition an assignment to the LM phase seems plausible.

The succeeding *Grandispora spiculifera* Assemblage might be subdivided into (1) a lower part, characterized by the presence of *Hymenozonotriletes explanatus*, perhaps assignable to the NR phase, and (2) an upper part characterized by the presence of *Dibolisporites distinctus*, *Grandispora spiculifera* (=synonym of *Colatisporites denticulatus* Neville 1973), *?Cristatisporites colliculus*, *Verrucosisporites nitidus* and *Tumulispora* spp., attributable to the NDi and/or following phases.

## Discussion

The above comparisons strongly suggest that in many areas outside Ireland a more or less parallel floral development took place. Many of the individual phases recognized in Ireland may have an interregional extent, since they can be traced both to the west and to the east (Table X). This is particularly true for the LM and NR phases, which can be found back, as far as in Australia, and the PV phase which can be recognized in Iran. On the other hand an interregional nature of the LN and NDi phases can not yet be inferred.

As the characteristic species for the LN phase, *Verrucosisporites nitidus*, has been recorded from strata assigned to the LM phase (Ra zone, Poland) and from an interval preceding this phase (Horton Group, Nova Scotia), the first appearance of this species has to be regarded as strongly diachronous. Consequently, the recognition of the LN phase outside Ireland has to be based on the presence of combinations of other characteristic species. However, the published information on such species is so far insufficient.

The characterization of the NDi phase is, even within Ireland, still somewhat difficult (p.193) and any recognition outside Ireland should therefore remain tentative.

## BIOSTRATIGRAPHICAL INTERPRETATION

It should be realized that the successive phases do not represent a zonation scheme. The phases are recognized to indicate palynological reflections of floral development, rather than serving as units of biostratigraphical classification and correlation of rock units. In principle it would be possible to propose a set of palynological assemblage zones, differentially diagnosed on the basis of the characteristics of the individual phases. However, it is here considered that from a practical point of view only interregionally recognizable zones should be established. It is believed that the following set of paly-

nological assemblage zones, based on the Bantry Bay sequence, may have potential in realistic interregional correlation (Table X).

(1) The *Retispora lepidophyta* Assemblage Zone. This zone is so far diagnosed by the combined characteristics of the LM, LE, LN and LCr phases, and is named after its most conspicuous element, *Retispora lepidophyta*.

The base of this zone is not represented in Ireland, but may be defined in the Ardenno-Rhine Basin, at the appearance of *R. lepidophyta*.

(2) The *Verrucosisporites nitidus* Assemblage Zone. This zone is diagnosed by the combined characteristics of the NR, NDi and NH phases and is named after its most conspicuous element *Verrucosisporites nitidus*.

The character of the diagnostic assemblages of this zone is completely transitional between the preceding *Retispora lepidophyta* and the succeeding *Spelaeotriletes pretiosus* Assemblage Zones.

(3) The *Spelaeotriletes pretiosus* Assemblage Zone. This zone is diagnosed by the characteristics of the PV phase, exclusively, and is named after its most characteristic element, *Spelaeotriletes pretiosus*. The definition of the upper boundary has to await the recognition of phases following the PV phase.

It is considered that in stratigraphical palynology the recognition of assemblage zones should have advantage over the application of concurrent range zones. Assemblage zones reflect the continuity of the floral record rather than the discontinuity. On an interregional scale appearances and disappearances of characteristic elements do not necessarily occur everywhere in the same order. Consequently, boundaries of concurrent range zones suggest an accuracy which does not always exist. Yet, within differential diagnosis of palynological assemblage zones the appearance and especially disappearance, may, of course, play a prominent role. A good example is the relatively rapid disappearance of *Retispora lepidophyta*, together with *Vallatisporites* sp. = *C. hystricosus* and *Rugospora flexuosa* over a wide area.

This example also illustrates another disadvantage of the practice of recognizing concurrent range zones. The easily recognizable boundary, characterized by the disappearance of *R. lepidophyta*, has been obscured both in Ireland and the Ardenno-Rhine Basin, by the commonly applied procedure of giving emphasis to the entrance of new elements, rather than to disappearances.

In Ireland, the base of the NV zone of Clayton and collaborators is defined on the appearance of *Verrucosisporites nitidus*. On an interregional scale, however, the arrival of this species has given rise to problems (see p.203). A much better base for a zone, instead of a subzone (LN), would therefore be the last occurrence of *R. lepidophyta*.

A comparable situation is found, with regard to the boundary between the PL and the TE zone in the Ardenno-Rhine Basin. The PL zone was originally based on the whole range of *R. lepidophyta* (Paproth and Streel, 1970); its top was defined on the last occurrence of this species. In order to comply with generally accepted stratigraphical procedures, however, the top of this

zone was redefined by Alberti et al. (1974) in terms of the first occurrence of *Hymenozonotriletes explanatus* (the characterizing element of the TE zone); thus including the PLs3 subzone in the TE zone.

#### CHRONOSTRATIGRAPHICAL INTERPRETATION

The Bantry Bay section and the other sections studied in the present paper have so far yielded little faunal evidence useful for biostratigraphical zonation and subsequent chronostratigraphical interpretation. The palynological information, however, can be readily applied for chronostratigraphical purposes.

Because of the interregional nature of at least part of the phases recognized in southern Ireland, one may assume a time-proportionate nature of the development of palynological assemblages. Thus, by comparison with the type area in the Ardenno-Rhine Basin one may directly obtain the ages of these phases. In this way one may recognize the Devonian—Carboniferous boundary, as well as subdivisions of the Tournaisian Stage in southern Ireland.

In the following paragraphs the significance of the scarce faunal evidence is briefly discussed, followed by an age-interpretation of the successive phases.

#### *Integration with faunal biostratigraphical evidence from the sections studied*

At Bantry Bay, the only faunal biostratigraphical contribution made has been based on conodonts. Matthews and Naylor (1973) described two poor assemblages from the Courtmacsherry Formation. The lower sample (B8) yielded *Polygnathodus symmetricus*, *Spathognathodus aculeatus*/*Clydagnathus* and *Spathognathodus stabilis*. Because of the common occurrence of two species, this assemblage was tentatively correlated with the *Spathognathodus* fauna derived from the Castle Slate Member (sample OH1) at Old Head of Kinsale. Using indirect arguments, Matthews and Naylor (1973) correlated this fauna with basal Carboniferous (Tn1b) conodont faunas from the Ardenno-Rhine Basin. A conodont fauna, comparable to that of Old Head of Kinsale has also been obtained from the Castle Slate Member of Ardmore.

The upper sample (B2), readily correlated with the *Siphonodella* fauna from the Courtmacsherry Formation at Old Head of Kinsale (sample OH4), was tentatively correlated with the Late Kinderhookian *S. cooperi hassi*—*G. punctatus* Zone in the U.S.A.

Since the spore assemblages derived from the Courtmacsherry Formation both at Bantry Bay and at Old Head of Kinsale are assigned to the PV phase, while the spore assemblage from the Castle Slate Member at Old Head of Kinsale has been attributed to the NR phase (lowermost VI subzone), the correlation between sample B8 and OH1 is either incorrect, or indicates a long range for the conodont fauna involved.

### *Ages of the phases in southern Ireland*

The ages of the here established phases may be deduced from correlations with the type area of the Tournaisian Stage in the Ardenno-Rhine Basin (Table X).

The LM phase can be correlated with the PLs2 subzone of the scheme of Paproth and Streeel (1970), on the basis of the presence of *Retispora lepidophyta*, *Knoxisporites literatus*, *Corbulispora subalveolaris*, *Grandispora echinata* and *Tumulispora rarituberculata*. The latter two species had their first appearance in the PLs1 subzone. From a comparison with Poland (Turnau, 1975, 1978), it seems that a distinction between the PLs1 and PLs2 subzones is only of regional significance within the Ardenno-Rhine Basin. Therefore, it is here anticipated that the LM phase may be correlated, at least in part, with the PLs1 subzone. Since the PLs2 subzone is of Tn1b age and the PLs1 of Tn1a age, the LM phase would be mainly of Tn1b and partly of Tn1a age.

The LE phase is correlated with the PLs3 (basal TE) subzone, which is of Tn1b age.

The Devonian—Carboniferous boundary as defined during the Carboniferous Congress at Heerlen 1935 (appearance of *Gattendorfia subinvoluta*) approximates the boundary between the Tn1a and Tn1b. The palynological recognition of this boundary can be based on the disappearance of *Retispora lepidophyta*, which occurs within Tn1b. Thus, the boundary between the *Retispora lepidophyta* Assemblage Zone and the *Verrucosisporites nitidus* Assemblage Zone also approximates the Devonian—Carboniferous boundary<sup>1</sup>.

On the basis of the absence of *Retispora lepidophyta*, the NR phase may be correlated with the TE zone of the Ardenno-Rhine Basin. In this zone the transition from the Tn1b to Tn2 occurs, consequently in Ireland this transition should occur within the NR phase.

The younger phases in Ireland can not be directly compared with the type area of the Tournaisian. The PV phase may be indirectly correlated, however, by means of conodonts. Based on the absence of siphonodellids in the Tn3, the PV phase (=PC Zone) is thought to be of Tn2 age (see Clayton et al., 1978).

### RELATION PALAEOGEOGRAPHY—PALYNOLOGY

#### *Southern Ireland*

Based on an integration of regional phases with sedimentary environments, Van der Zwan and Van Veen (1978, fig. 3) have presented palaeogeographical

<sup>1</sup> During the 9th Carboniferous Conference (Washington, 1979) the Devonian—Carboniferous Working Group recommended a redefinition of the base of the Carboniferous System, in terms of the first appearance of the conodont *Siphonodella sulcata* within the *Siphonodella* lineage. This level defines also the base of the *Siphonodella sulcata* zone. An exact palynological recognition of this redefined Devonian—Carboniferous boundary is not yet possible.

maps for the time-intervals represented by the LM and LE phases, and by the phases of the *V. nitidus* Assemblage Zone, respectively. These maps have formed the basis for a discussion of the observed compositional differences in palynological assemblages between Bantry Bay, Hook Head and Kerry Head. After an analysis of the influence of sorting processes on the composition of the palynological assemblages, it was concluded that the main compositional differences could well have resulted from differences in palaeogeography.

In the present discussion the relation palaeogeography—palynology, as observed for Bantry Bay, Hook Head and Kerry Head by Van der Zwan and Van Veen (1978), is extended to the other sections studied.

As discussed earlier (p.194), considerable lateral compositional variation in palynological assemblages occurs between the different localities. Yet, a certain similarity in composition of the assemblages from a number of the localities studied has resulted in the recognition of two local phases, each characterized by its own characteristic composition: (1) in the LM—LE regional phases, this is the RaLo local phase, as present in Bantry Bay and Garryvoe; (2) in the LCr—PV regional phases, this is the TCr local phase, which is present in Bantry Bay, Coomhola River, East Bantry, White Bay, Garryvoe and Ardmore. Furthermore, the composition of the assemblage from Helvick Head could be compared with that of Kerry Head. The local compositional characteristics of the assemblages from Hook Head could so far not be compared with those from other localities.

Integration of the palynological data with the palaeogeography shows:

(1) In the LM—LE phases, the species characterizing the RaLo phase (*Raistrickia* spp. and *Lophozonotriletes* spp.) may be considered to represent alluvial plain and coastal plain floras, whereas the assemblages from Hook Head represent alluvial fan floras.

(2) In the LCr—PV phases, species characterizing the TCr phase (*Tumulispota* spp. and *Cyrtospora cristifer*) may represent coastal—deltaic floras; the characteristic species of the assemblage from Helvick Head (*Verrucosiporites* spp.) may represent alluvial plain floras; and those from Hook Head are considered to be indicative for the transition alluvial fan—alluvial plain.

Evidently the here established relation palaeogeography—palynology could also be written as the relation palaeogeographical unit—local phase (assemblage); furthermore, the characteristic species of the local phases could be considered to reflect the flora of the nearest (continental) palaeogeographical unit.

As a consequence of this relation the assemblages from the geographical unit nearest to the coastal environment, will yield, apart from the spores derived from the whole hinterland, the greatest number of its own local elements; such in contrast with assemblages from the hinterland, from which local elements may be dispersed throughout the region.

Thus, one may recognize the following relations: (1) assemblages of the coastal—marine area will show, apart from the dominance of local forms, a considerable amount of forms derived from the alluvial plain and, to a lesser degree, forms from the alluvial fan area; (2) assemblages of the alluvial plain

will show, apart from the abundance of local forms, a considerable amount of alluvial fan material and, to a lesser degree, some (windblown?) coastal plain forms; and (3) assemblages of the alluvial fan area will show a few alluvial plain forms and even less coastal plain forms.

It follows that it is much easier to characterize palynologically the coastal plain area than the more inland areas. The palynological characterization of the coastal plain area may be based on the characteristic species of the local phase, exclusively, whereas the characterization of the alluvial fan area has to be based on the whole assemblage.

### *Outside Ireland*

Apart from the presumed coastal—deltaic environment of the *Cyrtospora cristifer*-bearing plant (Van der Zwan, 1979), a characterizing element of the TCr phase, the here established relation palaeogeography—palynology has so far not been traced outside Ireland. For *Tumulispora rarituberculata*, another characterizing element of the TCr phase, such a relation will be discussed hereafter.

Within southern Ireland the coastal—deltaic preference of the *T. rarituberculata*-bearing plant is evident. When we compare this with the situation in Spitsbergen, however, we observe a completely different situation. From this area the species is known from purely continental deposits (Playford, 1962, 1963), which is strongly in contrast with the situation in Ireland. It is here considered, however, that the occurrence of *T. rarituberculata* in different palaeogeographical units at different places could well be explained by accepting a hydrophyllous nature of the parent plant. An environment similar to the coastal—deltaic (swampy) areas in southern Ireland may also exist inland in the Spitsbergen area. The required wet conditions in Spitsbergen during the Early Carboniferous can be readily deduced from climatological models (tropical humid climate, Van der Zwan, in prep.) or directly, from the presence of coal deposits.

### *Stratigraphical implications*

In view of the here presumed or demonstrated environmental preference of a number of species, such a preference is also to be expected for other species. Considering this, the influence of such an environmental preference is likely to hamper the stratigraphical application of palynological species; particularly with regard to their first and last occurrences (e.g., compare appearance of *V. nitidus* in Garryvoe, p.194). In order to avoid these difficulties, one should try to determine the range of stratigraphically promising species in marine—deltaic deposits, even though numerous species will only be rarely represented. It is anticipated that the compositional characteristics of assemblages from marine—deltaic deposits are least influenced by the compositional differences resulting from environmental differences.

At least part of the stratigraphical data from marine sequences outside

Ireland (see p.203) are in support of this view. The appearance of Carboniferous species in the latest Devonian of the Ardenno-Rhine Basin and of Poland indicates that although some regional differences still exist, the general compositional development is the same. Comparison between these marine sequences and the continental Devonian sequences of southern Ireland shows that at least one species (*T. rarituberculata*) appeared much earlier in the marine sequences than in southern Ireland.

#### GENERAL CONCLUSIONS

A comparison of the palynological assemblages from Bantry Bay with more easterly sections in southern Ireland has resulted in a reconstruction of a continuous picture of the gradual compositional development of palynological assemblages in the Devonian—Carboniferous transition sequence. Within this development, eight phases may be distinguished, each characterized by regional patterns in the gradual appearance and disappearance of palynological taxa.

These regional phases may constitute the bases for diagnosing three successive assemblage zones (*Retispora lepidophyta* Assemblage Zone, *Verrucosisorites nitidus* Assemblage Zone, *Spelaotriletes pretiosus* Assemblage Zone), which can be traced interregionally and even intercontinentally.

The application of assemblage zones in regional and interregional stratigraphy has considerable advantage over the application of the concurrent range zones proposed by Clayton et al. (1978); the former emphasize the gradual compositional development of the palynological assemblages, whereas the latter place more weight on the first and last occurrence of taxa.

Because of the interregional traceability, the proposed assemblage zones are considered to constitute a practical palynological background for chronostratigraphical interpretation. In this respect, the boundary between the *Retispora lepidophyta* Assemblage Zone and the *Verrucosisorites nitidus* Assemblage Zone has an important potential in diagnosing the Devonian—Carboniferous boundary, since the zonal boundary approximates the conventional Devonian—Carboniferous boundary as based on goniatite biostratigraphy.

Apart from the regional phases, two palaeogeographically related local phases have been recognized, reflecting the floras of the coastal and alluvial plain, and the coastal—deltaic area, respectively. The influence of compositional differences resulting from environmental differences can not be neglected in regional and interregional chronostratigraphical interpretation of palynological data.

The implications of the present study with regard to regional classification and correlation of Devonian—Carboniferous transition sections within southern Ireland are visualized in Fig.2. From a lithostratigraphical point of view it is especially noteworthy that the palynologically determined Devonian—Carboniferous boundary correlates with a relatively thin mudstone unit (Claystone Member, Castle Slate Member) which is traceable over most of southern Ireland.

From the taxonomic part of the present paper it may be deduced that the classification and identification of Devonian and Carboniferous spores, even of many of the seemingly well-known forms, is by no means a routine procedure. The frequent occurrence of a wide range of morphological variation often transgressing generic or specific boundaries is, as a sequel to previous examples (Van der Zwan, 1979, 1980b) demonstrated in the discussion of the *Verrucosporites nitidus* morphon and the *Dictyotriletes submarginatus* morphon.

#### SELECTED SYSTEMATICS

Form genus: *Phyllothecotriletes* Lubert ex Potonié 1958

Type species: *Phyllothecotriletes nigratellus* (Lubert) Lubert 1955

**Species:** *Phyllothecotriletes nigratus* (Naumova) De Jersey 1966

1953: *Leiotriletes nigratus* Naumova

1955: *Trachytriletes nigratus* (Naumova) Kedo

1965: *Calamospora nigrata* (Naumova) Allen

*Holotype:* *Leiotriletes nigratus* Naumova 1953, plate 1, fig.9.

*Figured specimens:* Plate I, 3.

*Identifying characters:* Outline subcircular. Spore wall (1–2  $\mu\text{m}$  in thickness) smooth. Sharply delimited proximal polar area darker than remainder of spore wall; outline subtriangular with convex sides (1/6-(1/3)-1/2 of spore diameter), most apical part of polar area frequently brighter than remainder of polar area. Trilete rays distinct, simple, length 1/4–1/2 of spore radius.

*Observed diameter:* 40-(50)-89  $\mu\text{m}$ .

*Remarks:* The delimitation of the proximal polar area in *Phyllothecotriletes golatensis* Staplin 1960 is not distinct; nevertheless, its short trilete rays and the thickness of its spore wall suggest a close morphological relationship with the present species. Also *Calamospora* sp. in Warg and Traverse (1973) seems highly comparable.

The material identified by Allen (1965) as *Calamospora nigrata* (Naumova) Allen 1965 has a thinner spore wall and seems to have curvaturae; hence, this material has to be excluded from the present species.

Apart from the absence of longer trilete rays and curvaturae, the present species is morphologically related to *Retusotriletes planus* (p.186).

*Distribution elsewhere:* The present species has been recorded from the Middle Devonian up to the Tournaisian of the U.S.S.R. (Naumova, 1953; Kedo, 1957, 1963), of Australia (De Jersey, 1966) and probably of the U.S.A. (Warg and Traverse, 1973; Staplin, 1960).

Form genus: *Aneurospora* Streel 1964

Type species: *Aneurospora goensis* Streel 1964



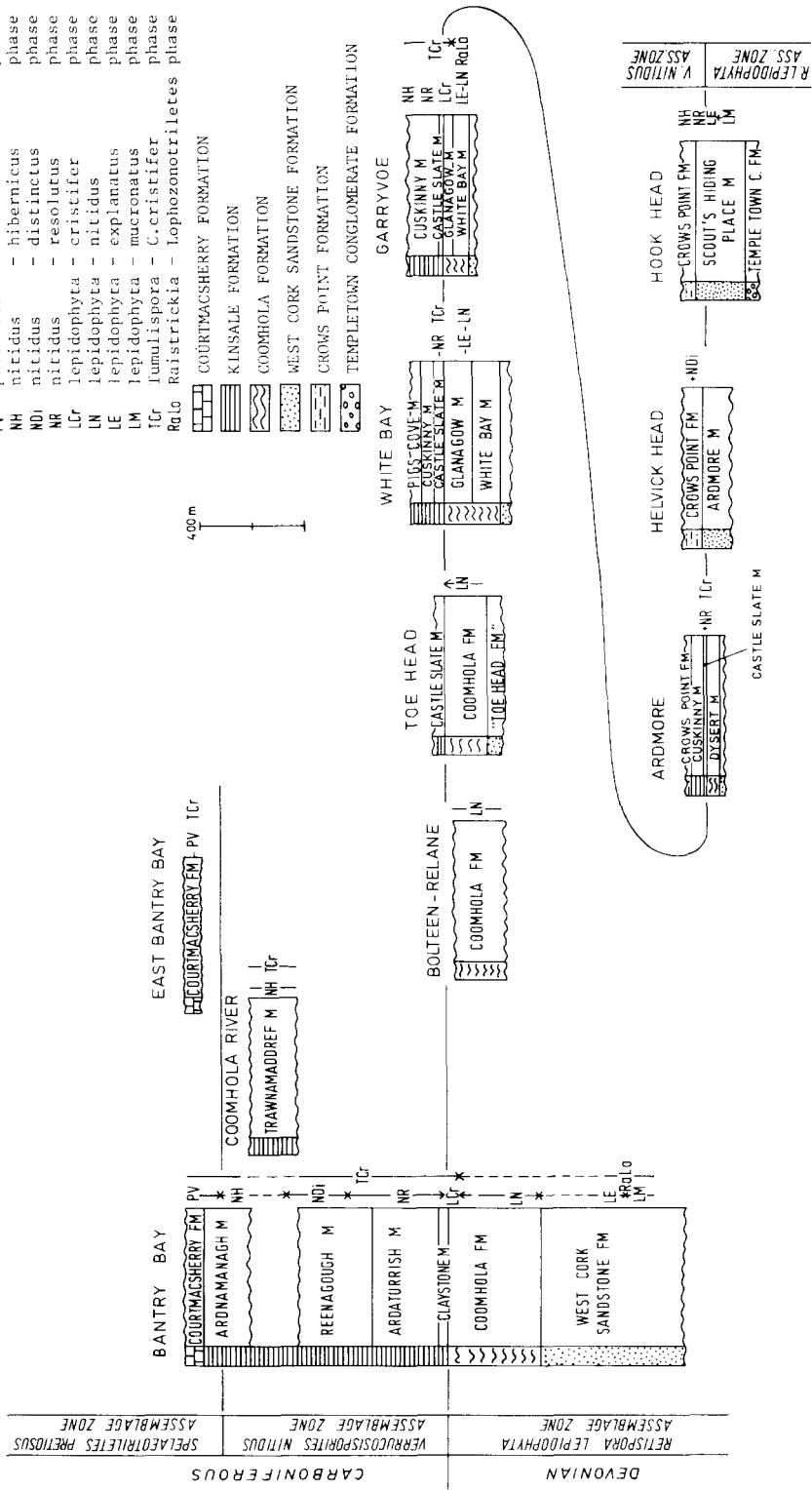


Fig. 2. Generalized correlation scheme of the Devonian—Carboniferous transition sections studied.

**Species:** *Aneurospora* cf. *semizonalis* (McGregor) Lele et Streel 1969

*Holotype:* *Retusotriletes semizonalis* McGregor 1964, plate 2, fig.3, 4

*Figured specimens:* Plate I, 10.

*Identifying characters:* Outline subtriangular with convex sides to subcircular. Spore wall interradially slightly thickened (2.5-(4)-5  $\mu\text{m}$ ) at the equator, thickening radially passing into distinct or indistinct curvaturae imperfectae. Ornamentation equatorially and distally consisting of irregularly distributed minute grana or bacula (0.5–1  $\mu\text{m}$  in height; 0.5–1  $\mu\text{m}$  in width; 0.5–3  $\mu\text{m}$  apart); proximal ornamentation reduced, concentrated along trilete rays, or absent. Trilete rays indistinct or distinct, simple, length 2/3–1/1 of spore radius.

*Observed diameter:* 35-(49)-65  $\mu\text{m}$ .

*Remarks:* The present species is closely in accordance with the description as given by McGregor (1964) and by Lele and Streel (1969). Since the ornamentation of the present material seems to be somewhat coarser, definitive attribution to the species is not yet justified.

The specimens attributed to this species by Streel (1967) are punctate.

**Species:** *Aneurospora* cf. *greggsii* (McGregor) Streel in Becker et al., 1974

*Holotype:* *Retusotriletes greggsii* McGregor 1964, plate 1, fig.1, 2

*Figured specimens:* Plate II, 1, 2.

*Identifying characters:* Outline subtriangular with convex sides to subcircular. The spore has a preferred eccentric compression. Spore wall interradially variably thickened (3–4.5  $\mu\text{m}$ ) at the equator; thickening radially passing into distinct or indistinct curvaturae imperfectae. Wall thickness distally 2  $\mu\text{m}$ . Ornamentation equatorially and distally mainly consisting of bacula and clavae (1–2  $\mu\text{m}$  in height; 0.5–1  $\mu\text{m}$  in width; 0.5–2  $\mu\text{m}$  apart); proximal ornamentation reduced (up to 4  $\mu\text{m}$  apart). Trilete rays indistinct or distinct, simple or labrate (labra up to 2  $\mu\text{m}$  in width), straight or sinuous, length 2/3–3/4 of spore radius.

*Observed diameter:* 32-(45)-63  $\mu\text{m}$ .

*Remarks:* McGregor (1964) noted a variable ornamentation for *Retusotriletes greggsii*, however, since he did not specifically mention the presence of bacula and clavae, conclusive identification has not been attempted.

**Species:** ?*Aneurospora* sp. A

*Figured specimens:* Plate II, 3, 4.

*Identifying characters:* Outline subtriangular with convex sides. Spore wall two-layered; inner layer thin, tightly appressed to outer layer, frequently loosened and folded; equatorially thickened (1-(2)-3  $\mu\text{m}$ ). Outer layer thin (about 1  $\mu\text{m}$ ), proximally smooth. Trilete rays distinct, straight or sinuous, simple or labrate; labra up to 2  $\mu\text{m}$  in width; length almost equal to spore radius. Outer layer distally ornamented with regularly distributed gradually

tapering coni or spinae (0.5–1  $\mu\text{m}$  in height; 0.5–1  $\mu\text{m}$  in width; 0.5–1  $\mu\text{m}$  apart).

*Observed diameter:* 27-(37)-45  $\mu\text{m}$ .

*Remarks:* The present species has provisionally been assigned to *Aneurospora* on the basis of its equatorial thickening, even though the presence of a two-layered spore wall is not mentioned in the generic diagnosis.

Form genus: *Cyclogranisporites* Potonié et Kremp 1954

Type species: *Cyclogranisporites leopoldii* (Kremp) Potonié et Kremp 1954

**Species:** *Cyclogranisporites cf. leopoldii* (Kremp) Potonié et Kremp 1954

*Holotype:* *Granulatisporites leopoldii* Kremp 1952, plate 15b, fig.15

*Figured specimens:* Plate XXIII, 1.

*Identifying characters:* Outline subtriangular with convex sides to subcircular. Spore wall (thickness excluding ornamentation 1  $\mu\text{m}$ ) ornamented proximally and distally with discrete smooth grana (0.5  $\mu\text{m}$  in height; 0.5–1  $\mu\text{m}$  in width; less than 0.5  $\mu\text{m}$  apart), outline irregularly elongated to polygonal. Trilete rays indistinct or distinct, approximately 2/3 of spore radius, occasionally accompanied by parallel internal thickenings of the spore wall, up to 2  $\mu\text{m}$  in width.

*Observed diameter:* 20-(28)-39  $\mu\text{m}$ .

*Remarks:* The present form differs from the type material in having lower grana and frequently longer trilete rays.

The species shows continuous variation towards *Verrucosisporites depressus* Winslow 1962 (p.216); it may be distinguished by its smaller size and smaller ornamentation.

Form genus: *Verrucosisporites* Ibrahim 1933 emend. Smith 1971

Type species: *Verrucosisporites verrucosus* (Ibrahim) Ibrahim 1933

*Remarks:* A number of the species here assigned to this form genus show a two-layered spore wall. For this reason they could be transferred to *Grumosporites* Smith et Butterworth 1967. However, within the present material the presence of two layers is only occasionally observed, and is probably due to differences in preservation. Therefore, with regard to the present species, this factor is not considered to represent a practical generic characteristic.

**Species:** *Verrucosisporites congestus* Playford 1964

*Holotype:* *Verrucosisporites congestus* Playford 1964, plate 2, fig.12

*Figured specimens:* Plate XXV, 1–5.

*Identifying characters:* Outline subtriangular with convex sides to subcircular. No preferred orientation. Spore wall (thickness excluding ornamentation 1–2  $\mu\text{m}$ ) ornamented proximally and distally with discrete smooth verrucae (2-(6)-20  $\mu\text{m}$  in longest diameter; 2–6  $\mu\text{m}$  in height); outline subcircular or elongated, frequently truncated; elements irregularly distributed (0–10  $\mu\text{m}$

apart); 8–20 verrucae project at the equator. Spacing and size of the elements are variable per specimen. Trilete rays frequently obscured by ornamentation, simple, length  $1/2$ – $3/4$  of spore radius.

*Observed diameter:* 30-(47)-70  $\mu\text{m}$ .

*Remarks:* Specimens with widely separated verrucae are comparable with *Verrucosisporites gobettii* Playford 1962; the present species may, however, be distinguished on its higher verrucae.

The species shows continuous variation towards *Verrucosisporites nitidus* Playford 1964; the latter species may be distinguished by its conspicuous “negative reticulum” and its more uniform elements.

**Species: *Verrucosisporites nitidus* Playford 1964**

1953: *Lophotriletes grumosus* Naumova

1964: *Verrucosisporites grumosus* (Naumova) Sullivan *non* Ibrahim 1933

*Holotype:* *Lophotriletes grumosus* Naumova 1953, plate 7, fig.14

*Figured specimens:* Plate XXIV, 1–5

*Identifying characters:* Outline subtriangular with convex sides to subcircular. No preferred orientation. Spore wall (thickness excluding ornamentation 1–2  $\mu\text{m}$ ) ornamented proximally and distally with smooth verrucae (2-(4)-10  $\mu\text{m}$  in greatest width; 1–4  $\mu\text{m}$  in height), characteristically closely spaced, outline polygonal, forming “negative reticulum”; 18–40 verrucae project at the equator. Size and spacing of the elements rather uniform per specimen. Trilete rays frequently obscured by ornamentation, simple, length  $1/2$ – $2/3$  of spore radius.

*Observed diameter:* 35-(46)-100  $\mu\text{m}$ .

