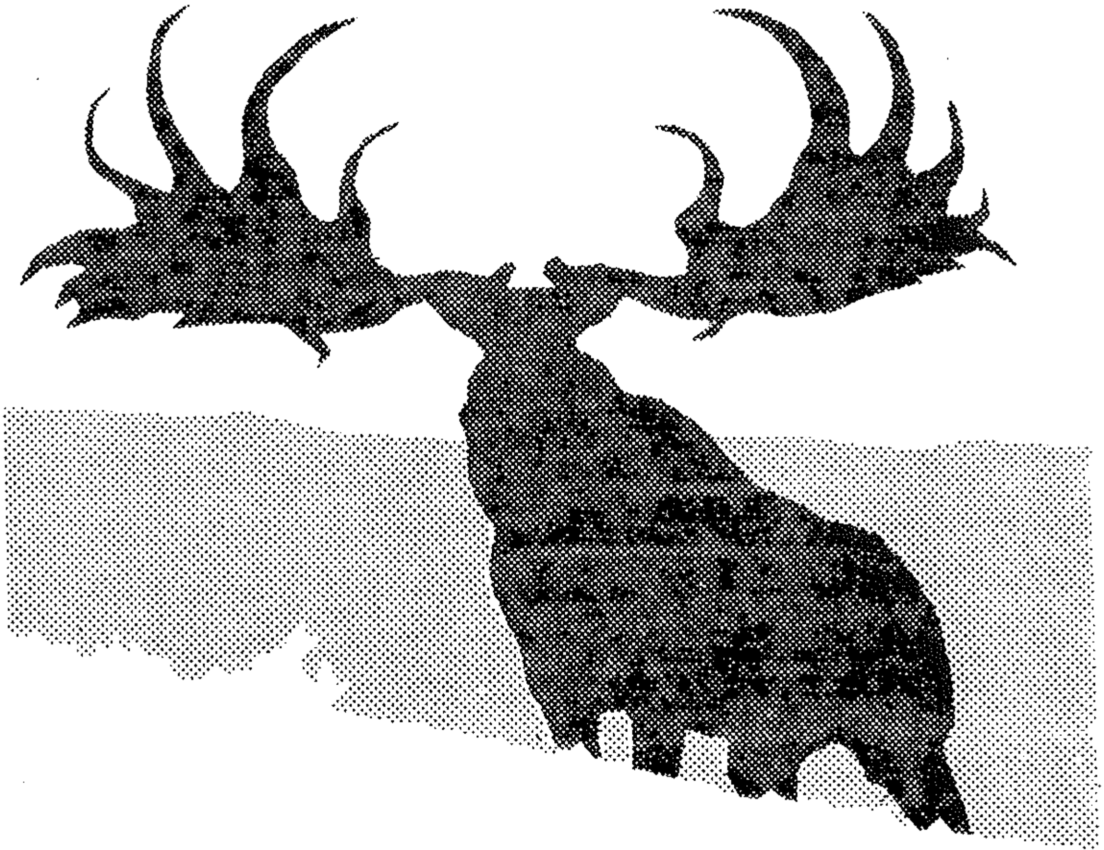
Cumann Staidéar Ré Cheathartha na hÉireann
Irish Association for Quaternary Studies

Boireann, Co. an Chláir
Burren, Co. Clare



Treoir Allamuigh IQUA Uimhir 18
IQUA Field Guide No. 18

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Boireann, Co. an Chláir
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á eagrú ag/edited by

Michael O'Connell

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Preface

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An integral part of these excursions is the preparation of a Field Guide. While only an informal publication, these IQUA Field Guides, now eighteen in all (see backcover for list), are valuable from both the point of view of the researcher and the readership. For the researcher, they provides an important forum to bring her/his investigations, sometimes still not finalised, to a wider audience and, at the same time, they bring together the results of recent research which are frequently published in scholarly journals not readily accessible to the interested public. In some instances, the results may not be suitable for publication in international journals, but, nevertheless, can be of considerable interest and use in the context of ongoing research at the local level.

While a guide was published in connection with the Burren Field Excursion of 1992 (Warren and O'Connell 1993) it was decided that, due to inadequacies in that publication and the interest of the subject matter to a wide variety of specialists and the general public, a new edition of the Guide was justified. In many instances, the authors have expanded and updated their original contributions and, also, the opportunity has been taken to use a larger format that is more suitable for the reproduction of complicated figures such as pollen diagrams. Unfortunately, contributions on the Quaternary geology of four sites were unavailable for inclusion in this edition of the Guide. For the sake of completeness, short summaries of these sites are provided.

Michael O'Connell
November 1994

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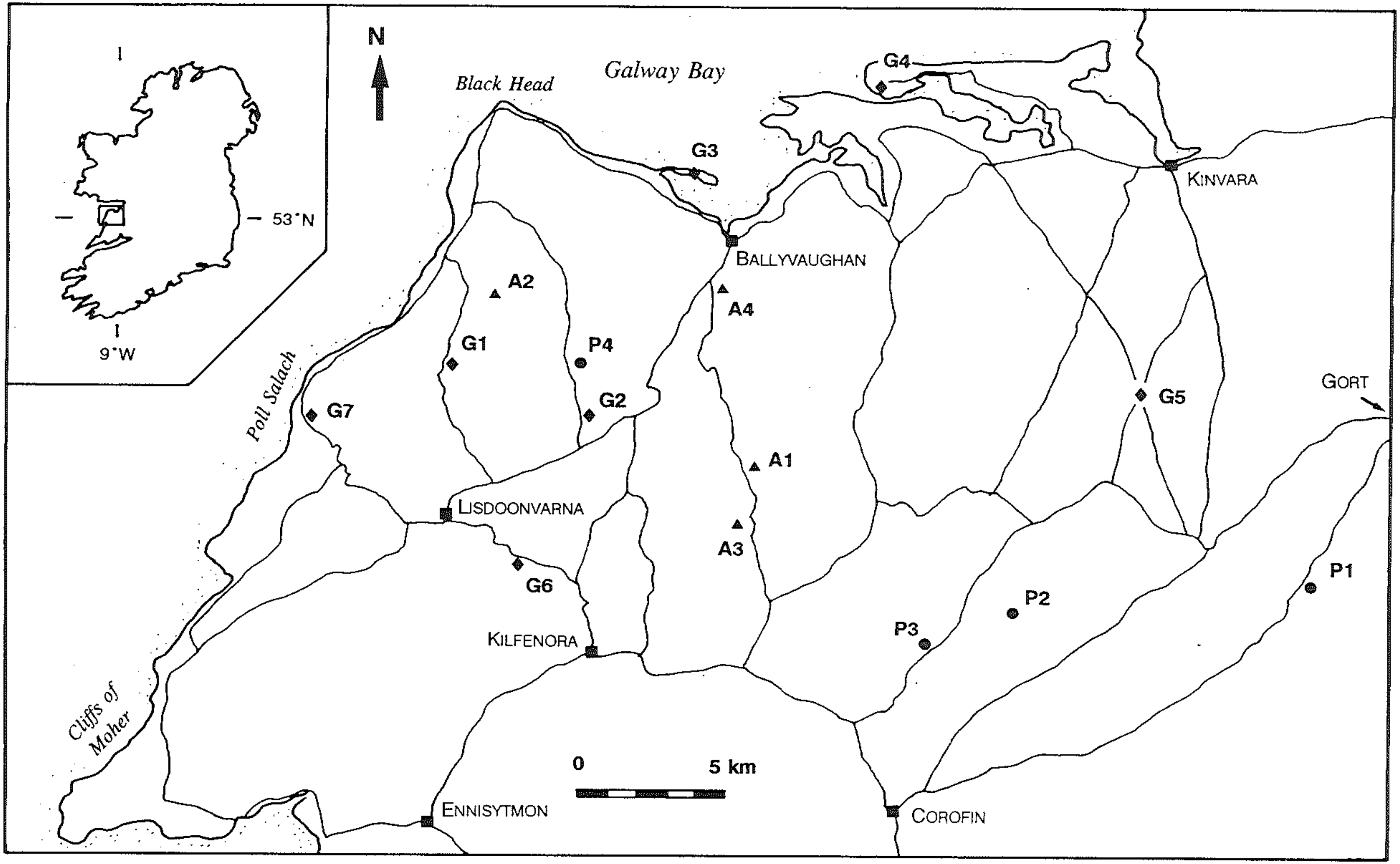
P1, Lurga (late-glacial); P2 and P3, Gortlecka and Rinn na Móna (post-glacial); and, P4, Lios Lairthín Mór (late post-glacial) (all palaeoecological studies).



INTRODUCTION

Geology and soils

D. Drew

The Burren karst is developed in the Visean Carboniferous limestones with two stages, the Brigantian (upper) and Asbian (lower) comprising the great majority of the exposed strata. The Asbian limestone is subdivided into two groups which have geomorphological and hydrological relevance. A massive unit, 70 m in thickness with few joints or bedding planes, is overlain by 140-m-thick strongly bedded sequence of limestones and is underlain by a similar sequence some 150 m thick. The massive unit forms steep, uniform slopes or cliffs, whilst the bedded units form tiers of stepped terraces, particularly on the northern (up-ice) flank of the Burren overlooking the southern side of Galway Bay. The bedded limestones include both minor (5-15 mm thick) and major (<600 mm thick) shale layers between certain beds and, in some instances, the shale provides a major obstacle to the vertical percolation of recharge water, thus greatly influencing groundwater behaviour.

The uppermost stage of the Carboniferous limestone is the Brigantian, characterised by more coarse-grained rocks than the Asbian and incorporating numerous nodules or sheets of chert between beds of limestone. The chert seems to function in a similar manner to the shale layers as an important control on the groundwater movement and to an extent on landform development. The Brigantian limestones tend to be more susceptible to the processes of mechanical weathering than those of the Asbian and hence provide the mineral-grain skeleton for better developed rendzina soils than are found on the mechanically more resistant limestones.

Resting unconformably on the Brigantian limestones are the Namurian strata – the basal shales of which grade upwards into a sequence of calcareous shales, phosphatic shales, siltstones and sandstones. In the western Burren, the Namurian rocks project northwards to form the uppermost part of the hills of Slieve Elva and Knockauns whilst the adjacent hill of Poulacapple is capped with a thin outlier of Namurian shales.

The Carboniferous rocks of the Burren are tilted to the south-southwest (dips of 1-5°) over much of the area, with gentle asymmetric folding along north-northeast-south-southwestern axes becoming apparent in the eastern Burren. Two major joint sets (north-south and east-west) occur over the whole area, their relative dominance and spacing varying locally. Faults are uncommon and fault-induced fractures are often calcite filled or associated with pod mineralisation.

The slight inclination of the rocks of the Burren plateau forms an extensive dip-slope, declining gradually in altitude from north to south and contrasting with the steep, sometimes vertical, north-facing scarp slope. The Burren upland consists of several plateau surfaces at different altitudes between 200 and 300 m above sea level. These may be structural surfaces or ancient erosional levels.

True mineral soils are developed only on the patches of glacial drift. In areas of glacial drift Brown Earth soils are found whilst on the non-limestone upper Carboniferous (Namurian) rocks of the south-western Burren the poor drainage and acidic conditions allow peaty and podzolic soils to develop. Some 20% of the plateau consists of bare rock (limestone pavement) or weathered bedrock surfaces (*Felsenmeer*) whilst a further 30% is comprised of a mosaic of rendzina soils, 50-250 mm in depth and bare rocks (cf. Finch 1971).

Caves of the Burren

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The caves of the Burren, in themselves a reflection of past and present hydrogeological conditions, have been controlled in their origin and evolution by three main factors:

(i) Geological controls: in particular the dip of the strata, the joint systems and the presence of relatively impermeable layers such as chert or shales within the limestone sequence.

(ii) The degree to which runoff is concentrated prior to sinking underground — such concentration into streams occurs on impermeable terrain such as the Namurian strata in the west of the Burren and to a lesser extent on some glacial deposits.

(iii) Modification of karstic processes by other factors, for example, the effects of changes in base level, or the effects of glacial erosion and deposition.

