Mississippian Microfloras From The South Munster Basin, Ireland

K. T. HIGGS* AND E. FORSYTHE

Keywords: Mississippian, Microfloras, South Munster Basin, Ireland.

Abstract: The Lower Carboniferous (Mississippian) succession of the South Munster Basin comprises a thick (2.5km) succession of shallow to deep marine clastic sediments. Lithostratigraphically these rocks are referred to as the Cork Group and have been divided into four formations in the South Cork Sub-basin and into five formations in the West Cork Sub-basin. Biostratigraphically the succession has been dated using miospores, conodonts and goniatites. However, the latter two fossil groups only occur intermittently throughout the succession, whereas miospores are abundant throughout. Detailed palynological studies have recognised a continuous succession of miospore assemblages which can be assigned to the Carboniferous miospore zonation scheme for northwest Europe (CLAYTON et al., 1977). The base of the Kinsale Formation contains the LN/VI miospore biozonal boundary which correlates closely with the base of the Carboniferous system. The Kinsale Formation and overlying Courtmacsherry / Reenydonegan Formations (Members 1-3) have yielded relatively well preserved miospores of early to late Tournaisian age (VI-CM Biozones). Member 4 of the Courtmacsherry Formation contains poorly preserved miospores of early Visan (Pu-TC Biozones) age. The overlying Lispatrick Formation contains very poorly preserved and low diversity assemblages of mid to late Visan age (VF °V CN (Cc Sub-biozone) Biozone). The White Strand Formation of the South Cork Sub-basin and the East Point, Middle Battery and Kilmore Formations of the West Cork Sub-basin contain slightly more diverse and better preserved miospore assemblages that are Serpukhovian (early Namurian) age (upper CN (Vm Sub-biozone) - SO Biozones). The taxonomic diversity and preservational quality of the miospore is highly variable, particularly from the upper part of the succession. This is due to both the high thermal maturity of the organic material and to the anoxic environment of a starved deep marine basin.

INTRODUCTION

The Mississippian rocks in the south of Ireland show a major facies change across of a line that extends westwards from Cork Harbour to the Kenmare River (JUKES, 1864, NAYLOR, 1969). North of this line, the Mississippian successions are dominated by limestones, whereas to the south they are dominated by marine siliciclastic rocks (Figure 1A). Sedimentation patterns and subsidence south of this facies line were controlled...
by the extensional Cork – Kenmare Fault system (Williams et al., 1989). This southern siliciclastic province, known as the South Munster Basin (George et al., 1976) was initiated in late Devonian times and contains a very thick (2.5km) succession of shallow to deep marine clastic sediments that ranges in age from latest Devonian (Strunian) to late Mississippian (Serpukhovian) age. The South Munster Basin has been subdivided into two depositional sub-basins, the Kinsale Sub-basin in the east and the Bantry Sub-basin in the west separated by structural highs, the Glandore High and the Sheeps Head High (Naylor et al., 1983).

STRATIGRAPHY

The basin fill succession has been termed the Cork Group (Sleeman, 1991) and has been divided into four formations in the Kinsale Sub-basin and into five formations in the Bantry Sub-basin (see Naylor et al., 1985, Pracht &
SLEEMAN, 2002). Overall the basin fill records a progressively deepening marine sequence that was deposited in series of transgressive pulses (MACARTHUR, 1987). The stratigraphy of the South Munster Basin in the two sub-basins is shown in Figure 2 and a summary of the succession is given below:

*Old Head Sandstone Formation* (840m). This is the oldest formation in the South Munster Basin and is characterised by a thick sequence of sandstones and heterolithic bedded sandstones and mudstones that were deposited in shallow marine and tidally influenced environments.

