

Early Devonian spore assemblages from the Dingle Group, County Kerry, Ireland

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ABSTRACT – The Dingle Group is the lowest lithostratigraphic division of the continental Old Red Sandstone magnafacies in the Dingle Peninsula of southwest Ireland. It is generally considered to be Late Silurian (Ludlow) to Early Devonian in age, but to date has yielded no unequivocal faunal or floral evidence of age. This paper describes two small but distinctive Early Devonian spore assemblages from the Dingle Group in the southwestern part of the Dingle Peninsula. The older assemblage is from the Eask Formation at Dunmore Head and is assigned to the *D. wetteldorfensis* (W) Interval Zone of early late Pragian age. The younger assemblage is from the Sleah Head Formation and is assigned to the *E. annulatus*-*B. bellatulus* (AB) Oppel Zone of early to middle(?) Emsian age. The stratigraphic significance of these newly inferred early Devonian datings is discussed, particularly with reference to the contact with the underlying Silurian Dunquin Group. The palynological evidence now shows that the bulk of the Dingle Group belongs to the Early Devonian and the most likely position for the Silurian-Devonian boundary is within the basal Bulls Head Formation.

RIASSUNTO – [Associazioni di spore del Devoniano Inferiore del Gruppo di Dingle, County Kerry, Irlanda] – Il Gruppo di Dingle è la più bassa divisione litostratigrafica della magnafacies continentale delle "Old Red Sandstone" nella Penisola di Dingle, nell'Irlanda sudoccidentale. Esso è generalmente considerato essere di età siluriana superiore (Ludlow)-devoniana inferiore, anche se finora non si sono ottenute dimostrazioni inequivocabili della sua età, su base faunistica o floristica. Questo lavoro descrive due associazioni di spore, piccole ma significative, di età devoniana inferiore, provenienti dal Gruppo di Dingle, nella parte sudoccidentale della Penisola di Dingle. L'associazione più antica è stata trovata nella Formazione di Eask a Dunmore Head ed è assegnata alla Zona di intervallo *D. wetteldorfensis* (W) della parte inferiore del Pragian superiore. L'associazione più recente proviene dalla Formazione di Sleah Head ed è assegnata alla Zona di Oppel *E. annulatus*-*B. bellatulus* (AB) di età emsiana inferiore-(?) media. Il significato stratigrafico di queste nuove datazioni del Devoniano inferiore viene discusso, con particolare riguardo al contatto col sottostante Gruppo di Dunquin, del Siluriano. I dati palinologici mostrano ora che il grosso del Gruppo di Dingle appartiene al Devoniano inferiore e che il limite Siluriano-Devoniano è con tutta probabilità collocato entro la parte basale della Formazione di Bulls Head.

INTRODUCTION

The Dingle Group is the lowest lithostratigraphic division of the Old Red Sandstone magnafacies in southwest Ireland. It is only seen in the Dingle Peninsula where it crops out extensively in the central and western part of the peninsula. The Dingle Group comprises a very thick succession of continental sediments in which red, purple, and green siltstones, sandstones, and conglomerates predominate. The group records initially mostly lacustrine sedimentation followed by deposition in laterally and axially draining fluvial systems (Boyd, 1983; Todd *et al.*, 1988a; Todd, 1989).

Jukes & du Noyer (1863) introduced the term "Dingle Beds" for the sequence of conglomerates, sandstones, and shales overlying the marine fossiliferous Silurian in the Dingle Peninsula. Holland (1969) formalized the term to Dingle Group to comply with the International Stratigraphic Code. The first formal lithostratigraphy of the Dingle Group was introduced by Gardiner & Horne (1972) and subsequently ampli-

fied and detailed by Horne (1974). Further revision by Todd *et al.* (1988a) segregated the Smerwick Formation from the Dingle Group and upgraded it to group status, and also introduced the Coomeenoole Formation and Sleah Head Formation into the stratigraphic nomenclature of southeast Dingle. All previous workers have noted marked sedimentary facies variations across the peninsula; consequently three separate stratigraphic schemes for the group have been established in northwest Dingle, southeast Dingle, and southwest Dingle. Vertical and lateral relationships of the formations in these three regions have been proposed by Todd *et al.* (1988a) and Pracht (1996).