*Remarks:* Holotype as designated by Naumova (1953, p.57) for *Lophotriletes grumosus* (IGN No.3450/3612). Unfortunately Naumova and later Playford did not indicate which of the two figures depicts the holotype; therefore Naumova’s plate 7, fig.14 is here designated to represent the holotype.

The present species shows continuous variation towards *Verrucosisporites congestus* Playford 1964 and towards *Verrucosisporites depressus* Winslow 1962; it may be distinguished by its size and uniform nature of the elements, together with its “negative reticulum”.

**Species: *Verrucosisporites depressus* Winslow 1962**

*Holotype:* *Verrucosisporites depressus* Winslow 1962, plate 19, fig.7

*Figured specimens:* Plate XXIII, 2–7.

*Identifying characters:* Outline subtriangular with convex sides to subcircular. Spore wall (thickness excluding ornamentation 1–3  $\mu\text{m}$ ) two-layered; inner layer occasionally slightly loosened and folded; outer layer ornamented proximally and distally with smooth verrucae and grana (0.5–1  $\mu\text{m}$  in height; 0.5-(1.5)-3  $\mu\text{m}$  in greatest width), elements usually closely spaced, outline irregularly elongated to polygonal, forming a “negative reticulum”; 36–75 elements project at the equator. Trilete rays distinct, simple or accompanied

by parallel internal thickenings of the spore wall, up to 4  $\mu\text{m}$  in width.

*Observed diameter:* 33-(45)-60  $\mu\text{m}$ .

*Remarks:* Within the variation of the species, one may observe specimens which do not show the characteristic "negative reticulum"; these specimens may constitute a transition to *Verrucosporites papulosus* Hacquebard 1957. The specimens depicted as *Verrucosporites papulosus* in Burmann (1975) show a "negative reticulum" and may well prove to be *Verrucosporites depressus*.

The present species shows continuous variation towards *Verrucosporites nitidus* Playford 1964 and towards *Cyclogranisporites* cf. *leopoldii* (present paper); it may be distinguished by its thickening along the trilete rays, the presence of a two-layered spore wall and by the size of the verrucae.

**Species:** *Verrucosporites tuberculatus* (Kedo) Turnau 1978

*Holotype:* *Lophozonotriletes tuberculatus* Kedo 1963, plate 10, fig. 248

*Figured specimens:* Plate II, 6.

*Identifying characters:* Outline subtriangular with convex sides. Spore wall (thickness excluding ornamentation 3–4  $\mu\text{m}$ ) two-layered; inner layer frequently slightly loosened and folded; outer layer ornamented proximally and distally with smooth verrucae (1–5  $\mu\text{m}$  in height; proximally 2–5  $\mu\text{m}$  in width, distally 2-(4)-10  $\mu\text{m}$  in width); elements usually closely spaced, outline irregularly elongated to polygonal, forming a "negative reticulum"; 24–42 elements project at the equator. Trilete rays in inner layer, distinct, simple, length 1/2–1/1 of spore radius.

*Observed diameter:* 35-(47)-60  $\mu\text{m}$ .

*Remarks:* Because of proximally smaller elements the present forms are included in *Verrucosporites tuberculatus* (Kedo) Turnau 1978, although the presence of an inner layer of the spore wall was not observed in the type material.

*Verrucosporites variotuberculatus* Sullivan 1968 may be distinguished by its generally larger size, its more subcircular outline and by the larger size of the verrucae; one may, however, suspect transitional forms.

*Distribution elsewhere:* The present species has been recorded from the Tournaisian of Poland (Turnau, 1978) and the U.S.S.R. (Kedo, 1963).

**Species:** *Verrucosporites* sp. A

*Figured specimens:* Plate III, 3.

*Identifying characters:* Outline subtriangular with convex sides to subcircular. Spore wall (1.5-(2)-3  $\mu\text{m}$  in thickness) ornamented with irregularly shaped verrucae (1–3  $\mu\text{m}$  in height; 1–8  $\mu\text{m}$  in width; 1-(2)-5  $\mu\text{m}$  apart). Ornamentation of the contact area somewhat reduced. Trilete rays indistinct, simple, length 2/3–1/1 of spore radius.

*Observed diameter:* 38-(49)-90  $\mu\text{m}$ .

*Remarks:* The irregularly shaped, large verrucae distinguish the present species from other species in *Verrucosporites*.

Form genus: *Planisporites* Knox 1950 emend. Potonié 1960

Type species: *Planisporites granifer* (Ibrahim) Knox 1950

Species: *Planisporites* sp. A

Figured specimens: Plate III, 4, 5

*Identifying characters:* Outline subtriangular with convex sides. Spore wall (1  $\mu\text{m}$  in thickness) proximally and distally ornamented with spinae and conical elements (0.5-(1)-2  $\mu\text{m}$  in height; 0.5-1  $\mu\text{m}$  in width; 0.5-(1)-2  $\mu\text{m}$  apart). Trilete rays indistinct or distinct, simple or labrate; labra up to 2  $\mu\text{m}$  in width, length almost equal to spore radius.

*Observed diameter:* 20-(29)-34  $\mu\text{m}$ , occasionally up to 57  $\mu\text{m}$ .

*Remarks:* The present unnamed species can be distinguished from other species of *Planisporites*, such as *P. granifer* (Ibrahim) Knox 1950, *P. furfuris* Balme et Hassel 1962, *P. conspersus* Playford 1971 and *P. scaber* Tagourdeau 1971, principally on the basis of its smaller size.

The species shows resemblance with *Acanthotriletes denticulatus* Naumova 1953 and with *A. parvispinosus* Naumova 1953, but from the description of these species it is not clear, whether or not the proximal hemisphere is ornamented.

Form genus: *Lophozonotriletes* Naumova 1953 emend. Van der Zwan

Type species: *Lophozonotriletes lebedianensis* Naumova 1953

1975: *Tumulispora lebedianensis* (Naumova) Turnau

*Emended diagnosis:* Outline subtriangular with convex sides to subcircular. Spore wall distally and equatorially ornamented with a variety of irregularly distributed elements, mainly consisting of verrucae of irregular shape and blunt conical elements. Elements partly confluent at their bases, thus forming short rugulae, which occasionally accentuate the margin of the contact area. Contact area smooth. Trilete rays distinct, simple or labrate.

*Remarks:* The present form genus is here emended in order to clarify the morphology of the type species. Since the type material was not available, this has been based on specimens identified as *L. lebedianensis* by McGregor and Owens (1966) and by Avchimovits (1974), as well as on personal observations of material derived from the Famennian of the Eifel, Germany (Plate III, 7). From these observations it is considered that the type species shows no sign of an equatorial crassitude other than the occasional presence of short rugulae arranged at the contact area margin. These rugulae, however, are never completely fused into a genuine cingulum.

Consequently cingulate species originally assigned to this form genus have to be transferred into other form genera. *L. rarituberculatus* (Luber) Kedo 1957 and *L. malevkensis* Naumova in Kedo 1963 have been transferred into *Tumulispora* Staplin et Jansonius 1964 by Potonié (1966) and by Turnau (1978), respectively. *Lophozonotriletes cristifer* (Luber) Kedo 1957 has been transferred into *Cyrtospora* Winslow 1962 by Van der Zwan (1979).

**Species: *Lophozonotriletes cf. lebedianensis* Naumova 1953**

1975: *Tumulispora lebedianensis* (Naumova) Turnau

*Holotype: Lophozonotriletes lebedianensis* Naumova 1953, plate 17, fig.42

*Figured specimens:* Plate IV, 1.

*Identifying characters:* Outline subtriangular with convex sides to subcircular. Spore wall (thickness about 2  $\mu\text{m}$ ) equatorially and distally ornamented with irregularly distributed, in part confluent, smoothly rounded verrucae (1–3  $\mu\text{m}$  in height; 2–5  $\mu\text{m}$  in greatest width; 0–4  $\mu\text{m}$  apart). Spore wall contact area smooth, usually accentuated by indistinct *curvaturae perfectae*. Trilete rays simple, distinct, length  $2/3$ – $1/1$  of spore radius.

*Observed diameter:* 35–50  $\mu\text{m}$ .

*Remarks:* The present form is closely comparable with the type material, it differs by its lower verrucae and by the presence of *curvaturae*.

*Tumulispora lebedianensis* (Naumova) Turnau 1975 is probably conspecific with *T. rarituberculata* (p.225), but not with *L. lebedianensis*.

The present species shows continuous variation towards *L. bellus* (see below); it may be distinguished on the basis of its lower, smoothly rounded verrucae.

**Species: *Lophozonotriletes bellus* Kedo 1963**

*Holotype: Lophozonotriletes bellus* Kedo 1963, plate 10, fig.244 is here designated to represent the holotype.

*Figured specimens:* Plate IV, 2–7; V, 2.

*Identifying characters:* Outline subtriangular with convex sides to subcircular. Spore wall (thickness 2–4  $\mu\text{m}$ ) equatorially and distally ornamented with irregularly distributed, in part confluent, irregularly shaped verrucae and blunt conical elements (2–(4)–6  $\mu\text{m}$  in height; 2–(4)–6  $\mu\text{m}$  in width, up to 8  $\mu\text{m}$  in length, occasionally up to 20  $\mu\text{m}$ ; 0–(3)–15  $\mu\text{m}$  apart). Spore wall contact area smooth, accentuated by indistinct *curvaturae perfectae*. Trilete rays simple, distinct, length  $2/3$ – $1/1$  of spore radius.

*Observed diameter:* 35–(48)–70  $\mu\text{m}$ .

*Variation:* Within the present material variation was observed from forms with discrete closely spaced elements to forms with confluent widely spaced elements. Furthermore, within the variation there occur forms with rather irregularly shaped, as well as forms with rather smoothly rounded elements.

*Remarks:* Based on the above-mentioned wide variation in the present material a broad species concept has been used. Arbitrary limits had to be drawn to distinguish the present species from *L. cf. lebedianensis*, *L. excisus* (p.220), *L. tuberosus* Sullivan 1964 and *L. curvatus* Naumova 1953. It may be distinguished from *L. cf. lebedianensis* and *L. tuberosus* by its higher verrucate–conate ornamentation; it may be distinguished from *L. excisus* by its denser ornamentation and usually shorter and lower elements; it may be distinguished from *L. curvatus* by its verrucate, rather than conate ornamentation.

The following forms, attributed to different species, are here considered

assignable to *L. bellus*: *L. aff. excisus* in Kedo (1963, plate 10, fig.236); *L. malevkensis* in Kedo (1963, plate 10, fig.242).

*Distribution elsewhere*: The present species has been recorded from the Tournaisian of Western Europe (Clayton, 1970; Burmann, 1975) and of the U.S.S.R. (Kedo, 1963).

**Species: *Lophozonotriletes excisus* Naumova 1953**

1953: *Lophozonotriletes gibberulus* Naumova  
 1961: *Lophozonotriletes dentatus* Hughes et Playford  
 1975: *Tumulispora dentata* (Hughes et Playford) Turnau

*Holotype*: *Lophozonotriletes excisus* Naumova 1953, plate 11, fig.18

*Figured specimens*: Plate IV, 8; V, 1.

*Identifying characters*: Outline subtriangular with convex sides to subcircular. Spore wall (2-(4)-5  $\mu\text{m}$  in thickness) equatorially and distally ornamented with irregularly distributed verrucae and blunt conii, mainly fused into rugulae (elements 2-(5)-8  $\mu\text{m}$  in height; 2-(4)-6  $\mu\text{m}$  in width, up to 13  $\mu\text{m}$  in length, occasionally up to 30  $\mu\text{m}$ ; 2-(6)-15  $\mu\text{m}$  apart). Rugulae are frequently arranged in the equatorial region. Spore wall contact area smooth, accentuated by rather distinct curvaturae perfectae. Trilete rays simple, distinct, length 2/3—1/1 of spore radius.

*Observed diameter*: 40-(50)-62  $\mu\text{m}$ .

*Remarks*: The present species shows continuous variation towards *L. bellus* (p.219), it may be distinguished by its higher, more confluent, wider spaced elements.

The following form, attributed to different species, is here considered assignable to *L. excisus*: *L. curvatus* in Naumova (1953, plate 19, fig.25, 26).

*Distribution elsewhere*: The present species has been recorded from the Frasnian to Viséan of North America (e.g., McGregor and Owens, 1966, plate 26, fig.35; Von Almen, 1970), of Great Britain (Mortimer and Chaloner, 1972), of Poland (Turnau, 1978), of the U.S.S.R. (e.g., Naumova, 1953; Kedo, 1963; Byvsheva, 1976) and perhaps of Bear Island (Kaiser, 1970).

Form genus: *Ceratosporites* Cookson et Dettmann 1958

Type species: *Ceratosporites equalis* Cookson et Dettmann 1958

**Species: *Ceratosporites delicatus* (Higgs 1975) nov. comb. Van der Zwan**

Basionym: *Schopfites delicatus* Higgs 1975, Micropaleontology, 21(4): p.396

*Holotype*: *Schopfites delicatus* Higgs 1975, plate 2, fig.6

*Figured specimens*: Plate VI, 7.

*Remarks*: The present form has been transferred to *Ceratosporites*, as forms with distal baculate ornamentation are more appropriately assigned to this genus.

Form genus: *Convolutispora* Hoffmeister, Staplin et Malloy 1955

Type species: *Convolutispora florida* Hoffmeister, Staplin et Malloy 1955



Species: *Convolutispora* cf. *usitata* Playford 1962

*Holotype*: *Convolutispora usitata* Playford 1962, plate 82, fig. 7, 8

*Figured specimens*: Plate VII, 3, 4.

*Identifying characters*: Outline subcircular. No preferred orientation. Spore wall (thickness excluding ornamentation 1–3  $\mu\text{m}$ ) apart from ornamentation smooth, ornamented proximally and distally with an imperfect reticulum. Muri (2–7  $\mu\text{m}$  in width; 3–5  $\mu\text{m}$  in height) undulating, with converging sides and flat tops. Lumina of highly irregular, elongated shape (2–5  $\mu\text{m}$  in width; up to 20  $\mu\text{m}$  in length). Trilete rays indistinct or distinct, simple, length  $2/3$ – $3/4$  of spore radius.

*Observed diameter*: 60–70  $\mu\text{m}$ .

*Remarks*: The present form differs from the type material mainly by its smaller size. The specimens recorded as *C.* cf. *usitata* by Smith and Butterworth (1967) have a comparable diameter, but have smaller ornamentation.

Form genus: *Camptotriletes* Naumova 1939 emend. Potonié et Kremp 1954

Lecto-type species: *Camptotriletes corrugatus* (Ibrahim) Potonié et Kremp 1954

Species: *Camptotriletes* sp. A

*Figured specimens*: Plate VII, 5, 6; VIII, 1.

*Identifying characters*: Outline subtriangular with convex sides. The spore has a preferred eccentric compression. Spore wall, apart from other ornamentation, minutely rugulate or reticulate (muri 1–2  $\mu\text{m}$  in width; lumina of highly irregular shape, 1  $\mu\text{m}$  in width, up to 5  $\mu\text{m}$  in length). Trilete rays indistinct or distinct, simple, length  $1/2$ – $2/3$  of spore radius. Equatorial region and distal hemisphere ornamented with large, smoothly rounded, undulating and anastomosing rugulae (2–6  $\mu\text{m}$  in width, up to 30  $\mu\text{m}$  in length; 3–8  $\mu\text{m}$  in height), discrete or fused into an imperfect reticulum (distance between rugulae 2–5  $\mu\text{m}$ ).

*Observed diameter*: 50–(58)–65  $\mu\text{m}$ .

*Remarks*: The unnamed species has provisionally been assigned to *Camptotriletes* on the basis of its rugulate ornamentation, though cristate elements have not been observed. The presence of additional minute rugulae, and the absence of coarse proximal ornamentation might suggest an attribution to the type species of *Dictyotriletes* (*D. bireticulatus* (Ibrahim) Smith et Butterworth 1967). However, since the latter form genus is considered to accommodate reticulate species, an assignment to *Camptotriletes* is here preferred.

The present species is distinguished from other species of *Camptotriletes* by its characteristic bi-rugulate ornamentation.

Form genus: *Acinosporites* Richardson 1964

1969: *Biornatisporites* Lele et Streele

Type species: *Acinosporites acanthomammilatus* Richardson 1964

*Remarks:* *Biornatisporites* is here considered a junior synonym of the present form genus, as both are diagnosed by the same type of ornamentation.

**Species:** ?*Acinosporites* sp. A

*Figured specimens:* Plate VIII, 2.

*Identifying characters:* Outline subtriangular with convex sides to subcircular. Spore wall (1–2  $\mu\text{m}$  in thickness) apart from ornamentation smooth; ornamented both proximally and distally with an imperfect reticulum. Muri (2–3  $\mu\text{m}$  in width; 3–5  $\mu\text{m}$  in height) with converging sides, smooth or surmounted with coni, spinae or bacula (1–2  $\mu\text{m}$  in height, at muri junctions 2–7  $\mu\text{m}$ ). Lumina polygonal (5–10  $\mu\text{m}$  in width, up to 30  $\mu\text{m}$  in length). Trilete rays indistinct or distinct, simple, frequently gaping, length  $1/2$ – $2/3$  of spore radius.

*Observed diameter:* 40-(50)-80  $\mu\text{m}$ .

*Remarks:* Ornamentation consisting of a reticulum with surmounted bacula or spinae could well be regarded as a characteristic feature for recognizing a separate form genus. However, a suitable form genus to accommodate such spores is so far not available. For this reason the present provisional assignment to *Acinosporites* remains questionable, as the latter form genus is characterized by rugulae with surmounted apiculate ornamentation, rather than by a reticulum. ?*Acinosporites* sp. A is distinguished from other species of *Acinosporites* in being distinctly reticulate.

The species is distinguished from *Dictyotriletes emsiensis* (Allen) McGregor 1973 by the presence of proximal ornamentation. It is distinguished from ?*Reticulatisporites fimbriatus* Winslow 1962, by the larger size of the surmounted elements and by the simple trilete rays, though a close morphological relationship is suspected. Also *Dictyotriletes similis* Kedo 1963 seems quite comparable; the species, however, is larger and has more densely ornamented muri. *Raistrickia macrura* (Luber) Dolby et Neves 1970 has relatively smaller lumina and larger bacula, still a close morphological relationship is suspected.

Form genus: *Dictyotriletes* Naumova 1939 ex Ischenko 1952 emend. Potonié et Kremp 1954

Lecto-type species: *Dictyotriletes bireticulatus* (Ibrahim) Potonié et Kemp 1954

*Remarks:* The type species of this form genus is characterized by a proximally smooth and a distally reticulate hemisphere. The species generally assigned to this form genus, however, are both proximally and distally reticulate. Therefore, it is here considered that species with proximal ornamentation ought to be transferred into a new genus. However, as the present material does not justify the establishment of such a genus, the present species are provisionally assigned to *Dictyotriletes*.

**Species: *Dictyotriletes submarginatus* Playford 1964**

*Holotype: Dictyotriletes submarginatus* Playford 1964, plate 8, fig.9

*Figured specimens:* Plate XXVII, 2, 3; XXVIII, 1–5; XXIX, 4.

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides, occasionally subcircular. Wall inner body thin, tightly appressed to outer wall, occasionally loosened and folded. Outer wall proximally smooth, occasionally ornamented with some mammillae (1–2  $\mu\text{m}$  in width; 2  $\mu\text{m}$  in height). Trilete rays distinct, straight or sinuous, labrate; labra up to 4  $\mu\text{m}$  in width; almost reaching the equator. Equator accentuated by a usually continuous ring, formed by the first murus of the distal reticulum and resembling an equatorial crassitude. Outer wall, apart from other ornamentation, distally smooth or punctate; distal surface ornamented by an irregular, more or less imperfect, polygonal reticulum. Muri straight or undulating, tops smooth or serrate; muri frequently formed by confluent bacula, coni or verrucae. Individual elements are occasionally found in the irregularly shaped lumina (muri 1–3  $\mu\text{m}$  in width, 1–3  $\mu\text{m}$  in height; lumina 2-(5)-10  $\mu\text{m}$  in width, up to 20  $\mu\text{m}$  in length).

*Observed diameter:* 30-(47)-65  $\mu\text{m}$ .

*Remarks:* The specimens originally described by Playford (1964) were regarded as having a “pseudocingulum”, formed by the equatorial encroachment of the distal reticulum. Hibbert and Lacey (1969) expressed their doubts of this feature by saying: it is “not clear if the equatorial structure is a true cingulum, or is a feature produced by the fusion of muri”. Bertelsen (1972) recorded *Dictyotriletes cf. submarginatus* and depicted scanning micrographs showing a distinctly depressed contact area, thus indicating an equatorial differentiation. On the present material a depressed contact area was not observed, but a continuous ring-like equatorial differentiation is usually present.

The species shows continuous variation towards *Dictyotriletes* sp. A (p.224) *Asperispora perlota* (p.228) and ?*Cristatisporites colliculus* (p.228); it may be distinguished on the basis of an equatorial ring, as well as by its reticulum formed by confluent bacula, coni and verrucae.

**Species: *Dictyotriletes cf. minor* Naumova 1953**

*Holotype: Dictyotriletes minor* Naumova 1953, plate 2, fig.7

*Figured specimens:* Plate VIII, 4.

*Identifying characters:* Outline subtriangular with convex sides to subcircular. Spore wall (1  $\mu\text{m}$  in thickness) distally ornamented with an irregularly shaped, imperfect, polygonal reticulum (muri 1  $\mu\text{m}$  in height, 1  $\mu\text{m}$  in width; lumina 1–3  $\mu\text{m}$  in width, up to 6  $\mu\text{m}$  in length). Spore wall proximally smooth, occasionally showing three apical papillae. Trilete rays indistinct, simple, length  $2/3$ – $1/1$  of spore radius.

*Observed diameter:* 22-(34)-50  $\mu\text{m}$ .

*Remarks:* Because of the occasional presence of apical papillae, the present identification remains tentative.

**Species: *Dictyotriletes* sp. A**

*Figured specimens:* Plate XXIX, 1–3.

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides. Wall inner body thin, smooth, tightly appressed to outer wall. Outer wall proximally smooth. Trilete rays distinct, straight, labrate; labra up to 4  $\mu\text{m}$  in width; reaching the equator. Outer wall distally and equatorially ornamented by a rather perfect, polygonal reticulum. Muri formed by confluent verrucae (2–3  $\mu\text{m}$  in width, 2–3  $\mu\text{m}$  in height). Lumina highly irregular in shape (1–4  $\mu\text{m}$  in width, up to 15  $\mu\text{m}$  in length).

*Observed diameter:* 47  $\mu\text{m}$ .

*Remarks:* The species shows continuous variation towards *Dictyotriletes submarginatus* (p.223) and ?*Cristatisporites colliculus* (p.228); it may be distinguished by the absence of an equatorial differentiation and by its reticulum consisting of confluent verrucae.

Form genus: *Hystricosporites* McGregor 1960

Type species: *Hystricosporites delectabilis* McGregor 1960

**Species: *Hystricosporites* sp.**

*Figured specimens:* Plate X, 1.

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides. Ratio diameter inner body/total spore diameter 2/3. Wall inner body (6  $\mu\text{m}$  in thickness) smooth. Outer wall with distinct spongy infrastructure (thick, thickness indeterminable). Surface distally ornamented with about 13 processes, characterized by a bulbous base with a circular outline, and a stout, gently tapering shaft, with a slightly extended triangular bifurcate termination (up to 15  $\mu\text{m}$  in height, up to 7  $\mu\text{m}$  in basal width, 15–20  $\mu\text{m}$  apart). Proximal surface ornamented by numerous radially arranged straight to slightly sinuous ribs (up to 2  $\mu\text{m}$  in width), length almost equal to spore radius. Trilete rays indistinct, simple, length about 1/6 of inner body radius.

*Observed dimensions:* total spore diameter 75  $\mu\text{m}$ ; diameter inner body 50  $\mu\text{m}$ .

*Remarks:* The bifurcate terminations are usually broken, giving the processes a truncated appearance.

The present forms show a close morphological relationship with *Hystricosporites furcatus* Owens 1971; it differs, however, in lacking curvaturae and labra.

Form genus: *Tumulispora* Staplin et Jansonius 1964

Type species: *Tumulispora variverrucata* (Playford) Staplin et Jansonius 1964

**Species: *Tumulispora variverrucata* (Playford) Staplin et Jansonius 1964**

1963: *Lophozonotriletes variverrucatus* Playford

*Holotype: Lophozonotriletes variverrucatus* Playford 1963, plate 91, fig.6

*Figured specimens:* Plate XI, 7, 8; XII, 1–3.

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides to subcircular. Ratio diameter inner body/total spore diameter  $2/3$ – $(7/10)$ – $4/5$ . Wall inner body thin, tightly appressed to outer wall. Outer wall proximally smooth or finely punctate. Trilete rays indistinct or distinct, simple or gaping, straight or sinuous, in length  $2/3$ – $1/1$  of inner body radius. Equatorial crassitude tapering towards the equator, laevigate or finely punctate, occasionally finely granulate. Distal central area verrucate, verrucae partly concentrated in a ring along the margin, partly at random. Verrucae with smoothly rounded or irregular surface. In basal outline sub-circular, elongated or irregular. Verrucae highly variable on a single specimen. (Verrucae along the margin 2–7  $\mu\text{m}$  in width, up to 4  $\mu\text{m}$  in height, 0–4  $\mu\text{m}$  apart, occasionally up to 15  $\mu\text{m}$  apart; verrucae on central area up to 15  $\mu\text{m}$  in width, up to 30  $\mu\text{m}$  in length.)

*Observed dimensions:* total spore diameter 28–(41)–50  $\mu\text{m}$ , diameter inner body 18–(28)–40  $\mu\text{m}$ .

*Remarks:* The present species is distinguished from other species of *Tumulispora* by the presence of a ring of verrucae along the distal central area margin. Rare transitions are observed to *T. rarituberculata* (Luber) Potonié 1966; these transitions, however, occur infrequently and do not justify synonymizing the two species.

*Archaeozonotriletes malevkensis* Naumova in Kedo (1963) is highly comparable with the present species, the species may be distinguished by the more prominent nature of the fine ornamentation of the spore wall.

*Distribution elsewhere:* The present species has been recorded from strata of Tournaisian age of Canada (Staplin and Jansonius, 1964), Spitsbergen (Playford, 1963), Iran (Coquel et al., 1977) and Australia (Playford, 1976, plate 6, fig.7, 8).

*Archaeozonotriletes malevkensis* Naumova in Kedo (1963) has been recorded from the earliest Carboniferous of the U.S.S.R. (e.g., Kedo, 1963; Byvsheva, 1976).

**Species: *Tumulispora rarituberculata* (Luber) Potonié 1966**

1941: *Zonotriletes rarituberculatus* Luber in Luber and Waltz

1956: *Euryzonotriletes rarituberculatus* (Luber) Ischenko

1957: *Lophozonotriletes rarituberculatus* (Luber) Kedo *non* Naumova 1953

1961: *Lophozonotriletes triangulatus* (Ischenko) Hughes et Playford

1963: *Lophozonotriletes malevkensis* Naumova in Kedo

1978: *Tumulispora malevkensis* (Naumova) Turnau

*Holotype: Zonotriletes rarituberculatus* Luber in Luber et Waltz 1941, plate I, fig.5

*Figured specimens:* Plate XI, 4–6, 9; XII, 4–8.

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides to subcircular. Ratio diameter inner body/total spore

diameter  $7/10$ -( $3/4$ )- $4/5$ . Wall inner body thin, tightly appressed to outer wall, rarely observable. Outer wall proximally smooth or finely punctate. Trilete rays indistinct or distinct, simple or gaping, straight or sinuous, in length  $2/3$ — $1/1$  of inner body radius. Equatorial crassitude truncated at or tapering towards the equator; surface laevigate or finely punctate, occasionally minutely granulate. Distal ornamentation consisting of verrucae, regularly or randomly distributed. Verrucae smoothly rounded or truncated; elements occasionally confluent at their bases; in outline subcircular or elongated. Size of verrucae uniform or highly variable on a single specimen ( $2$ — $8$   $\mu\text{m}$  in width, up to  $25$   $\mu\text{m}$  in length; up to  $4$   $\mu\text{m}$  in height;  $0$ — $7$   $\mu\text{m}$  apart).

*Observed dimensions:* total spore diameter  $27$ -( $37$ )- $60$   $\mu\text{m}$ , diameter inner body  $18$ -( $28$ )- $47$   $\mu\text{m}$ .

*Variation:* Within the observed variation two variants are informally recognized: variant A (Plate XII, 4), characterized by a subtriangular outline, a ratio diameter inner body/total spore diameter of  $7/10$ , a tapering equatorial crassitude and uniformly distributed, smoothly rounded verrucae, restricted to the distal central area; variant B (Plate XI, 6; XII, 5—8), characterized by a more subcircular outline, a ratio diameter inner body/total spore diameter of  $3/4$ , a truncated equatorial crassitude and irregularly distributed verrucae over the distal hemisphere, both on central area and crassitude.

*Remarks:* The overall morphology would justify an attribution to *Tumulispora malevkensis* (Naumova) Turnau 1978, as well as to *T. rarituberculata* (Luber) Potonié 1966. The only distinction between these two species appears to be a difference in size. Because of the presence of transitional specimens, however, the species are here considered synonyms.

The species is distinguished from *T. variverrucata* (Playford) Staplin et Jansonius 1964 by the absence of a ring of verrucae on the margin of the central area.

Variant A conforms with one of the specimens of *Lophozonotriletes malevkensis* as figured by Kedo (1963, plate 10, fig.240). At least in Ireland this variant may have some value for local stratigraphy.

*Distribution elsewhere:* The present species has been recorded from strata of latest Famennian and Tournaisian age of North America (e.g., McGregor, 1970), Western Europe (e.g., Clayton et al., 1977c), Poland (Turnau, 1978), Bear Island (Kaiser, 1970), Spitsbergen (Playford, 1962, 1963), the U.S.S.R. (e.g., Kedo, 1963; Byvsheva, 1976), Iran (Coquel et al., 1977) and Australia (Playford, 1976). Furthermore, some questionable records are known from Frasnian and Famennian strata of Canada (Kerr et al., 1965); Libya (Lanzoni and Magloire, 1969) and of England (Mortimer and Chaloner, 1972).

Form genus: *Asperispora* Staplin et Jansonius 1964

Type species: *Asperispora naumovae* Staplin et Jansonius 1964

Species: *Asperispora acuta* (Kedo) nov. comb. Van der Zwan

Basionym: *Archaeozonotriletes acutus* Kedo 1963, Akad. Nauk, B.S.S.R., Inst. Geol. Nauk, Palaeontol. Stratigr. B.S.S.R., 4: p.71.

*Holotype*: *Archaeozonotriletes acutus* Kedo 1963, plate 7, fig.167

*Figured specimens*: Plate XIII, 1—5.