*Kinsale Formation* (762m). This is principally a mudstone dominated succession. The basal member is the Castle Slate Member (561m thick) and is composed of massive cleaved dark grey mudstone sequence with subordinate fine siliceous nodules and bioclastic limestone lenses near the base. The mudrocks of the Castle Slate Member represent a sudden deepening of the sea and this unit forms a widespread marker horizon right across the basin. The overlying Narrow Cove Member is composed mainly of flaser bedded sandstones with lesser mounts of linsen bedded mudstones and this sequence represents a regressive depositional phase. In the Bantry Sub-

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<td>Late Devonian (Strunian)</td>
<td>BP HD VI</td>
<td>LN LE LL</td>
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Fig. 2 – Carboniferous stratigraphy and biostratigraphy of the South Munster Basin.
-basin the Ardaturrish Member is composed of heterolithic lithologies and is sedimentologically equivalent to the Narrow Cove Member. In West Cork this member is succeeded by the Reenagough Member, a distinctive pale coloured sand dominant sequence deposited locally as a shallow marine sand shelf complex. This regressive phase is followed by a second transgressive event across the basin that deposited the Pigs Cove Member, a mudstone / siltstone dominant succession. In the Bantry Sub-basin this event it is represented by the Ardnamanagh Member.

**Courtmacsherry Formation** (343m). This formation is characterised by calcareous mudrocks with occassional muddy bioclastic limestone beds and nodules. The formation is subdivided into four members. Member 1 and Member 3 are similar in composition, being mainly mudstone dominant, whereas Member 2 is much sandier in composition. Member 4 is mainly composed of dark grey to black, pyritic mudrocks with ferroan carbonate beds and concretions. In the Bantry Sub-basin the Reenydonegan Formation is stratigraphically equivalent to the Courtmacsherry Formation and is also subdivided into 4 members (Naylor & Sevastopulo, 1993).

**Lispatrick Formation** (67m). This formation comprises a sequence of dark grey to black, often pyritic mudstones containing interbedded layers of ferroan dolomite and phosphatic nodules in the lower part of the formation and bands of black chert in the upper part (Naylor et al., 1985).

**White Strand Formation** (346m). The base of this formation is marked by the entry of turbiditic sandstones into the succession. The basal part of the formation and the contact with the underlying Lispatrick Formation is only seen at the Old Head of Kinsale. The most complete succession occurs at the Ballinglanna section on the Seven Heads Peninsula where the formation is divided into 3 members. Member 1 is characterised by turbiditic and often slumped sandstones with interbedded grey mudstones. Member 2 is mudstone dominant and Member 3 is comprises a sandstone dominant sequence very similar to that seen in Member 1. In the Bantry Sub-basin the Upper Mississippian rocks are restricted to Whiddy Island where the succession comprises three formations (Naylor et al., 1978). The East Point Formation has a minimum thickness of 171m and is characterised by black pyritic mudstones which are often cherty and contain calcareous bullions. The succeeding Middle Battery Formation (230m) is subdivided into five members and is marked by the entry of thin beds of siltstone and sandstone. The youngest formation is the Kilmore Formation which has a minimum thickness of 110m and comprises an alternating sandstone and mudstone sequence.

All of the rocks of the South Munster Basin have been affected by strong Variscan deformation that has produced extensive folding, faulting and penetrative cleavage development (Naylor et al., 1983, Cooper et al., 1986).

**PALYNOLOGY**

Miospores occur abundantly throughout the succession and provide the primary means of stratigraphic age dating and correlation. Strong thermal alteration of the rocks in the South Munster Basin has consequently the carbonised and darkened spore exines. Spore colouration index (TAI 4-5) and high vitrinite reflectance values are indicative of meta-anthracite coal rank with palaeotemperatures in excess of 250°C (Clayton, 1989). Therefore strong oxidation techniques are required to lighten the black spore residues for study and identification. This has been achieved by using both prolonged oxidation in Schultze Solution (>20hrs) and shorter blasts of oxidation using more powerful fuming Schultze Solution (<2hrs). In addition, the oxidised residues required cold mounting followed by rapid examination and photography before any of the oxidised specimens could revert back to a dark colour. Several slides of each sample were studied at various oxidation stages to ensure a full microfloral assemblage (as possible) was recorded from each sample.