The nature of the stratigraphic contact between the Dingle Group with underlying marine Silurian Dunquin Group has been extensively debated in the literature (Doran *et al.*, 1973; Horne, 1974, 1976; Holland, 1987; Todd *et al.*, 1988b; Todd, 1991). It appears that in the southwestern part of the peninsula a conformable boundary exists between the groups; however, farther to the north and east there is evidence for unconformable and faulted contacts.

LITHOSTRATIGRAPHY	AGE DETERMINATIONS
<u>DINGLE GROUP</u>	
BALLYMORE FMN.	411 Ma +/- 3.3 zircon age Williams <i>et al.</i> , in prep
SLEA HEAD FMN.	Latest PRAGIAN - Early EMSIAN Spores - this paper
COUMEENOOLE FMN.	Late EMSIAN Spores - Van der Zwan, 1980
EASK FMN.	Early PRAGIAN Spores - this paper
BULLS HEAD FMN.	? PRIDOLI-LOCKHOVIAN ?
<u>DUNQUIN GROUP</u>	
CROAGHMAHRIN FMN	LUDLOW macrofaunas - Holland, 1988

Text-fig. 1 - Lithostratigraphy and summary of biostratigraphic and isotopic ages from the late Silurian and early Devonian of the Dingle Peninsula.

STRATIGRAPHY

STRATIGRAPHY OF THE DINGLE GROUP, SOUTHWEST DINGLE

In southwest Dingle the group has been subdivided into five formations by Todd *et al.*, (1988a; see Text-fig. 1). These are summarized below, in ascending stratigraphic order.

Bulls Head Formation (800 m) is predominantly a lacustrine sequence composed of thin beds of purple-grey, fine-grained siltstones and sandstones which are typically interbedded with thin mudrock layers and show small scale cross lamination.

Eask Formation (1100 m) comprises red and grey medium-grained sandstones that are generally parallel-laminated with common associated planar cross-bedding. Interbedded grey and purple mudstones show evidence of dessication and incipient pedogenesis. Sediments of this formation have been interpreted as having been deposited in a distributary fluvial system that drained north-north-westerly as a broad alluvial apron.

Coumeenoole Formation (450 m) is composed of medium-grained grey sandstones that are planar and trough cross-bedded; intraformational mudclasts are common throughout. This sequence is considered to represent an axial river system that drained towards the northeast.

Slea Head Formation (600 m) is characterized by thickly bedded green-grey, coarse to pebbly sandstones, typically showing large scale cross-bedding. Thin grey-green mudstones are occasionally developed. The Slea Head Formation is considered to be the product of high discharge braided stream deposition in an axial river system that also drained towards the northeast.

Ballymore Formation (1200 m) - the youngest formation of the Dingle Group - consists of fine-grained red and purple sandstones and mudrocks that typically occur in fining-upward cycles. The middle part of the formation contains a tuff bed (Horne, 1974, p. 415). The Ballymore sequence is considered to represent a continued and more laterally extensive development of the northeast-draining axial river system.

In the southwestern part of the peninsula, the rocks described above are disposed in a broad synclinal structure, termed the Fahan Syncline. The sequence investigated in this study occurs on the northwest limb of the Fahan Syncline and crops out in a continuous coastal section from Dunquin Harbour to Slea Head.

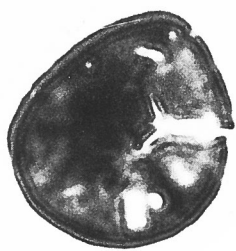
PREVIOUS BIOSTRATIGRAPHIC DATA FROM THE DINGLE GROUP

The only previous biostratigraphic data obtained from the Dingle Group are palynological. The first

EXPLANATION OF PLATE 1

- Fig. 1 - *Retusotriletes pichovii* Naumova, 1953. Slea Head Formation, SH1(d), Q65/1.
 Figs. 2, 3 - *Retusotriletes maculatus* McGregor & Camfield, 1976. 2) Eask Formation, DU1(a), U35/1; 3) DU1(b), U32/1.
 Fig. 4 - *Retusotriletes triangulatus* (Streel) Streel, 1967. Eask Formation, DU1(b), S41/2.
 Figs. 5, 6 - *Archaeozonotriletes chulus* Cramer var. *chulus* Richardson & Lister, 1969. 5) Eask Formation, DU1(a), Q52/2; 6) Eask Formation, DU1(a), G54/3.
 Fig. 7 - *Archaeozonotriletes chulus* Cramer var. *nanus* Richardson & Lister, 1969. Eask Formation, DU1(b), V50/4.
 Fig. 8 - *Apiculiretusispora plicata* (Allen) Streel, 1967. Slea Head Formation, SH1(a), R67/2.
 Figs. 9, 10 - *Apiculiretusispora brandtii* Streel, 1964. 9) Eask Formation, DU1(b), S42/4; 10) Slea Head Formation, SH1(g), R57/2.
 Fig. 11 - *Brochotriletes bellatulus* Steemans, 1989. Eask Formation, DU1(b), R41/4.
 Fig. 12 - *Chelinospora* sp. cf. *C. vermiculata* Chaloner & Streel, 1968. Slea Head Formation, SH1(a), N58/4.