*Identifying characters*: Overall outline and outline inner body subtriangular with convex sides, occasionally subcircular. Specimens frequently in eccentric compression. Wall inner body thin, smooth, tightly appressed to outer wall, occasionally loosened and folded. Outer wall proximally smooth, occasionally bearing some scattered grana ( $1\ \mu\text{m}$  in width, up to  $2\ \mu\text{m}$  in length). Trilete rays indistinct or distinct, simple or labrate ( $2\text{--}4\ \mu\text{m}$  in width); in length equal to inner body radius. Contact area occasionally accentuated by indistinct curvaturae imperfectae. Outer wall equatorially thickened into a well-developed, occasionally discontinuous crassitude ( $2\text{--}7\ \mu\text{m}$  in width). Outer wall distally punctate, ornamented equatorially and distally with mammillae and spinae with bulbous bases ( $1\text{--}8\ \mu\text{m}$  in height;  $1\text{--}6\ \mu\text{m}$  in width); equatorially larger than distally; elements often basally fused into rugulae, which are arranged in a highly irregular pattern ( $0\text{--}5\ \mu\text{m}$  apart). Additionally some minute coni (less than  $1\ \mu\text{m}$  in basal width and height) may be present.

*Observed diameter*: 25-(40)-60  $\mu\text{m}$ .

*Variation*: Variation is observed in size and shape of the ornamentation, ranging from mainly mammillate to distinctly spinate, as well as from continuously fused to discrete.

Additionally, a certain variation in total spore diameter is observed per sample; the older samples (mainly LN phase) contain slightly smaller specimens (mean diameter  $35\ \mu\text{m}$ ) than the younger ones (mainly NR and NDi phases; mean diameter  $45\ \mu\text{m}$ ). It could not be established whether this variation is of any real stratigraphical significance.

*Remarks*: The present species is here transferred to *Asperispora* on the basis of its narrow equatorial crassitude and its distal mammillate, spinate ornamentation. The holotype shows discrete spinae. The additional occurrence of mammae as well as the presence of basally fused elements is here considered to belong to the normal variation within the species.

*Asperispora acuta* is distinguished from the species here described as *Spelaeotriletes* sp. by its more verrucate ornamentation, and from the species here described as *Dentatispora* sp. by its longer spinae and its more distinctly recognizable inner body.

*Lophozonotriletes dentatus* sensu Kaiser (1970) is probably more comparable with *Asperispora acuta*. Also the specimen recorded as *Acanthotriletes famenensis* Naumova 1953 in Combaz and Streel (1970) is probably assignable to this species.

*Distribution elsewhere*: The present species has been recorded from strata of latest Famennian to Tournaisian age of the U.S.S.R. (e.g., Kedo, 1963; Byvsheva, 1976), of England (Dolby and Neves, 1970) and of northern France (identified as *Acanthotriletes famenensis* Naumova 1953, in Combaz

and Streel, 1970). When *Lophozonotriletes dentatus* Hughes et Playford 1961 as recorded from Bear Island in Kaiser (1970) would prove to be synonymous, then its range would be extended up to the Viséan.

**Species:** *Asperispora perlota* (Naumova) nov. comb. Van der Zwan

Basionym: *Archaeozonotriletes perlota* Naumova 1953, Trans. Inst. Geol. Sci. Acad. Sci. U.S.S.R., Rel. 143, Geol. Ser., 60: 87.

1953: *Archaeozonotriletes perlota* Naumova

1972: *Dictyotriletes perlota* (Naumova) Mortimer et Chaloner

*Holotype:* *Archaeozonotriletes perlota* Naumova 1953, plate 14, fig.2

*Figured specimens:* Plate XXVI, 1, 2.

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides, occasionally subcircular. Wall inner body thin, tightly appressed to outer wall, occasionally loosened and folded. Outer wall proximally smooth. Trilete rays distinct, straight or sinuous, labrate; labra up to 4  $\mu\text{m}$  in width; length equal to inner body radius. Outer wall equatorially thickened into a well-defined crassitude (3-(4)-7  $\mu\text{m}$  in width). Outer wall distally, apart from other ornamentation, smooth or punctate; surface ornamented by an irregular, imperfect, polygonal reticulum. Muri formed by more or less confluent bacula or conic (muri 1–2  $\mu\text{m}$  in width, 1–2  $\mu\text{m}$  in height; lumina 2-(7)-10  $\mu\text{m}$  in width, up to 20  $\mu\text{m}$  in length). Individual minute bacula and conic occur frequently in the lumina.

*Observed diameter:* 34-(45)-60  $\mu\text{m}$ .

*Remarks:* The species has been transferred into *Asperispora* on the basis of its well-developed equatorial crassitude and the presence of a reticulum formed by confluent apiculate elements.

The species shows continuous variation towards *Dictyotriletes submarginatus* (p.223); it may be distinguished by the presence of an equatorial crassitude as well as by its reticulum, constituted by confluent bacula and conic.

Form genus: *Cristatisporites* Potonié et Kremp emend. Butterworth, Jansonius, Smith et Staplin 1964

Type species: *Cristatisporites indignabundus* (Loose) Potonié et Kremp 1954

**Species:** ?*Cristatisporites colliculus* Playford 1971

*Holotype:* *Cristatisporites colliculus* Playford 1971, plate 15, fig.1–3

*Figured specimens:* Plate XXX, 1–5.

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides. Wall inner body thin, tightly appressed to outer wall, occasionally loosened and folded. Outer wall proximally smooth. Trilete rays indistinct or distinct, straight or sinuous, labrate; labra up to 3  $\mu\text{m}$  in width; almost reaching the equator. Outer wall equatorially thickened into a crassi-



tude of variable width (2-(3)-8  $\mu\text{m}$ ), formed by confluent coni. Outer wall distally, apart from other ornamentation, smooth or punctate; distal surface ornamented by cristae or spinae, which are usually fused into an irregular, imperfect, polygonal reticulum. Individual elements frequently occur in the highly irregularly shaped lumina. (Muri 1-(2.5)-7  $\mu\text{m}$  in width, up to 5  $\mu\text{m}$  in height; lumina 0–5  $\mu\text{m}$  in width, up to 10  $\mu\text{m}$  in length.)

*Observed diameter:* 31-(45)-92  $\mu\text{m}$ .

*Remarks:* The assignment of the present species to *Cristatisporites* remains questionable, since the presence of a cuesta has not been demonstrated.

The present species shows continuous variation towards *Dictyotriletes submarginatus* (p.223) and *Dictyotriletes* sp. A (p.224); it may be distinguished by its reticulum of fused spinae and cristae.

Form genus: *Grandispora* Hoffmeister, Staplin et Malloy emend. Playford 1971

1957: *Spinozonotriletes* Hacquebard

Type species: *Grandispora spinosa* Hoffmeister, Staplin et Malloy 1955

Species: *Grandispora* cf. *notensis* Playford 1971

*Holotype:* *Grandispora notensis* Playford 1971, plate 19, fig.3, 4

*Figured specimens:* Plate XVI, 4.

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides. Ratio diameter inner body/total spore diameter (2/3)–3/4. Wall inner body thin, smooth. Outer wall (2–5  $\mu\text{m}$  in thickness) proximally laevigate to finely punctate. Trilete rays distinct, labrate; labra represented as flexuous elevated folds (2–6  $\mu\text{m}$  in width), occasionally diverging; length equal to spore radius. Outer wall distally and equatorially ornamented with scattered coni, spinae and occasionally verrucae (2–7  $\mu\text{m}$  in height; 2–4  $\mu\text{m}$  in width; 3–15  $\mu\text{m}$  apart).

*Observed dimensions:* Total spore diameter 85-(115)-140  $\mu\text{m}$ , diameter inner body 60-(74)-100  $\mu\text{m}$ .

*Remarks:* The present forms conform rather closely with the type material, however, its ornamentation seems to be more scattered, its labra somewhat longer and the wall of the inner body somewhat thinner.

Species: *Grandispora* sp. A

*Figured specimens:* Plate XVII, 1.

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides. Ratio diameter inner body/total spore diameter 2/3–(3/4). Wall inner body thin, smooth, three apical papillae distinctly present. Outer wall (1  $\mu\text{m}$  in thickness) proximally laevigate or punctate. Trilete rays distinct, occasionally simple, usually labrate; labra represented as flexuous

elevated folds (1–7  $\mu\text{m}$  in width); length almost equal to spore radius. Outer wall equatorially and distally uniformly ornamented with conii, mammillae and verrucae (1–2  $\mu\text{m}$  in height; 1–3  $\mu\text{m}$  in width; 1–4  $\mu\text{m}$  apart).

*Observed dimensions:* Total spore diameter 40-(56)-70  $\mu\text{m}$ , diameter inner body 30-(41)-50  $\mu\text{m}$ .

*Remarks:* The present species is distinguished from *Archaeozonotriletes flavus* (Kedo) Kedo 1974 and from *Grandispora debilis* Playford 1971 mainly by its apical papillae. The present species is distinguished from *Grandispora notensis* Playford 1971, *Grandispora* cf. *notensis* (p.229) and *Grandispora echinata* Hacquebard 1957 by the combination of the presence of apical papillae, its ratio diameter inner body/total spore diameter and its size.

*Grandispora* sp. A of Streel in Becker et al. (1974, plate 19, fig.4, 5) seems rather comparable with the present form, especially with regard to the suspected presence of apical papillae, it differs in being somewhat smaller and by having somewhat shorter labra.

**Species: *Grandispora* sp. B**

*Figured specimens:* Plate XVII, 2, 3.

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides. Ratio diameter inner body/total spore diameter 2/3-(4/5)-9/10. Wall inner body smooth, three apical papillae distinctly present. Outer wall proximally smooth. Trilete rays distinct, labrate; labra sinuous (2–5  $\mu\text{m}$  in width); length equal to inner body radius. Outer wall distally, apart from other ornamentation, punctate; distal surface ornamented with grana, conii or spinae (0.5-(1)-3  $\mu\text{m}$  in height; 0.5-(1)-3  $\mu\text{m}$  in width), which may be in part grouped into an imperfect polygonal reticulum (lumina 2–10  $\mu\text{m}$  in width, up to 15  $\mu\text{m}$  in length).

*Observed dimensions:* Total spore diameter 34-(44)-58  $\mu\text{m}$ , diameter inner body 25-(35)-48  $\mu\text{m}$ .

*Remarks:* The present species may show continuous variation towards *Kraeuselisporites hibernicus* Higgs 1975; it may be distinguished by its pseudosaccate nature, its distinct apical papillae and its somewhat smaller ornaments.

Form genus and species: apiculate pseudosaccate spore type A

*Figured specimens:* Plate XVIII, 4.

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides. The spore has a preferred eccentric compression. Ratio diameter inner body/total spore diameter about 9/10. Wall inner body thin, occasionally showing three apical papillae. Outer wall (1–1.5  $\mu\text{m}$  in thickness) usually spinate, occasionally granulate (elements 0.5–1.5  $\mu\text{m}$  in height; 0.5–1  $\mu\text{m}$  in width; 0.5-(1)-3  $\mu\text{m}$  apart). Ornamentation proximally somewhat reduced and sometimes confined to an area parallel to the trilete rays.

Trilete rays distinct, simple or labrate; labra up to  $2\ \mu\text{m}$  in width; length  $2/3$ – $1/1$  of spore radius.

*Observed dimensions:* Total spore diameter 23-(29)-40  $\mu\text{m}$ , diameter inner body 20-(25)-35  $\mu\text{m}$ .

*Remarks:* The presence of both proximal and distal, apiculate ornamentation makes an assignment to any known pseudosaccate form genus impossible. Since the present material can not be kept in a permanent state, no new genus has been established.

Form genus: *Retispora* Staplin 1960

Type species: *Retispora florida* Staplin 1960 nom. illeg. (correct name *Retispora lepidophyta* (Kedo) Playford 1976)

**Species:** *Retispora lepidophyta* (Kedo) Playford 1976

1957: *Hymenozonotriletes lepidophytus* Kedo

1960: *Retispora florida* Staplin

1962: *Leiozonotriletes naumovae* Balme et Hassel

1962: *Endosporites lacunosus* Winslow

1966: *Remysporites lepidophytus* (Kedo) Luber in Pokrovskaya

1974: *Spelaeotriletes lepidophytus* (Kedo) Streel in Becker et al.

*Holotype:* *Hymenozonotriletes lepidophytus* Kedo 1957, plate 2, fig.20 designated by Jansonius (1978, card 3498).

*Figured specimens:* Plate XVII, 4–9.

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides to subcircular. Ratio diameter inner body/total spore diameter  $1/2$ -( $3/5$ )- $4/5$ . Wall inner body smooth, three apical papillae often visible. Outer wall proximally thin, finely punctate. Trilete rays indistinct or distinct, simple or labrate, length equal or almost equal to spore radius. Contact area rarely accentuated by curvaturae. Transition between proximal and distal hemisphere generally accentuated by a continuous, thickened equatorial ring. Outer wall distally thickened, foveolate to foveoreticulate. Subcircular to almost polygonal foveolae of highly variable size ( $0.5$ – $7\ \mu\text{m}$ ) and distribution, ranging from small and widely spaced depressions to an almost reticulate or even imperfectly reticulate pattern, through a progressive thinning of the intervening walls. Intervening walls as well as equatorial thickening ornamented with minute spinae (generally  $0.5\ \mu\text{m}$  in height, exceptionally up to  $2\ \mu\text{m}$ ). Both the depressed and elevated areas of the distal outer wall are finely punctate.

*Observed dimensions:* Total spore diameter 33-(53)-90  $\mu\text{m}$ , diameter inner body 20-(33)-55  $\mu\text{m}$ .

*Variation:* As has been noted in many other publications, the present species shows considerable morphological variation, such as (a) variation in total spore diameter, (b) variation in ratio of diameter inner body/total spore diameter, (c) variation in width and shape of the foveolae, and (d) variation in the continuity of the intervening walls. This whole range of variable characters has also been observed in the present material.

On the basis of the presumed time-proportionate trend observed in the variation of the species, Streel (1966) proposed a zonation scheme, in which the larger forms, with a relatively low mean ratio of diameter inner body/total spore diameter (0.6–0.64) occur in the older strata, whereas the smaller forms with a relatively high mean ratio of diameter inner body/total spore diameter (0.64–0.7) occur in the younger strata. In this level atypical forms were also represented. These forms show either a distinctive reduction of the intervening walls (trend A), or they show an extremely high ratio of diameter inner body/total spore diameter (trend B).

In an attempt to trace this zonation scheme in southern Ireland the assemblages containing *R. lepidophyta* were compared. This comparison resulted into some remarkable conclusions concerning the variation of the species:

(1) The time-proportionate trend, which Streel (1966) demonstrated for the reduction in total spore diameter and for the increase in ratio of diameter inner body/total spore diameter, could be traced laterally, within the LM and LE phases, between Bantry Bay and Hook Head. Apart from Hook Head, specimens from all the localities from these phases could be attributed on the basis of their mean size (52  $\mu\text{m}$ ) and mean ratio diameter inner body/total spore diameter (0.64) to the DE zones of Streel's zonation scheme; whereas the specimens from the same phases of Hook Head could be attributed to the CD zones (mean size 67  $\mu\text{m}$ , mean ratio diameter inner body/total spore diameter 0.6). Furthermore a comparable geographical relationship was observed with regard to the ornamentation of the distal hemisphere. The specimens of Bantry Bay and Garryvoe frequently show relatively small foveolae (Plate XVII, 5–7), whereas specimens from Hook Head frequently show relatively wide foveolae (Plate XVII, 9).

Warg and Traverse (1973) reached comparable results from their study on *R. lepidophyta* derived from different lithologies.

(2) In the LN and LCr phases (not recorded at Hook Head) some of the atypical forms recorded by Streel (1966) were represented. Furthermore from the LCr phase some specimens comparable with *R. lepidophyta* var. *minor* Kedo and Golubtsov (1971) have been recorded. Since the occurrence of atypical forms of *R. lepidophyta* can be related to the upper part of the range of the species, these forms may have more biostratigraphical value, than the reduction in diameter and the increase in ratio diameter inner body/total spore diameter.

*Distribution elsewhere:* The present species has been recorded from the latest Devonian strata of North America (e.g., McGregor, 1970; Winslow, 1962), Europe (e.g., Kedo, 1957; Clayton et al., 1977c; Turnau, 1978), Iran (Coquel et al., 1977), North Africa (Lanzoni and Magloire, 1969) and Australia (Playford, 1976).

Form genus: *Spelaeotriletes* Neves et Owens 1966

Type species: *Spelaeotriletes triangulus* Neves et Owens 1966

Species: *Spelaeotriletes* sp.

*Figured specimens:* Plate XVIII, 6

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides. Ratio diameter inner body/total spore diameter  $3/4-4/5$ . Wall inner body smooth, thin, frequently folded. Outer wall proximally smooth or finely punctate. Trilete rays distinct, slightly sinuous, labrate ( $3-4\ \mu\text{m}$  in width). Outer wall equatorially thickened ( $3-4\ \mu\text{m}$  in width), thickening in polar view somewhat undulating, due to ornamentation. Outer wall equatorially and distally ornamented with verrucae and occasionally mammillae ( $2-5\ \mu\text{m}$  in width;  $1-2\ \mu\text{m}$  in height) with irregular outline; ornaments frequently basally fused, usually closely spaced ( $0-(1)-3\ \mu\text{m}$  apart). *Observed dimensions:* Total spore diameter  $47-65\ \mu\text{m}$ , diameter inner body  $35-45\ \mu\text{m}$ .

*Remarks:* The present form is assigned to *Spelaeotriletes* on the basis of its pseudosaccate nature and its distal verrucate ornamentation.

The specimens examined show much resemblance to *Archaeozonotriletes famenensis* as recorded in Kedo (1963). However, the original description of Naumova (1953) and the later record by Kedo (1974), Paproth and Streel (1970) and Becker et al. (1974), are rather dissimilar, because of the presence of a more apiculate ornamentation.

The species is distinguished from *Asperispora acuta* (p. 226) and from *Dentatispora* sp. (see below) by its mainly verrucate ornamentation.

Form genus: *Dentatispora* Tiwari 1964

Type species: *Dentatispora indica* Tiwari 1964

Species: *Dentatispora* sp.

*Figured specimens:* Plate XIX, 1.

*Identifying characters:* Overall outline and outline inner body subtriangular with convex sides to subcircular. Ratio diameter inner body/total spore diameter  $1/2-4/5$ . Wall inner body smooth, thin, frequently folded. Outer wall proximally smooth. Trilete rays indistinct or distinct, simple or labrate ( $1-4\ \mu\text{m}$  in width), in length equal to inner body radius or reaching the equator. Outer wall equatorially thickened ( $2-5\ \mu\text{m}$  in width), distally apart from further ornamentation punctate to microreticulate (lumina up to  $1.5\ \mu\text{m}$  in diameter); equatorially and distally ornamented with spinae ( $2-15\ \mu\text{m}$  in height;  $2-(5)-10\ \mu\text{m}$  in width; equatorially usually longer than distally); distal elements randomly distributed ( $0-10\ \mu\text{m}$  apart);  $12-36$  spinae project at the equator.

*Observed dimensions:* Total spore diameter  $40-55\ \mu\text{m}$ , diameter inner body  $20-40\ \mu\text{m}$ .

*Remarks:* The present form differs from the Permian species of *Dentatispora* (compare e.g., Tiwari, 1965) by the combination of its smaller size and its relatively narrow equatorial crassitude.

The present form is rather comparable with *Archaeozonotriletes macrospinosus* var. *punctatus* sensu Kedo (1963), though its spinae are generally longer. It is distinguished from *Asperispora acuta* (p.226) by its usually longer spinae and its well-developed inner body. It differs from *Spelaeotriletes* sp. (p.233) by its apiculate ornamentation.

The specimens depicted in McGregor (1970, plate 21, fig.10) as unidentified, and in Jachowicz (1970) as *Acanthotriletes paucispinus* Naumova (1953), could well be identical with the present form.

Form genus: *Rugospora* Neves et Owens 1966

Type species: *Rugospora corporata* Neves et Owens 1966

Species: *Rugospora* cf. *minuta* Neves et Ioannides 1974

*Holotype*: *Rugospora minuta* Neves et Ioannides 1974, plate 8, fig.7

*Figured specimens*: Plate XIX, 2, 3.

*Identifying characters*: Overall outline and outline inner body subtriangular with convex sides to subcircular. Ratio diameter inner body/total spore diameter about 6/7. Wall inner body thin. Outer wall thin, ornamented with sinuous low rugulae (0.5-(1)-2  $\mu\text{m}$  in width; 2-(5)-10  $\mu\text{m}$  in length; 0-(1)-2  $\mu\text{m}$  apart); frequently radially arranged in the equatorial region; ornamentation proximally reduced or absent. Trilete rays indistinct or distinct, simple or labrate; labra up to 3  $\mu\text{m}$  in width; length 2/3–1/1 of inner body radius.

*Observed dimensions*: Total spore diameter 27-(35)-45  $\mu\text{m}$ , diameter inner body 25-(30)-40  $\mu\text{m}$ .

*Remarks*: The present material is highly comparable with *Rugospora minuta*, it differs by its smaller size, the occasional occurrence of proximal ornamentation, and by frequently being labrate.

Species: *Rugospora* sp. A

*Figured specimens*: Plate XIX, 4, 5.

*Identifying characters*: Overall outline and outline inner body subtriangular with convex sides. Ratio diameter inner body/total spore diameter about 9/10. Wall inner body thin. Outer wall thin, ornamented with sinuous, low rugulae (0.5-1  $\mu\text{m}$  in width, up to 5  $\mu\text{m}$  in length; 0-(1)-3  $\mu\text{m}$  apart). Trilete rays distinct, simple or labrate; labra up to 2  $\mu\text{m}$  in width; length 2/3–1/1 of spore radius.

*Observed dimensions*: Total spore diameter 30-(34)-38  $\mu\text{m}$ , diameter inner body 26-(30)-37  $\mu\text{m}$ .

*Remarks*: The present species is quite comparable with *Hymenozonotriletes rugosciusculus* Juschko in Kedo (1963). An attribution had to be abandoned, as from Kedo's figure it could not be ascertained whether the species is rugulate; furthermore the present material may be distinguished by a usually subtriangular outline. *H. rugosciusculus* as figured by McGregor (1970, plate 23, fig.5) has, however, a subtriangular outline, comparable with the present forms.

*Rugospora* sp. A is distinguished from *Rugospora* cf. *minuta* (p.234) by having a finer ornamentation. Transitional forms have, however, been observed.

Form genus: *Diaphanospora* Balme et Hassel 1962 emend. Evans 1970

1962: *Pulvinispora* Balme et Hassel

Type species: *Diaphanospora riciniata* Balme et Hassel 1962 emend. Evans 1970

Species: *Diaphanospora scolecophora* (Neves et Ioannides 1974) nov. comb. Van der Zwan

Basionym: *Pulvinispora scolecophora* Neves et Ioannides 1974, Geol. Surv. Gt. Br., Bull., 45: 74.

*Holotype*: *Pulvinispora scolecophora* Neves et Ioannides 1974, plate 5, fig.9

*Figured specimens*: Plate XX, 2.

*Remarks*: Since the form genus *Pulvinispora* is synonymous with *Diaphanospora*, the forms have become illegitimate. Therefore a transfer of the present forms into another form genus has become necessary. As the present author interprets the distal rugulate pattern as folds in an outer layer of the spore wall, the present form is assigned to *Diaphanospora*.

Species: *Diaphanospora* cf. *depressa* (Balme et Hassel) Evans 1970

*Holotype*: *Pulvinispora depressa* Balme et Hassel 1962, plate 2, fig.1

*Figured specimens*: Plate XX, 3.

*Identifying characters*: Outline subtriangular with convex sides. Spore wall two-layered; inner layer (3  $\mu\text{m}$  in thickness) proximally smooth. Trilete rays distinct, simple or labrate; labra up to 1  $\mu\text{m}$  in width; length almost equal to inner body radius. Proximal surface of inner layer radially thickened at the equator (thickenings up to 7  $\mu\text{m}$  in width). Inner layer distally ornamented with grana (about 1  $\mu\text{m}$  in width; 0–3  $\mu\text{m}$  apart), occasionally fused into short rugulae. Inner layer closely enveloped by a thin, hyaline outer layer, which is proximally attached and distally loosened and folded.

*Observed diameter*: Diameter inner body 38–48  $\mu\text{m}$ .

*Remarks*: The presence of an outer layer is in most specimens quite distinct. The granulate ornamentation of the specimens is mostly confined to the distal hemisphere of the inner layer; occasionally, however, the ornamentation seems to occur on the outer layer.

The present material is quite comparable with the type material, it differs only by its more subtriangular outline and the slightly thicker inner layer of the spore wall.

Form genus: *Latosporites* Potonié et Kremp 1954

Type species: *Latosporites latus* (Kosanke) Potonié et Kremp 1954

**Species: *Latosporites* sp. A**

*Figured specimens:* Plate XXI, 6, 7.

*Identifying characters:* Outline elliptical. Profile distal hemisphere inflated, giving the spore a preferred eccentric compression. Wall (2–5  $\mu\text{m}$  in thickness) smooth or finely infrastructured. Monolete ray distinct, straight, simple or labrate; labra up to 10  $\mu\text{m}$  in width; length  $3/4$  of spore length, passing into thickened curvaturae (up to 3  $\mu\text{m}$  in width).

*Observed dimensions:* Length 35–63  $\mu\text{m}$ .

*Remarks:* *Latosporites* sp. in Clayton et al. (1977c, plate 5, fig.5) seems quite comparable with the present form.

**Species: *Latosporites* sp. B**

*Figured specimens:* Plate XXI, 8.

*Identifying characters:* Outline elliptical to subcircular. Profile distal hemisphere inflated, giving the spore a preferred eccentric compression. Wall (1–2  $\mu\text{m}$  in thickness) smooth or finely punctate, occasionally folded. Monolete ray distinct, straight, simple or labrate; labra formed by straight to flexuous parallel folds; length  $2/3$ – $4/5$  of spore length.

*Observed dimensions:* Length 44–(50)–58  $\mu\text{m}$ .

*Remarks:* The present form differs from *Latosporites* sp. A (see above) by the absence of thickened curvaturae.

Group: ACROTARCHA Evitt 1963

Genus: *Micrhystridium* Deflandre 1937 emend. Downie et Sarjeant 1963

Type species: *Micrhystridium inconspicuum* (Deflandre) Deflandre 1937

**Species: *Micrhystridium* sp.**

*Figured specimens:* Plate XXI, 4.

*Identifying characters:* Vesicle spherical. Wall (thickness indeterminable) bearing 9–12 processes, tapering from a wide base into a sharp point (8–10  $\mu\text{m}$  in length; 3–5  $\mu\text{m}$  in basal width). Wall otherwise laevigate.

*Observed dimensions:* Vesicle diameter 10–18  $\mu\text{m}$ .

*Remarks:* The opaque nature of the specimens makes an assignment on species level impossible; *Micrhystridium stellatum* Deflandre 1945, however, seems quite comparable.

Phylum: ANNELIDA Lamarck

Classis: POLYCHAETIA Grube

Scolecodonts

Genus: cf. *Staurocephalites* Hinde 1879

Type species: *Staurocephalites niagarensis* Hinde 1879



Species: cf. *Staurocephalites* sp.

Figured specimens: Plate XXI, 9.

Characteristic features: Total length 135  $\mu\text{m}$ , total height 50  $\mu\text{m}$ . Denticles 8–20  $\mu\text{m}$  in height, 6–15  $\mu\text{m}$  in basal width, somewhat inclined towards the posterior.

Remarks: The absence of the posterior part hampers further identification.

#### MORPHONS

After the establishment of the morphon-concept (Van der Zwan, 1979), intended to unite palynological taxa, showing continuous variation in morphological characteristics, this concept has been exemplified by the *Cyrtospora cristifer* morphon (Van der Zwan, 1979; see also Plate XXII) and by the *Auroraspora macra* morphon (Van der Zwan, 1980b).

In the present paper this concept will be applied to (1) a group of granulate/verrucate spores, viz., *Verrucosisporites nitidus*, *V. congestus*, *V. depressus* and *Cyclogranisporites* cf. *leopoldii*, and (2) a group of more or less reticulate spores, viz., *Dictyotriletes submarginatus*, *Dictyotriletes* sp. A, *Asperispora perlota* and ?*Cristatisporites colliculus*.

#### THE VERRUCOSISPORITES NITIDUS MORPHON

The morphological characteristics of *Verrucosisporites nitidus*, *V. congestus*, *V. depressus* and *Cyclogranisporites* cf. *leopoldii* have formed the basis for the recognition of individual taxa. However, the demarcation of these taxa is usually hampered by the frequently occurring transitional forms.

Such transitional forms have been observed between *Verrucosisporites congestus* (p.215) and *V. nitidus* (p.216) (specimens with a limited space between the verrucae; Plate XXV, 1); between *V. nitidus* and *V. depressus* (p.216) (specimens with verrucae of 2–3  $\mu\text{m}$  in width, indistinct trilete rays and no separately recognizable inner layer of the spore wall; Plate XXIV, 1) and between *V. depressus* and *Cyclogranisporites* cf. *leopoldii* (p.215) (specimens with an intermediate diameter and an intermediate size of the grana: Plate XXIII, 2).

Based on the presence of continuous variation linking *V. nitidus*, *V. congestus*, *V. depressus* and *C. cf. leopoldii*, these forms have been united into the *V. nitidus* morphon.

It should be noted that *Verrucosisporites tuberculatus* (p.217), though closely related morphologically, could not be included in this morphon, because of its distinctly smaller proximal ornamentation.

Common characteristics: (1) Equatorial outline — subcircular to subtriangular with convex sides. (2) Ornamentation — proximally and distally ornamented with smooth grana or verrucae.

Variable characteristics: (1) Variation in trilete mark — simple or accompanied by parallel internal thickenings of the spore wall. (2) Variation in

arrangement of ornamentation — continuous variation from forms having a “negative reticulum” towards forms with well-separated verrucae. (3) Variation in spore wall — presence of forms with a probably single-layered spore wall and of forms with a two-layered wall.

### *Biostratigraphical significance*

#### *Bantry Bay and Coomhola River*

The present concept of the *Verrucosisporites nitidus* morphon has been based on material from the Upper Devonian — Lower Carboniferous of the Bantry Bay and Coomhola River sections. When applying the scheme of phases in compositional development, deposits containing members of the *V. nitidus* morphon can be correlated with the *Retispora lepidophyta* Assemblage Zone (LM, LN, LCr phases), with the *Verrucosisporites nitidus* Assemblage Zone and with the *Spelaeotriletes pretiosus* Assemblage Zone (Table XI). The individual species have their first appearance at different intervals in this scheme; *V. depressus* in the LM phase, *V. nitidus* at the base of the LN phase, *V. congestus* within the LN phase and *C. cf. leopoldii* in the LCr phase. *V. depressus*, *V. nitidus* and *V. congestus* are common elements throughout, except in the LM phase; *C. cf. leopoldii* is rare.