The present day base level for much of the Burren plateau is the upper part of the valley of the Fergus River between Corofin and Kilfenora. Some 60% of the runoff from the plateau is discharged from springs in this area. Much of the remainder of the Burren water discharges via coastal or submarine springs.

Fig. 2 shows the sinking streams and springs of the Burren. The concentration of sinking streams around the margins of the Namurian strata (particularly the hills of Slieve Elva and Poulacapple) is very apparent. Associated with these sinking streams are a series of river caves mainly developed in the north-south jointing systems and oriented north-south down-dip. Such caves are commonly developed within a single bedding plane for long distances, occasionally stepping down one or more bed via a vertical drop. The vertical location of these cave conduits is often determined by the presence of chert-rich zones within the uppermost beds of the Brigantian limestones, which appear to constrain the vertical movement of water.

The passage morphology of these caves typically comprises a wide, low roof section of enlarged bedding plane incised by a narrow trench or canyon which contains the stream. The trench is typically 0.3-3 m wide but may be up to 30 m deep. Passage cross-sections are therefore typically T-shaped. The roof section of passage is of phreatic origin whilst the trench has been cut under vadose conditions.

Three types of active stream cave may be recognised:

(i) Simple, single stream conduits in which the morphology and dimensions of the cave passage are obviously related to the present day stream, e.g. Polldubh.

(ii) Stream caves with abandoned (dry) sections of passage, oxbows, offset meander belts at different heights above the active stream route, appreciable deposition of calcite speleothems and fossil allogenic sediments, sometimes undergoing re-excavation. Pollnagollum and to some extent the Cullaun series of caves are examples of this type.

(iii) Caves of the first or second type which have intersected reaches of apparently much older, now fossil cave systems. Such 'older' caves are often characterised by a circular or oval passage cross-section suggesting a wholly phreatic origin, and by extensive fill deposits. Faunarooska and Pollballiny caves are examples of polycyclic caves.

The age of the Burren caves has not been thoroughly investigated but limited evidence from Uranium-Thorium dating of calcite specimens suggests that Type (i) caves may be of Holocene age, Type (ii) caves may originate in last Inter-Glacial times at the latest (in Pollnagollum cave calcite from the lowest, active, stream canyon has been dated to 10.5-3.2 ka (10 500-3200 B.P.) whilst calcite in the upper canyon dates at 70 ka). The segments of old passage invaded by modern cave streams are of unknown age though calcite from a passage of similar morphology in Aillwee Cave, central Burren, has been dated at >350 ka.

Caves of these various types may be found in near proximity; for example, the caves listed above are all located on Slieve Elva.

Those parts of the central and eastern Burren that are distant from the present day outcrop of the Namurian strata are very different in morphology from the active stream caves. Although a shale cover must have existed in various parts of the central and eastern Burren until comparatively recent times, no cave systems associated with such conditions have yet been discovered. The region is characterised by an absence of sinking streams but there is a plethora of small springs. The majority of these springs are small seepages of water that sink underground once more within a short distance and are the consequence of glacial derangement of the ground water flow system. There is little apparent relationship between the known caves of the area and the present day hydrology. Phreatic passage forms are predominant implying a sub-watertable origin for the caves.

Sediment infills are widespread ranging in type from complex bedded sequences of fine (e.g. Pol-an-Ionain cave, Aillwee Cave) to extensive sand deposits of unknown provenance (e.g. Glencurran Cave).

Speleothem dates from caves of the central Burren fall into three groups: 5-8 ka (6 samples), 40-42 ka (3 samples) and >350Ka (2 samples) ka. In all of these instances the dates relate to an episode of calcite deposition rather than providing an indication of age for the cave itself.

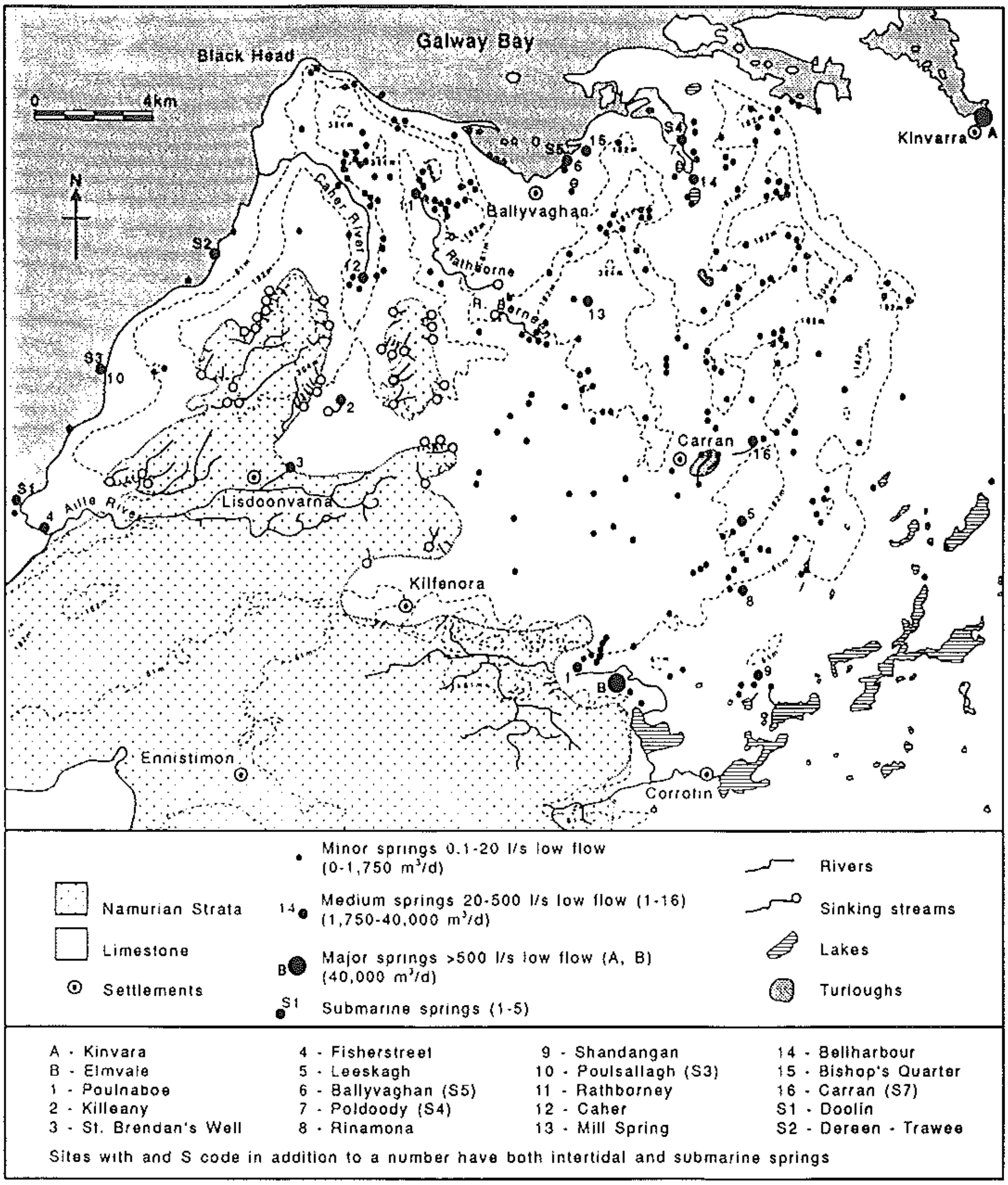

Fig. 2. Map showing the main geological and hydrological features of the Burren.

Palaeoecology

M. O'Connell

The Burren, a Carboniferous limestone region of some 450 km^2 in north-west Co. Clare, western Ireland, has long been noted for its classic glacio-karstic features, its unusual flora and vegetation and dense concentration of archaeological field monuments, especially megaliths, ringforts and medieval castles. Reconstruction of past environments in this highly karstified terrain with its patchy and often non-existent soil cover, scarcity of bogs, and surface waters largely confined to seasonal lakes or turloughs, has presented a particular challenge to the palaeoecologist. Indeed, the scarcity of material suitable for palaeoecological research has acted as a deterrent to such investigations.

The earliest palaeoecological investigations from the Burren are those of Watts (1963) relating to the late-glacial period. In his 1963 publication, Watts presents two pollen profiles: Gortalecka, nr. Mullaghmore and Lough Goller, 2 km south of Lisdoonvarna, which lies in the shale region and hence outside the Burren proper (see Fig. 14 for location of sites from which pollen records have been published). The latter profile, together with a profile from Poulroe, a site due west of Gort in the eastern Burren lowlands, is also presented in Watt's (1977) review paper on the Irish late-glacial. More recently, late-glacial sediments at Lurga, E. Burren and at Illauncronan, north-east of Crusheen have been studied (Andrieu *et al.* 1993; update on results of investigations at Lurga in this volume).

With regard to the Holocene, four diagrams are available from the southern part of the Burren: three from the Mullach Mór area (Feighan 1985; Watts 1984) and one profile from the Carron depression (Crabtree 1982). The diagrams from the Mullach Mór area, in particular, contain a valuable record of vegetation development and the impact of past human activity, as well as providing information on the history of certain typically Burren species such as *Potentilla fruticosa* (Watts 1984). They show that, at least in the south-east Burren, the present vegetation with its abundance of species such as *Dryas octopetala* and *P. fruticosa* and its sparse cover of woody vegetation, is a development of the historical period, i.e. post A.D. 400 (Watts 1984; see also Watts, this volume).

A recently completed study in the north-western Burren has provided a record of vegetation and land-use in the Poulacapple area that extends back to over 3000 years (Jeličić 1991; Jeličić and O'Connell 1992; and this volume). The results show that, apart from two short periods, the area about this site had a vegetation cover largely comparable to that of today.

Other investigations that have yielded evidence of past tree and shrub cover include macrofossil analyses carried out in the context of archaeological excavations. At Cahercommaun ringfort, for example, charcoal of the following woody species was recorded from late first millennium A.D.

contexts: *Corylus* (hazel), *Taxus* (yew), *Fraxinus* (ash), *Crataegus* (whitethorn), *Prunus* (sloe, cherry, etc.), *Populus/Salix* (poplar/willow) and *Ulmus* (elm) (Hencken 1938; for details of charcoal recorded by C. Cotter in Gragan West see O'Connell and Jeličić, this volume).

The archaeological record

P. Gosling

Despite the number, and degree of preservation, of archaeological monuments of all ages which grace the landscapes of the Burren, archaeological research on this region has been sporadic, disparate and uneven. This is particularly evident in the general absence, until recently, of any overviews of the archaeology of the Burren as a whole.

Thomas J. Westropp published a series of seminal field reports from the Burren between 1894-1917, principally in the pages of the *Journal of the Royal Society of Antiquaries of Ireland*. Though full of detail on individual monuments, Westropp's work generally eschewed an analytical approach, and his interpretation of monuments is, in many cases, now obsolete. Contemporary work on coastal middens by Brunicardi (1914), though it produced a lean harvest, did draw attention to the maritime aspects of the Burren's archaeology. Following in their footsteps, de Valera and Ó Nualláin have provided us with a detailed record of the megalithic tombs of the region (1961). Their short commentary on the morphology and distribution of the Burren's wedge tombs is particularly useful in providing background information on the past and present topography of the region.

For later periods, Rynne's work on the Iron Age in Co. Clare (1982) also touched on the Burren, and Sheehan (1982) has compiled a list of early ecclesiastical sites in the region as part of a useful discussion of the distribution of these monuments. Finally, there is Robinson's excellent map of these uplands (1977) which illustrates the potential rewards of a holistic and interdisciplinary approach to the archaeology of this unique landscape.

Apart from some early work by Westropp (1909), it has been the work of palaeo-environmentalists (Crabtree 1982; Drew 1982; Jeličić and O'Connell 1992; also O'Connell and Jeličić, this volume; Plunkett Dillon 1983, and Watts 1984 and this volume) that has shed most light on the early human settlement history of the Burren. However, the recently published reviews by Waddell (1990) and the present writer (Gosling 1990a, b), coupled with Sheehan's work (1982), provide, for the first time, the outline of a modern archaeological overview of the region.