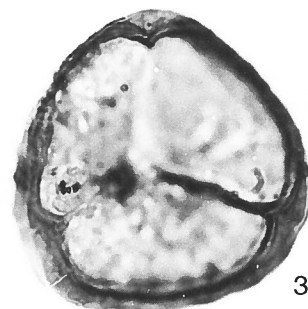
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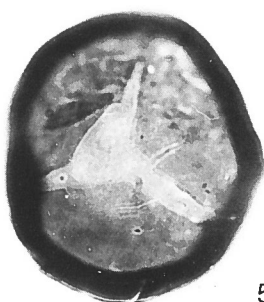
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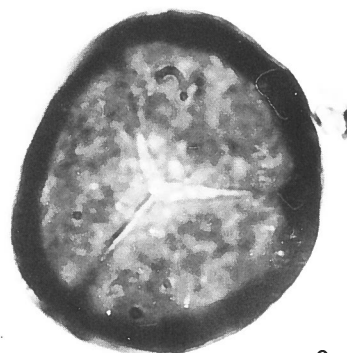
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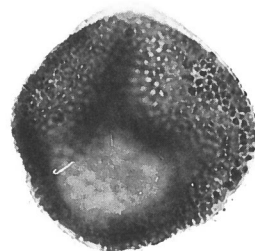
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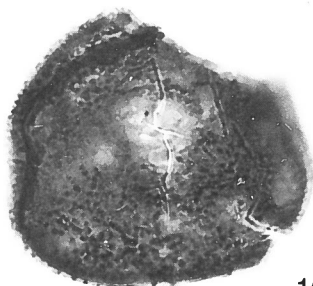
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record was a miospore assemblage reported by Visscher as personal communications in Gardiner & Horne (1976, fig. 3a), and in Horne (1976, fig. 28). Although no details of this assemblage were given, it was shown to be indicative of an age close to the Silurian-Devonian boundary. The sample was shown on a stratigraphic section to be from a level close to the base of the Eask Formation. Van der Zwan (1980) described a considerably younger (Devonian: late Emsian) spore assemblage from the Eask Formation. His sample was apparently obtained from the same sample suite from which Visscher and Horne had collected in 1973; however, it is unclear whether Van der Zwan's sample came from the same stratigraphic level as the sample reported by Gardiner & Horne (1976) and Horne (1976). The provenance of both these samples remains problematical because insufficient stratigraphic and geographic information was given. For the Van der Zwan sample, the only information provided was that it came from the Eask Formation at Dunmore Head. Reference to the geological sketch map (including lithostratigraphic boundaries) of the Dunmore Head area (Horne, 1976, fig. 11) indicates that this sample was most probably collected from somewhere in the Coumeenoole Strand section on the south side of Dunmore Head. This part of the Dingle Group succession at Coumeenoole Strand is now assigned to the Coumeenoole Formation (Todd *et al.*, 1988a). Unfortunately, detailed sampling by the present author of the grey-purple mudrocks in the Coumeenoole section has so far failed to locate Van der Zwan's (1980) palyniferous level.

PALYNOLOGY

Forty samples have been collected and processed from the five formations of the Dingle Group; of these only two proved productive palynologically. The samples were processed using standard laboratory techniques, i.e., HF to remove silicates, and ZnBr₂ heavy-liquid separation to eliminate very fine residual minerals. The two productive samples yielded very sparse organic residues composed mainly of laths and irregular fragments of woody debris and opaque matter. The relatively small numbers of sporomorphs present are thermally mature and required extensive oxidation (18-20

hours) in Schulze solution to render them sufficiently pale for identification. The spores in both assemblages are small, generally within the 25-55 µm size range. Figured miospore specimens (Plates 1-3 herein) are housed in the micropalaeontology collection of the Geology Department, University College Cork.