#### *Comparison within Ireland*

**Bolteen—Relane** (Table III) — Only the LN phase is represented. Here *V. depressus* and *V. congestus* appear first and *V. nitidus* appears later; *V. depressus* is the most common species.

**Toe Head** (Table IV) — Only the LN phase is represented. In this section *V. nitidus* appears earlier than *V. depressus*; both species are rather rare.

**White Bay** (Table V) — *V. nitidus* has been recorded from the NR phase.

**Garryvoe** (Table VI) — In this section *V. depressus* appears first late in the LE—LN phases. *V. nitidus* appears early in the NR phase and *V. congestus* appears within the NR phase. Together they are equally represented throughout the *Verrucosisporites nitidus* Assemblage Zone.

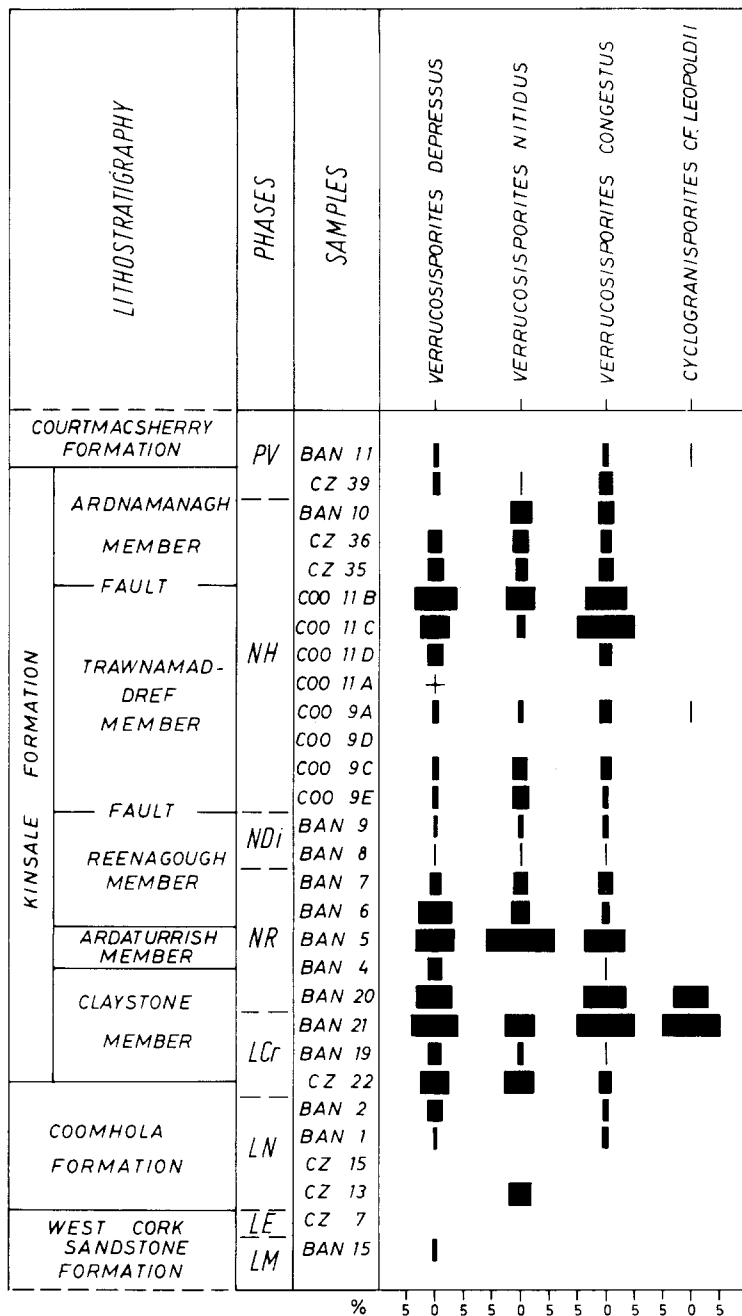
**Ardmore, Helvick Head** (Table VIII) — *V. nitidus*, *V. congestus* and *V. depressus* have been recorded from the NR phase and from the NDi phase, respectively.

**Hook Head** (Table VII) — *V. nitidus*, *V. congestus* and *V. depressus* occur regularly in the NR and NH phases.

Clayton et al. (1974) used the first appearance of *V. nitidus* in southern Ireland to draw an important zonal boundary: the boundary between the PL zone and the LN subzone of the NV zone (see Table X). However, *V. nitidus* shows continuous variation with *V. depressus*. The transitional forms are difficult to identify and consequently any boundary based on the first occurrence of *V. nitidus* remains highly subjective.

TABLE XI

Quantitative distribution of the *Verrucosiporites nitidus* morphon in the Bantry Bay and Coomhola River sections (+ qualitative record)



*Distribution elsewhere*

*Verrucosisorites nitidus* has been recorded from North America (e.g., Playford, 1964), Western Europe (e.g., Clayton et al., 1977c), Poland (Turnau, 1978), the U.S.S.R. (Naumova, 1953) and Australia (Playford, 1971, 1976, 1978). These occurrences range in age from Late Devonian up to Viséan.

*Verrucosisorites congestus* has been recorded from North America (e.g., Playford, 1964; McGregor, 1970), Western Europe (Mortimer and Chaloner, 1972; Burmann, 1975) and from Algeria (Lanzoni and Magloire, 1969). These occurrences range in age from Late Devonian to Viséan.

*Verrucosisorites depressus* was described from Ohio, U.S.A. (Winslow, 1962) and was subsequently reported from Iran (Coquel et al., 1977). These records are of Tournaisian age.

*Cyclogranisorites leopoldii* was originally described from the Late Carboniferous of Germany (Kremp, 1952).

*Discussion*

The information available suggests that in southern Ireland the qualitative and quantitative representation of some of the members of the *V. nitidus* morphon (viz., *V. nitidus*, *V. congestus*) may be used for regional biostratigraphy. However, on an interregional scale the stratigraphical application is hampered by differences in first appearance at different localities.

Noteworthy is the variation in distribution pattern of the *V. nitidus* morphon in southern Ireland, as observed by Van der Zwan and Van Veen (1978). Although the individual members of the *V. nitidus* morphon can be found in different environments, their maximum quantitative representation is in the alluvial plain environment.

This distribution pattern, together with the continuous variation linking the individual members, might indicate that the *V. nitidus* morphon reflects the intraspecific morphological variation of spores of a single plant taxon. On the other hand, however, because of the vast environment preferred, it is not possible to decide whether or not the *V. nitidus* morphon represents a natural morphological variation.

Consequently the *V. nitidus* morphon is here proposed as a practical, purely morphological unit for informally classifying a category of Late Devonian—Early Carboniferous verrucate/granulate spores.

THE *DICTYOTRILETES SUBMARGINATUS* MORPHON

The individually recognized reticulate species *Dictyotriletes submarginatus* (p.223), *Dictyotriletes* sp. A (p.224), *Asperispora perlota* (p.228) and *?Cristatisporites colliculus* (p.228) are characteristic elements of Late Devonian—Early Carboniferous deposits of southern Ireland. A distinction between these species, however, is generally difficult, as many transitional forms occur.

Such transitions have been found between *A. perlota* and *D. submarginatus* (forms with a narrow equatorial crassitude and a reticulum of more or less

confluent bacula or conii; Plate XXVII, 1); between *D. submarginatus* and *Dictyotriletes* sp. A (forms with an equatorial ring and a reticulum formed by confluent verrucae; Plate XXVIII, 4); between *D. submarginatus* and ?*C. colliculus* (forms with an equatorial ring and a reticulum with narrow lumina and muri formed by confluent bacula and spinae; Plate XXIX, 4); and between *Dictyotriletes* sp. A and ?*C. colliculus* (forms with a reticulum formed by confluent mammillae; Plate XXIX, 3).

Based on the continuous variation observed between *D. submarginatus*, *Dictyotriletes* sp. A, *A. perlota* and ?*C. colliculus*, these forms have been united into the *D. submarginatus* morphon.

Common characteristics: (1) Overall outline — subtriangular with convex sides. (2) Trilete mark — distinct, straight or sinuous, labrate, length equal to inner body radius. (3) Outer wall — proximally smooth, distally ornamented with a reticulum.

Variable characteristics: (1) Variation in width of the equatorial crassitude — continuous variation is observed from forms with a wide equatorial crassitude, forms with an equatorial ring, to forms without an equatorial crassitude. (2) Variation in dimensions, shape and arrangement of the distal ornamentation — continuous variation is observed from forms having a reticulum with relatively wide lumina and muri, formed by more or less confluent bacula and conii; forms having a reticulum with relatively wide lumina and undulating muri with serrate tops; forms having a reticulum with relatively narrow lumina and muri formed by confluent verrucae; forms having a reticulum formed by the fusion of spinae; to forms having variably spaced, discrete cristae.

### *Biostratigraphical significance*

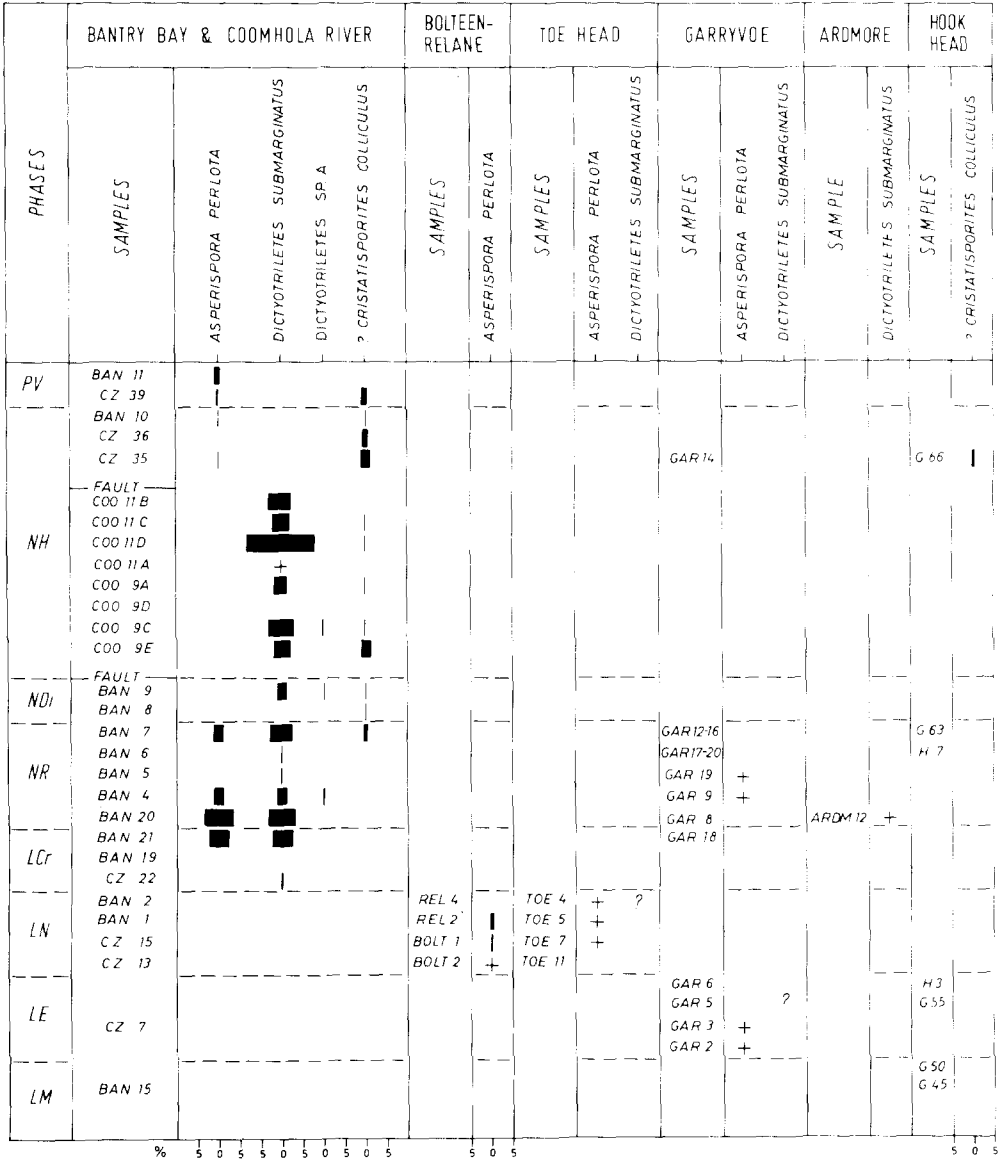
#### *Bantry Bay and Coomhola River*

The present concept of the *D. submarginatus* morphon has been based on material from the Upper Devonian—Lower Carboniferous of the Bantry Bay and Coomhola River sections. When applying the scheme of phases in compositional development, deposits containing species of the *D. submarginatus* morphon can be correlated with the *Retispora lepidophyta* Assemblage Zone (LCr phase), with the *Verrucosisporites nitidus* Assemblage Zone and with the *Spelaeotriletes pretiosus* Assemblage Zone. The individual species occur at different intervals of this scheme (Table XII): *A. perlota* from the LCr phase up to the PV phase; *D. submarginatus* from the LCr phase up to the NH phase; *Dictyotriletes* sp. A from the NR phase up to the NH phase; and ?*C. colliculus* from late in the NR phase up to the PV phase.

In this scheme only *A. perlota*, *D. submarginatus* and ?*C. colliculus* are regular components; *Dictyotriletes* sp. A is rare. Furthermore, *A. perlota* and *D. submarginatus* are most important in the LCr and NR phases; *D. submarginatus* and ?*C. colliculus* are important in the NDi and NH phases; and *A. perlota* and ?*C. colliculus* are equally represented in the late NH phase and in the PV phase.

TABLE XII

Quantitative distribution of the *Dictyotriletes submarginatus* morphon in the south Irish sections studied (+ qualitative record)



Thus, on the basis of the first occurrences and increase in quantitative importance, one may recognize a time-proportionate trend: from *A. perlota* and *D. submarginatus* in the LCr and NR phases to *A. perlota*, *D. submarginatus* and ?*C. colliculus* in the NDi—PV phases.

In order to evaluate regional significance of this qualitative and quantitative information, the data from Bantry Bay—Coomhola River are hereafter compared with those from other localities in Ireland (see Table XII).

#### *Comparison within Ireland*

**Bolteen—Relane** — In this section the species of the *D. submarginatus* morphon are already present in the LN phase; the recorded forms are all attributed to *A. perlota*.

**Toe Head** — In this section the species are present in the LN phase; they are mainly attributed to *A. perlota*, but occasionally specimens transitional between *A. perlota* and *D. submarginatus* are recognized.

**Garryvoe** — In this section species are present in the LE—LN and NR phases. Those from the LE—LN phase are attributed to *A. perlota*, additionally a transitional specimen between *A. perlota* and *D. submarginatus* is recorded. From the NR phase only *A. perlota* is recorded.

**Ardmore** — The investigated sample assigned to the early NR phase contained one specimen of *D. submarginatus*.

**Hook Head** — Higgs (1975) recorded *D. submarginatus* occurring in assemblages which may be regarded to range from the LE up to the PV phases; however, no specimens were illustrated and subsequently no conclusive assignment to any of the members of the morphon is possible. The present author recorded ?*C. colliculus* in sample G66, assigned to the NH phase.

**Other records from southern Ireland** — Clayton et al. (1974), Clayton in Naylor (1975), Naylor et al. (1977), Keegan (1977) and Sleeman et al. (1978) recorded *D. submarginatus*, as well as *C. colliculus* from their LL, LE, LN, VI subzones (*Retispora lepidophyta* and *Verrucosiporites nitidus* Assemblage Zones), in many sections along the south coast of Ireland. As no sufficient illustrations and descriptions are given, conclusive assignment to any member of the morphon is impossible.

It should be noted that *A. perlota* was also recorded by Clayton and Graham (1974) from Givetian or Frasnian rocks of Clear Island, South Ireland.

The data from the above-mentioned sections are supplementary to those from Bantry Bay and Coomhola River, especially with regard to the LE and LN phases and the Givetian/Frasnian record. In the LE, LN phases *A. perlota* is most common and specimens transitional between *A. perlota* and *D. submarginatus* are occasionally recorded. As these transitional specimens are recorded, the possibility of finding a typical *D. submarginatus* is not excluded.

#### *Distribution elsewhere*

In order to assess the interregional significance of the *D. submarginatus* morphon, comparisons have been made with localities outside Ireland:

Nova Scotia, Canada — Playford (1964) described from Tournaisian deposits *D. submarginatus*; the specimens of his plate 8, 11–13, may be assignable to *Dictyotriletes* sp. A.

North Wales — Hibbert and Lacey (1969) described specimens as *D. cf. submarginatus* from Visean deposits.

Scotland — Neves et al. (1973) depicted a specimen from Visean deposits as *D. submarginatus*.

England — Mortimer and Chaloner (1972) described specimens assignable to *A. perlota* from the Frasnian.

Denmark — Bertelsen (1972) described *D. cf. submarginatus* from the Visean.

G.D.R. — Burmann (1975) recorded from the Middle Tournaisian *Dictyotriletes asperites*, which may be compared with ?*C. colliculus*.

Poland — Turnau (1975) recorded from the Middle Tournaisian and Lower Visean *D. submarginatus*, which is highly comparable with *Dictyotriletes* sp. A.

U.S.S.R. — Naumova (1953), Kedo (1957), Nekrajata (1974) recorded *A. perlota* from Late Frasnian and Famennian deposits. Byvsheva (1976, plate 17, 6) recorded *Archaeozonotriletes mischkinensis* Byvsheva 1971, which she compared with *D. submarginatus*; from the photomicrographs, however, no conclusive identification is possible.

Australia — Playford (1971, 1978) recorded ?*C. colliculus* from the Visean of the Bonaparte Gulf Basin, northern Australia and from the Drummond Basin, Queensland.

The specimens depicted in Playford (1976) of assemblages derived from the Upper Tournaisian (sample: Laural Downs-2, core 3, 76, 2–79 m), of the Canning Basin, Western Australia, exhibit a variation of forms assignable to ?*C. colliculus* and to forms perhaps comparable with *D. submarginatus*; thus one may note a comparable variation as found in the NH phase in Bantry Bay.

### Discussion

From the above given information it may be deduced that within assemblages from the Late Devonian–Early Carboniferous transition sequences of southern Ireland one may recognize a time-proportionate trend showing a gradual shift from assemblages characterized by *A. perlota*, via assemblages characterized by *A. perlota* and *D. submarginatus* to assemblages with *A. perlota*, *D. submarginatus* and ?*C. colliculus*. In combination with the scarce data from outside Ireland, it seems reasonable to suspect *A. perlota* to be the characteristic element from the Givetian/Frasnian up to the Famennian and earliest Tournaisian strata, and *D. submarginatus* with ?*C. colliculus* to characterize the Tournaisian and Visean strata.

The possible existence of a time-proportionate trend may support the view that the elements of the *D. submarginatus* morphon reflect the natural variation of the spores of a single plant taxon. Therefore one might as well tentatively consider the *D. submarginatus* morphon in southern Ireland to constitute a series of palynodemes (compare Visscher, 1971).



However, because of the lack of quantitative information from Givetian/Frasnian and Visean strata, as well as from areas outside Ireland, such an evolutionary model can not yet be fully established. Consequently, the *D. submarginatus* morphon is here regarded as a practical morphological unit for classifying reticulate spores showing continuous morphological variation, transgressing their species boundaries.

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PLATE I (approx.  $\times$  900) (p.257)

1. *Punctatisporites debilis* Hacquebard 1957.
2. *Punctatisporites solidus* Hacquebard 1957.
3. *Phyllothecotriletes nigratus* (Naumova) De Jersey 1966.
4. *Retusotriletes incohatus* Sullivan 1964.
5. *Leiotriletes ornatus* Ischenko 1956.
6. *Retusotriletes leptocentrum* Higgs 1975.
7. *Retusotriletes planus* Dolby et Neves 1970.
8. *Retusotriletes* sp. A of Higgs 1975.
9. *Apiculiretusispora fructicosa* Higgs 1975.
10. *Aneurospora* cf. *semizonalis* (McGregor) Lele et Streel 1969; a, b: proximal and distal view.

PLATE II (approx.  $\times$  900, unless otherwise stated) (p.258)

- 1, 2. *Aneurospora* cf. *greggsii* (McGregor) Streel in Becker et al. 1974.
- 3, 4. ?*Aneurospora* sp. A (present paper); 3a, b: distal and proximal view.
- 5, 9. *Granulatisporites microgranifer* Ibrahim 1933.
6. *Verrucosisporites tuberculatus* (Kedo) Turnau 1978 (approx.  $\times$  1250); a: most distal view; b: equatorial view; c: proximal view, inner layer; d: most proximal view.
7. *Cyclogranisporites commodus* Playford 1964.
8. *Granulatisporites parvus* (Ibrahim) Potonié et Kremp 1954.

PLATE III (approx.  $\times$  900, unless otherwise stated) (p.259)

1. *Lophotriletes linguaeformis* Bertelsen 1972; a, b: proximal and distal view.
2. *Pustulatisporites* sp. A of Higgs 1975.
3. *Verrucosisporites* sp. A (present paper).
- 4, 5. *Planisporites* sp. A (present paper).
6. *Lophozonotriletes* sp. (scanning micrograph, approx.  $\times$  2000).
7. *Lophozonotriletes lebedianensis* Naumova 1953; a, b: proximal and distal view.

PLATE IV (approx.  $\times$  900) (p.260)

1. *Lophozonotriletes* cf. *lebedianensis* Naumova 1953; a, b: proximal and distal view.
- 2-7. *Lophozonotriletes bellus* Kedo 1963; 2: specimen resembling *Lophozonotriletes* aff. *excisus* sensu Kedo 1963; a, b: proximal and distal view; 3a, b: proximal and distal view; 4a, b, c: proximal, equatorial and distal view; 5: distal view; 6: specimen in eccentric compression, showing a: curvaturae and b: distal ornamentation; 7: form transitional to *Lophozonotriletes excisus* Naumova 1953, specimen in eccentric compression, showing a: contact area and b: distal ornamentation.
8. *Lophozonotriletes excisus* Naumova 1953; specimen with, in part, equatorially arranged rugulae; a, b: proximal and distal view.

PLATE V (approx.  $\times$  900) (p.261)

1. *Lophozonotriletes excisus* Naumova 1953; a, b: proximal and distal view.
2. *Lophozonotriletes bellus* Kedo 1963.
- 3-6. *Lophozonotriletes curvatus* Naumova 1953; 3, 4, 5, specimens in eccentric compression; 3, showing a: contact area and b: equatorial ornamentation; 4, showing a: contact area and b: distal ornamentation; 5, showing a: contact area with equatorial ornamentation, b: trilete rays and c: distal ornamentation; 6, specimen in polar compression, a, b: proximal and distal view.



PLATE VI (approx.  $\times$  900) (p.262)

1. *Lophozonotriletes tuberosus* Sullivan 1964.
- 2, 3. *Baculatisporites fusticulus* Sullivan 1968.
- 4, 5. *Dibolisporites distinctus* (Clayton) Playford 1976; 4: specimen from Hook Head; 5: specimen from Bantry Bay.
6. *Dibolisporites abstrusus* (Playford) Playford 1976.
7. *Ceratosporites delicatus* (Higgs 1975) nov. comb. Van der Zwan.
8. *Raistrickia macrura* (Luber) Dolby et Neves 1970.
9. *Raistrickia baculosa* Hacquebard 1957.
10. *Raistrickia variabilis* Dolby et Neves 1970.

PLATE VII (approx.  $\times$  900, unless otherwise stated) (p.263)

1. *Raistrickia spathulata* (Winslow) Higgs 1975.
2. *Convolutispora vermiformis* Hughes et Playford 1961.
- 3, 4. *Convolutispora* cf. *usitata* Playford 1962; 4: scanning micrograph, approx.  $\times$  1000.
- 5, 6. *Camptotriletes* sp. A (present paper); 5: specimen in eccentric compression, showing contact area; 6: scanning micrograph, approx.  $\times$  1000 .

PLATE VIII (approx.  $\times$  900) (p.264)

1. *Camptotriletes* sp. A (present paper); specimen in eccentric compression, showing a: distal ornamentation and b: contact area.
2. ?*Acinosporites* sp. A (present paper).
3. ?*Dictyotriletes trivialis* Naumova in Kedo 1963; a, b: distal and proximal view.
4. *Dictyotriletes* cf. *minor* Naumova 1953; a, b: proximal and distal view.
5. *Corbulispora subalveolaris* (Luber) Sullivan 1964.
6. ?*Reticulatisporites fimbriatus* Winslow 1962.
7. *Emphanisporites hibernicus* Clayton, Higgs et Keegan 1977.
8. *Emphanisporites rotatus* McGregor 1961.
9. *Stenozonotriletes clarus* Ischenko 1956.

PLATE IX (approx.  $\times$  900, unless otherwise stated) (p.265)

1. *Murospora dubitata* Higgs 1975.
- 2, 3. *Knoxisporites literatus* (Waltz) Playford 1963; 2a, b: distal and proximal view.
4. *Knoxisporites hederatus* (Ischenko) Playford 1963; a, b: proximal and distal view.
5. *Knoxisporites ruhlandii* Doubinger et Rauscher 1966.
- 6, 7. *Crassispora maculosa* (Knox) Sullivan 1964; specimens in eccentric compression, 6: contact area, 7: scanning micrograph, approx.  $\times$  500.

PLATE X (approx.  $\times$  900) (p.266)

1. *Hystricosporites* sp. (present paper); a, b, c: proximal, equatorial and distal view.
2. *Corystisporites* sp. of Van Veen (in prep.); specimen in eccentric compression, showing a: contact area and b: distal ornamentation.
3. *Crassispora maculosa* (Knox) Sullivan 1964; specimen in eccentric compression, showing both contact area and distal ornamentation.

PLATE XI (approx.  $\times$  900, unless otherwise stated) (p.267)

1. *Crassispora trychera* Neves et Ioannides 1974.
- 2, 3. *Densosporites spitsbergensis* Playford 1963.
- 4-6, 9. *Tumulispora rarituberculata* (Luber) Potonié 1966; 4, 5: atypical specimens; 6: variant B; 9: scanning micrograph, approx.  $\times$  2000.

- 7, 8. *Tumulispora variverrucata* (Playford) Staplin et Jansonius 1964; 7: scanning micrograph, approx.  $\times$  2000; 8a, b: distal and proximal view.

PLATE XII (approx.  $\times$  900) (p.268)

- 1—3. *Tumulispora variverrucata* (Playford) Staplin et Jansonius 1964; 1a, b: distal and proximal view; 2a, b: distal and proximal view; 3a, b: distal and proximal view.  
4—8. *Tumulispora rarituberculata* (Luber) Potonié 1966; 4: variant A, a, b: distal and proximal view; 5—8: variant B; 5, specimen in eccentric compression, showing a: distal ornamentation, and b: equatorial crassitude; 6a, b: distal and proximal view; 7a, b: distal and proximal view; 8a, b: proximal and distal view.

PLATE XIII (approx.  $\times$  900) (p.269)

- 1—5. *Asperispora acuta* (Kedo 1963) nov. comb. Van der Zwan; 1, specimen in eccentric compression, showing a: equatorial crassitude and b: distal ornamentation; 2a: distal view, b: equatorial view, showing folded wall inner body; 3a, b: proximal and distal view; 4a, b: proximal and distal view; 5: tetrade.

PLATE XIV (approx.  $\times$  900) (p.270)

- 1, 2. *Vallatisporites vallatus* Hacquebard 1957; 1: specimen from the PV phase; 2: specimen from the LCr phase.  
3—6. *Vallatisporites verrucosus* Hacquebard 1957; 3: specimen from the PV phase; 4—6: specimens from the LN—LCr phases; 5a, b: proximal and distal view.  
7, 8. *Vallatisporites* sp. = *C. hystricosus* Winslow 1962; 7a, b, c: proximal, distal and equatorial view.

PLATE XV (approx.  $\times$  900) (p.271)

- 1, 2. *Hymenozonotriletes explanatus* (Luber) Kedo 1963.  
3, 9. *Auroraspora asperella* (Kedo) Van der Zwan 1980b; figured 3: variant B, and 9: variant A of Van der Zwan 1980b.  
4, 5. *Kraeuselisporites hibernicus* Higgs 1975; 5a, b: proximal and distal view.  
6. *Auroraspora rectiformis* (Naumova) Van der Zwan 1980b.  
7. *Colatisporites decorus* (Bharadwaj et Venkatachala) Williams in Neves et al. 1973; figured: variant A of Van der Zwan 1980b.  
8. *Endoculeospora gradzinskii* Turnau 1975; figured: variant B of Van der Zwan 1980b.  
10. *Auroraspora macra* Sullivan 1968.

PLATE XVI (approx.  $\times$  900, unless otherwise stated) (p.272)

1. *Grandispora echinata* Hacquebard 1957.  
2. *Calyptosporites triangulatus* Higgs 1975 (approx.  $\times$  700).  
3. *Auroraspora hyalina* (Naumova) Streel in Becker et al. 1974.  
4. *Grandispora* cf. *notensis* Playford 1971.  
5. *Grandispora cornuta* Higgs 1975.  
6. ?*Grandispora conspicua* (Playford) Playford 1971; specimen in eccentric compression, showing a: contact area and b: equatorial ornamentation.

PLATE XVII (approx.  $\times$  900) (p.273)

1. *Grandispora* sp. A (present paper); a, b, c: proximal, equatorial and distal view.  
2, 3. *Grandispora* sp. B (present paper); 2: proximal view, showing apical papillae; 3a, b: proximal and distal view.

- 4—9. *Retispora lepidophyta* (Kedo) Playford 1976; 4—8, specimens from Bantry Bay, 4: specimen resembling var. *tener* Kedo 1963; 5—7: foveolate specimens; 6: specimen with minute foveolae; 8: small specimen from the LCr phase, comparable with var. *minor* Kedo and Golubtsov 1971; 9: foveoreticulate specimen from Hook Head .

PLATE XVIII (approx.  $\times$  900) (p.274)

1. *Spelaeotriletes obtusus* Higgs 1975.
2. *Discernisporites micromanifestus* (Hacquebard) Sabry et Neves 1971.
3. *Spelaeotriletes crustatus* Higgs 1975.
4. Apiculate pseudosaccate spore type A; a, b: proximal and distal view.
5. *Spelaeotriletes resolutus* Higgs 1975.
6. *Spelaeotriletes* sp. (present paper); a, b: proximal and distal view.
7. *Spelaeotriletes pretiosus* (Playford) Neves et Belt 1970.
8. *Spelaeotriletes balteatus* (Playford) Higgs 1975.