Ten archaeological excavations have so far been conducted in the Burren (Cahill 1989; Cotter 1989; Gibson 1986, 1987; Hencken 1935 and 1938; Lynch 1988; Ní Ghabhláin 1991; Ó Drisceoil 1988; Rynne 1968). Four of these, by Cahill, Rynne, Lynch and Cotter, were rescue excavations prompted by natural and human agencies which threatened a lintel grave, house site, a megalithic tomb and 'mound', respectively. Gibson's work is part of an American research programme entitled the *Chiefdoms of County Clare Project*, while Ní Ghabhláin's excavation was part of a research project into ecclesiastical settlement within the diocese of Kilfenora. However, the results of these projects, along with the reports on Ó Drisceoil's and Lynch's excavations have not, as yet, been fully published (cf. Lynch, this volume). The two remaining excavations, at Poulawack and *Cathair Chomáin*, were part of the work of the Harvard Archaeological Expedition in Ireland (c. 1932-6). This pioneering project consisted of the excavation of a range of monuments in order to elucidate then current problems in Irish archaeology, which was still in its infancy as an academic discipline.

Though concerned solely with presenting excavation results, Hencken's reports on the Harvard Expedition's work at Poulawack (1935) and *Cathair Chomáin* (1938), contain a wealth of information on the settlement history of the region. When taken in conjunction with the preliminary results of Ó Drisceoil's work on the fulacht fia at Carron (1988), and Lynch's work on the portal tomb at Poulnabrone (1988; also this volume), they provide us with a framework on which to base a discussion of the Neolithic and Bronze Ages, as well as the Early Historic Period, in the Burren. Furthermore, the pools of light which these excavations shed on the recesses of the Burren's past indicate the existence of stable prehistoric and historic communities there: communities with sophisticated belief systems, material surpluses, and long traditions of association with this 'rocky place'.

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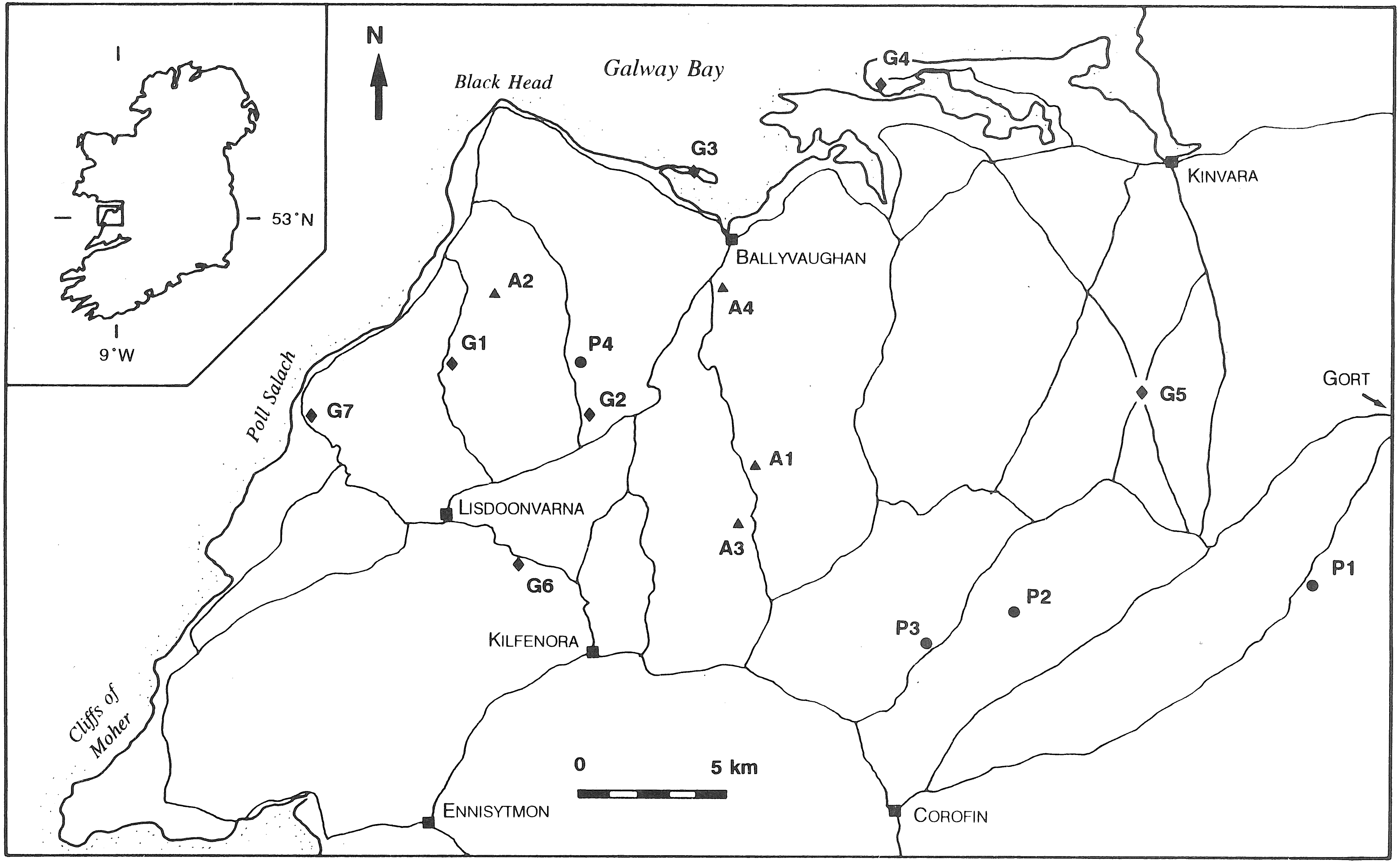

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The present day base level for much of the Burren plateau is the upper part of the valley of the Fergus River between Corofin and Kilfenora. Some 60% of the runoff from the plateau is discharged from springs in this area. Much of the remainder of the Burren water discharges via coastal or submarine springs.

Fig. 2 shows the sinking streams and springs of the Burren. The concentration of sinking streams around the margins of the Namurian strata (particularly the hills of Slieve Elva and Poulacapple) is very apparent. Associated with these sinking streams are a series of river caves mainly developed in the north-south jointing systems and oriented north-south down-dip. Such caves are commonly developed within a single bedding plane for long distances, occasionally stepping down one or more bed via a vertical drop. The vertical location of these cave conduits is often determined by the presence of chert-rich zones within the uppermost beds of the Brigantian limestones, which appear to constrain the vertical movement of water.

The passage morphology of these caves typically comprises a wide, low roof section of enlarged bedding plane incised by a narrow trench or canyon which contains the stream. The trench is typically 0.3-3 m wide but may be up to 30 m deep. Passage cross-sections are therefore typically T-shaped. The roof section of passage is of phreatic origin whilst the trench has been cut under vadose conditions.

Three types of active stream cave may be recognised:

(i) Simple, single stream conduits in which the morphology and dimensions of the cave passage are obviously related to the present day stream, e.g. Polldubh.

(ii) Stream caves with abandoned (dry) sections of passage, oxbows, offset meander belts at different heights above the active stream route, appreciable deposition of calcite speleothems and fossil allogenic sediments, sometimes undergoing re-excavation. Pollnagollum and to some extent the Cullaun series of caves are examples of this type.

(iii) Caves of the first or second type which have intersected reaches of apparently much older, now fossil cave systems. Such 'older' caves are often characterised by a circular or oval passage cross-section suggesting a wholly phreatic origin, and by extensive fill deposits. Faunarooska and Pollballiny caves are examples of polycyclic caves.

The age of the Burren caves has not been thoroughly investigated but limited evidence from Uranium-Thorium dating of calcite specimens suggests that Type (i) caves may be of Holocene age, Type (ii) caves may originate in last Inter-Glacial times at the latest (in Pollnagollum cave calcite from the lowest, active, stream canyon has been dated to 10.5-3.2 ka (10 500-3200 B.P.) whilst calcite in the upper canyon dates at 70 ka). The segments of old passage invaded by modern cave streams are of unknown age though calcite from a passage of similar morphology in Aillwee Cave, central Burren, has been dated at >350 ka.

Caves of these various types may be found in near proximity; for example, the caves listed above are all located on Slieve Elva.

Those parts of the central and eastern Burren that are distant from the present day outcrop of the Namurian strata are very different in morphology from the active stream caves. Although a shale cover must have existed in various parts of the central and eastern Burren until comparatively recent times, no cave systems associated with such conditions have yet been discovered. The region is characterised by an absence of sinking streams but there is a plethora of small springs. The majority of these springs are small seepages of water that sink underground once more within a short distance and are the consequence of glacial derangement of the ground water flow system. There is little apparent relationship between the known caves of the area and the present day hydrology. Phreatic passage forms are predominant implying a sub-watertable origin for the caves.

Sediment infills are widespread ranging in type from complex bedded sequences of fine (e.g. Pol-an-Ionain cave, Aillwee Cave) to extensive sand deposits of unknown provenance (e.g. Glencurran Cave).

Speleothem dates from caves of the central Burren fall into three groups: 5-8 ka (6 samples), 40-42 ka (3 samples) and >350Ka (2 samples) ka. In all of these instances the dates relate to an episode of calcite deposition rather than providing an indication of age for the cave itself.

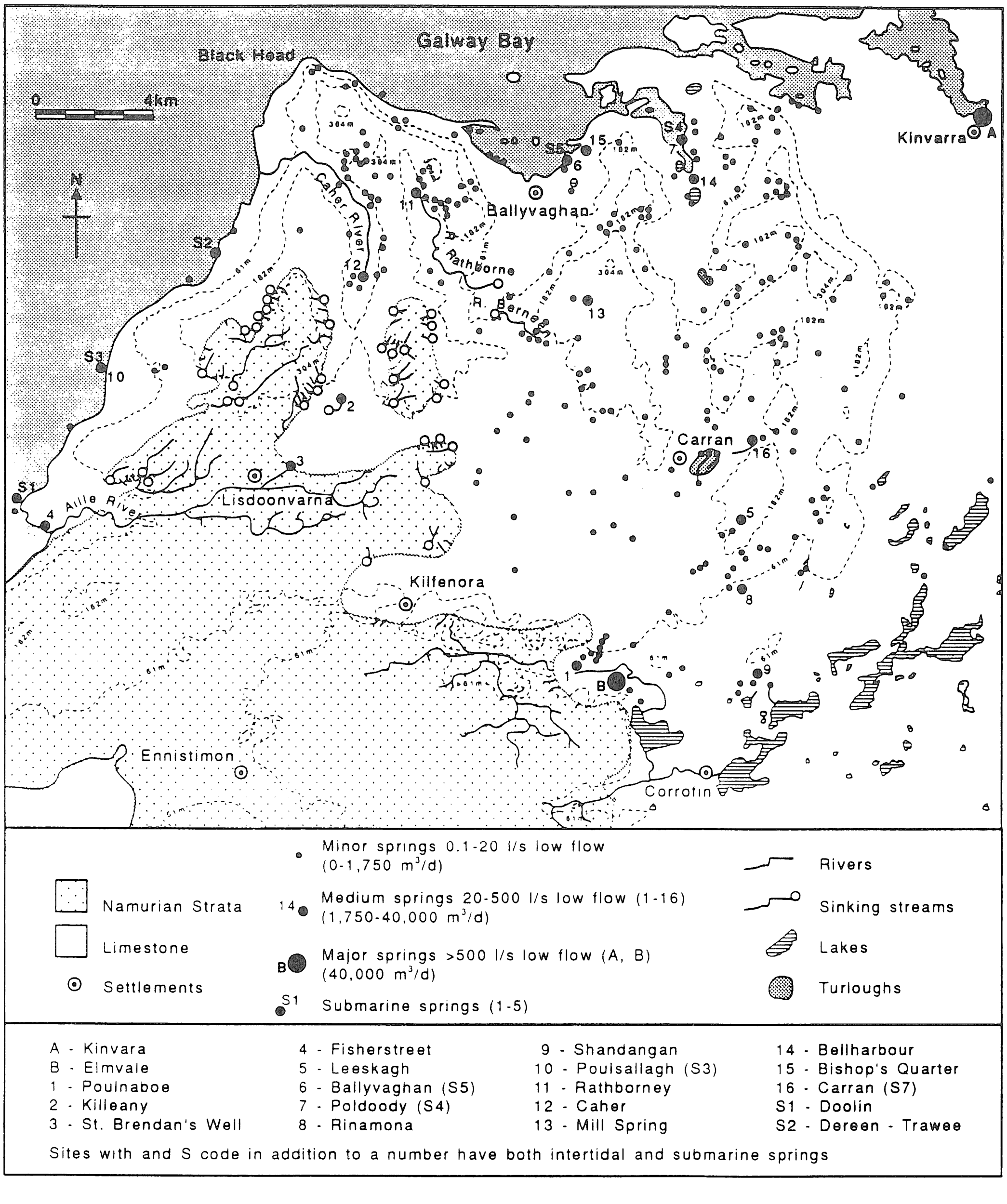


Fig. 2. Map showing the main geological and hydrological features of the Burren.