SYSTEMATIC NOTES

No formal systematics are presented as the species recorded herein are well-established and have, in most cases, been extensively described in the literature. However, two of the species are newly combined with more appropriate spore genera and their respective basionyms are given below.

Genus *DIAPHANOSPORA* Balme & Hassell emend.
Evans, 1970

Type species – *Diaphanospora riciniata* Balme & Hassell emend. Evans, 1970; by original designation.

DIAPHANOSPORA BOLLANDENSIS (Steenmans)
comb. nov.

1989 *Perotrilites bollandensis* STEEMANS, p. 150; pl. 42, figs. 4-11.

DIAPHANOSPORA SUBITA (Arkangelskaya) comb. nov.

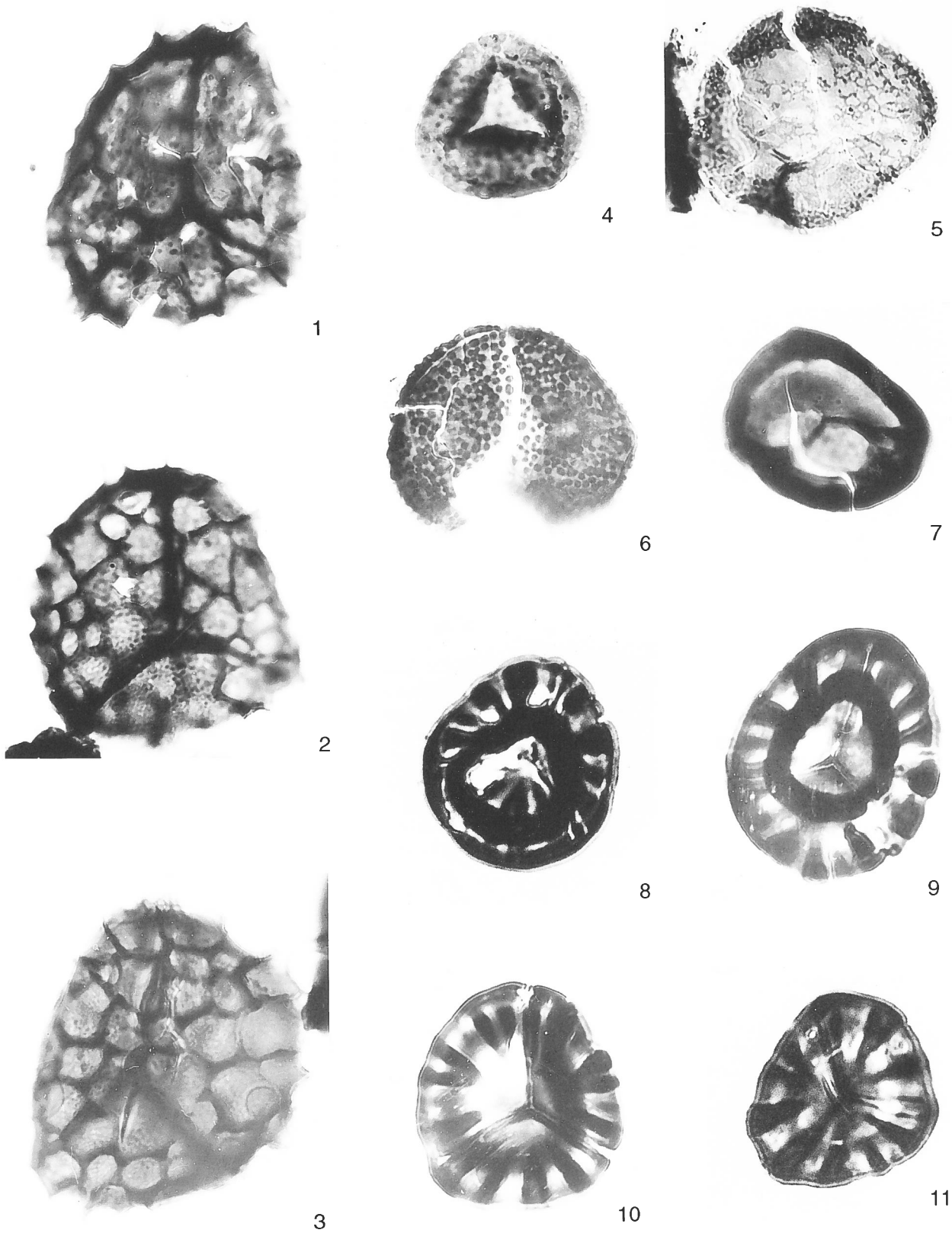
1978 *Lycospora subita* ARKANGELSKAYA, pp. 119-120; pl. 11, figs. 13-14.