Previous palynological studies in the South Munster Basin have been almost exclusively focused on the Upper Devonian (Strunian) and Lower Mississippian (Tournaisian) part of the succession, e.g., Clayton et al., 1974, Van Der Zwam 1980, Van Veen, 1981, Keegan, 1977, Sleeman et al., 1978, Higgs et al., 1988. The latter authors collated and synthesised all the previous palynological data and described a zonation scheme that consists of seven miospore zones for the Strunian and to Upper Tournaisian interval. By contrast relatively little palynological work has been carried out on upper part of the South Munster Basin succession, the exceptions being Naylor et al., 1978 and Higgs, 1993. The present study presents new information from the Middle and Upper Mississippian intervals in the South Munster Basin. The new palynological data has been obtained from 143 samples collected from the following sections:
In the Kinsale Sub-basin, Old Head of Kinsale section (the type section for the Cork Group stratigraphy, NAYLOR, 1966); the Innishannon boreholes (FUSCIARDI, 1995), the Rockfort House disused railway section near Bandon; the Ballinglanna section on Seven Heads. In the Bantry Sub-basin, the Reenydonegan Point section and the Whiddy Island section (see Figure 1B). The details of the sections and the stratigraphic position of the productive samples in each section are documented in FORSYTHE, 1999. Generally the spore assemblages obtained from Middle and Upper Mississippian levels are generally poorly preserved and are of low taxonomic diversity. However, they contain

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Fig. 3 – Mississippian miospore zonation scheme for northwest Europe (after CLAYTON et al., 1977) and OWENS et al., 2004
sufficient zonal taxa to allow correlation with the Carboniferous miospore zonation scheme for northwest Europe as described by Clayton et al., 1977 and modified by Owens et al., 2000 (see Figure 3). A continuous palynostratigraphy is now described for the South Munster Basin succession and this is summarised below with particular emphasis on the new data from the Middle and Upper Mississippian intervals.

UPPER DEVONIAN (STRUNIAN) MICROFLORAS

The late Devonian (Strunian) microfloras of the South Munster Basin are not described in this paper as they have been extensively documented in previous publications (see Higgs et al., 1988). The Strunian miospore assemblages are assignable to the LL, LE, and LN Miospore biozones and occur in the Old Head Sandstone Formation (see Figure 3). The nominal zonal taxa of the se biozones are illustrated on Plate 1.

LOWER MISSISSIPPIAN (TOURNAISIAN) MICROFLORAS

Lower Mississippian microfloras have been obtained from the Kinsale Formation and from Members 1-3 of the overlying Courtmacsherry Formation (Kinsale Sub-basin) and Reenydonegan Formation (Bantry Sub-basin). The miospores recovered are generally abundant and moderately to well preserved. Taxonomic diversity is moderate to good (25-40 identifiable taxa) except in the Member 1 (Castle Slate Member) of the Kinsale Formation and in Member 3 of Courtmacsherry and Reenydonegan Formations where diversity is poor to moderate (15-25 identifiable taxa). A detailed account of these Tournaissian biozonal assemblages has been given in Higgs et al., 1988, with the exception of the youngest Tournaissian CM Biozonal assemblages which are reported here for the first time from the South Munster Basin succession. The base of the Carboniferous system in the South Munster Basin is correlated with the LN / VI Miospore biozonal boundary and this occurs at the base of the Kinsale Formation right across the basin. Palynological data presented in George et al., 1976 established that the LN / VI miospore zonal boundary occurred at the base of the Kinsale Formation at the Old Head of Kinsale Section in south County Cork This section was chosen as the stratotype for the base of the Courceyan Stage, the lowest regional stage in the Carboniferous of Britain and Ireland.