Palaeoecology

M. O'Connell

The Burren, a Carboniferous limestone region of some 450 km^2 in north-west Co. Clare, western Ireland, has long been noted for its classic glacio-karstic features, its unusual flora and vegetation and dense concentration of archaeological field monuments, especially megaliths, ringforts and medieval castles. Reconstruction of past environments in this highly karstified terrain with its patchy and often non-existent soil cover, scarcity of bogs, and surface waters largely confined to seasonal lakes or turloughs, has presented a particular challenge to the palaeoecologist. Indeed, the scarcity of material suitable for palaeoecological research has acted as a deterrent to such investigations.

The earliest palaeoecological investigations from the Burren are those of Watts (1963) relating to the late-glacial period. In his 1963 publication, Watts presents two pollen profiles: Gortalecka, nr. Mullaghmore and Lough Goller, 2 km south of Lisdoonvarna, which lies in the shale region and hence outside the Burren proper (see Fig. 14 for location of sites from which pollen records have been published). The latter profile, together with a profile from Poulroe, a site due west of Gort in the eastern Burren lowlands, is also presented in Watt's (1977) review paper on the Irish late-glacial. More recently, late-glacial sediments at Lurga, E. Burren and at Illauncronan, north-east of Crusheen have been studied (Andrieu *et al.* 1993; update on results of investigations at Lurga in this volume).

With regard to the Holocene, four diagrams are available from the southern part of the Burren: three from the Mullach Mór area (Feighan 1985; Watts 1984) and one profile from the Carron depression (Crabtree 1982). The diagrams from the Mullach Mór area, in particular, contain a valuable record of vegetation development and the impact of past human activity, as well as providing information on the history of certain typically Burren species such as *Potentilla fruticosa* (Watts 1984). They show that, at least in the south-east Burren, the present vegetation with its abundance of species such as *Dryas octopetala* and *P. fruticosa* and its sparse cover of woody vegetation, is a development of the historical period, i.e. post A.D. 400 (Watts 1984; see also Watts, this volume).

A recently completed study in the north-western Burren has provided a record of vegetation and land-use in the Poulacapple area that extends back to over 3000 years (Jeličić 1991; Jeličić and O'Connell 1992; and this volume). The results show that, apart from two short periods, the area about this site had a vegetation cover largely comparable to that of today.

Other investigations that have yielded evidence of past tree and shrub cover include macrofossil analyses carried out in the context of archaeological excavations. At Cahercommaun ringfort, for example, charcoal of the following woody species was recorded from late first millennium A.D.

contexts: *Corylus* (hazel), *Taxus* (yew), *Fraxinus* (ash), *Crataegus* (whitethorn), *Prunus* (sloe, cherry, etc.), *Populus/Salix* (poplar/willow) and *Ulmus* (elm) (Hencken 1938; for details of charcoal recorded by C. Cotter in Gragan West see O'Connell and Jeličić, this volume).

The archaeological record

P. Gosling

Despite the number, and degree of preservation, of archaeological monuments of all ages which grace the landscapes of the Burren, archaeological research on this region has been sporadic, disparate and uneven. This is particularly evident in the general absence, until recently, of any overviews of the archaeology of the Burren as a whole.

Thomas J. Westropp published a series of seminal field reports from the Burren between 1894-1917, principally in the pages of the *Journal of the Royal Society of Antiquaries of Ireland*. Though full of detail on individual monuments, Westropp's work generally eschewed an analytical approach, and his interpretation of monuments is, in many cases, now obsolete. Contemporary work on coastal middens by Brunicardi (1914), though it produced a lean harvest, did draw attention to the maritime aspects of the Burren's archaeology. Following in their footsteps, de Valera and Ó Nualláin have provided us with a detailed record of the megalithic tombs of the region (1961). Their short commentary on the morphology and distribution of the Burren's wedge tombs is particularly useful in providing background information on the past and present topography of the region.

For later periods, Rynne's work on the Iron Age in Co. Clare (1982) also touched on the Burren, and Sheehan (1982) has compiled a list of early ecclesiastical sites in the region as part of a useful discussion of the distribution of these monuments. Finally, there is Robinson's excellent map of these uplands (1977) which illustrates the potential rewards of a holistic and interdisciplinary approach to the archaeology of this unique landscape.

Apart from some early work by Westropp (1909), it has been the work of palaeo-environmentalists (Crabtree 1982; Drew 1982; Jeličić and O'Connell 1992; also O'Connell and Jeličić, this volume; Plunkett Dillon 1983, and Watts 1984 and this volume) that has shed most light on the early human settlement history of the Burren. However, the recently published reviews by Waddell (1990) and the present writer (Gosling 1990a, b), coupled with Sheehan's work (1982), provide, for the first time, the outline of a modern archaeological overview of the region.

Ten archaeological excavations have so far been conducted in the Burren (Cahill 1989; Cotter 1989; Gibson 1986, 1987; Hencken 1935 and 1938; Lynch 1988; Ní Ghabhláin 1991; Ó Drisceoil 1988; Rynne 1968). Four of these, by Cahill, Rynne, Lynch and Cotter, were rescue excavations prompted by natural and human agencies which threatened a lintel grave, house site, a megalithic tomb and 'mound', respectively. Gibson's work is part of an American research programme entitled the *Chiefdoms of County Clare Project*, while Ní Ghabhláin's excavation was part of a research project into ecclesiastical settlement within the diocese of Kilfenora. However, the results of these projects, along with the reports on Ó Drisceoil's and Lynch's excavations have not, as yet, been fully published (cf. Lynch, this volume). The two remaining excavations, at Poulawack and *Cathair Chomáin*, were part of the work of the Harvard Archaeological Expedition in Ireland (c. 1932-6). This pioneering project consisted of the excavation of a range of monuments in order to elucidate then current problems in Irish archaeology, which was still in its infancy as an academic discipline.

Though concerned solely with presenting excavation results, Hencken's reports on the Harvard Expedition's work at Poulawack (1935) and *Cathair Chomáin* (1938), contain a wealth of information on the settlement history of the region. When taken in conjunction with the preliminary results of Ó Drisceoil's work on the fulacht fia at Carron (1988), and Lynch's work on the portal tomb at Poulnabrone (1988; also this volume), they provide us with a framework on which to base a discussion of the Neolithic and Bronze Ages, as well as the Early Historic Period, in the Burren. Furthermore, the pools of light which these excavations shed on the recesses of the Burren's past indicate the existence of stable prehistoric and historic communities there: communities with sophisticated belief systems, material surpluses, and long traditions of association with this 'rocky place'.

GEOLOGY/GEOMORPHOLOGY

Polldubh cave, Slieve Elva (Site G1)

D. Drew

Polldubh cave is located on the south-western flank of Slieve Elva (grid ref. M 135 034) and is a good example of a simple stream cave related to present day landforms and hydrology and very probably of Holocene age. As the plan survey (Fig. 3) shows the cave passage is closely associated with the present day shale-limestone boundary. It parallels the boundary and functions as a drain which collects water from the numerous stream sinks at the shale margin.

The cave is developed in the north-south joint system and follows the shallow (0-5°) dip to the south. The cave system is developed within the uppermost 2-10 m of the Brigantian limestone and is therefore always within a few metres of the surface. The water re-appears at the surface a short distance beyond the limit of exploration in the cave and then flows south, sinking again into a very immature cave system. Under high flow conditions in this section, the capacity of the cave passage is exceeded and a stream flows on the surface. Thus, all the stages of initiation and early development of karstic drainage are represented in the Polldubh system.

The main stream sink Polldubh South (B3) feeding the Polldubh system has created a series of small canyon passages all of which unite into a single conduit some 2.6 m high developed in four beds. The passage meanders gently (amplitude c. 15 m). The phreatic roof bedding plane is c. 150 mm high and contains flood-borne deposits. Further downstream the passage enlarges (scalloping on the walls increases in diameter from 1-20 mm to 30-40 mm corresponding to a reduction in stream velocity). Evidence for changes in stream discharge is provided by the patches of semi-calcreted gravels that are now being eroded. The level of frequent and occasional floods can be determined by reference to the zones of calcite deposition on the passage walls above the stream (no deposition <500 mm, thick deposits >1 m). At 120 m from the entrance the water from Polldubh North enters the cave at roof level, the passage being developed in the same bed as Polldubh South. The steepening of gradient associated with this junction has allowed the cave stream to cut through the chert layers above which the passage upstream is perched. Polldubh North has a uniform cross-sectional area though height and width alter. Several small (250 x 200 mm) vadose passages enter the streamway at roof level. Beyond the point at which Polldubh North passes out from beneath the shales, calcite deposition, mainly derived from seepages down north-south joints, is extensive. A collapse to the surface at the intersection of solutionally enlarged cross joints forms entrance B3a to the cave.

To the west of Polldubh the limestone forms a plateau for 1 km, beyond which the land descends steeply for c.1 m to the sea. The plateau area includes an area of hummocky drift and an extensive, complex enclosed depression (uvala) oriented north-south but with extensions east towards the shale margin and westwards towards the scarp. This enclosed depression is thought to relate to an earlier phase of karstification in the area (Lloyd and Self 1982b). To the north of Polldubh are two cave systems (Pollballiny and Faunarooska) which also drain a part of the shale/limestone boundary. However, in their further reaches both of these caves invade fragments of a much older phreatic cave oriented to the west and north-west and, unlike Polldubh, drain westwards to submarine springs.

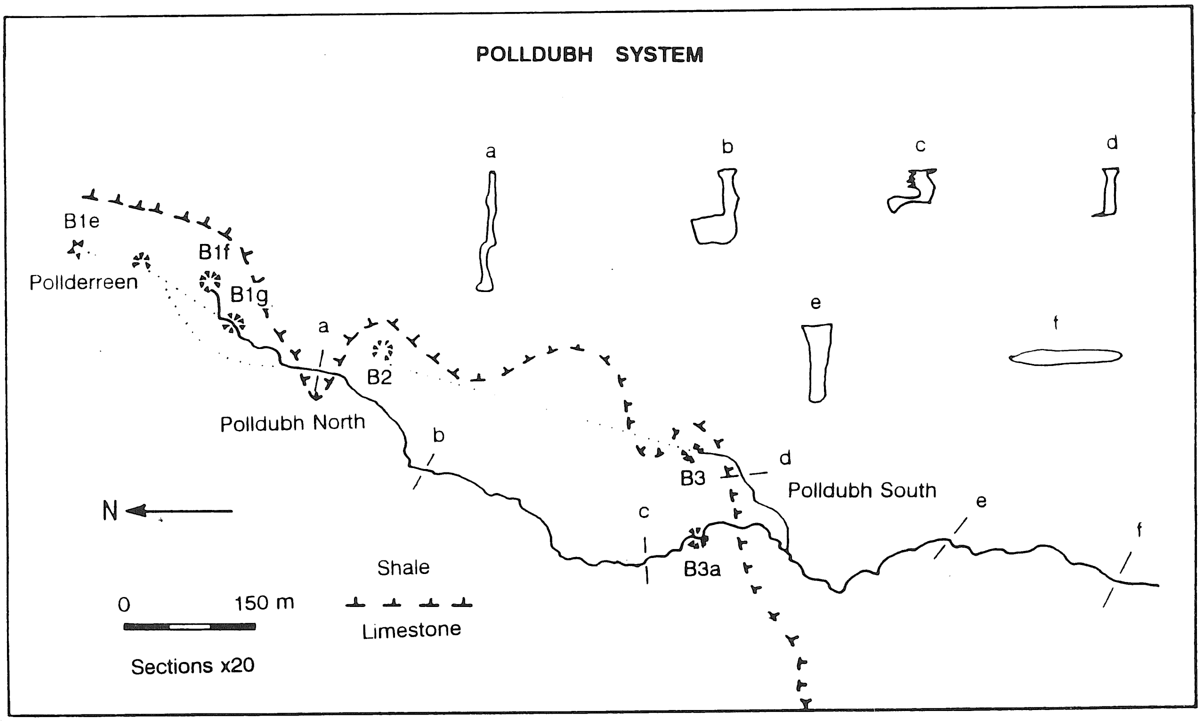


Fig. 3. Plan survey of Polldubh Cave, Slieve Elva (adapted from Self 1981).