PLATE XIX (approx.  $\times$  900, unless otherwise stated) (p.275)

1. *Dentatispora* sp. (present paper); a, b, c: proximal, equatorial and distal view.
- 2, 3. *Rugospora* cf. *minuta* Neves et Ioannides 1974.
- 4, 5. *Rugospora* sp. A (present paper).
6. *Rugospora flexuosa* (Juschko) Streel in Becker et al. 1974; a, b: proximal and distal view.
7. ?*Ancyrospora capillata* Dolby et Neves 1970 (approx.  $\times$  450).

PLATE XX (approx.  $\times$  900) (p.276)

1. *Rugospora flexuosa* (Juschko) Streel in Becker et al. 1974; a, b: proximal and distal view.
2. *Diaphanospora scolecophora* (Neves et Ioannides 1974) nov. comb. Van der Zwan; a, b: proximal and distal view.
3. *Diaphanospora* cf. *depressa* (Balme et Hassel) Evans 1970; a, b, c: proximal, equatorial and distal view.
- 4, 5. *Perotrilites caperatus* Higgs 1975; 5: showing zona.
6. *Diducites mucronatus* (Kedo) Van Veen (in press).

PLATE XXI (approx.  $\times$  900) (p.277)

1. *Diducites mucronatus* (Kedo) Van Veen (in press).
2. *Diducites poljessicus* (Kedo) Van Veen (in press).
3. *Diducites versabilis* (Kedo) Van Veen (in press).
4. *Micrhystridium* sp. (present paper).
5. *Diducites plicabilis* Van Veen (in press).
- 6, 7. *Latosporites* sp. A (present paper).
8. *Latosporites* sp. B (present paper).
9. cf. *Staurocephalites* sp. (present paper).

PLATE XXII (approx.  $\times$  900) (p.278)

Members of the *Cyrtospora cristifer* morphon of Van der Zwan 1979; additional photomicrographs.

1. *Mooreisporites* sp. A of Van der Zwan 1979.
- 2—5. *Ceratosporites* sp. A of Van der Zwan 1979; 2, specimen transitional to *Mooreisporites* sp. A, having some radially arranged bacula, a, b: distal and proximal view; 3, specimen transitional to *Mooreisporites* sp. A, having bacula both radially arranged

and concentrated near the distal pole, a, b: distal and equatorial view; 4, specimen with more or less distally concentrated bacula, a, b: distal and proximal view; 5, specimen transitional to *Cyrtospora cristifer* variant B, having thicker distal spore wall and ornamentation concentrated near the distal pole, specimen in eccentric compression, showing a: distal spore wall and b: contact area.

- 6—8. *Cyrtospora cristifer* (Luber) Van der Zwan 1979; 6, variant B, a, b: distal and proximal view; 7, 8, variant A; 8: specimen with some radially arranged ornamentation.

PLATE XXIII (approx.  $\times$  1250, unless otherwise stated) (p.279)

1. *Cyclogranisporites* cf. *leopoldii* (Kremp) Potonié et Kremp 1954; a, b: distal and proximal view.  
2—7. *Verrucosisorites depressus* Winslow 1962; 2: specimen transitional to *C.* cf. *leopoldii*; 3: specimen showing two-layered spore wall; 5, 6: scanning micrographs, approx.  $\times$  1000; 7a, b: distal and proximal view.

PLATE XXIV (approx.  $\times$  1250) (p.280)

- 1—5. *Verrucosisorites nitidus* Playford 1964; 1: specimen transitional to *V. depressus*; 2, specimen in eccentric compression, showing a: trilete rays and b: equatorial and distal ornamentation; 4, specimen in eccentric compression, showing a: distal ornamentation and b: trilete rays.

PLATE XXV (approx.  $\times$  1250; scanning micrograph  $\times$  1000 (p.281)

- 1—5. *Verrucosisorites congestus* Playford 1964; 1: specimen transitional to *V. nitidus*; 5: specimen resembling *V. gobettii* Playford 1962.

PLATE XXVI (approx.  $\times$  1250) (p.282)

- 1, 2. *Asperispora perlota* (Naumova 1953) nov. comb. Van der Zwan; 1: specimen in eccentric compression, showing a: trilete rays, b: wall inner body and c: distal ornamentation; 2a, b, c: proximal, equatorial and distal view.

PLATE XXVII (approx.  $\times$  1250) (p.283)

1. Form intermediate between *Asperispora perlota* and *Dictyotriletes submarginatus*; a, b, c: proximal, equatorial and distal view.  
2, 3. *Dictyotriletes submarginatus* Playford 1964; 2a, b: proximal and distal view; 3: tetrad.

PLATE XXVIII (approx.  $\times$  1250; scanning micrographs  $\times$  1000) (p.284)

- 1—5. *Dictyotriletes submarginatus* Playford 1964; 1, 5: specimens with reduced equatorial ring, 1a, b: proximal and distal view; 2, 3: scanning micrographs showing distal ornamentation; 4: specimen transitional to *Dictyotriletes* sp. A, a, b: proximal and distal view.

PLATE XXIX (approx.  $\times$  1250) (p.285)

- 1—3. *Dictyotriletes* sp. A (present paper); 1a, b: proximal and distal view; 3: specimen transitional to ?*Cristatisporites colliculus*.  
4. *Dictyotriletes submarginatus* Playford 1964; specimen transitional to ?*Cristatisporites colliculus*, a, b: proximal and distal view.

PLATE XXX (approx.  $\times$  1250, unless otherwise stated) (p. 286)

- 1—5. ?*Cristatisporites colliculus* Playford 1971; 1a, b: proximal and distal view; 3: specimen with discrete ornamentation; 4: tetrad, scanning micrograph, approx.  $\times$  1000; detail showing reticulum, scanning micrograph, approx.  $\times$  5000.

## PLATE I (explanation on p. 252)

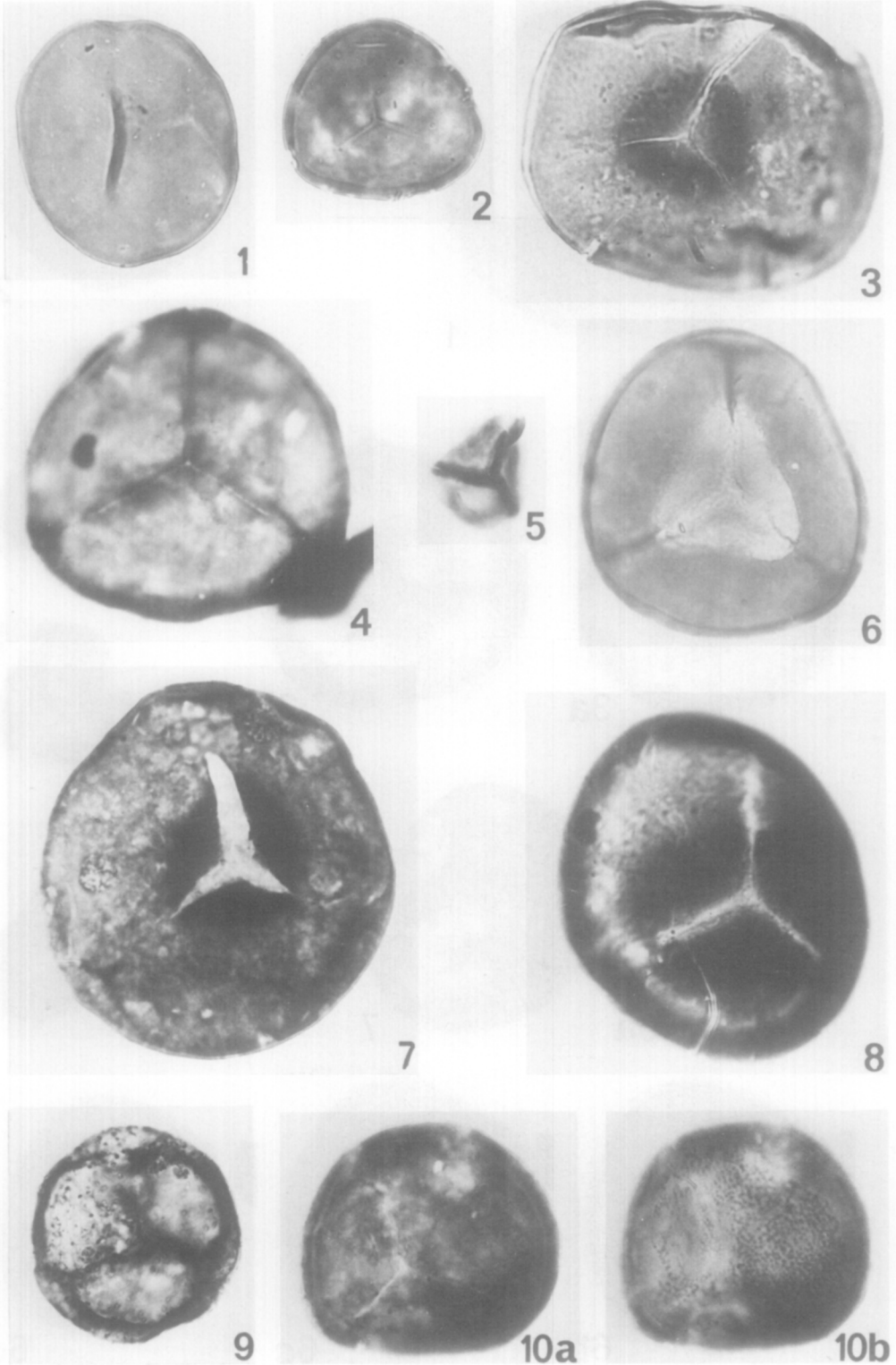
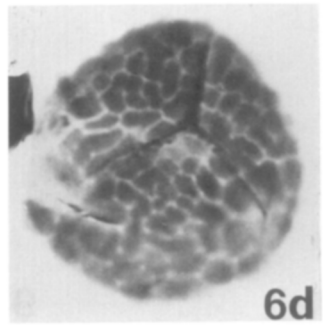
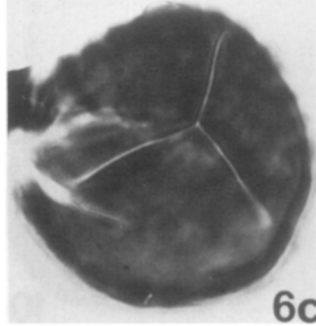
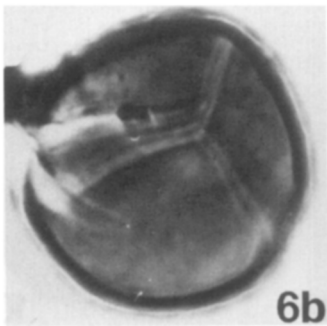
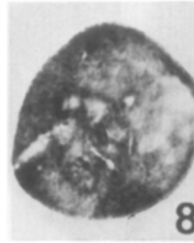
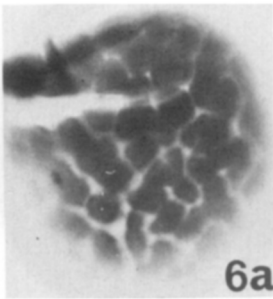
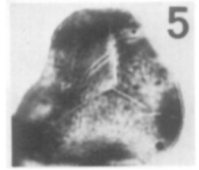
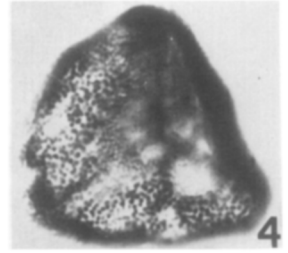
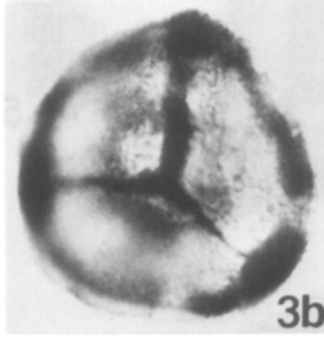
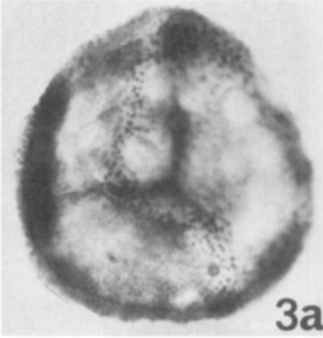
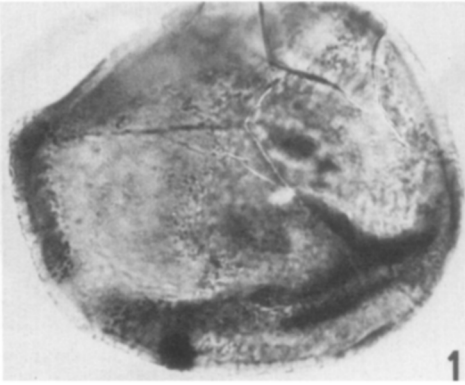


PLATE II (explanation on p. 252)



## PLATE III (explanation on p. 252)

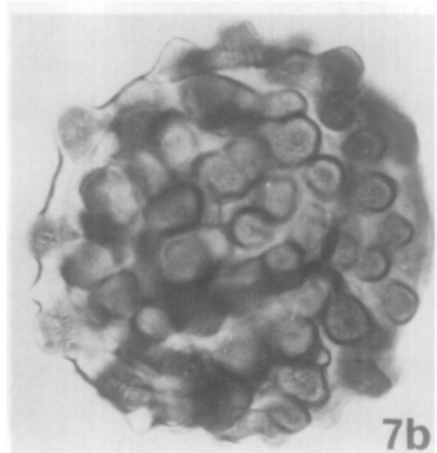
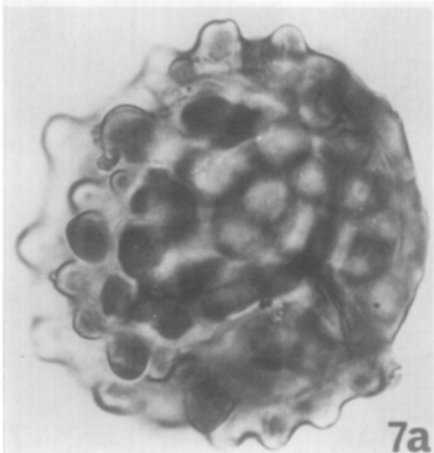
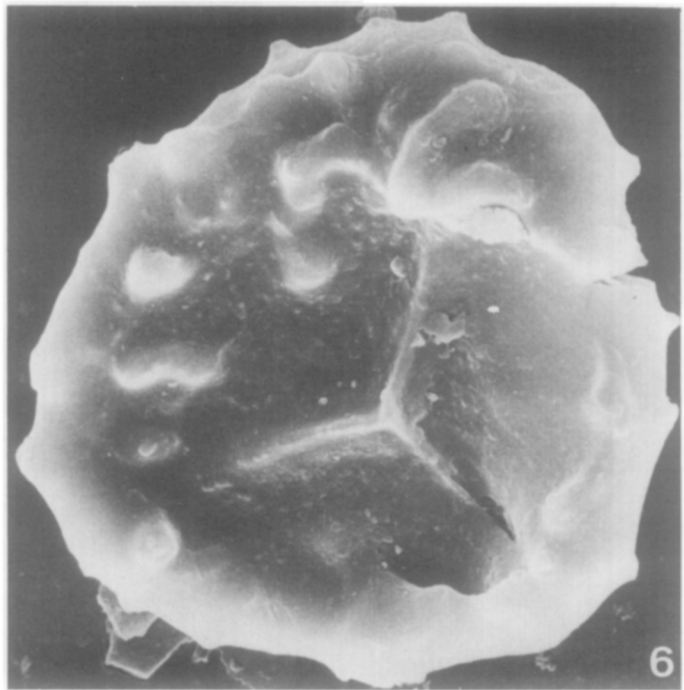
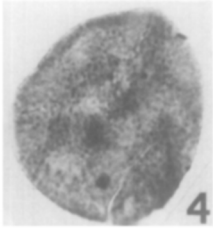
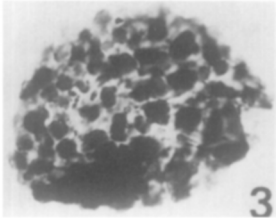
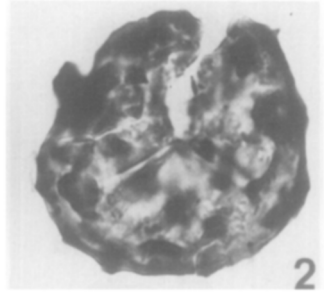
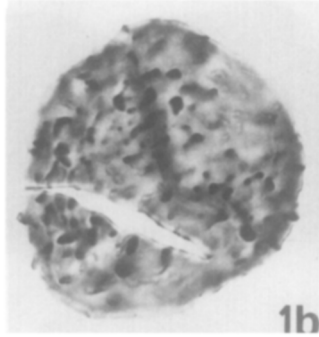
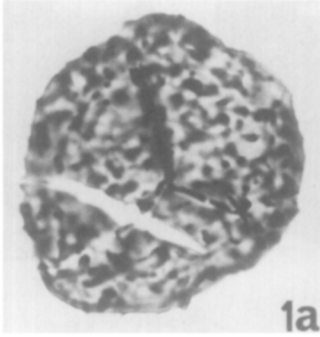
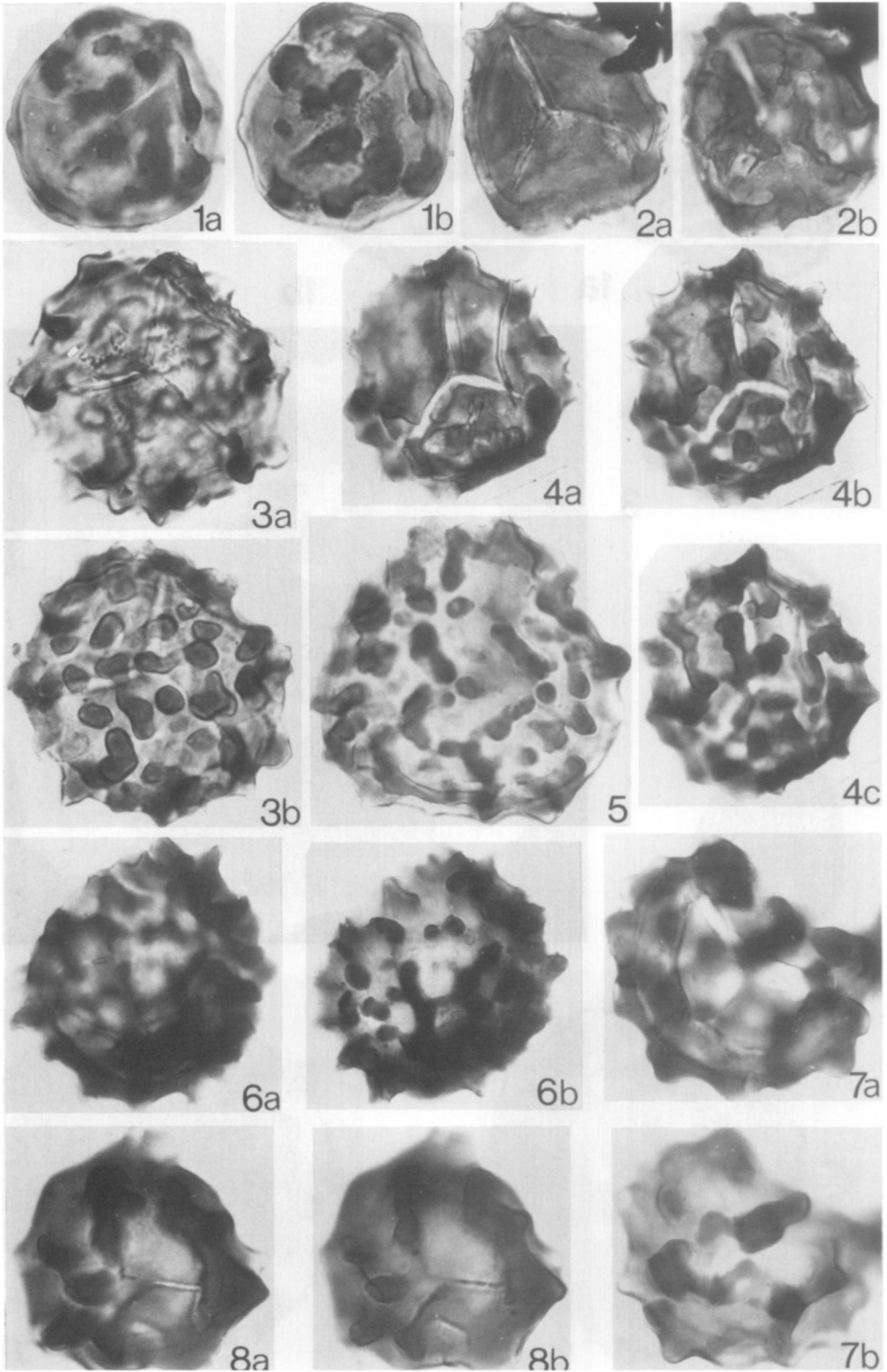


PLATE IV (explanation on p. 252)





## PLATE V (explanation on p. 252)

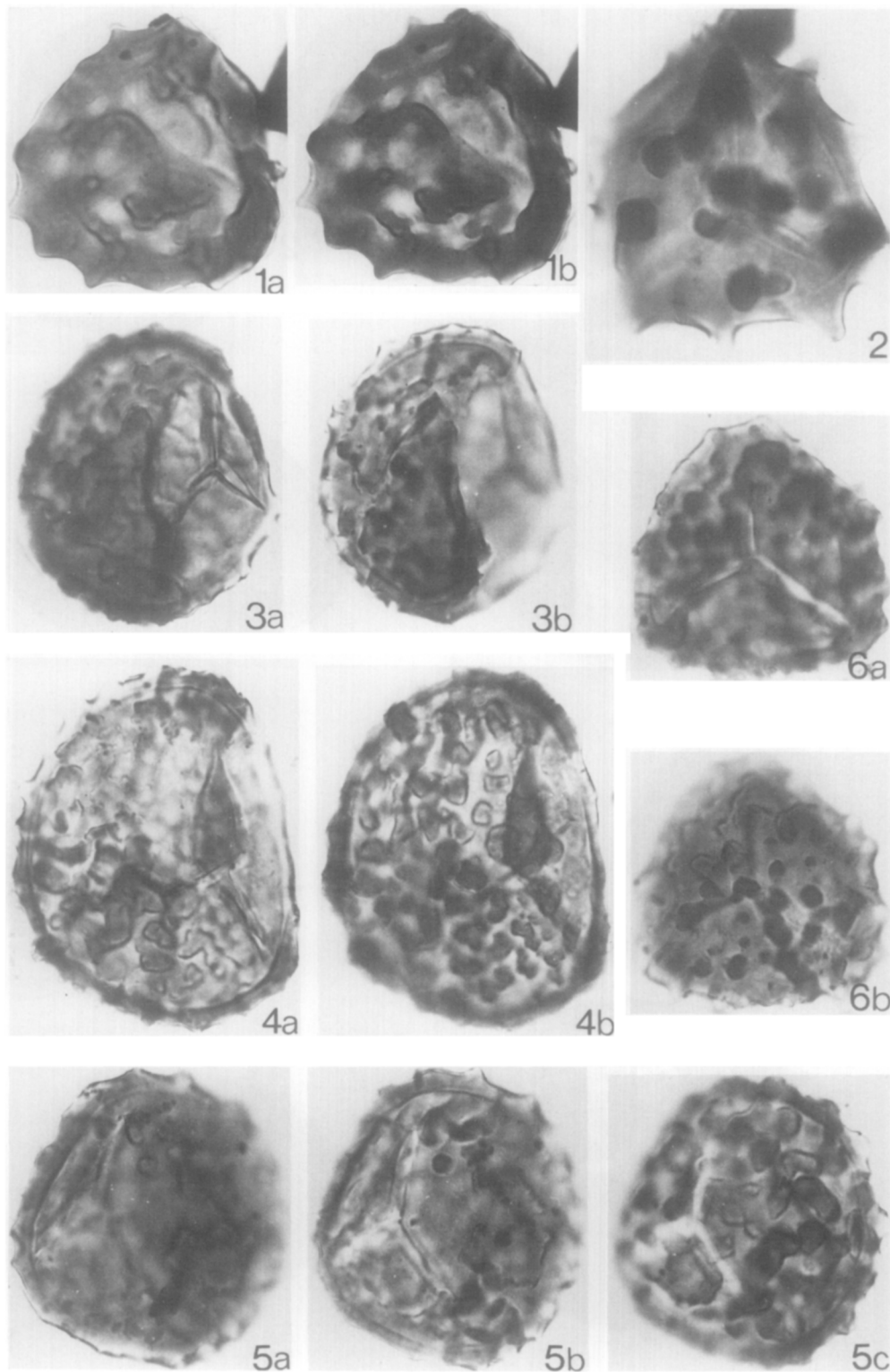
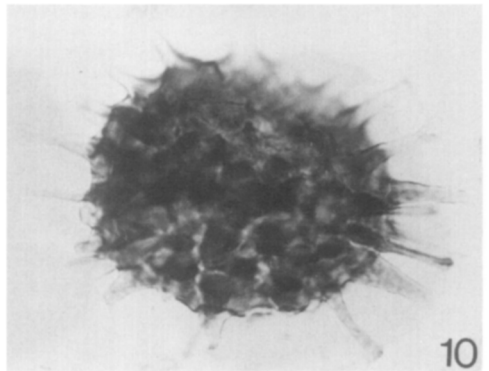
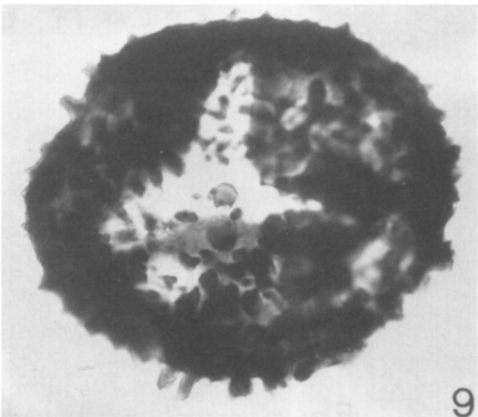
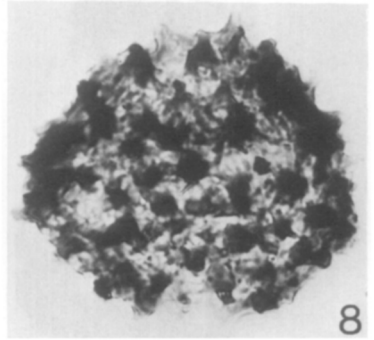
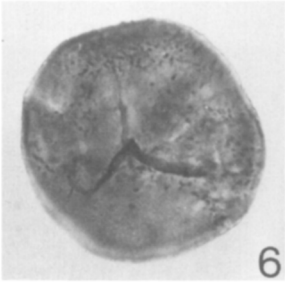
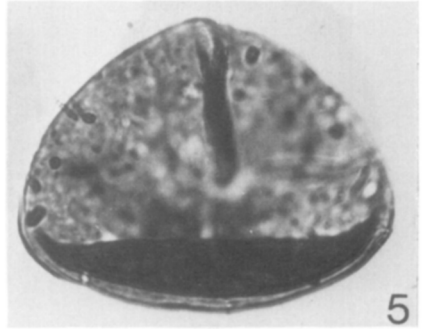
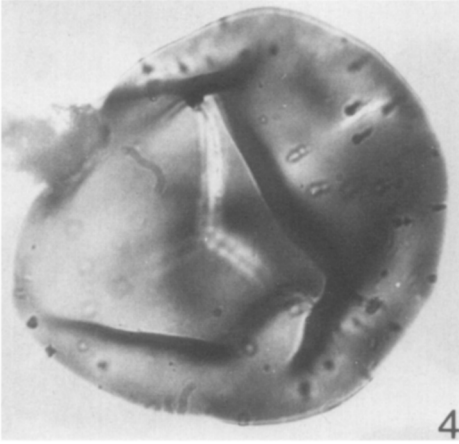
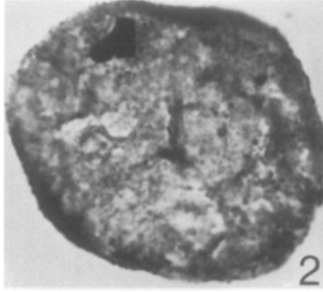
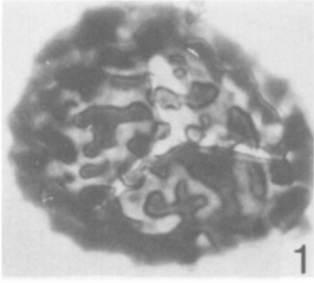


PLATE VI (explanation on p. 253)