VI Biozone - VI Biozonal assemblages first appear in the lower part of the Castle Slate Member of the Kinsale Formation. These basal assemblages are characteristically of low taxonomic diversity being dominated by species of simple acamerate genera such as Retusotriletes, Punctatisporites, Plicatispora, which contrasts markedly with the relatively rich Late Devonian LN Biozonal assemblages seen in the underlying Old Head Sandstone Formation. However, the presence of small numbers of reworked LN biozonal species in these basal VI assemblages has in the in the past lead to the erroneous assignment of some these assemblages to the older LN Biozone (Van Veen, 1981, Van der Zwan, 1980). Stratigraphically younger VI biozonal assemblages from the middle and upper parts of the Castle Slate Member are more diverse in composition and contain species such as, Coryxstisporites spinosus, Crassisspora cf. maculosa, Tumulispora rarituberculata var rarituberculata, Bascaudaspora submarginata, Spelaeotriletes obtusus and Auroraspora corporiga.

VI Biozone assemblages at the Nohoval Cove section in south Cork are associated with an early Carboniferous “Gattendorfia stufa” goniatite fauna containing Imitoceras cf. prorsum (Matthews, 1983).

HD Biozone – The appearance of Cristatisporites hibernicus and Umbonatisporites distinctus defines the HD Biozone. C. hibernicus tends to be the more common and consistent element for recognising HD biozonal assemblages. The lowest HD assemblages first appear just above the base of Member 2 of the Kinsale Formation in both sub-basins. The upper part of the HD Biozone is characterised by the first appearance of Neoraistrickia cymosa which occurs at the base of Pigs Cove Member of the Kinsale Formation in the Kinsale Sub-basin and the base of the Ardnamanagh Member in the Bantry Sub-basin.

BP Biozone – Is defined by the first appearance of Spelaeotriletes balteatus. Other distinctive taxa occurring in the biozone are Rugospora polyptycha and Vallatisporites vallatus. BP assemblages first appear in the middle parts of Pigs Cove and Ardnamanagh Members of the Kinsale Formation in the Kinsale and Bantry Sub-basin respectively.

PC Biozone – The biozone is primarily recognised by the first appearance of Spelaeotriletes pretiosus, however, it tends to be rare (<1%) in the early part of the biozone.
Several other taxa such as *Raistrickia clavata*, *Colatisporites decorus*, *Granulatisporites microgranifer* also make their first appearances in this Biozone. The base of the PC biozone correlates with the Kinsale / Courtmacsherry Formational boundary in the Kinsale Sub-basin, the only exception to this is in the north Ringabella section where it occurs 1.5m below the boundary. PC Miospore Biozonal assemblages have been recorded throughout Members 1, 2 and the lower part of Member 3 of the Courtmacsherry Formation at the Old Head of Kinsale; Ringabella; Ringaskiddy (HIGGS et al., 1988); Rockfort House Section; and Innishannon drill-cores 3202/6 and 3202/15 (FORSYTHE, 1999); and the Seven Heads peninsula (NAYLOR et al., 1988). In the Bantry Sub-basin PC biozonal miospores have been reported from the Member 1 (HIGGS et al., 1988) and Member 2 and lowermost part of Member 3 (FORSYTHE, 1999) of the Reenydonegan Formation at the North Bantry Bay section. The lower part of the PC Biozone is correlated with the *Siphonodella-Polygnathus inornatus* conodont faunas and the upper part with the *Polygnathus communis carina* biozone (MATTHEWS & NAYLOR, 1973).