Cullaun 2 cave, Poulacapple (Site G2)

David Drew

The western flank of the Namurian outlier of Poulacapple is fretted by a series of shallow valleys (containing glacial drift) incised into which are gorge-like younger valley forms. The valleys are oriented east-west or northeast-southwest. The streams occupying these valleys now sink underground at limestone windows in the shales and a sequence of headwater retreat of these sinkholes is apparent. The resulting sets of cave passages drain down-dip to the south and are matched by a similar series of caves to the west draining the eastern flank of Slieve Elva (Fig. 4). The majority of these caves drain to the Killeany/St. Brendan's Well springs which form a tributary of the Aille River but the most southerly (Cullaun 5) drains to the springs of the upper Fergus River. Although consisting of simple networks of parallel or dendritic drainage conduits the caves of this area are more complex than Polldubh.

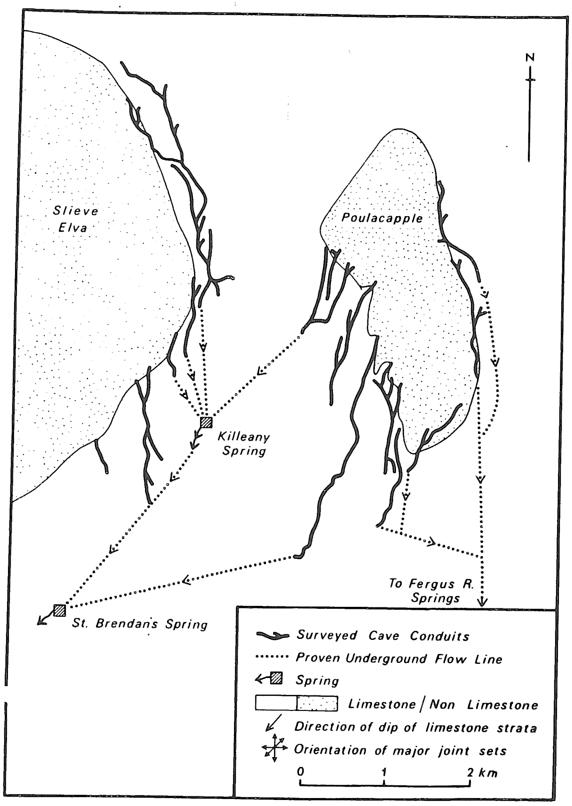


Fig. 4. The drainage of the Killeany, Poulacapple, eastern Slieve Elva area (after Lloyd and Self 1982a).

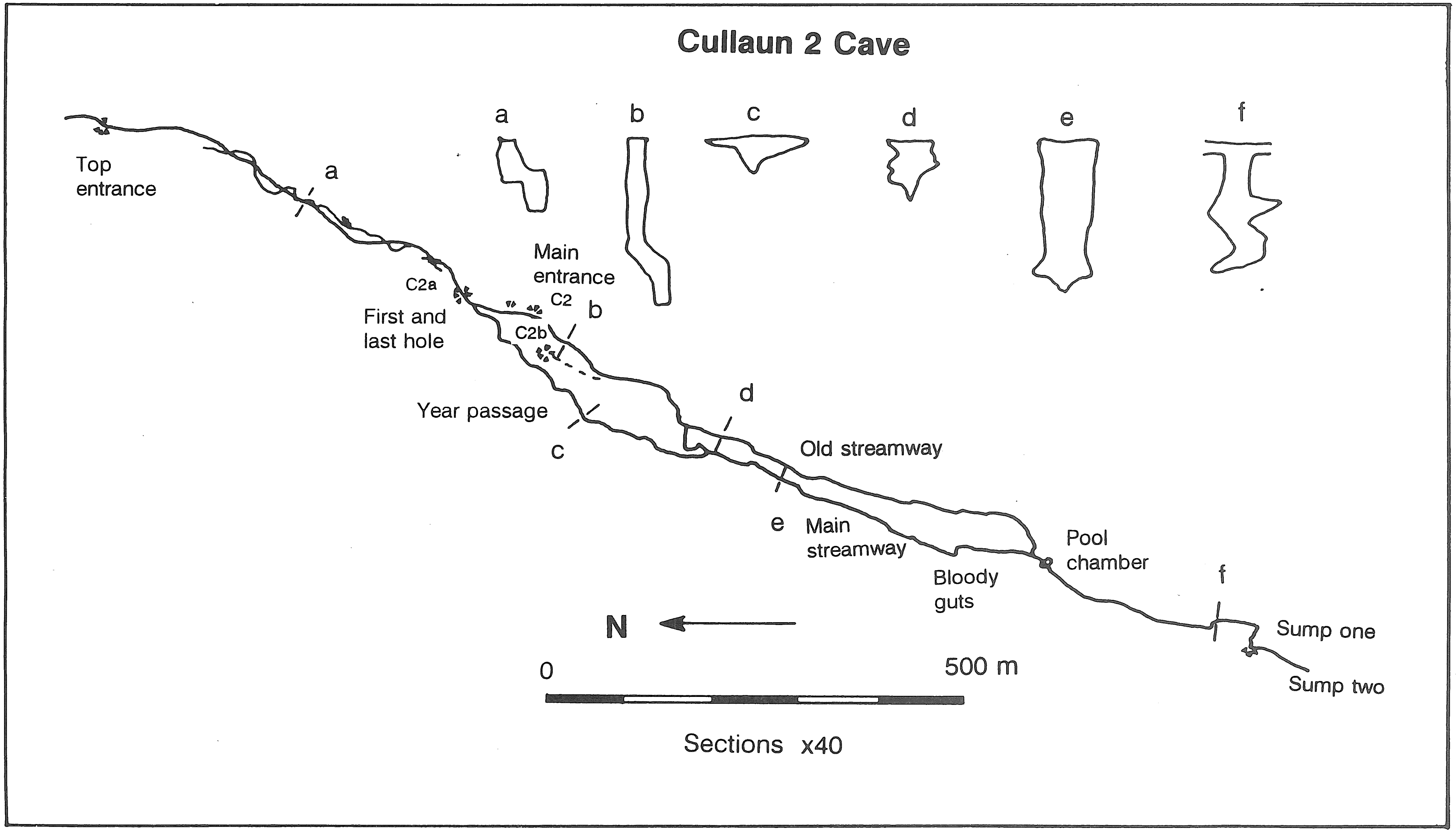


Fig. 5. Plan survey of Cullaun 2 Cave, Poulacapple (after Self 1981).

The cave is entered some 500 m down valley of the stream sink though long stretches of the cave between the two points consist of an unroofed canyon passage (the cave is developed only some 1-3 m beneath the ground surface in this section; grid ref. M 182 019). Fig. 5 shows a plan survey of the cave. The initial section of the cave is a dry canyon (the stream occupies a recent, bedding-controlled route). The passage is typically 5 m in height and 350-700 mm wide with a well-developed phreatic roof element. Uranium-thorium dating of calcite deposits from the walls of the canyon in the vicinity of Cross-Section (b) in Fig. 5 gave an age of 1 ka for a deposit 2.5 m above the floor and 3.8 ka for a deposit 5 m above the floor (top of canyon). Although these are minimum ages for the passage they do support the possibility of a post-glacial age for at least a part of the cave system. If this is the case then downcutting rates for the canyon would be c. 0.7-3 mm/year. These are extremely rapid rates of solutional erosion though remarkably similar to the rates of corrasional fluvial downcutting that appear to have taken place in the river gorges excavated into the Namurian shales by the Aille River and its tributaries in post-glacial times (0.5-2.5 mm/year).

The cave canyon divides into two parts for short distances, an upper 4 m high segment developed along a calcite filled north-south joint and a lower (more recent) 1 m high segment developed in a different joint set and meandering independently of the older route (cross-section (b)).

The gradient of the cave floor below this area steepens (exceeding the dip of the strata) and a 200 x 200 mm trench is incised into the floor of the 700 mm-wide main canyon by a small tributary stream. The steepened section of passage corresponds to back-cutting from a vertical descent by the stream that originally formed the canyon. At the vertical descent the main cave stream joins the passage from a wide bedding cave some 150-250 mm high developed in the same bedding plane as the roof of the canyon. Evidently the cave waters were inhibited from further vertical downcutting in this zone (in part due to the presence of extensive chert lenses) and prolonged solution under phreatic conditions of slow water movement have allowed slight differences in rock solubility to be picked out. Extensive thin rock shelves and solution hollows (cross-section (d)) have resulted. Downstream of this junction, the entrance canyon continues as a fossil conduit pursuing an independent though parallel course to the active stream passage. On the passage wall of the active streamway, above flood level, are a line of erratic stalagmites (helicites). Throughout Cullaun 2 Cave there is a strong inverse relationship between passage width (stream velocity) and the diameter of the rock scalloping.

Rine Point, west of Ballyvaughan (Site G3)

R.W.G. Carter, V. Morel and G. Penober

Rine Point is a 2-km-long gravel spit on the west flank of Ballyvaughan Bay (grid ref. M 205 100). Access to the site is by a trackway leading from the Ballyvaughan/Blackhead road, 3 km west of Ballyvaughan, and running down to the proximal (attachment) point of the spit. The spit shows excellent examples of sediment sorting and grading as well as geomorphological features such as coarse washovers and small cell structures (Fig. 6).

It is important to view Rine Point within the context of sea-level rise and the general coastal evolution of Galway Bay and the limestone coast of the Burren in particular. Galway Bay was progressively submerged by the late-Pleistocene and early-Holocene rise in sea-level (Carter *et al.* 1989). Although very little is known about Galway Bay (and for that matter sea level changes in general on western Irish seaboard) it is clear that Galway Bay occupies an intermediate location between the relatively rapidly rising sea-levels of the south and south-west coasts and the stationary or even falling sea-levels in the north-west of the country.

Details of Holocene environmental change in Galway Bay are unknown; indeed the carbonate environment does not favour widespread sediment deposition (the basal Holocene sediment unit on the floor of the Bay is only a few tens of centimetres thick) (Keary and Keegan 1978) so that conventional siliclastic sequences are absent (Bertois *et al.* 1972). But it is unlikely that mean sea-level ever rose above the present level, at least not by more than a few centimetres (cf. the ^{14}C dates of 3210±110 B.P. (Gif-2667) from Knockagoneen Cliff (M300245) and 2560±110 B.P. (Gif-2668) from Seaweed Point (M257229) (Delibrias and Guillier 1988, p. 92; cf. also Keary and Dunne 1973) on the north side of the bay are from middens and therefore are not a reliable indication of higher sea levels. (Note: the coordinates given by Delibrias and Guillier (1988) for these sites are incorrect).

As sea-level rose in Galway Bay it is likely it would have been accompanied by increasing levels of wave energy as the 'windows' between the Aran Islands and the mainland opened and deepened. At some point in time the wave energy would have been sufficient to initiate erosion and transport of the coastal materials. The sediment source for the Rine Point spit comes from a glacial diamicton which mantles the north side of Gleninagh Mountain. It comprises large amounts of locally-derived Carboniferous limestone blocks and occasional erratics (mainly granites) up to 2 to 3 m across. An additional supply may derive from direct erosion of the limestone bedrock.