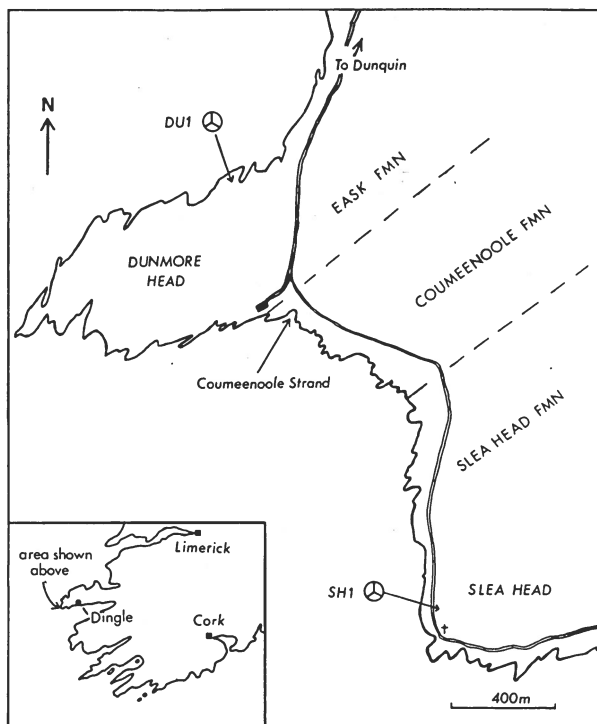
Comments – Both the above species are perinate and possess an equatorially darkened (thickened) band along the margin of the intexine. Evans (1970) has clearly demonstrated that the type material of *Perotrilites* Couper, 1953 is zonate, not perinate, and therefore this genus cannot be applied to spores wholly enveloped by a thin outer layer. As noted by Playford (1971), such perinate spores could be assigned to either *Diaphanospora* or *Velamispores* Bharadwaj & Venkatachala, 1962. The type species of the former genus, *D. riciniata* Balme & Hassell 1962, characteristically possesses an equatorially thickened band at the outer margin of the intexine. Therefore, *Diaphanospora* is considered the more appropriate generic repository for the above two species recorded in the present study.

EXPLANATION OF PLATE 2

- Figs. 1-3 – *Dictyotrilites emsiensis* (Allen) McGregor, 1973. 1) Eask Formation, DU1(b), N30/1; 2) Eask Formation, DU1(a), M41/1; 3) Eask Formation, DU1(c), H45/2.
Fig. 4 – *Dibolisporites wetteldorfensis* Lanniger, 1968. Eask Formation, DU1(b), V39/4.
Fig. 5 – *Dictyotrilites favosus* McGregor & Camfield, 1976. Eask Formation, DU1(b), V44/2.
Fig. 6 – *Verrucosiporites polygonalis* Lanniger, 1968. Eask Formation, DU1(b), N38/3.
Fig. 7 – *Amicosporites* sp. Eask Formation, DU1(b), U50/1.
Figs. 8-11 – *Emphanisporites annulatus* McGregor, 1961. 8) Sleah Head Formation, SH1(b), N 30/1; 9) Sleah Head Formation, SH1(a), E 57/4; 10) Sleah Head Formation, SH1(a), P69/2; 11) Sleah Head Formation, SH1(b), L57/2.

All figures ×1000.





Text-fig. 2 - Locality map of study area with sample locations, thus: DU1, collected from Eask Formation; SH1, from Sleah Head Formation.

COMPOSITION OF THE SPORE ASSEMBLAGES

Eask Formation assemblage

Sample DU 1 was collected from a thin grey-dark green shale unit within the Eask Formation on the northern coast of Dunmore Head (Text-fig. 2), ca. 630 m above the base of the formation, which is ca. 1100 m thick in this area (Boyd, 1983). The following miospore taxa have been identified in the assemblage:

Apiculiretusispora plicata (Allen) Streel, 1967

Apiculiretusispora brandtii Streel, 1964

Archaeozonotriletes chulus Cramer var. *chulus* Richardson & Lister, 1969

Archaeozonotriletes chulus Cramer var. *nanus* Richardson & Lister, 1969

Amicosporites sp.

Camptozonotriletes caperatus McGregor, 1973

Diaphanospora bollandensis (Steemans) comb. nov.