**CM Biozone** – CM Biozonal assemblages are reported here for the first time from the South Munster Basin. The zonal species *Schopfites claviger* first appears in the middle to upper parts of Member 3 of the Courtmacsherry Formation in Member 3 of the Courtmacsherry Formation. Other commonly occurring taxa in the CM Biozonal assemblages include, *Anaplanisporites baccatus*, *Colatisporites decorus*, *Crassispora trychera* and Rugospora minuta. Stratigraphically the CM assemblages have been recorded from the Old Head of Kinsale section; the Rockfort House disused railway section; Innishannon drill-core 3202/6. In Bantry Sub-basin. CM Biozone assemblages have also been recorded from 11.5 metres above the base of Member 3 of the Reenydonegan Formation at Reenydonegan Point. In this latter section, CM biozonal assemblages are associated with a *Scaliognathus anchoralis* conodont fauna (NAYLOR & SEVASTOPULO, 1993) of latest Tournaisian age.

**MIDDLE MISSISSIPPIAN (VISÉAN) MICROFLORAS**

This paper presents the first account of an almost continuous succession of Middle Mississippian (Viséan) miospore assemblages from the South Munster Basin. The assemblages have been obtained from Member 4 of the Courtmacsherry Formation and throughout the overlying Lispatrick Formation in the Kinsale Sub-basin. However, no Viséan spore assemblages have yet been recorded in the Bantry Sub-basin. Miospores from this interval are typically poorly preserved and the assemblages are of low taxonomic diversity (10 -15 identifiable taxa). A sufficient number of stratigraphically important taxa have been recorded to allow tentative correlations to be made with the standard western European miospore zonation scheme. The most complete Viséan spore succession has been recorded from the Old Head of Kinsale section where all of the Viséan miospore biozones are recognised with the exception of the NM Biozone.

**Pu Biozone** – *Lycospora pusilla*, the zonal index species for the Pu Biozone, first appears in the basal beds of Member 4 of the Courtmacsherry Formation in the Old Head of Kinsale section. It is rare at this level, comprising <1% of the total spore assemblage and it remains uncommon even in the younger Pu assemblages of Member 4.

**TS Biozone** – The first appearance of the TS zonal taxa *Knoxisporites stephanephorus* and *Knoxisporites triradiatus* occur in the upper part of Member 4 of the Courtmacsherry Formation at Old Head of Kinsale section and also in the Innishannon drill cores 3202/15 and 3202/06. Other taxa occurring in these TS assemblages are *Lycospora pusilla* (8%), *Lycospora noctuina*, *Crassispora trychera*, *Colatisporites decorus*, *Convolutispora mellita*, *Anaplanisporites baccatus*, and Rugospora minuta. The cingulate form *Densosporites intermedius* first appears in this zone.

**TC Biozone** – The base of the TC Biozone has been identified in the uppermost metre of Member 4 of the Courtmacsherry Formation at Old Head of Kinsale section and in uppermost part of Member 4 in the Innishannon drill core 3202/06. Assignment to this biozone is based by the first appearance of the zonal species *Schulzospora campyloptera*, together with specimens of the genera *Waltzispora* and *Triquiritites*. TC biozonal assemblages also occur in the lowermost 14m of the overlying Lispatrick Formation both in the Lispatrick Point and Well Cove sections on the Old Head of Kinsale. TC biozonal assemblages from the lower part of the Lispatrick Formation contain additional taxa such as *Perotrilitess tessellatus* and *Dictyotriletes sagenoformis*, plus numerous specimens of *Convolutispora ampla*, *C. florida* and *C. tessellatus*. The presence of middle Viséan TC Biozone at this
VF Biozone – The nominal zonal taxa of the VF Biozone have not been recorded and assignment to the biozone is based on the first appearance of *Savitrisporites nux*, and *Crassispora maculosa*. CLAYTON et al., 1977 list these two taxa as first occurring at the base of the VF Biozone. Interestingly, the distinctive species *Raistrickia nigra* (a zonal species for the older NM Biozone) is also present in these VF assemblages. Normally *R. nigra* appears stratigraphically before the inception of *S. nux* and *C. maculosa* which suggests the NM Biozone may possibly be represented in the non-sampled interval (5.5m) between the highest TC and lowest VF biozonal horizons. Miospore assemblages assignable to the VF Biozone have been recorded from 19.5m above the base of the Lispatrick Formation in the Lispatrick Point section on the Old Head of Kinsale and from the lower to middle part of the Lispatrick Formation at Ballinglanna section, and Inishannon drill cores 3202/06, 3202/07 and 3202/17. A poor miospore assemblage at Ballinglanna occurs below horizons containing late Viséan (P1 Zone) bivalves and *Gnathodus bilineatus* conodont fauna (NAYLOR et al., 1987).