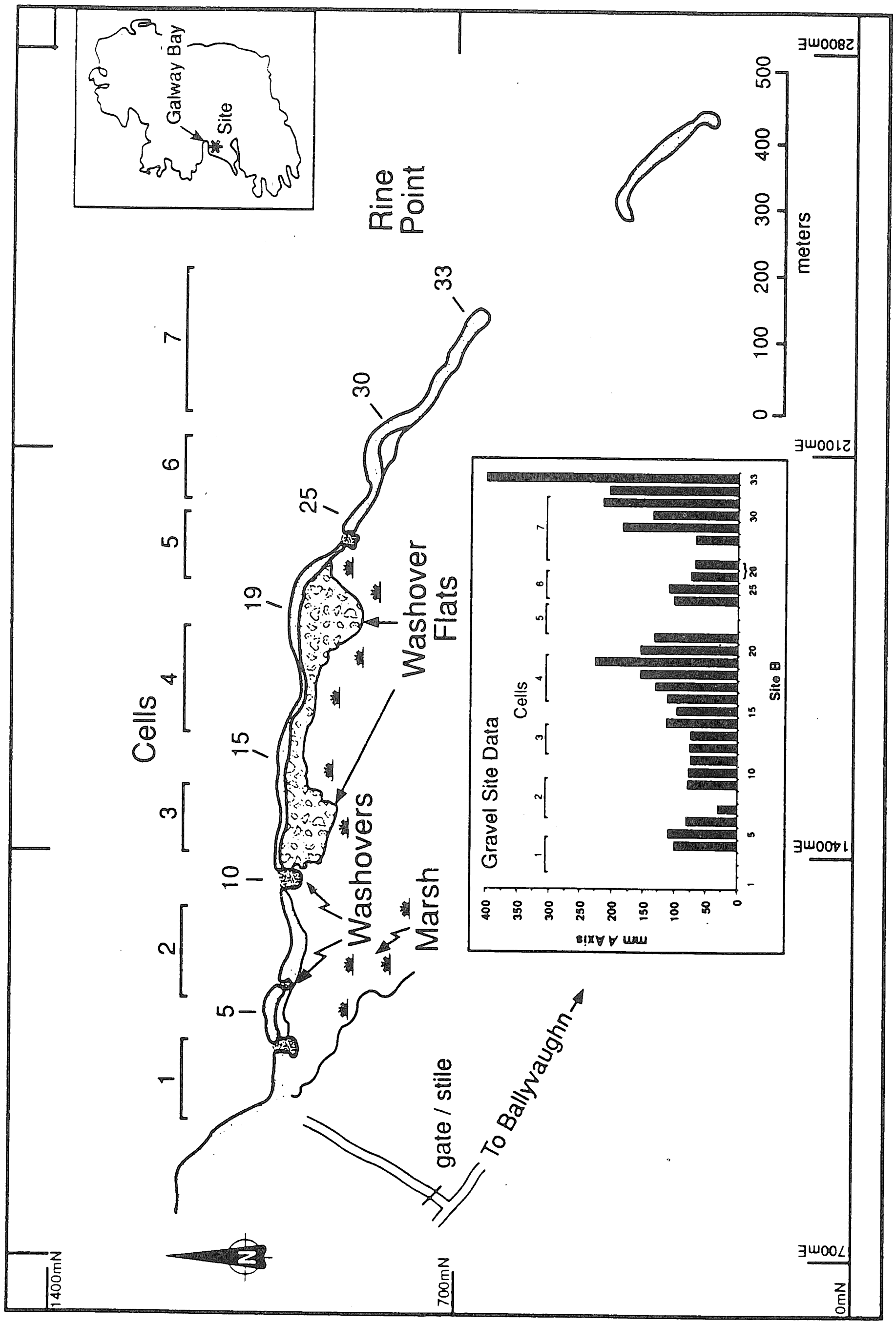


Fig. 6. Gravel spit at Rine Point, west of Ballyvaughan.

To the east of Black Head a strong longshore wave gradient exists. As swell waves enter Galway Bay they are partially refracted before breaking obliquely from east to west. Locally, this has the effect of moving sediment eastwards into Ballyvaughan Bay, although exactly the ame pattern may be observed both along the south shore of Galway Bay around Newtownlynch and further north on Tawin Island and around Carrowmore.

The longshore gradient swept gravel of pebble and cobble-sized material east, developing a solitary drift-aligned beach ridge from Gleninagh Castle eastwards to Rine Point. The morphosedimentary structure of Rine Point suggests strongly that since the formation of the spit the sediment supply has failed, leading to local reorganisation in terms of both sediment and landforms. Most characteristic is the segmentation of the spit into a series of seven cells ranging from 200 to 650 metres in length (Fig. 6). Each cell represents a zone in which the oblique waves have attempted to adjust the beach planform to an equilibrium form (Carter *et al.* 1987). Segmentation processes involve the local remobilisation of barrier sediments, so that updrift material is moved downdrift often accumulating as a prominent headland. Rine Point shows this very clearly especially about 700 m east of the access track. The intracell transfer of sediment results in barrier thinning and breaching, at first via washovers. The landward movement of sediment tends to accentuate the cell structure. Along the length of Rine Point there are several good examples of coarse washover, and towards the distal end (1350 m from the access) the spit has breached leaving a distinctive overwash flat comprising a hard gravel packed surface.

The sedimentary structure of Rine Point is interesting. The proximal barrier comprises well-sorted gravel washovers, topped with a veneer of calcareous sand (which may be, in part, aeolian). This sand has accumulated relatively slowly, and acts as a matrix for individual projective clasts thrown onto the barrier during storms. The sand also contains organic soils and occasional crushed shell layers. Alongshore the clasts increase and decrease in size largely within cells, but interestingly the largest beach face clasts occur at the distal end, where they have accumulated (Fig. 6). It is not unusual for large clasts to be preferentially transported alongshore (Carter *et al.* 1987).

Drumlin at Aughinish (Site G4)

The following summary account is based on Warren (1993a). A well exposed section in a drumlin on the south-west coast of the Aughinish peninsula, Galway Bay (M227 126) provides a relatively rare opportunity to investigate drumlin composition and structure in the Burren region.

The exposure, transverse to the drumlin crestline (alignment 260°), is c. 500 m long and exposes an 8-10 m vertical sequence of glacial sediments. The glacial sediments consist of almost an exclusively horizontally bedded diamicton, the beds (1-2 m thick) being conformable and grading one into the next. There are also extensive lenses of almost clast-free silt-sand.

There is strong accord between ice direction indicators within the sediment and drumlin orientation. Preliminary fabric analysis suggests a strong preferred a-axis orientation of 256° while the drumlin crest line is aligned 2,600.

On the basis of the diamicton characterists, it is argued that (i) deposition took place subglacially by active ice, (ii) there was a periodic depositional process so that each bed relates to a specific depositional period or event and (iii) the 'pudding stone' appearance of each bed suggests a fluid bed but both over consolidation and strong fabric suggest direct glacial deposition.

Drumlin at Tulla Crossroads (Site G5)

The following summary account is based on Finch and Walsh (1973) and Finch and Warren (1993). This site consists of an old aggregate pit cut in a north-south-east–south-south-east oriented drumlin north of Tulla crossroads (M365 029). The sections, though at present not well exposed, clearly illustrates that the drumlin is composed of three distinct diamicton beds (Finch and Walsh 1973, Plate XX). These are distinguished by the density and size of contained clasts. Lenses of sand and gravel also occur, probably as interbeds. The till matrix appears to be more sandy than that at Aughinish, which, while it would facilitate dewatering, would have the effect of making the saturated sediment less mobile. It is argued, however, that there is sufficient similarity between the sediments exposed here and those at Aughinish to indicate comparable depositional processes (Finch and Warren (1993).

Drumlin at Ballycastell (Site G6)

The following summary account is based on Warren (1993b). A drumlin section at Ballycastell, c. 3 km south-east of Lisdoonvara (grid ref. R 157 972), shows well developed glaciotectonic structures. The drumlin, one of a several drumlins which are spread across the Carboniferous limestone on to the overlying shales, consists largely of diamicton derived from the subadjacent Upper Carboniferous shales. In the lower part of the section, large rafts of shale are exposed. Trust faults are seen where the rafts have been pushed up or sheared over each other and the surrounding diamicton.

Geomorphological features at Poll Salach (Site G7)

The following descriptions of glacial deposits and a storm beach at Poll Salach (M 085 015), south-west Burren, are based on those by Warren (1993c).

- **Glacial deposits**

The glacial deposits, which are clearly a till i.e. deposited directly by ice, form a series of elongate mounds with boulders appearing at the surface. These deposits, which are different from those elsewhere in the Burren, are composed of a very course boulder till containing angular boulder-sized clasts in a silt-to-pebble matrix.

West of the sharp bend on the road (L54), the till is exposed in a section. It lies on a roche moutonée which has a well striated, ice-moulded surface. The striae run approximately northeast-southwest and the roche moutonée indicates ice movement from the northeast.

The mounds do not parallel the direction of ice flow. It is suggested that they are associated with extensional ice-flow which, for a time, may have moved almost east-west in this area.

- **Storm beach**

On the low ground at Poll Salach and also at other places in this part of the Burren coast, a blocky storm beach parallels the coast. Though the beach is active, it is striking that the boulders which form it are sub-angular to sub-rounded rather than rounded. It is suggested that they are derived from the till and that the lack of roundness is due to rapid solution associated with sea spray.

ARCHAEOLOGY

Poulnabrone portal tomb (Site A1)

A. Lynch

The striking portal tomb at Poulnabrone (grid ref. M 234 009) is one of four such monuments in Co. Clare. It is also one of the few portal tombs excavated in recent times and has contributed significantly to our knowledge of this monument type.

In 1985, a crack was noted in one of the portal (entrance) stones which threatened the stability of the structure and as a consequence, excavation and conservation works were carried out by the National Monuments Section of the Office of Public Works. The entire chamber was excavated and the north-west quadrant of the surrounding cairn (Fig. 7).

The orthostats of the chamber were found to be sitting directly on the limestone bedrock, held in place by the weight of the capstone. The sill-stone at the entrance to the chamber was sitting in an east-west gryke, and just outside the sill-stone, three stones had been placed on edge forming a portico or antechamber which had been backfilled with earth and stones shortly after construction. The cairn, which is roughly oval in plan was constructed by piling large slabs of limestone against the chamber orthostats and then covering these with smaller flat stones to produce a relatively smooth surface sloping down to the limestone pavement. Several large stones had been placed on edge in grykes within the cairn matrix to help stabilise the structure. It is unlikely that the cairn was very much higher than it is today and it seems to have served a strictly functional purpose in helping to consolidate the chamber orthostats.

The burial deposit within the chamber produced the disarticulated remains of at least thirty three individuals, seventeen of these were adults and sixteen were children. Study of the remains has shown that the majority of adults died before reaching the age of thirty, there was an equal distribution of males and females among the adults and the vertebral pathology suggests a lifestyle characterised by hard physical labour. The dental data suggest a coarse diet with a high abrasive content – stoneground cereals would produce the type of attrition seen in the teeth. The tip of a flint or a chert arrowhead was found in the superior margins of an ilium that probably belonged to a male. Apart from the remains of a newborn baby which were found in a gryke close to the sill-stone, it is unlikely that the burials are in their primary position since the bones were totally disarticulated and some had been pushed into grykes to depths of up to 57 cm. It is likely that the remains were initially interred somewhere else (or left exposed to decay) and later transferred to the tomb.

Fig. 7. View of the chamber of Poulnabone portal tomb after excavation. Sill stone and broken portal stone are in the foreground.
Photo: J. Bambury, Office of Public Works.

Items which may have been of particular significant to these people were placed in the tomb with their remains and included a bone pendant (Fig. 8), part of a bone pin, a polished stone axe, stone beads, two large quartz crystals, flint and chert implements and sherds of pottery.

Ten radiocarbon dates were obtained from the human bone and these indicate that the tomb was used sporadically over a period of 600 years between 3800 and 3200 cal. B.C. The neonate was a later Bronze Age insertion. If we assume that the time lapse between death and interment was not very great then we can suggest a date of c. 3800 cal. B.C. for construction of the tomb.