## PLATE VII (explanation on p. 253)

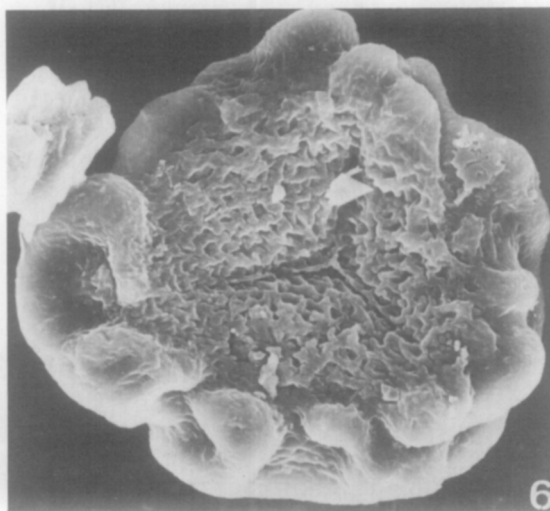
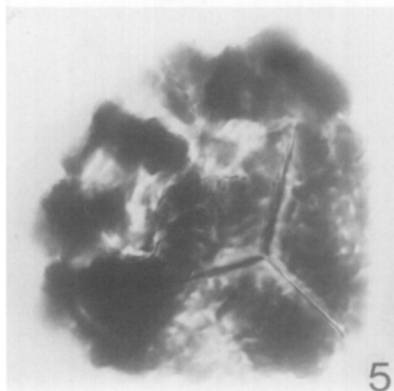
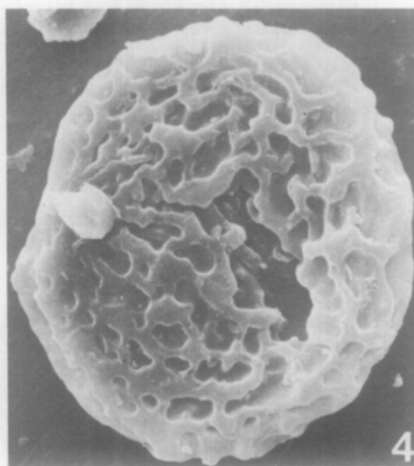
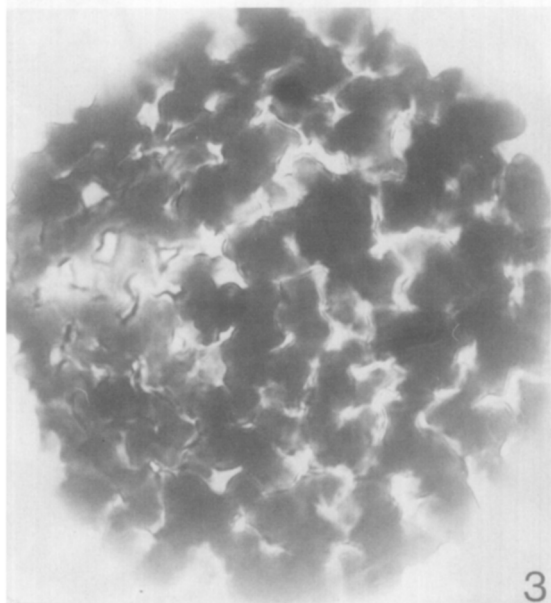
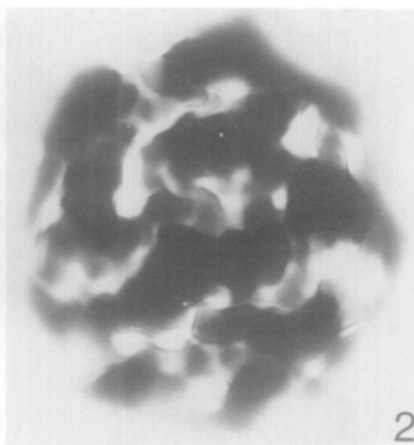
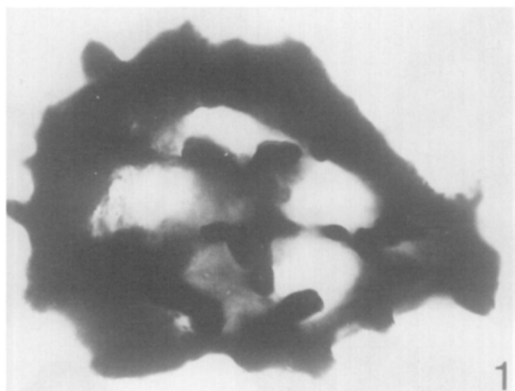
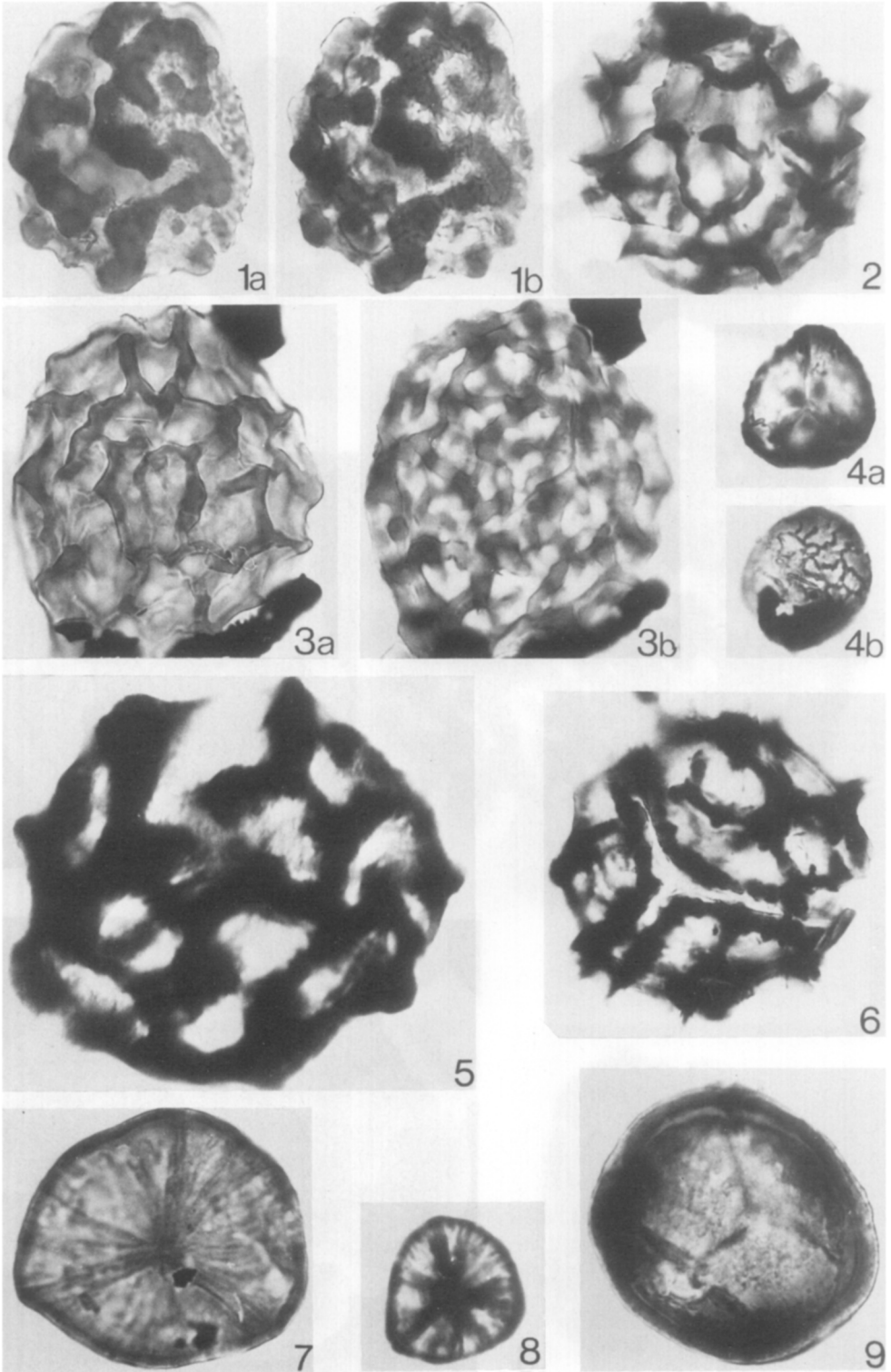


PLATE VIII (explanation on p. 253)



## PLATE IX (explanation on p. 253)

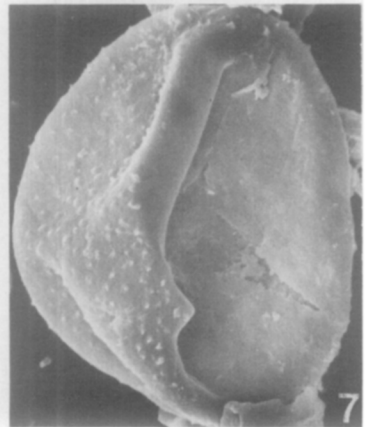
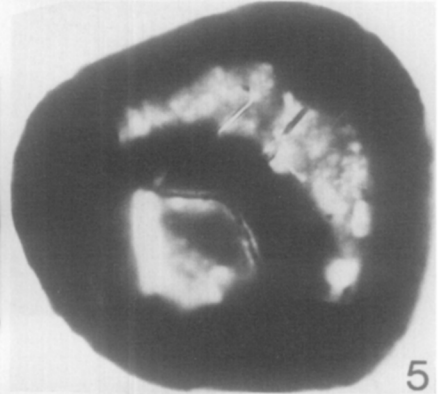
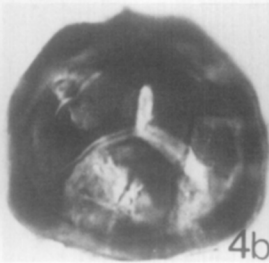
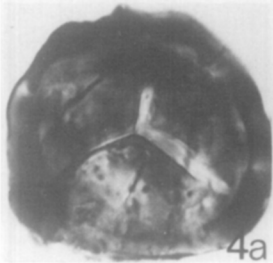
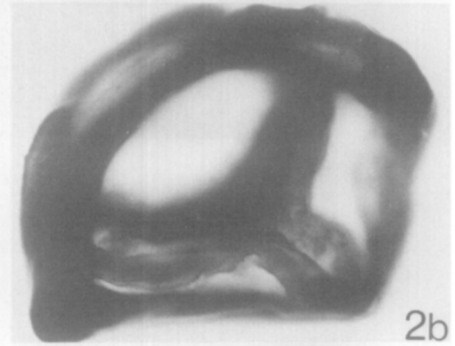
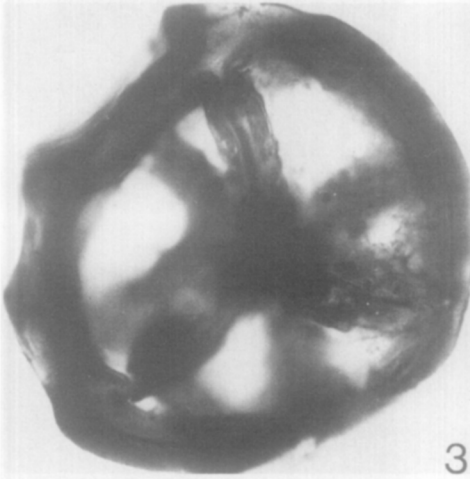
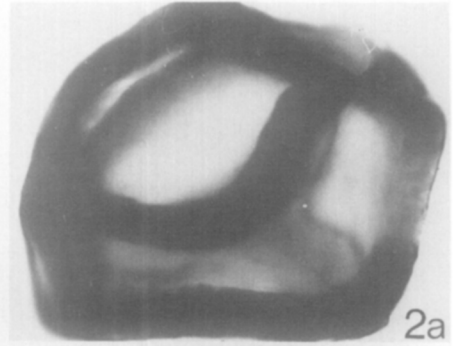
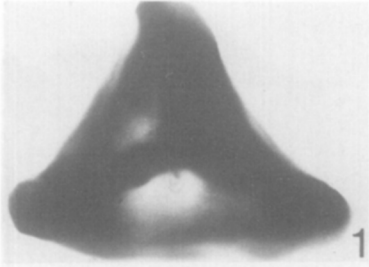
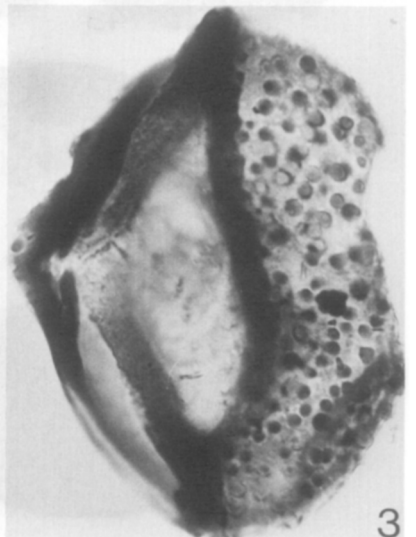
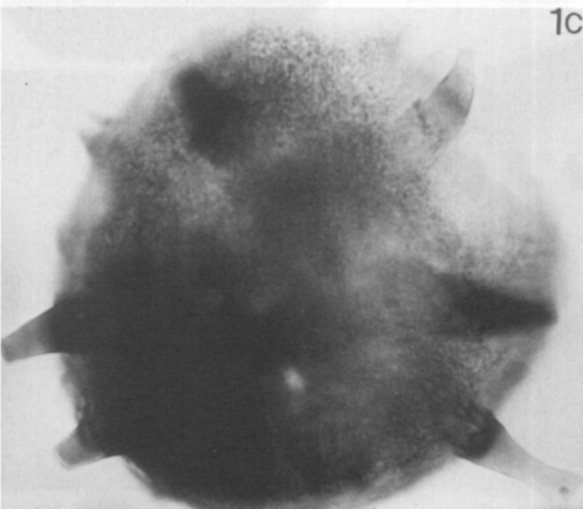
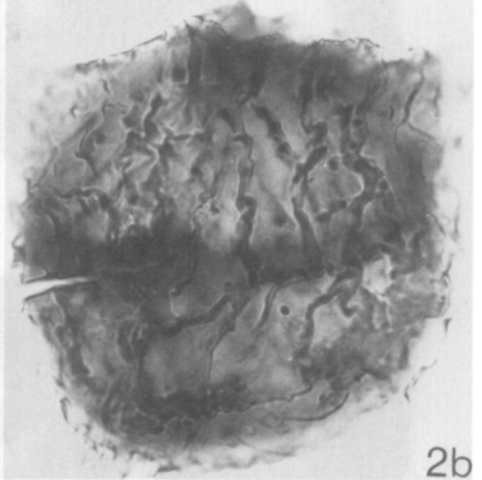
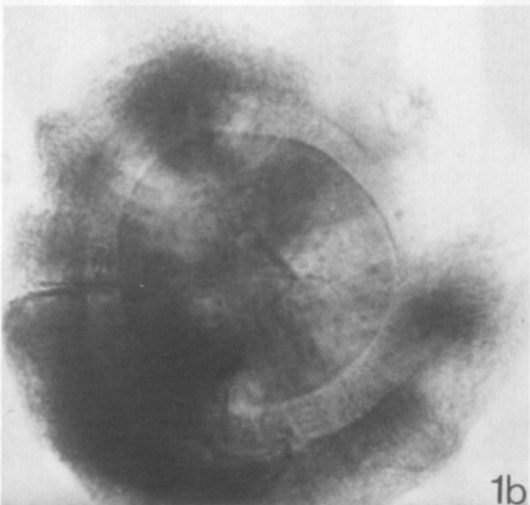
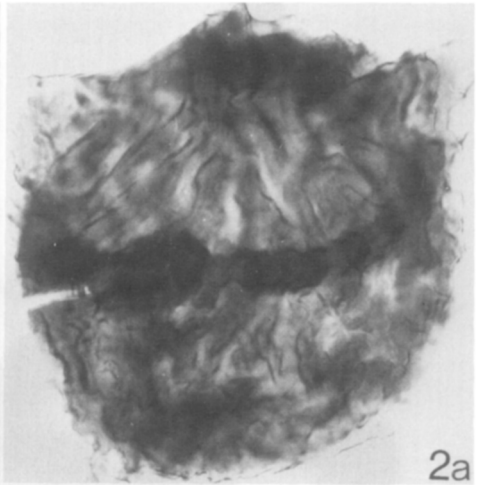
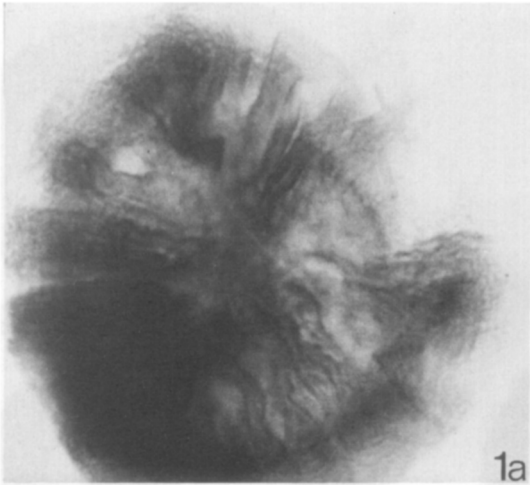


PLATE X (explanation on p. 253)



## PLATE XI (explanation on p. 253)

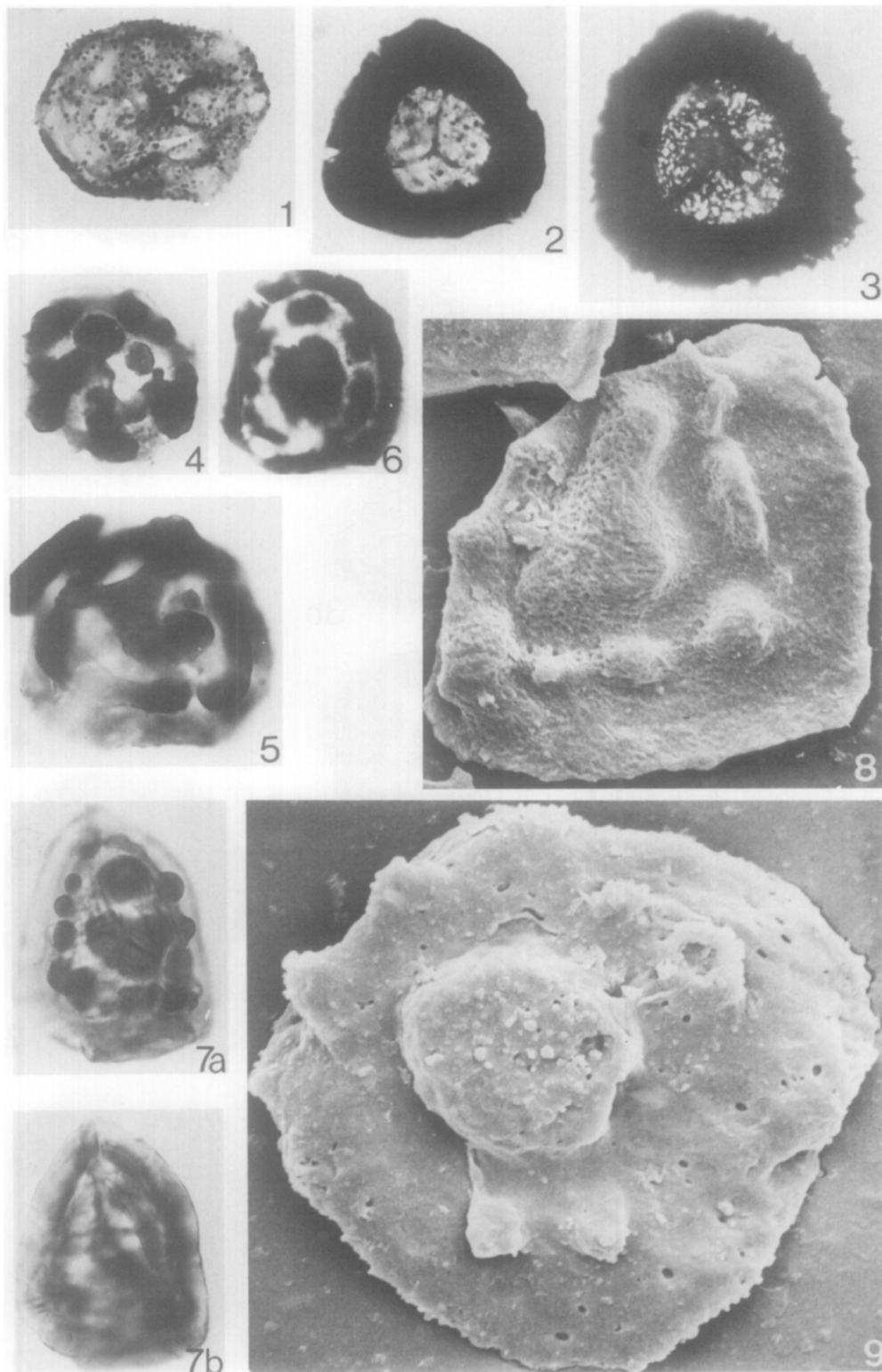


PLATE XII (explanation on p. 254)

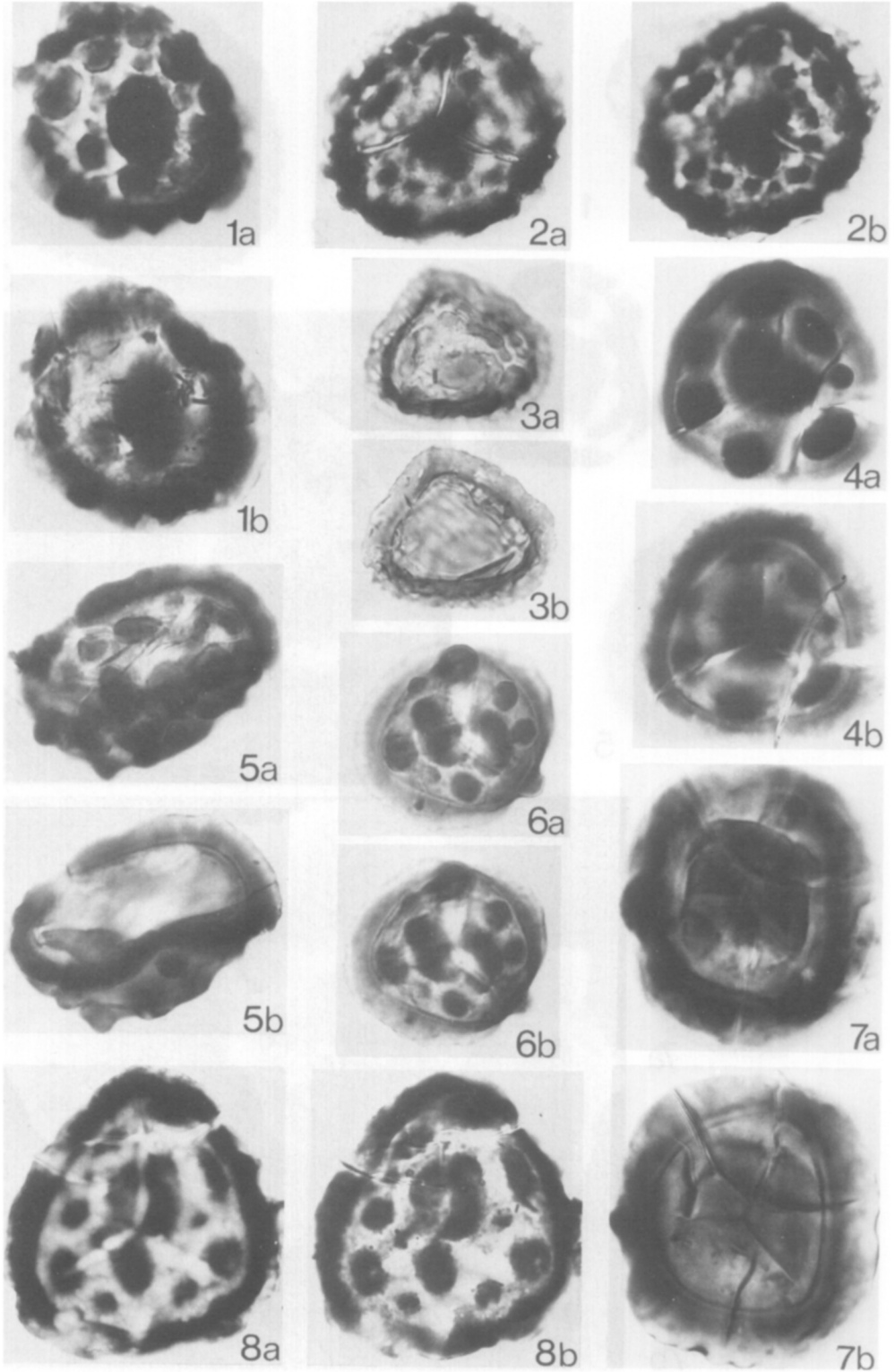




PLATE XIII (explanation on p. 254)

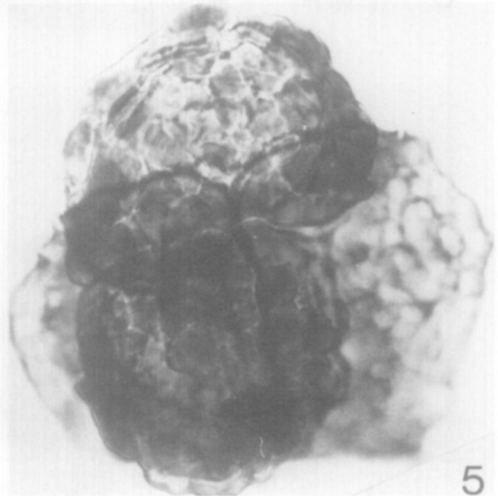
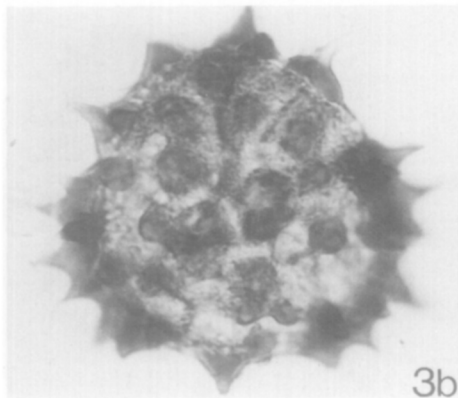
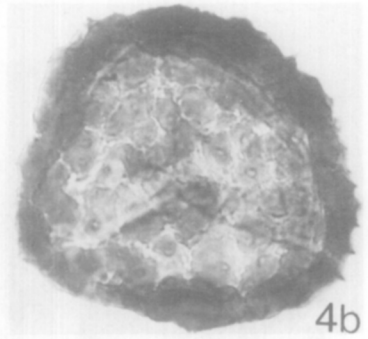
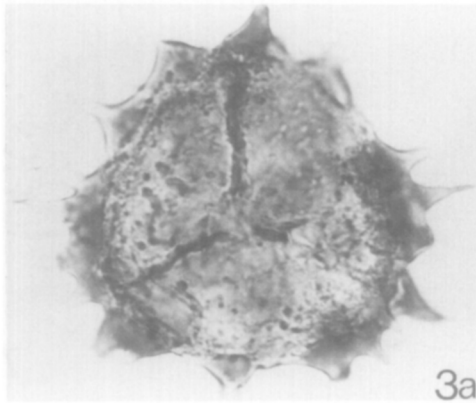
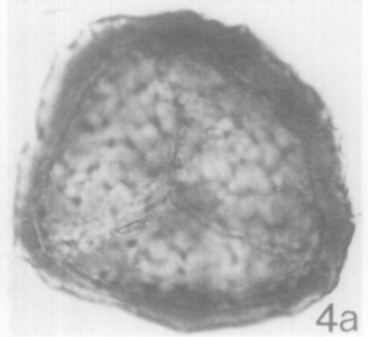
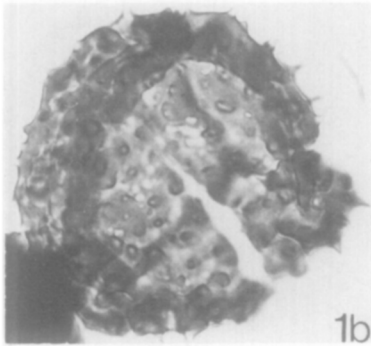
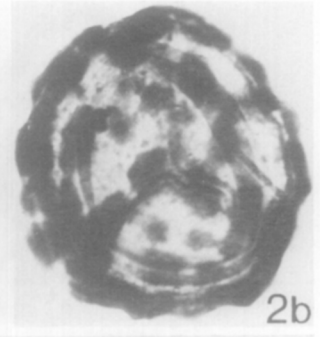
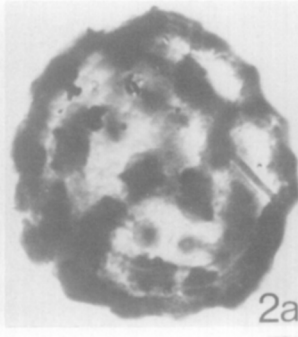
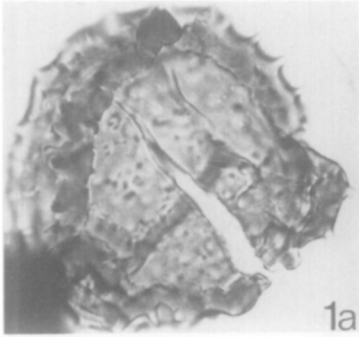
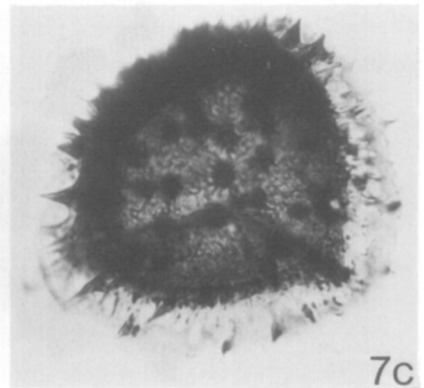
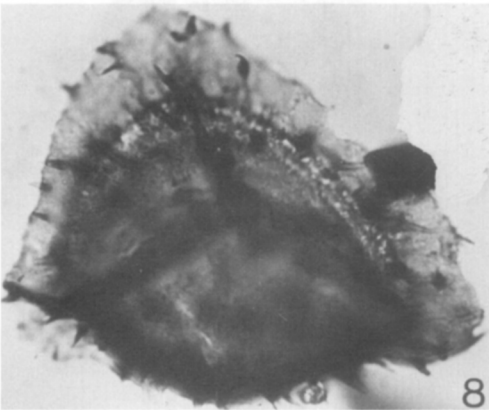
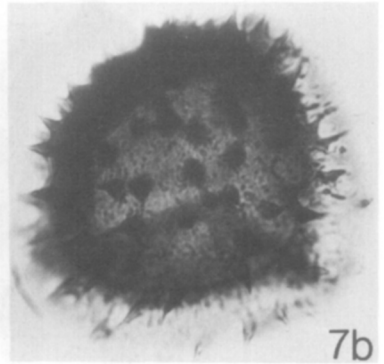
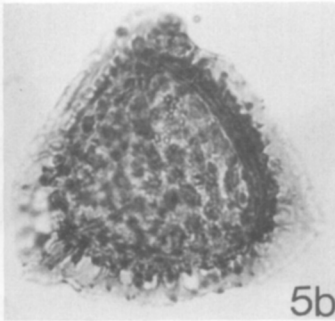
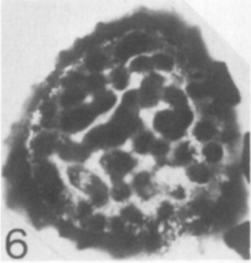
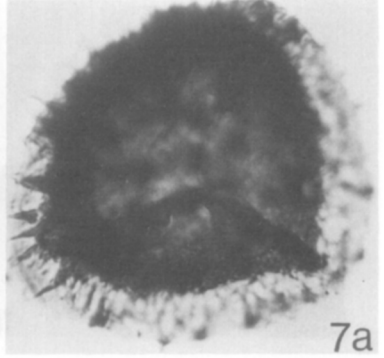
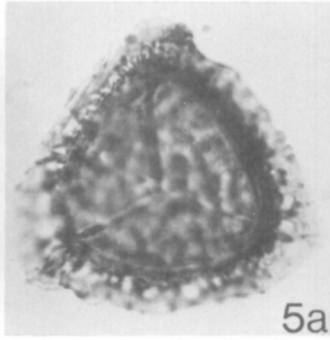
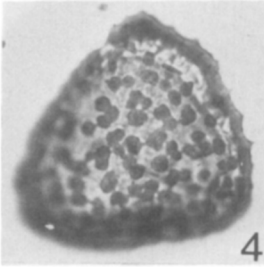
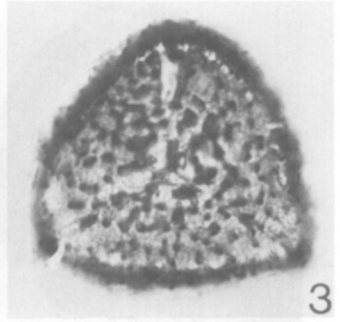
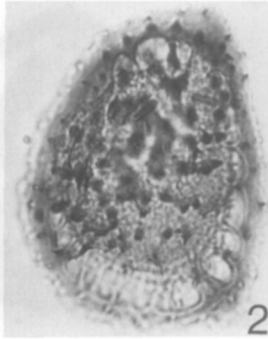
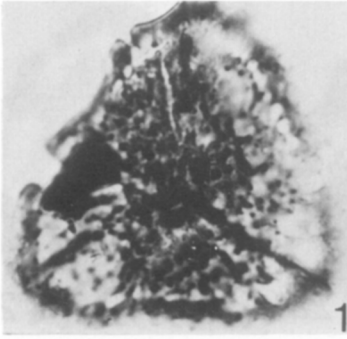