Diaphanospora subita (Arkangelskaya) comb. nov.

Dibolisporites wetteldorfensis Lanniger, 1968

Dictyotriletes emsiensis (Allen) McGregor, 1973

Dictyotriletes favosus McGregor & Camfield, 1976

Emphanisporites rotatus McGregor emend. McGregor, 1973

Retusotriletes maculatus McGregor & Camfield, 1976

Retusotriletes pychovii Naumova, 1953

Retusotriletes triangulatus (Streel) Streel, 1967

Verrucosisporites polygonalis Lanniger, 1968.

The most commonly occurring taxa in the assemblage are *Dictyotriletes emsiensis*, *Emphanisporites rotatus*, *Retusotriletes pychovii*, and *Archaeozonotriletes chulus* var. *chulus*.

The age of the assemblage can be confidently determined by the presence of several stratigraphically important miospore species, such as *Verrucosisporites polygonalis*, *Dibolisporites wetteldorfensis*, *Camptozonotriletes caperatus*, *Dictyotriletes emsiensis*, *Dictyotriletes favosus*, *Diaphanospora bollandensis*, and *Diaphanospora subita*. The presence of these species allows correlation with the published Devonian miospore zonation schemes of the Old Red Sandstone Continent and adjacent marine basins. In the Richardson & McGregor (1986) scheme the Eask Formation assemblage can be correlated with the *Verrucosisporites polygonalis*-*Dictyotriletes emsiensis* Assemblage Zone, which is considered to be Siegenian and earliest Emsian? in age. A more precise age assignment is obtainable by correlating the assemblage with the zonation scheme of Streel *et al.* (1987) and Steemans (1989), specifically with the *Verrucosisporites polygonalis*-*Dibolisporites wetteldorfensis* (PoW) Oppel Zone. This zone has been subdivided into four interval zones (Text-fig. 3); in ascending stratigraphic order these are the *V. polygonalis* (Po), *D. wetteldorfensis* (W), *C. parvus* (Pa), and *D. subgranifer* (Su) Interval Zones. The presence of *Verrucosisporites polygonalis* and *Dibolisporites wetteldorfensis* and the

EXPLANATION OF PLATE 3

Figs. 1-5 - *Emphanisporites rotatus* McGregor emend McGregor, 1973. 1) Eask Formation, DU1(a), Q39/1; 2) Eask Formation, DU1(a), J48/3; 3) Eask Formation, DU1(b), L29/4; 4) Eask Formation, DU1(a), K51/4; 5) Sleah Head Formation, SH1(a), J58/3.

Fig. 6 - *Indotriletes* sp. Sleah Head Formation, SH1(g), V49/3.

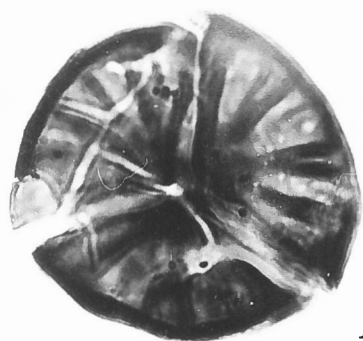
Fig. 7 - *Diaphanospora* sp. Sleah Head Formation, SH1(g), G 68/1..

Figs. 8, 9 - *Camptozonotriletes caperatus* McGregor 1973. 8) Eask Formation, DU1(c), T30/2; 9) DU1(c), V53/3.

Fig. 10 - *Diaphanospora subita* (Arkangelskaya) comb. nov. Eask Formation, DU1(c), J46/4.

Fig. 11 - *Diaphanospora bollandensis* (Steemans) comb. nov. Eask Formation, DU1(b), V50/2.

All figures $\times 1000$.