CN Biozone (Cc Subzone) – Assignment to the Cc Subzone of the CN Biozone is based primarily on the occurrence of the zonal taxon *Cingulizonates cf. capistratus*. This species first appears 31m above the base of the formation in the Lispatrick Point section at the Old Head of Kinsale. Other taxa appearing at this level are *Diatomozonotriletes saetosus*, *D. cervicornutus*, *Reticulatisporites carnosus*, and *Convolutispora varicosa*. Miospore assemblages from five samples from the upermost part of the formation are very poorly preserved and of sparse composition but all contain *C. cf. capistratus*. The Cc Subzonal assemblages are associated with bivalve and goniatite faunas of late Viséan (Pl1 Zone) age at the Old Head of Kinsale section.

UPPER MISSISSIPPIAN (SERPUKHOVIAN) MICROFLORAS

There have been only two previous palynological studies of the Upper Mississippian strata in the South Munster Basin. NAYLOR et al., 1978 made a preliminary palynological investigation of the Middle Battery and Kilmore Formations of Whiddy Island in Bantry Bay and HIGGS, 1993, described miospore assemblages from the White Strand Formation at Ballinglanna and Broad Strand on the Seven Heads Peninsula. The present study reports data from a more detailed palynological sampling programme undertaken by FORSYTHE, 1999, on all the sections mentioned above, plus an additional section at White Strand on the Old Head of Kinsale. In general terms, the miospores recovered from the Upper Mississippian interval are generally poorly to moderately preserved and the assemblages are of low to moderate taxonomic diversity (10-25 identifiable taxa). The assemblages are mainly composed of relatively long ranging forms, however, a small number of stratigraphically important taxa have been identified that allows tentative correlation with the recently revised Namurian miospore zonation scheme described by OWENS et al., 2004.

CN (Vm Subzone) – Miospore assemblages assignable to the Vm Sub-zone of the CN Biozone appear just above the base of Member 1 of the White Strand Formation at the Old Head of Kinsale. These assemblages contain *Florinites similis*, *Schopfipollenites ellipsoidei*, *Crassispora kosankei*, *Verrucosisporites morulatus Anoplanisporites globulus*, *Pustulatisporites papillosus*, *Cirratiradites cf. elegans* and *Cingulizonates cf. capistratus*. Similar Vm Sub-zone assemblages have also been obtained from higher levels of Member 1 at the northern end of White Strand, however the top of the member is not exposed in this section. In the Bantry Sub-Basin poorly-preserved miospore assemblages obtained from the base and middle part East Point Formation are assigned to the Vm Subzone of the CN Biozone based on the occurrence of *Florinites similis*, *Schopfipollenites ellipsoidei*, *Crassispora kosankei*, *Verrucosisporites morulatus*, *Pustulatisporites papillosus*, *Cingulizonates cf. capistratus* and *C. bialatus*. Biostratigraphically the Vm Sub-zone miospore assemblages occur with the goniatite *Eumorphoceras* sp. (NAYLOR et al., 1985) of the early Serpukhovian E1-E2 Zone age at the Old Head of Kinsale and on Whiddy island they occur 149m below E2b Zone goniatite horizons (NAYLOR et al., 1978).