PLATE XIV (explanation on p. 254)



## PLATE XV (explanation on p. 254)

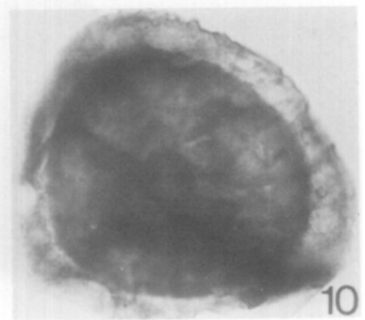
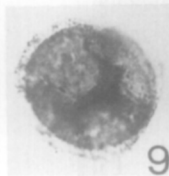
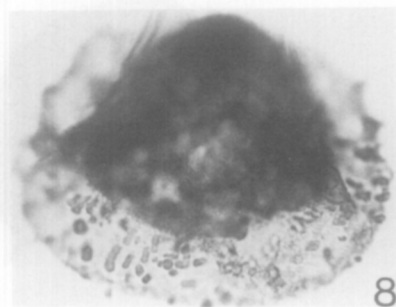
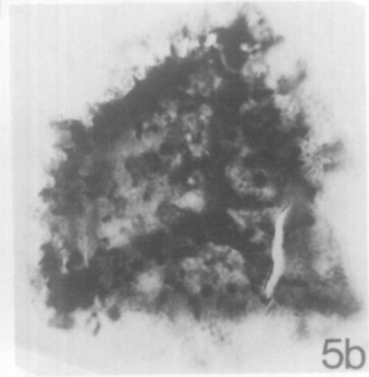
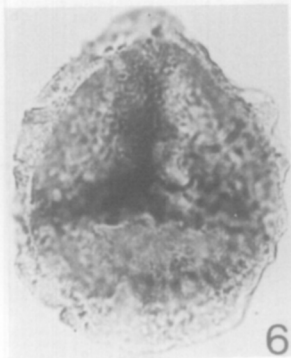
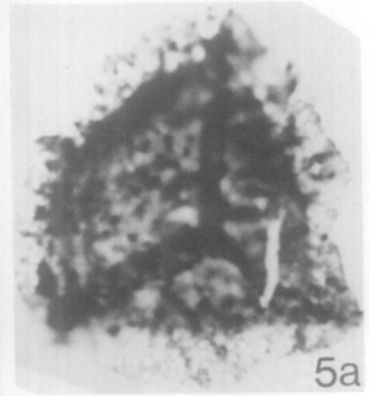
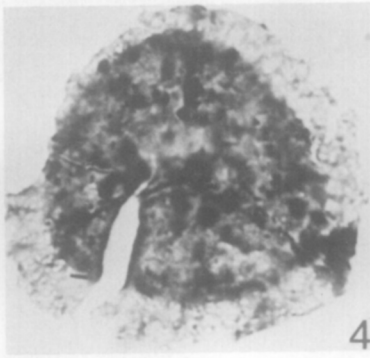
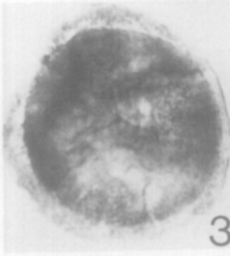
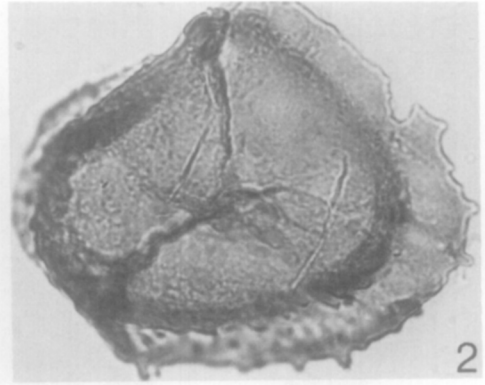
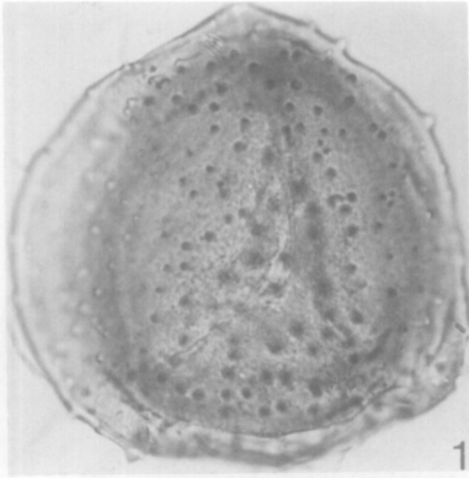
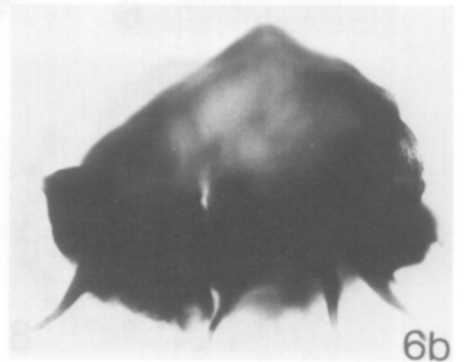
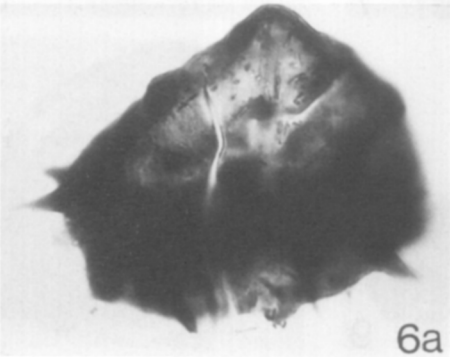
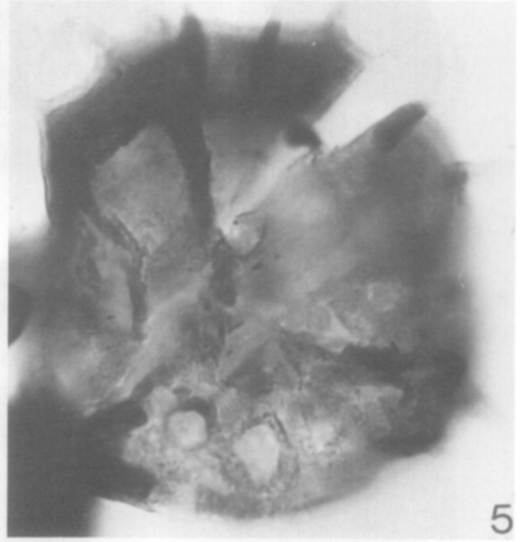
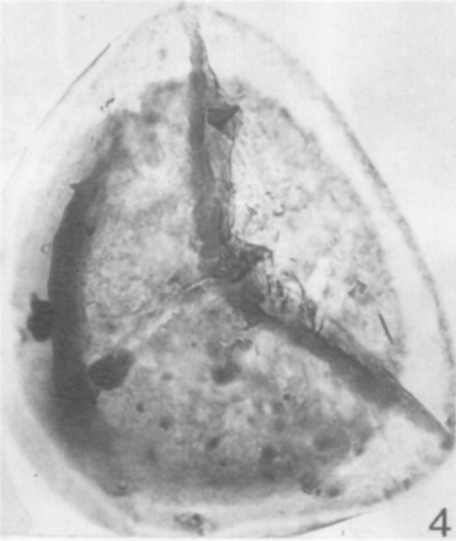
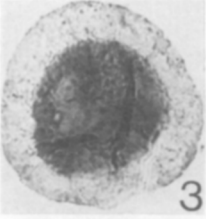
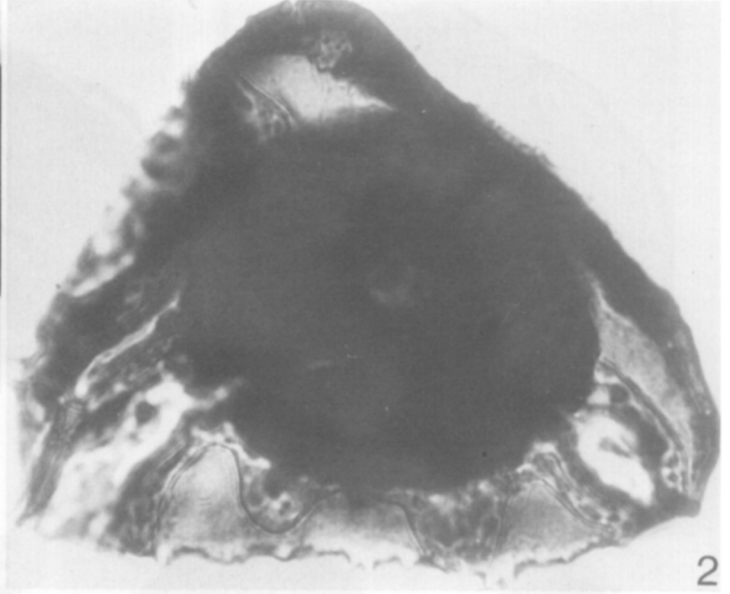
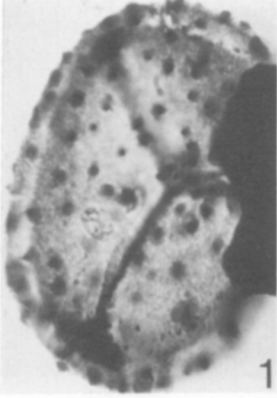


PLATE XVI (explanation on p. 254)



## PLATE XVII (explanation on p. 254-255)

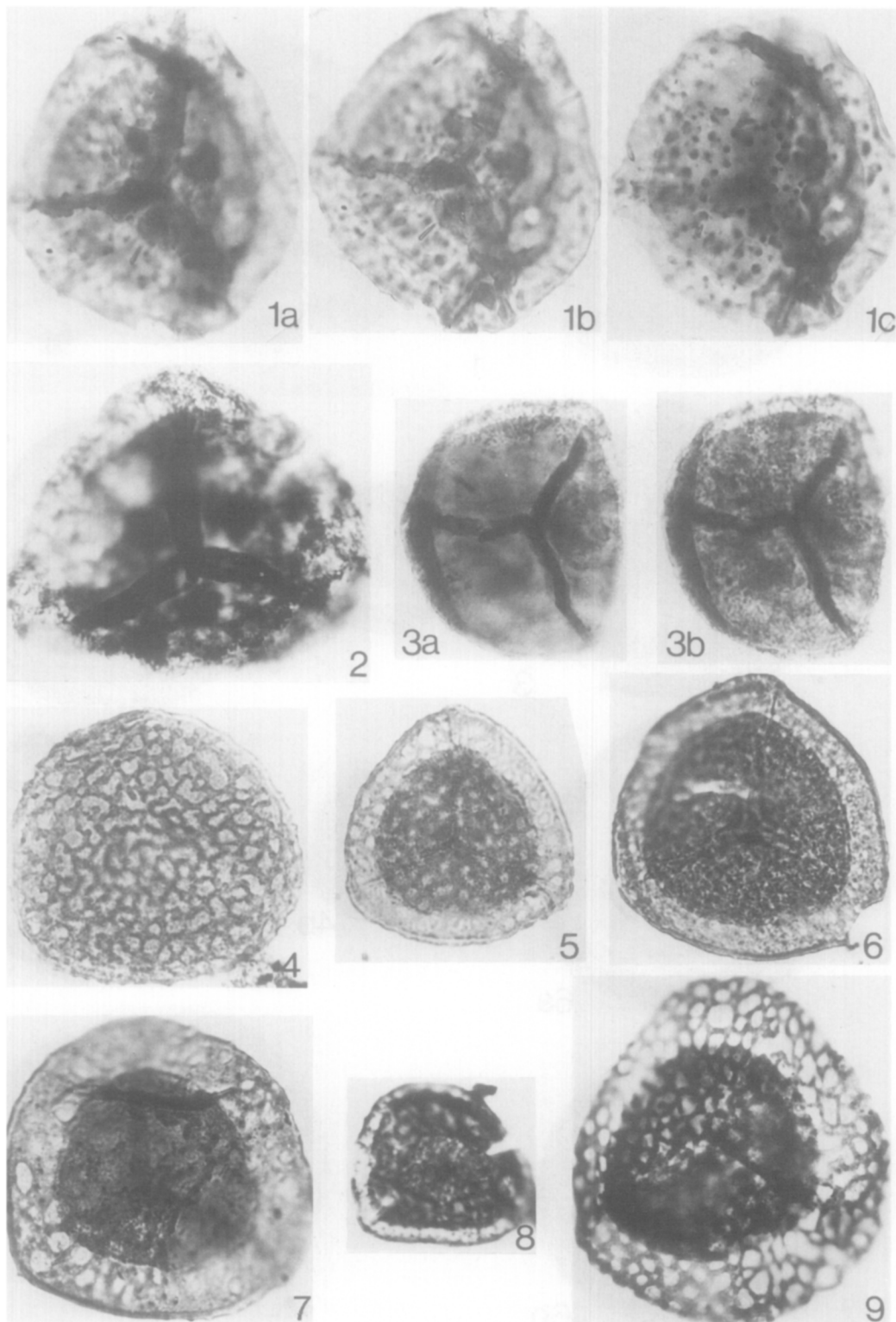
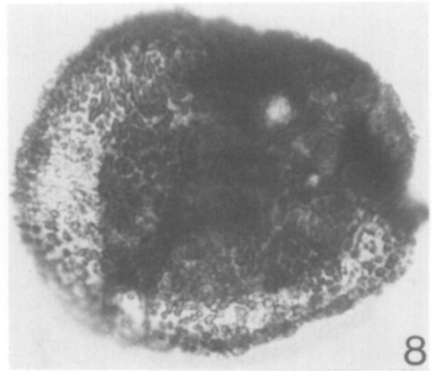
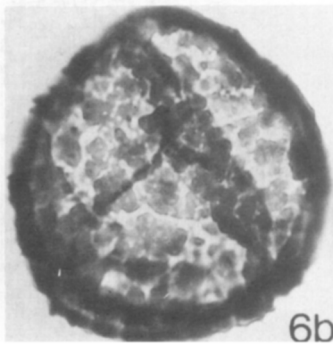
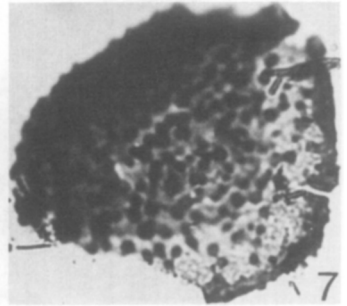
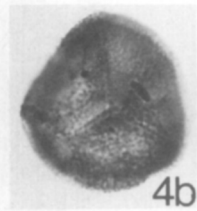
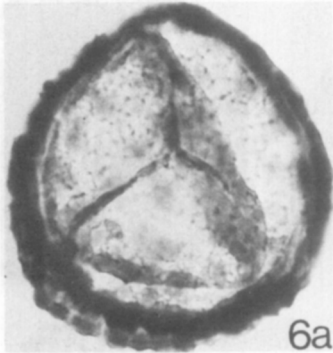
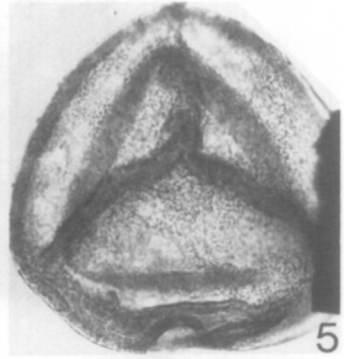
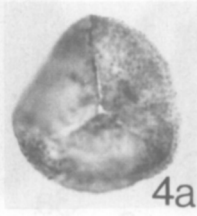
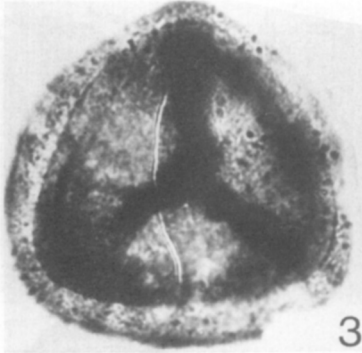
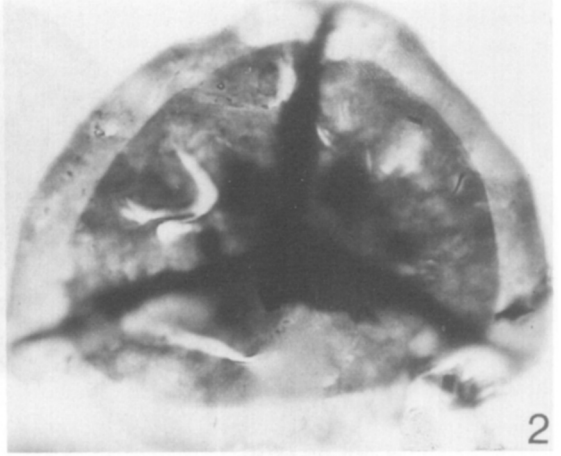


PLATE XVIII (explanation on p. 255)



## PLATE XIX (explanation on p. 255)

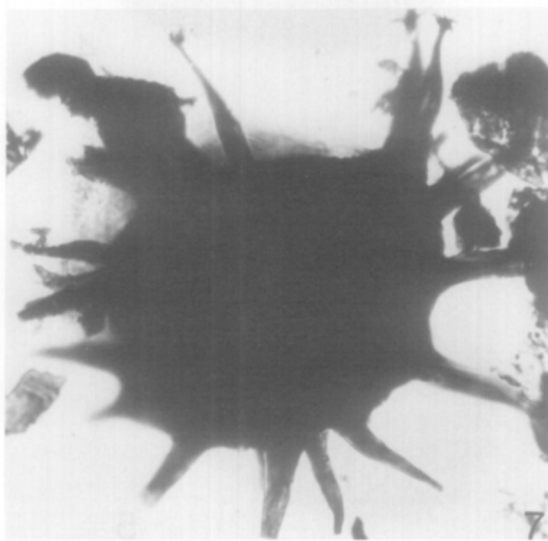
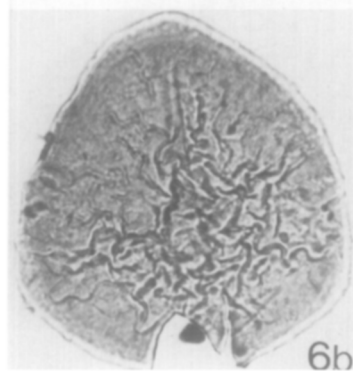
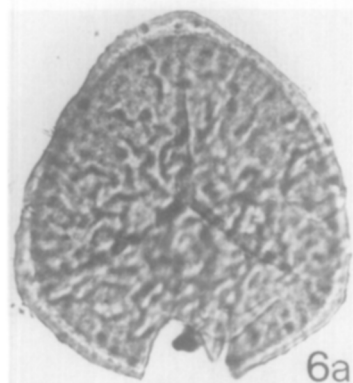
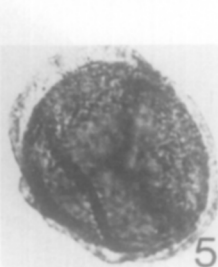
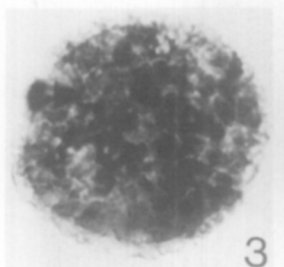
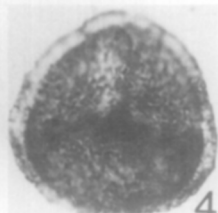
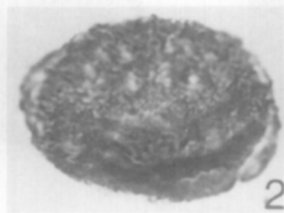
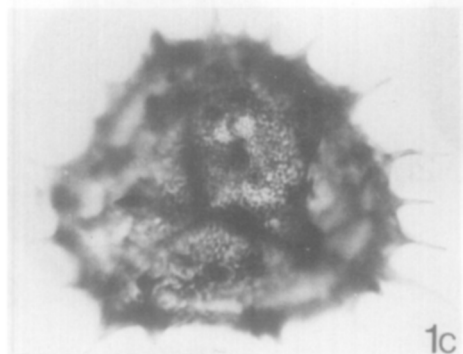
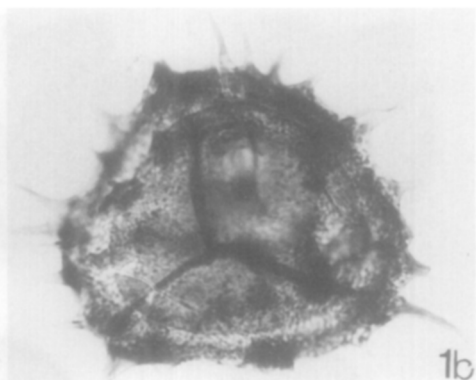
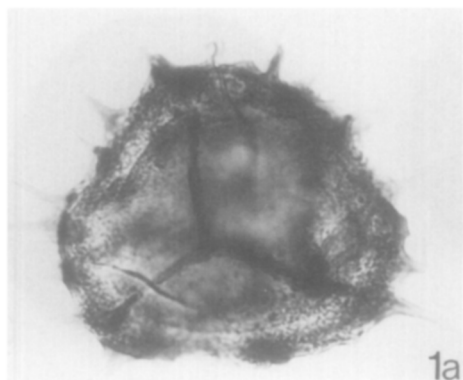
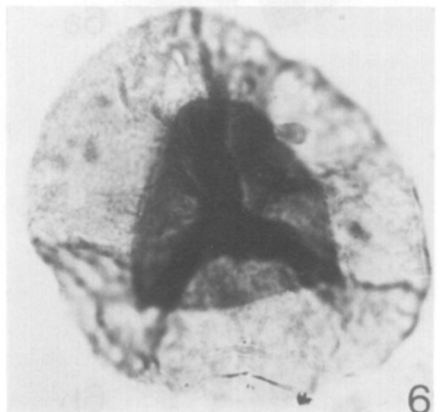
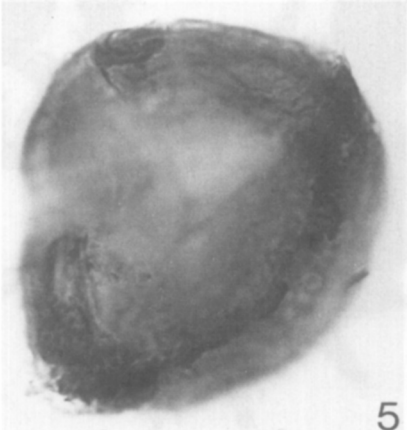
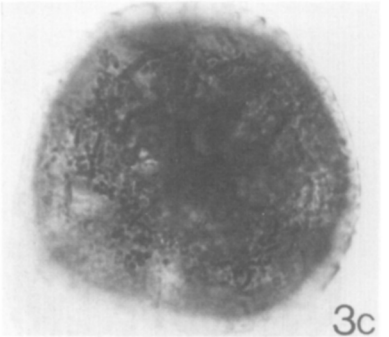
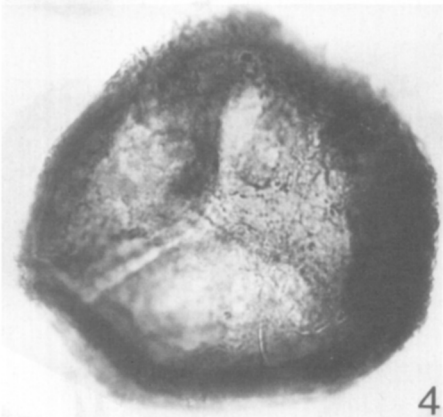
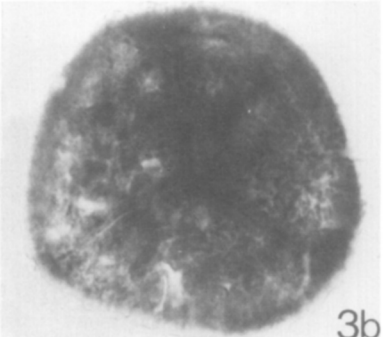
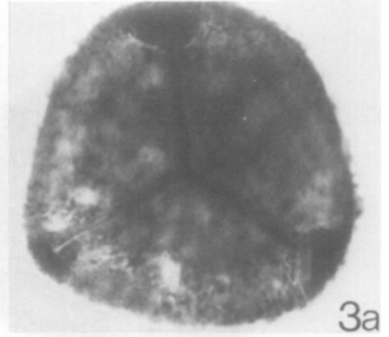
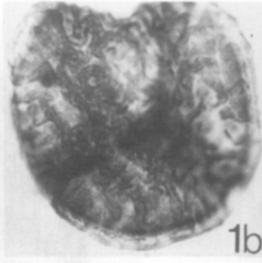
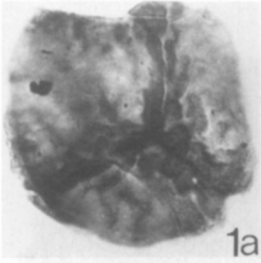


PLATE XX (explanation on p. 255)





## PLATE XXI (explanation on p. 255)

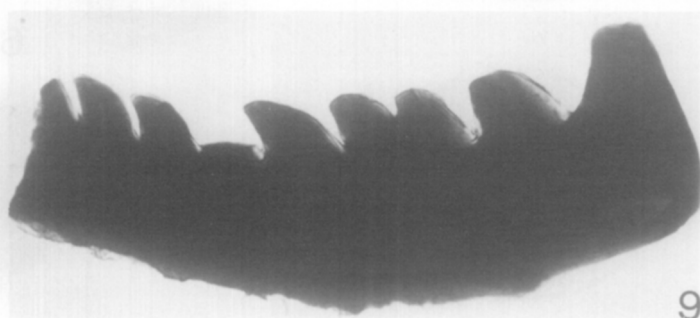
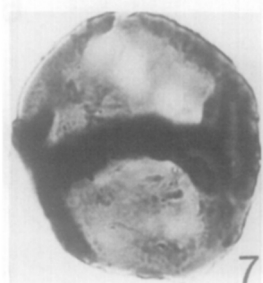
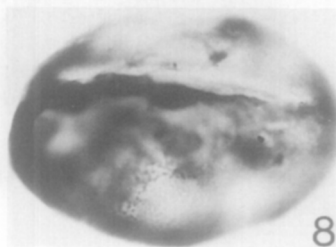
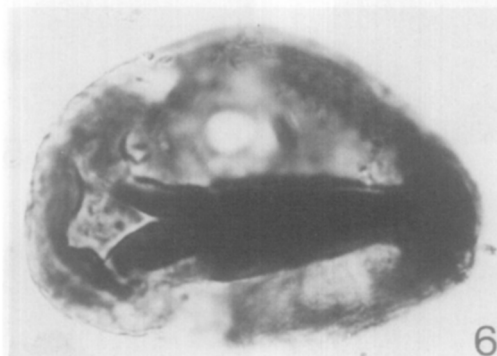
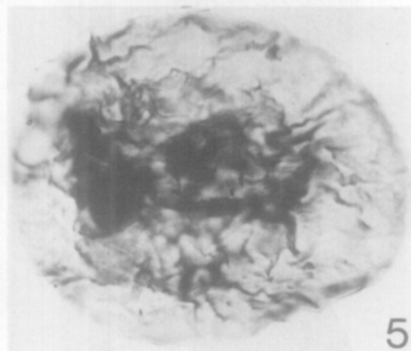
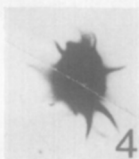
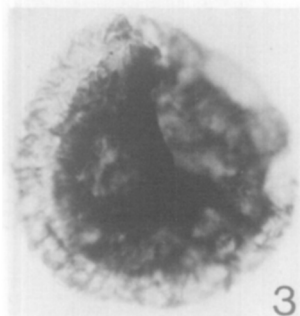
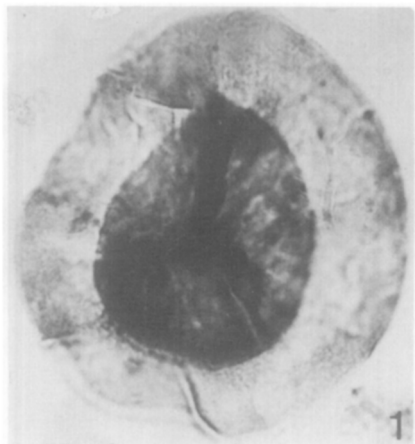
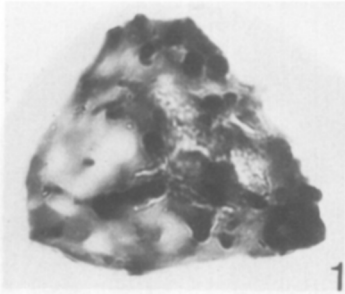
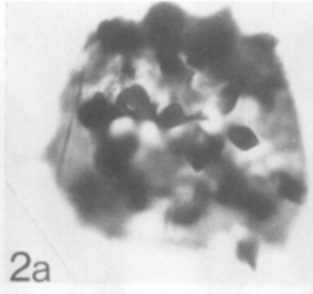


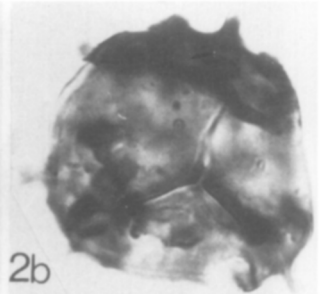
PLATE XXII (explanation on p. 255)