The cutting through the cairn revealed a pre-cairn soil cover averaging 10-12 cm in depth. This was a friable brown earth with shell fragments and frequent stones. Pollen analysis undertaken by Dr. Michael O'Connell had negative results – it was assumed that the original pollen content had been more or less completely lost through decomposition in the alkaline environment.

Preliminary results of the animals bone analysis indicates the presence of cattle, pig, sheep/goat, dog, hare, stoat, pine marten, wood mouse and bird.

Conservation works at the monument included the replacement of the broken portal stone and the insertion of a new stone into the gap between the two eastern chamber orthostats to provide extra support for the capstone.

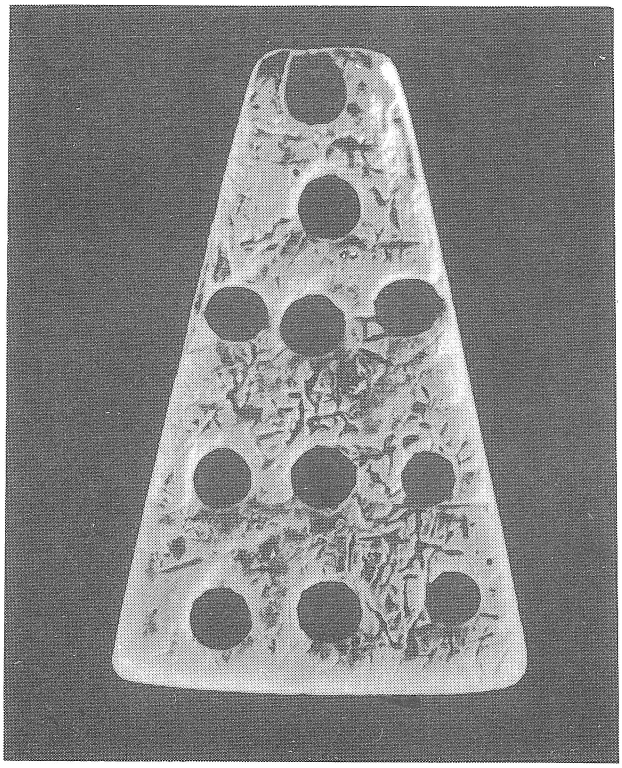


Fig. 8. Bone pendant found in the chamber of Poulnabrone portal tomb during excavation (length: 2.25 cm). Photo: C. Brogan, Office of Public Works

Geological note on megaliths in the Burren

D. Drew

The builders of the wedge and portal tombs in north-west Co. Clare appear to have conformed to particular 'lithological' rules. Thus, in both types of tomb the roof slab is invariably placed 'right way up', i.e. as it was oriented prior to quarrying. The side slabs of the portal dolmens are places with the 'up' side facing outwards whilst the side slabs of the great majority of the wedge tombs are built with the 'up' side facing inwards. Thus, the side slabs, particularly of the wedge tombs, preserve to a large extent the solutional weathering forms (karren) that were present when the tombs were built, whilst the top slabs have been subject to subaerial weathering for the entire period since the tomb was built.

It is noticeable that on Poulnabrone the undisturbed, east-facing side slab shows subdued, rounded karren forms characteristic of development under a solid cover. However, the top slab had developed a series of sub-circular, angular hollows (kamenitza) of subaerial origin superimposed upon the original smooth karren and similar to those found on the surrounding exposed limestones. The mean depth of these hollows is 43 mm compared with 27 mm for adjacent wedge tombs, thus reinforcing the generally accepted younger age for the wedge tombs. It also provides some evidence for the existence of a soil cover at the time at which the tombs were built.

The kamenitza on Poulnabrone exhibit overflow channels downslope with a mean depth of 23 mm. This suggests that originally the top slab was more nearly horizontal than at present and that, for whatever reason, tilting to its present inclination took place at some point in the first 2000-2500 years following construction.

Ancient field boundaries, Ballyelly-Coolmeen area, Slieve Elva (Site A2)

D. Drew

The Burren plateau contains a remarkably high density of field monuments including a great variety of enclosures. Such enclosures and their boundary walls, of apparent antiquity, are particularly well preserved on the high plateau areas (winterage) of the Burren either because these were the preferred areas for settlement or because their relative remoteness has minimised later disturbance. The existence of such evidence for intensive agricultural usage is intriguing in view of the marginal status of the area for present-day agriculture (Drew 1982).

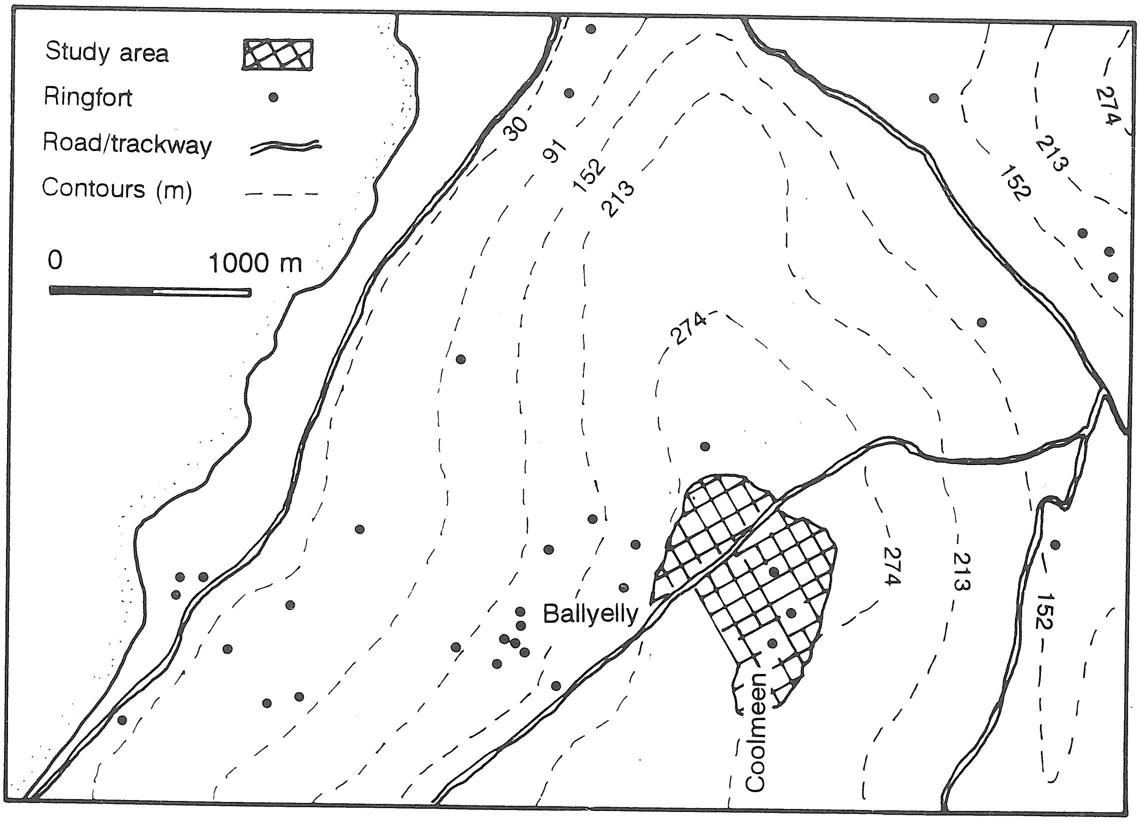


Fig. 9. Map of part of the western Burren, including the Ballyelly-Coolmeen area where the field boundaries have been studied (after Plunkett Dillon 1985). Contours at 200 ft intervals, i.e. 100 (30 m), 300 (91 m), 500 (152 m), 700 (213 m) and 900 ft (274 m), are also shown.

The townlands of Ballyelly and Coolmeen occupy a relatively flat area on the dip slope near the northern extremity of Slieve Elva (Fig. 9). To the north the land falls steeply to the Caher valley, to the west is a scarp of c. 280 m down to the sea and to the south-east is the Namurian capped summit of Slieve Elva. The study area (grid ref. M 154 061; Fig. 10) is underlain by the upper most beds of the Brigantian limestone which form areas of limestone pavement where the more competent beds outcrop. Chert lenses are abundant in this area. The nearest reliable water source is from the numerous small streams which sink underground at the shale/limestone contact some 500-1000 m to the south-east. Rendzina soils 20-150 mm deep provide a patchy (c. 70%) cover. Close to the Namurian outcrop grikes are considerably enlarged by solution, and soil and vegetation is largely confined to the grikes. Vegetation consists of the normal Burren herb-grass association with *Calluna vulgaris* locally abundant especially in areas of cherty limestone. Cattle are grazed throughout the year over all but the eastern (winterage) part of the area.

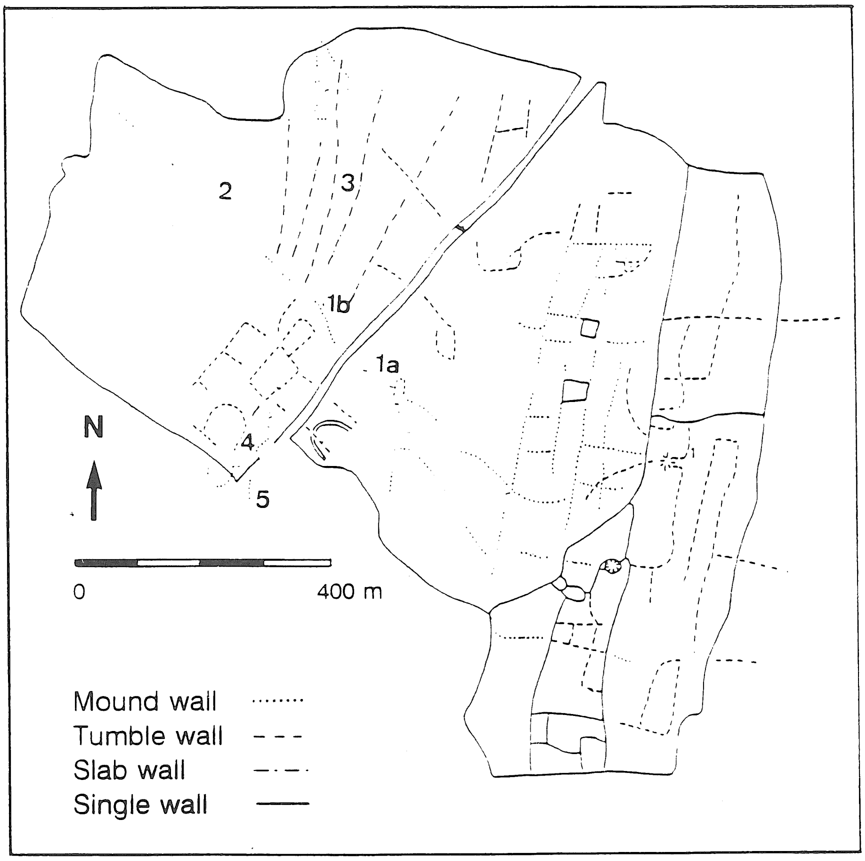


Fig. 10. Map of ruined field boundaries in the Ballyelly-Coolmeen area. Locations 1-5, which are referred to in the text, are indicated (adapted from Plunkett Dillon 1985).

Although this part of Slieve Elva is amongst the most exposed regions of the Burren, open to Atlantic gales and at an altitude of 250-300 m, it contains within a small compass a great variety of field monuments including examples of all of the major field boundary types.

The description and analysis of the field sites given below is based largely on the work of Plunkett Dillon (1982, 1985) together with more recent supplementary work by this author.

Plunkett Dillon classifies walls into four groups as follows (Fig. 11):

Single Walls. One stone in width, 1-1.5 m high, sometimes with orthostats, commonly enclosing block shaped or irregular fields 0.1-170 ha in extent. They are considered to be relatively recent in age, i.e construction took place probably in the last 300 years.

Slab Walls. One slab wide, 1-2 slabs high, often in parallel lines, enclosing strip or block fields of 0.2-6 ha.