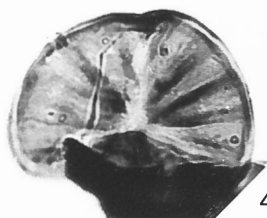
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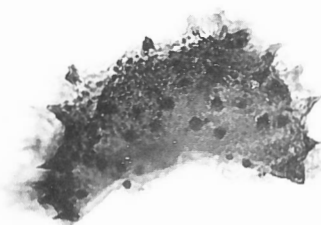
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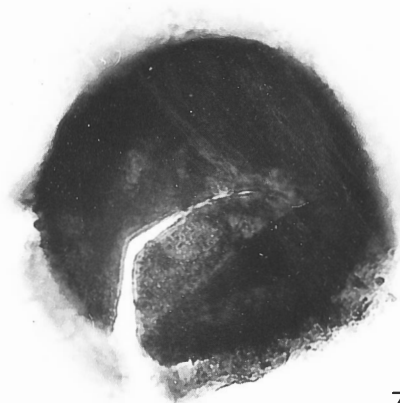
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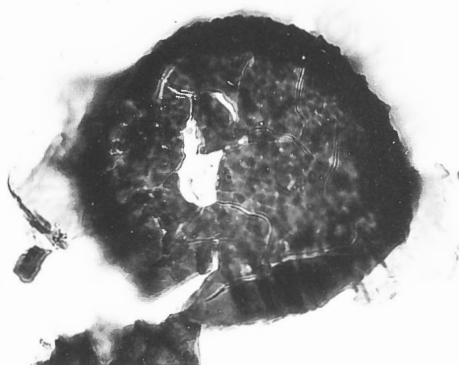
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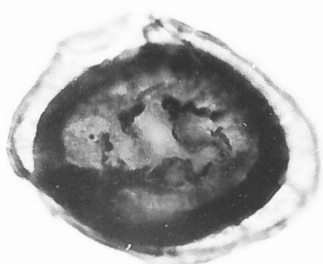
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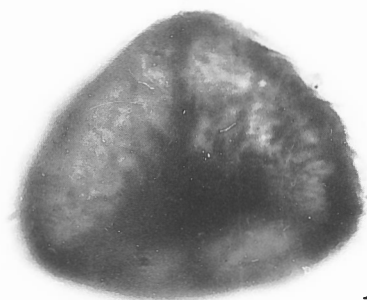
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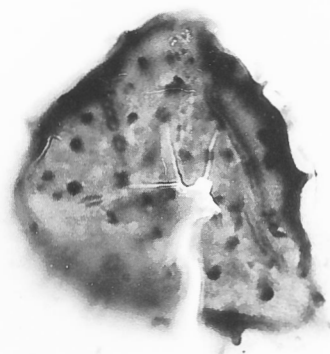
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Chronostratigraphy		Spore Zones (Streel <i>et al.</i> , 1987)	
EARLY DEVONIAN	Early EMSIAN	annulatus - bellatulus Zone	AB
	PRAGIAN	polygonalis - wetteldorfensis Zone	Su
			Pa
			W
			Po
	LOCKHOVIAN	breconensis - zavallatus	BZ
		micronatus - newportensis Zone	MN
LATE SILURIAN	PRIDOLI		
	LUDLOW		

Text-fig. 3 - Chronostratigraphy and miospore zonation of the Early Devonian of western Europe; after Streel *et al.*, (1987), Steemans (1989), and Yolkin *et al.*, (1997).

absence of *Camazonotriletes parvus* and *Dictyotriletes subgranifer* (the index species of the youngest two interval zones) indicates the Eask Formation assemblage is assignable to the *wetteldorfensis* (W) Interval Zone. Steemans (1989, p. 184) considered the W Interval Zone to be early Siegenian (Pragian) in age. However, the Pragian-Emsian stage boundary has recently been redefined, at the appearance of the condont *Polynathus kibaticus* (Yolkin *et al.*, 1997); accordingly, the W Interval Zone should now be considered of early late Pragian age.

Slea Head Formation Assemblage

Sample SH 1 was collected from a thin, grey-dark green, cleaved mudrock interbedded with thick pebbly sandstones of the Slea Head Formation, cropping out in the roadside section on the north side of Slea Head (ca. 140 m north of the grotto: see Text-fig. 2). The sample is from ca. 450 m above the base of the Slea Head Formation, which is ca. 600 m thick in this area (Todd, 1989).

The following miospore taxa have been identified in the assemblage:

- Apiculiretusispora plicata* (Allen) Streel, 1967
- Apiculiretusispora brandtii* Streel, 1964
- Archaeozonotriletes chulus* Cramer var. *chulus* Richardson & Lister, 1969
- Brochotriletes bellatulus* Steemans, 1989

Chelinospora sp. cf. *C. vermiculata* Chaloner & Streel, 1968

Camptonotriletes caperatus McGregor, 1973

Diaphanospora bollandensis (Steemans) comb. nov.

Diaphanospora subita (Arkangelskaya) comb. nov.

Diaphanospora sp.

Dictyotriletes emsiensis (Allen) McGregor, 1973

Emphanisporites annulatus McGregor, 1961

Emphanisporites rotatus McGregor emend. McGregor, 1973

Indotriletes sp.