TK Biozone – The TK Miospore Biozone is recognised on the appearance of the zonal species *Stenozonotriletes triangulus* and *Punctatisporites pseudopunctatus*, together
with *Camptotretilates verrucosus* and *Discernisporites irregularis*. At Ballinglanna, TK assemblages have been recovered from the 5m above the base of the exposed section and this stratigraphic interval probably correlates with the upper part of the Member 1 of the White Strand Formation. TK biozonal assemblages occur throughout the lower and middle parts of the overlying mud dominant Member 2. In the Bantry Sub-Basin TK Biozonal assemblages containing *Stenozonotretilates triangularis* are recorded from Member 1 to Member 4 of the Middle Battery Formation.

**SO Biozone** – The appearance of *Indotriradites ornatus* is taken to define the SO Biozone. This species first appears in the upper part of the Member 2 at Ballinglanna and also occur throughout Member 3. *Cirratiradites rarus* first appears in the upper part of Member 3 at Ballinglanna (HIGGS, 1993). In the Bantry Sub-Basin *Indotriradites ornatus* appears in Member 5 of the Middle Battery Formation and continues up into the lower part of the overlying Kilmore Sandstone Formation.

**CONCLUSIONS**

- A succession of Lower Mississippian (Tournaisian) VI-CM miospore biozones has been recorded from the South Munster Basin. The Old Head of Kinsale section is probably the only section in Western Europe that displays a continuous sequence of all the Strunian and Tournaisian (LL-CM) biozones. The upper Tournaisian CM miospore biozone is recorded for the first time in the South Munster Basin and occurs in Member 3 of the Courtmacsherry Formation at the Old Head of Kinsale, Rockfort House section, Innishannon drillcores, Minane Bridge Quarry and in the Reenydonegan Point section at Bantry Bay.

- A succession of Middle Mississippian (Viséan) miospore assemblages is recorded for the first time in the South Munster Basin. All of the Viséan miospore biozones, with the exception of the upper Asbian NM Biozone have been identified. Viséan assemblages occur in Member 4 of the Courtmacsherry Formation and throughout the overlying Lispatrick Formation indicating a significantly younger age than previously thought. The palynological data also confirm the highly condensed nature of the upper Courtmacsherry Formation and Lispatrick Formation sequences with 18.9 million years represented by 171m of strata.

- Upper Mississippian (Serpukhovian) miospore flora previously recorded from the South Munster Basin lacked sufficient diagnostic taxa to permit zonal correlations. However, miospores recorded in the present study have yielded small numbers of zonal taxa which now permit tentative assignments to be made with the upper Mississippian CN (Vm Sub-zone), TK and SO Biozones.

- Palynological studies of sedimentary sequences from starved marine basins are both difficult and challenging. Palynological assemblages obtained from such sequences typically possess high amounts of amorphous organic matter (AOM) and relatively small numbers of spores due to the low supply of sediment and spores from the terrestrial hinterland. In the present study, miospores of this type have been obtained from the upper part of the South Munster Basin succession. They typically comprise low diversity assemblages often lacking the key zonal species. Correlation of these assemblages with the standard western European miospore zonation scheme, which was originally based on taxonomically rich assemblages obtained from terrestrial and shallow marine deposits of the Midland Valley of Scotland and northwest England, is therefore more tentative and less certain. Nevertheless, the presence of even a small number of zonal taxa in these distal marine assemblages has significant biostratigraphic value, particularly where other forms of stratigraphic age control are absent or very limited.