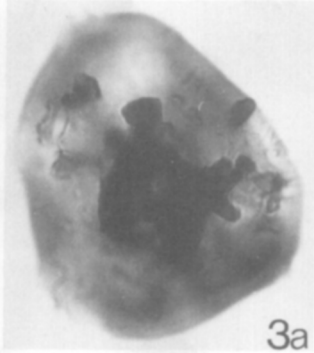
1 2a



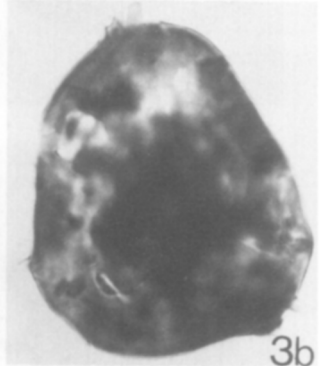
2b



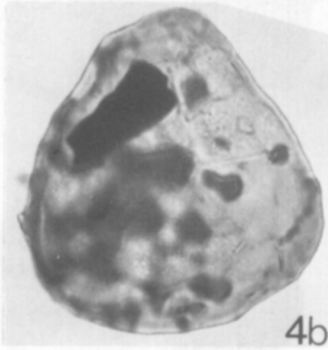
4a



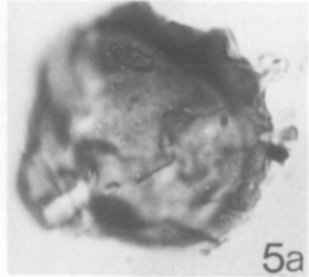
3a



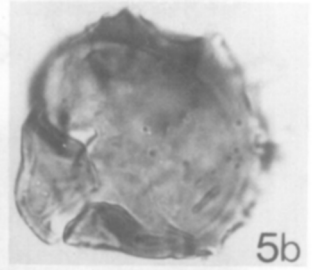
3b



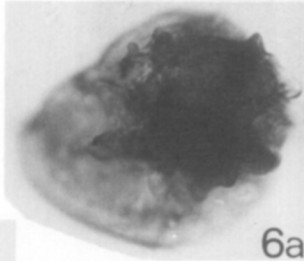
4b



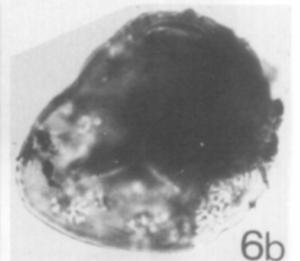
5a



5b



6a



6b



7



8

## PLATE XXIII (explanation on p. 256)

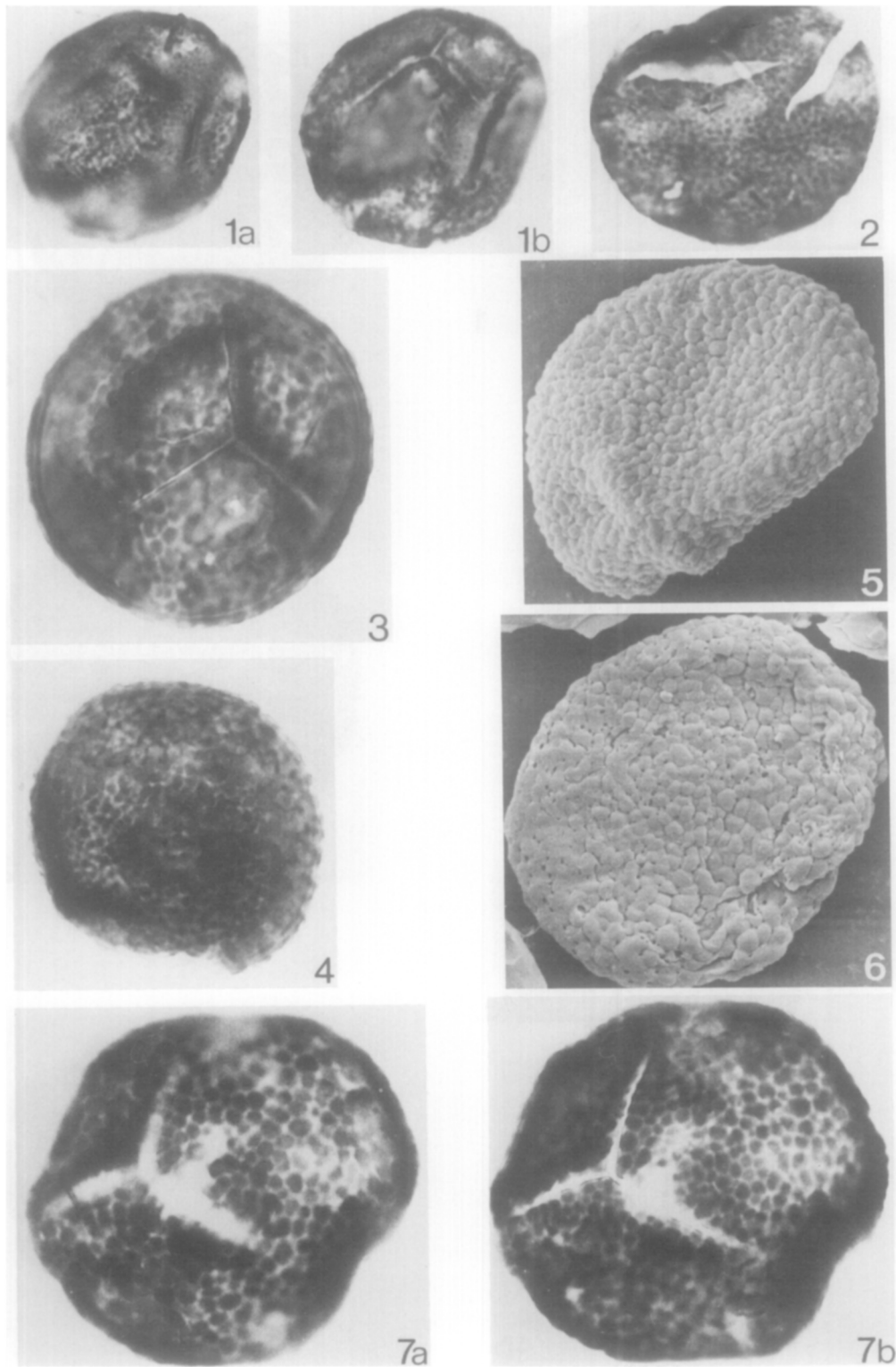
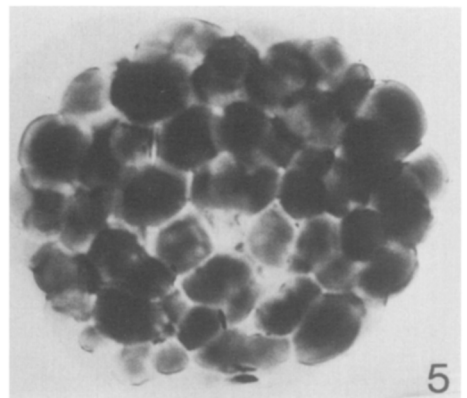
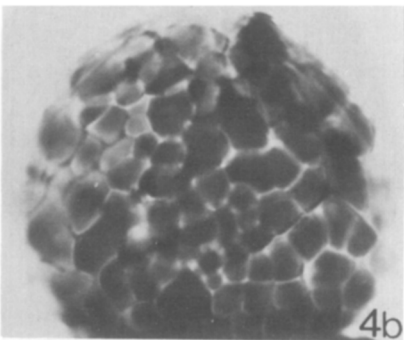
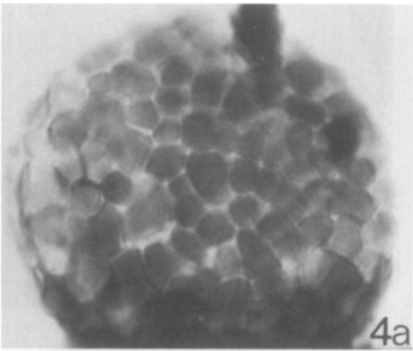
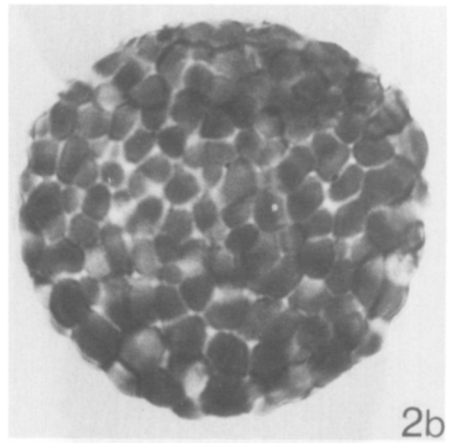
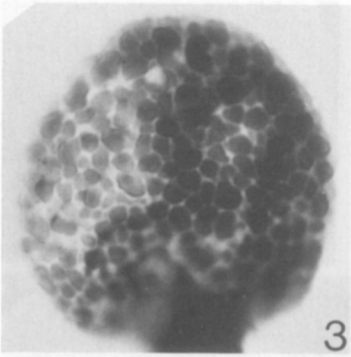
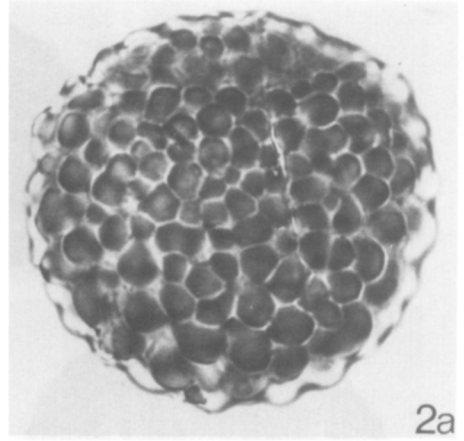
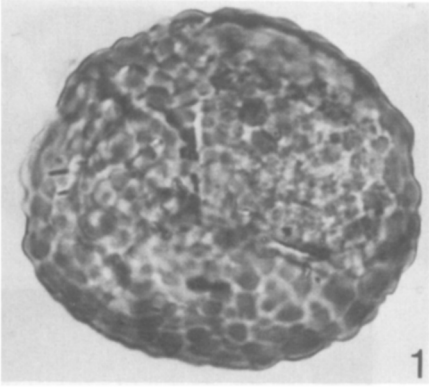


PLATE XXIV (explanation on p. 256)



## PLATE XXV (explanation on p. 256)

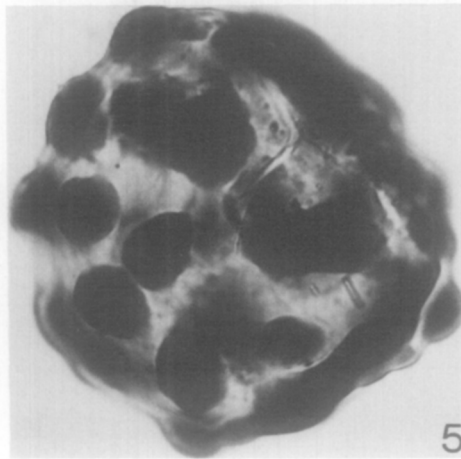
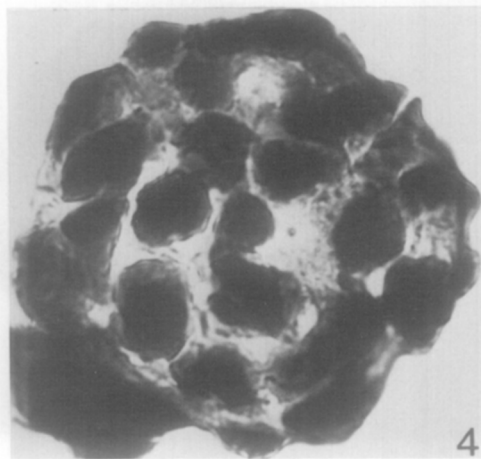
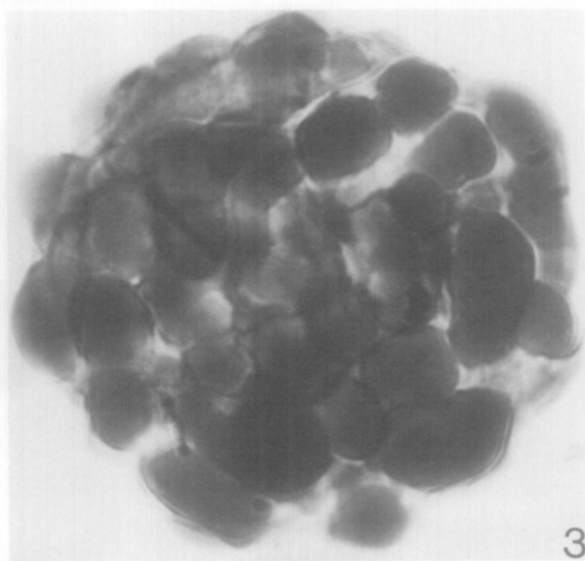
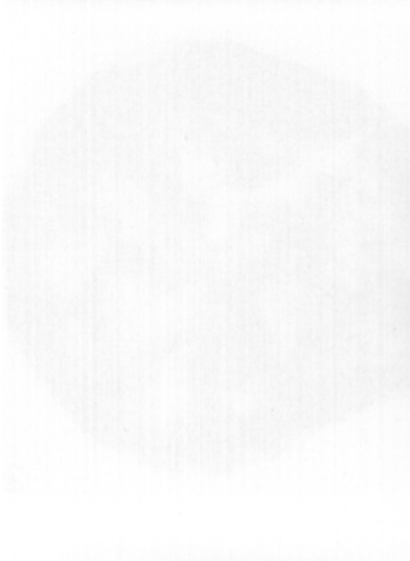
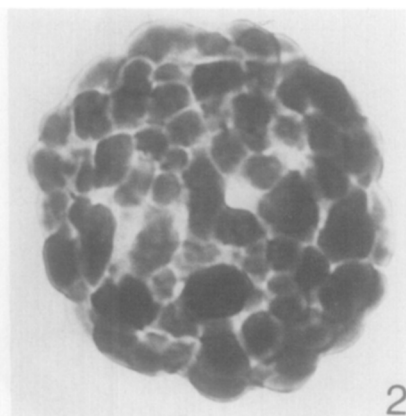
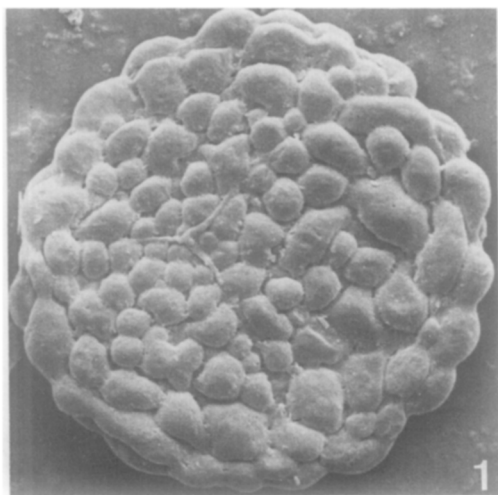
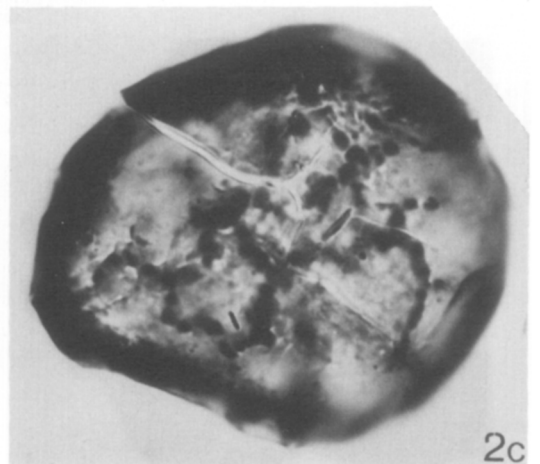
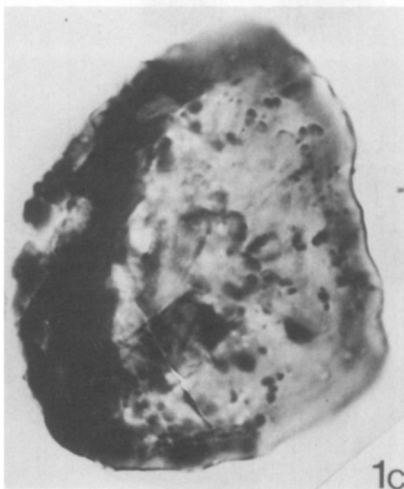
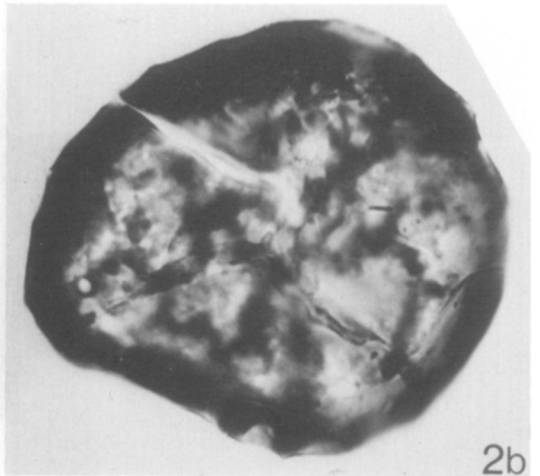
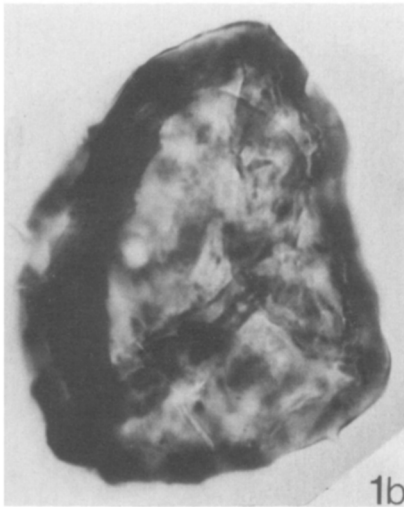
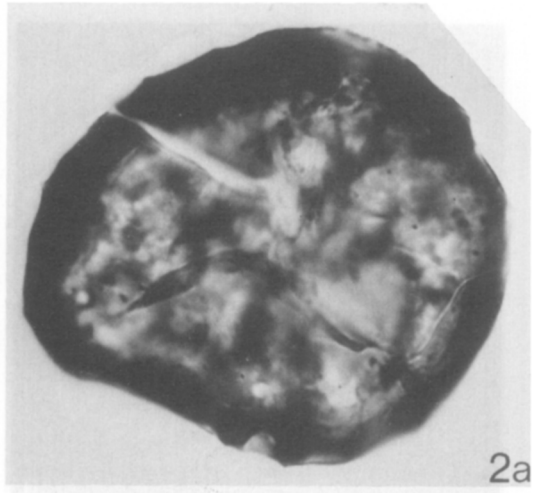
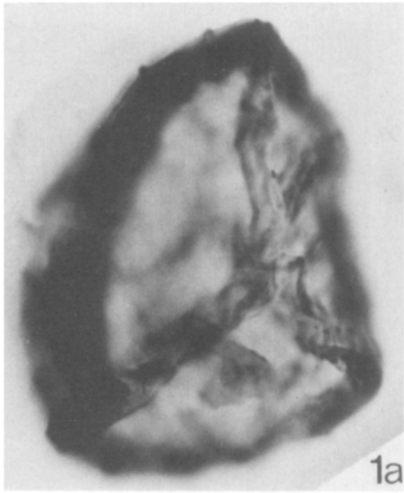


PLATE XXVI (explanation on p. 256)



## PLATE XXVII (explanation on p. 256)

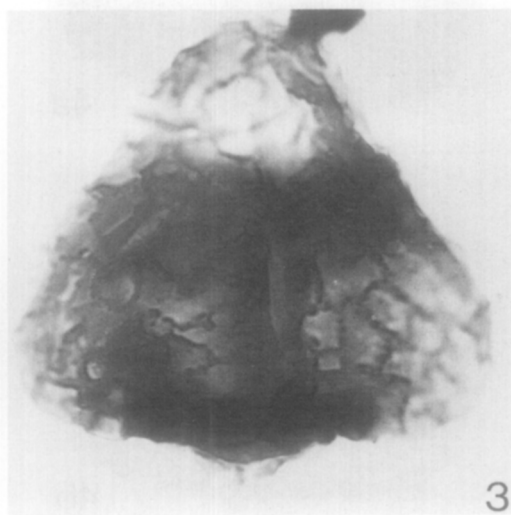
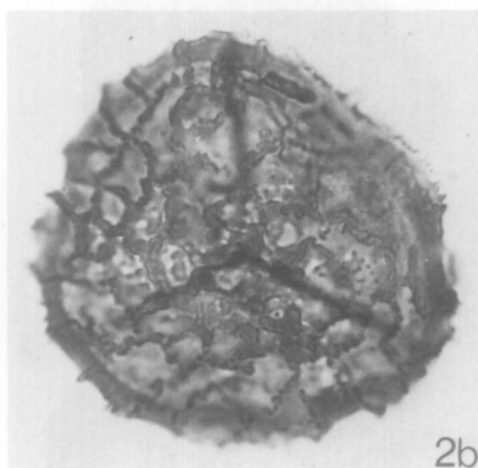
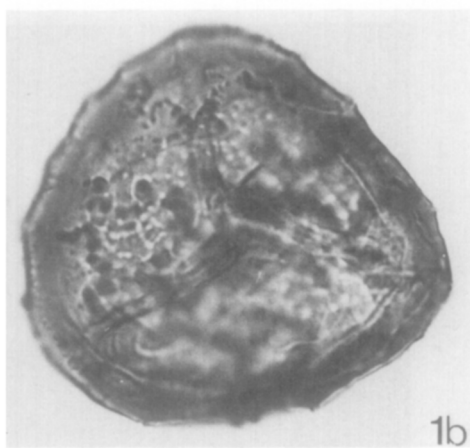
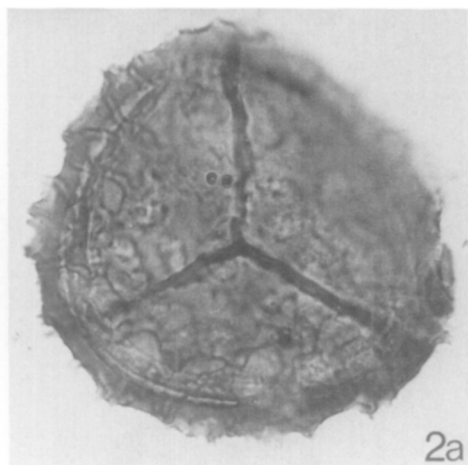
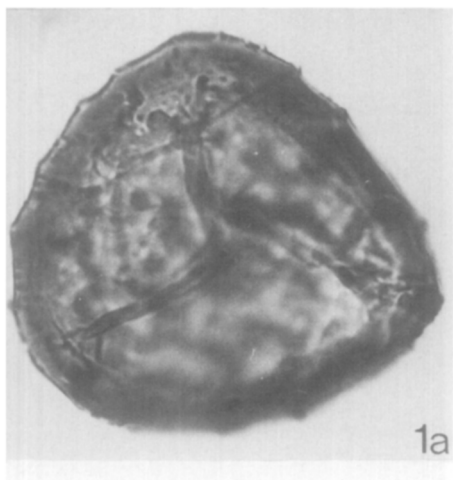


PLATE XXVIII (explanation on p. 256)

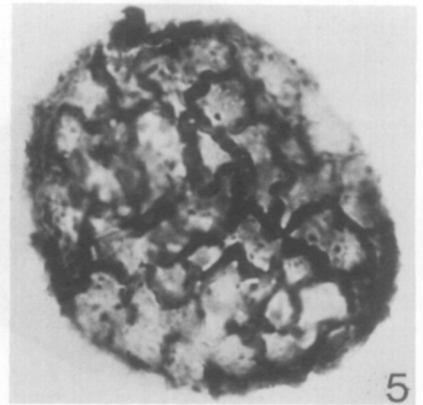
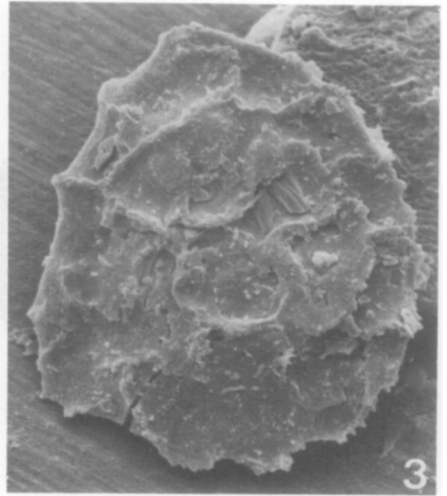
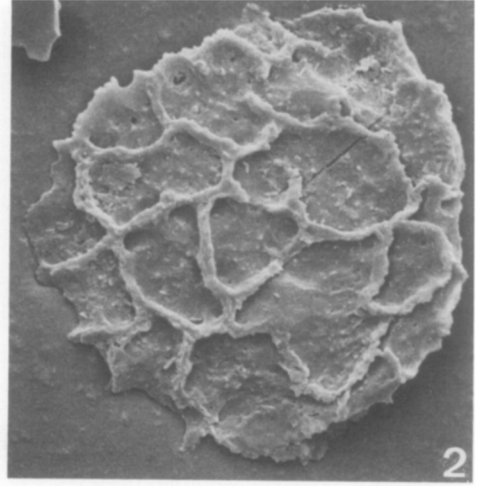
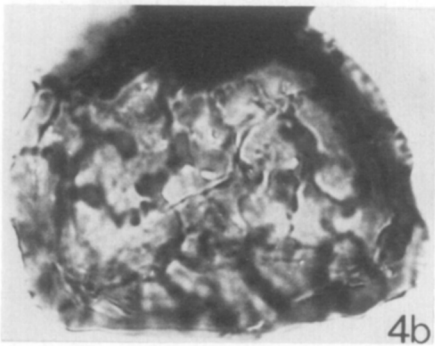
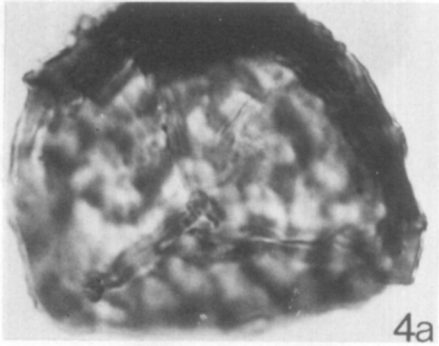
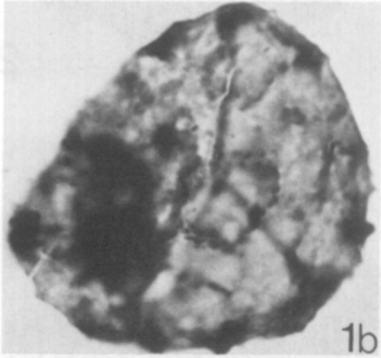
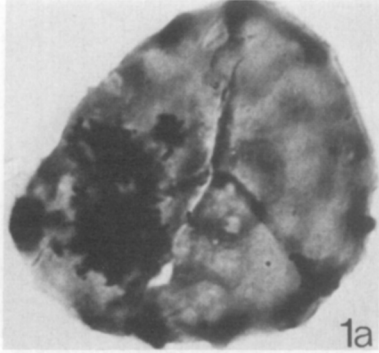




PLATE XXIX (explanation on p. 256)

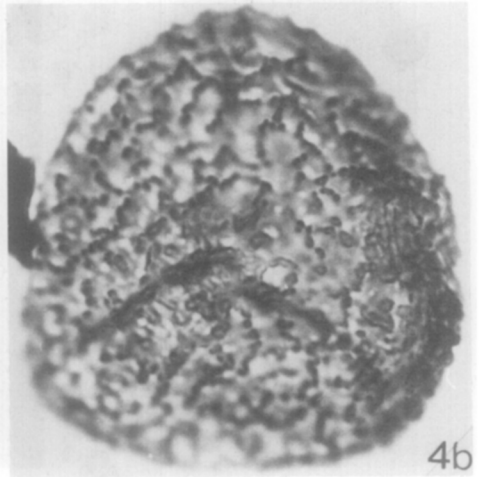
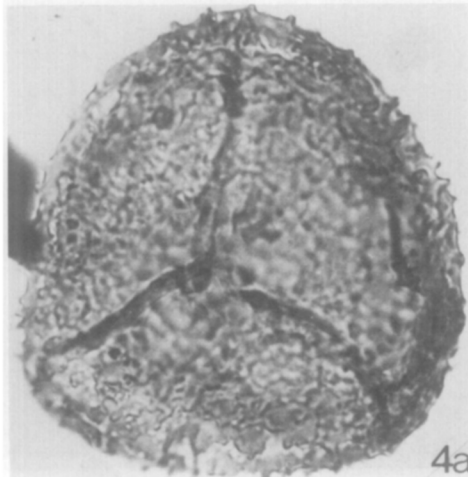
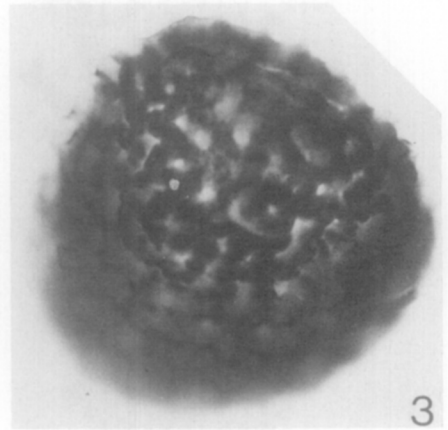
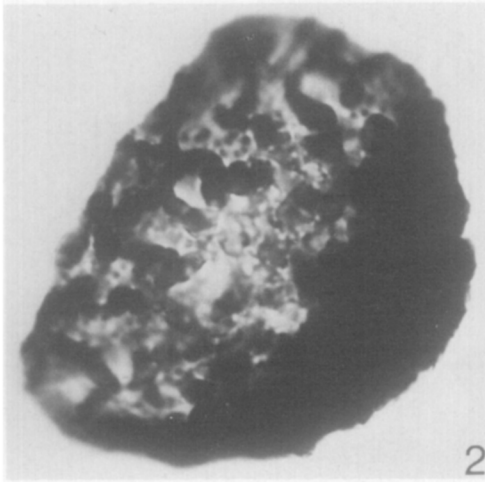
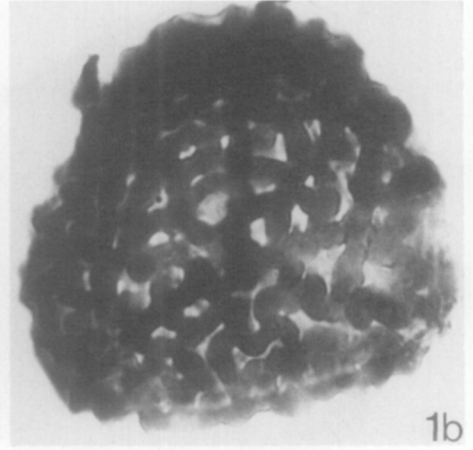
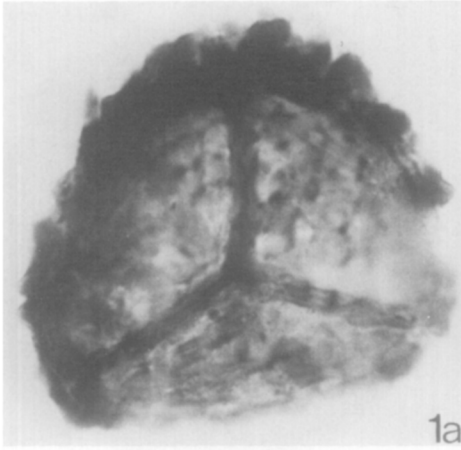


PLATE XXX (explanation on p. 256)