Retusotriletes pychovii Naumova, 1953

Retusotriletes triangulatus (Streel) Streel, 1967

Verrucosisporites polygonalis Lanniger, 1968.

The most commonly occurring taxa in this low-diversity assemblage are *Emphanisporites annulatus*, *E. rotatus*, *Apiculiretusispora plicata*, *Diaphanospora* spp., and *Retusotriletes* spp.

Most of the spore taxa recorded in the previous sample (DU 1) are also present in sample SH 1. However, the Slea Head Assemblage is distinguished by containing the distinctive *E. annulatus*, which is particularly common, comprising up to 20% of the assemblage. Another important but rare species in this assemblage is *Brochotriletes bellatulus*. The presence of these two species allows confident assignment to the Devonian miospore zonation schemes of the Old Red Sandstone Continent and adjacent marine basins.

The Slea Head Assemblage is attributable to the *Emphanisporites annulatus*-*Camazonotriletes sextantii* Assemblage Zone of Richardson & McGregor (1986). These authors dated this zone as early Emsian to early late Emsian and noted that large prominently spined zonate-pseudosaccate spores first appeared in the upper part of the zone. The absence of this group of spores in the Slea Head assemblage suggests a position in the lower part of the zone. Correlation with the zonation scheme of Streel *et al.*, (1987) indicates assignment to the *E. annulatus*-*B. bellatulus* (AB) Oppel Zone (Text-fig. 3). In documenting the stratigraphic range of the AB Zone in Belgium and Germany, Steemans (1989) suggested that the base of the zone is latest Siegenian (Pragian). However, the biostratigraphic redefinition of the the Pragian-Emsian stage boundary by Yolkin *et al.* (1997) suggests that lower AB Zone (lacking large spinose zonate-pseudosaccate taxa) should be dated as early to possibly middle Emsian. This type of assemblage with *Emphanisporites annulatus* has been extensively recorded in eastern Canada, western and eastern Europe, North Africa, Russia, China, and South America: see Richardson & McGregor (1986) and Steemans (1989) for details.

AGE OF THE DINGLE GROUP

The palynological evidence presented here shows that the upper part of the Eask Formation at Dunmore Head is of early late Pragian age and that

the middle to upper part of the Sleah Head Formation is datable as early to possibly middle Emsian. Both determinations predate the late Emsian age reported by Van der Zwan (1980). However, given the uncertain provenance of Van der Zwan's sample, no meaningful comparison or correlation is possible with the present palynological data.

The age of the basal part of the Dingle Group remains uncertain as no biostratigraphic data have yet been obtained from the Bulls Head Formation and lower part of the Eask Formation (see Text-fig. 1). The Croaghmahrin Formation at the top of the underlying Dunquin Group is dated as Silurian (Ludlow) on marine macrofaunal evidence (Holland, 1988). The conformable transition between the Dunquin Group and the overlying Dingle Group has led to suggestions that the Silurian-Devonian boundary is likely to be located in the Dingle Group at a middle to high level (Holland, 1969, p. 306) or at a low to middle position (Todd, 1991, p. 97). However, the palynological evidence now shows that the bulk of the Dingle Group belongs to the Lower Devonian and the most likely position for the Silurian-Devonian boundary is within the basal Bulls Head Formation. If this is the case then the Bulls Head Formation and the lower part of the Eask Formation probably accumulated in latest Silurian (Pridoli) and early Devonian (Lochkovian) times. The new Devonian timescale of Tucker *et al.* (1998, fig. 3) indicates that the interval comprising the Pridoli Series and the Lochkovian Stage is of much shorter duration than previously thought, probably comprising only 5-6 Ma. It is therefore reasonable to suggest that this time interval is mainly condensed in the 800 m-thick Bulls Head Formation, a predominantly lacustrine sequence which presumably accumulated at slower rates and in much quieter conditions than the overlying high energy sandstone-dominated formations of the main part of the Dingle Group.

The age of the top of the Dingle Group has not yet been determined biostratigraphically. However, recent isotopic (U-Pb zircon) dating of a tuff bed in the Ballymore Formation, the youngest formation in the Dingle Group, has given a 411 ± 3.3 Ma age (Williams *et al.*, in prep.). Correlation of this zircon age date with the new Devonian timescale of Tucker *et al.* (1998) indicates a position within the Emsian; this accords with the palynological dates presented in this paper.

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