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**REFERENCES**


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PLATES
PLATE I
Magnification x500

A. *Retispora lepidophyta* (Kedo) Playford, 1976
B. *Knoxisporites literatus* (Waltz) Playford, 1963
C. *Indotriradites explanatus* (Luber) Playford, 1991
D. *Verrucosisporites nitidus* (Naumova) Playford, 1964
E. *Retusotriletes incohatus* Sullivan, 1964
F. *Vallatisporites verrucosus* Hacquebard, 1957
G. *Auroraspora corporiga* Higgs *et al.*, 1988
H. *Bascaudaspora submarginata* (Playford) Higgs *et al.*, 1988
I. *Tumilispora raritubercolatus* (Luber) Playford, 1991
J. *Cristatisporites hibernicus* (Higgs) Higgs, 1996
K. *Umbonatisporites distinctus* Clayton, 1971
L. *Vallatisporites vallatus* Hacquebard, 1957
M. *Neoraistricia cymosa* Higgs *et al.*, 1988
N. *Spelaeotriletes balteatus* (Playford) Higgs, 1996
O. *Spelaeotriltetes pretiosus* (Playford) Utting, 1987
P. *Spelaeotriltetes pretiosus* (Playford) Utting, 1987
Q. *Raistrickia clavata* Playford, 1964
R. *Schopfites claviger* Sullivan, 1968
S. *Schopfites claviger* Sullivan, 1968
T. *Anaplanisporites baccatus* (Hoffmeister, Staplin & Malloy) Smith & Butterworth, 1967
Lower carboniferous (mississippian) microfloras from the south munster basin, Ireland

Pl. I
PLATE II
Magnification x500

A. Lycospora pusilla (Ibrahim) Somers, 1971
B. Lycospora pusilla (Ibrahim) Somers, 1971
C. Lycospora pusilla (Ibrahim) Somers, 1971
D. Convolutispora florida Hoffmeister, Staplin & Malloy, 1955
E. Rugospora minutu Neves & Ioannides, 1974
F. Knoxisporites triradiatus Hoffmeister, Staplin & Malloy, 1955
G. Knoxisporites stepanephorus Love, 1960
H. Schulzospora campyloptera (Waltz) Hoffmeister, Staplin & Malloy, 1955
I. Perotrilites tessellatus (Staplin) Neville, 1973
J. Convoulispora ampla Hoffmeister, Staplin & Malloy, 1955
K. Dictyotrites sagenoformis Clayton, 1971
L. Triquirites sp.
M. Waltzispora sp.
N. Raistrickia nigra Love, 1960
O. Savirisporites nux (Butterworth & Williams) Smith & Butterworth, 1967
P. Crassispora maculosa (knox) Sullivan, 1964
Q. Densosporites intermedius Butterworth & Williams, 1958
S. Reticulatisporites carnosus (Knox) Neves, 1964
T. Diatomozonotriletes cervicornatus (Staplin) Playford, 1963
U. Diatomozonotriletes saetosus (Hacquebard & Barss) Hughes & Playford, 1961
Lower carboniferous (mississippian) microfloras from the south munster basin, Ireland
PLATE III
Magnification x500

A. Waltzisora planiangulata Sullivan, 1964
B. Lophotriletes tribulosus Sullivan, 1964
C. Diatomozonotriletes rarus Playford, 1963
D. Camptotriletes verrucosus Butterworth & Williams, 1958
E. Convolutispora varicosa Butterworth & Williams, 1958
F. Verrasosisporites morulatus Hoffmeister, Staplin & Malloy, 1955
G. Stenozonotriletes triangulus Neves, 1961
H. Knoxisisperites triradiatus Hoffmeister, Staplin & Malloy, 1955
I. Knoxisisperites stephanophorus Love, 1960
J. Savirrisporites nux (Butterworth & Williams) Smith & Butterworth, 1967
K. Schulzospora rara Kosanke, 1950
N. Cirratiradites rarus (Ibrahim) Schopf, Wilson & Bentall, 1944
O. Crassispora kosankei (Potonié & Kremp) emend Bharadwaj, 1957
P. Indotriradites ornatus (Neves) Higgs, 1996
Q. Indotriradites ornament (Neves) Higgs, 1996
R. Schopfipollenites ellipsoides (Ibrahim) Potonié & Kremp, 1954
S. Florinites similis Kosanke, 1950
Lower carboniferous (mississippian) microfloras from the south munster basin, Ireland