Tumble Walls. With a core of 1-2 courses of stone then rubble, they often appear as linear heaps of stones. They enclose fields both rectangular and irregular with areas of less than 1.6 ha. Plunkett Dillon suggests a possible association with ring forts.

Mound Walls. Some 30-80 cm in height and 80-180 cm wide, built predominantly of large slabs laid horizontally. Field systems are often incomplete or difficult to recognise but range from 0.01-2 ha in extent and may be regular or irregular in shape. Unlike other wall types which often parallel the joint systems, mound walls may meander across the grain of the terrain.

Table 1. The distinguishing characteristics of field layouts.

Field shape of at least 75% of the field layouts	Range of field sizes in layout (ha)	Occurrence of repeating elements within the layout	Predominant boundary types used in the layout
Regular block	0.15-8.6	—	Single double earth bank
Regular block	0.02-3	—	Single tumble mound
Regular block	0.21-3	Fields set between parallels	Single double earth
Rugular strip	0.25-6.4	Fields set between parallels	Single slab
Irregular	0.05-2.9	—	Single
Irregular	0.01-1.1	—	Single tumble mound
Mixed	4-170	—	Single earth bank

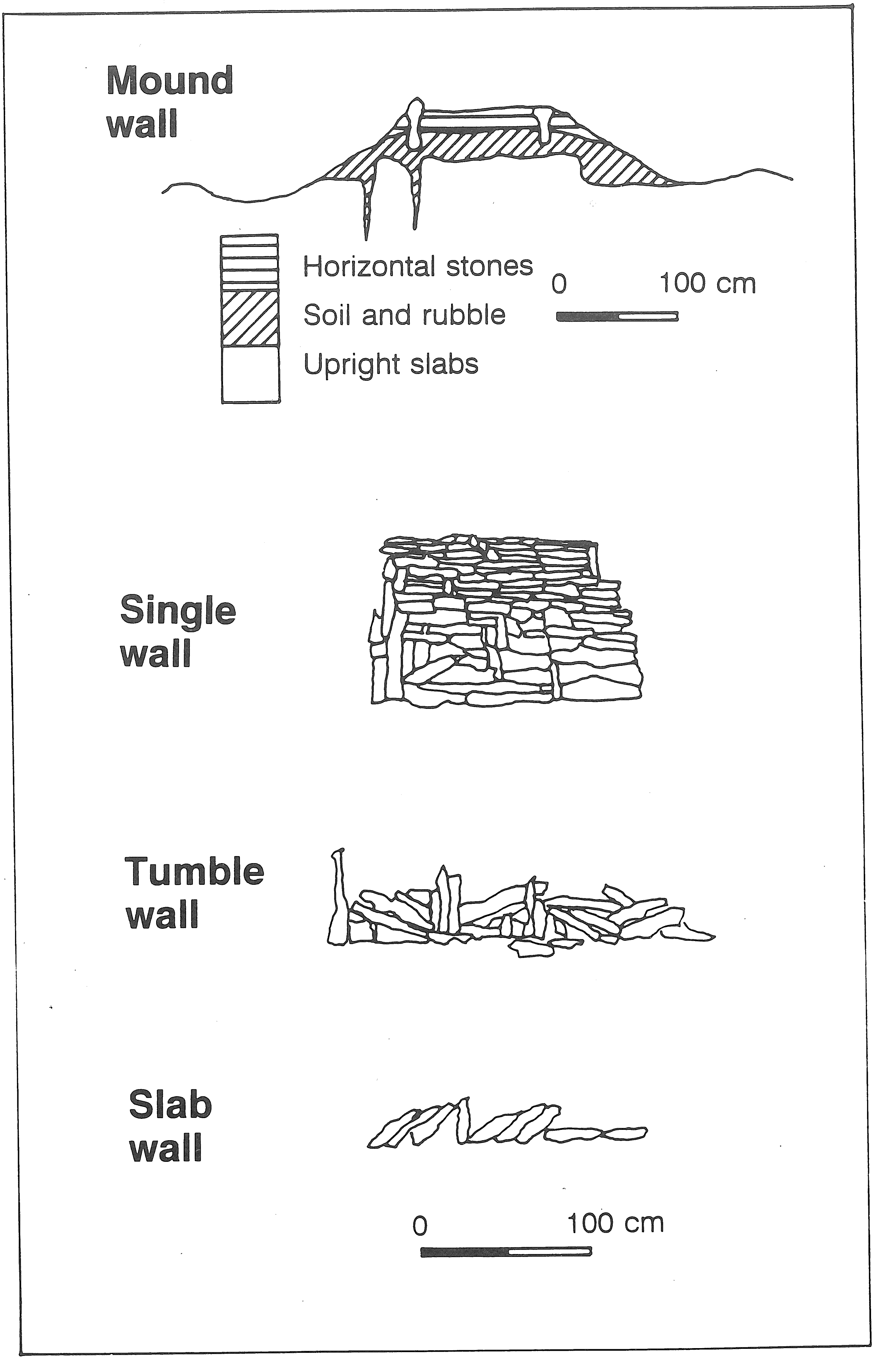


Fig. 11. Main wall types in the Burren (after Plunkett Dillon 1985).

In terms of relative age, there are examples of tumble, slab and single walls climbing over mound walls. This and other evidence suggests that the mound walls may be among the oldest field boundaries in the Burren. Plunkett Dillon suggests that the mound walls of this area may be linked to the large cairn and that the enclosures may have supported cultivation. She associates the tumble walls with pastoralism. Field layouts are summarised in Table 1.

In Ballyelly-Coolmeen there is little direct evidence for settlement other than two circular and two rectangular forts and several smaller circular and rectangular features that were possibly house sites. The field boundary systems at locations 1-5 in this area (Fig. 10) are now described.

Location 1. An example of an extensive mound wall which pursues a sinuous course across the area at an oblique angle to the dominant joint sets. The wall crosses small scarps and to the east of the droveway crosses a small tumble wall enclosure and links with a series of rectangular enclosures. To the west of the droveway the mound wall continues beyond the townland boundary to the steep descent to the sea. Although *Calluna* is abundant in the area it is conspicuously absent from the wall vegetation.

Location 2. The mound wall described above crosses an area of bare limestone a part of which is characterised by an uneroded rock surface or by smooth karren forms and joints unopened by solutional erosion. This suggests the comparatively recent removal of a buffering (calcareous) soil cover. Further westwards the limestone surface the karren forms are more angular *(Spitzkarren)* and joints more opened implying a longer period of subaerial erosion.

Location 3. A series of parallel slab walls (20-30 m apart) originates in this area and extends northwards beyond the townland and towards the Caher valley. The slab walls are crossed by a tumble wall and intersect a small system of mound wall-bounded enclosures.

Location 4. A 2 m length of mound wall has been removed at this point allowing the structure of the wall to be seen. Unlike the other wall types, mound walls are built primarily of large slabs of limestone placed horizontally on the ground. This affords a degree of protection to the underlying soil from leaching and erosion and to the bedrock surface from solutional erosion. Thus the character of both soil and bedrock surface when the wall is built may be preserved.

In the case of several mound walls investigated in the Burren it has been found that they rest upon a pedestal of bedrock in the same manner as do erratic or transported blocks elsewhere in the Burren. The height of the pedestal corresponds to the extent of vertical lowering of the surrounding limestone surface that has taken place since the wall was constructed. The pedestal form for Ballyelly-Coolmeen mound walls is shown in section in Fig. 12. The pedestal averages 140 mm in height over the exposed section and its location, transverse to the orientation of the long axis of the major clint blocks, makes it improbable that it is other than a weathering residual. On the rock surface that lay beneath the slab wall the joints are some 10-20 mm wide (due to solutional erosion) compared with 100-200 mm on either side of the pedestal.

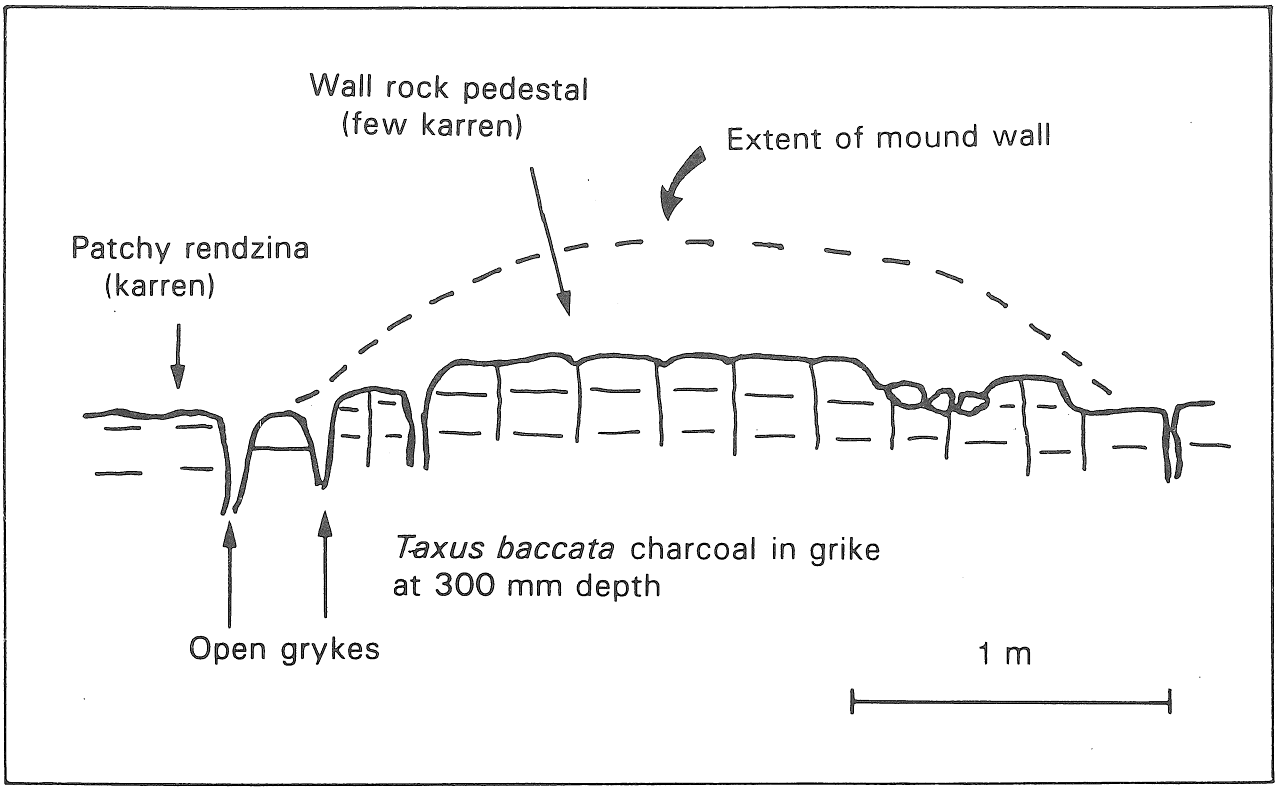


Fig. 12. Diagrammatic section through a mound wall, Ballyelly (composite of walls at locations 4 and 5 in Fig. 11).

In theory it is possible to estimate the age of mound walls by reference to the amount of lowering of the surrounding limestone surface that has taken place since they were constructed, but in practice such estimates are liable to considerable uncertainty. Williams (1964) measured current solutional loss of limestone within the southern Burren catchments and estimated an average annual lowering of the limestone surface of 0.051 mm. This global value of necessity included zones of accelerated erosion such as cave conduits and zones of minimal or zero erosion such as limestones overlain by calcareous drift. If instead the mean height of rock pedestals beneath transported blocks in the area is used, a direct comparison with the environment of the tumble walls is obtained and the need to extrapolate present day erosion rates for several millennia into the past is obviated. The mean pedestal height beneath some 78 blocks in the north-western Burren is 350 mm. If it is assumed that this is the result of c. 10 000 years of erosion then an annual rate of 0.035 mm/year is obtained. If the range of sub-wall pedestal heights and the range of values that comprise the mean value for natural pedestals is taken into account, an age for the mound walls within the range 2900-4000 B.P. results which would imply that they were constructed in the Bronze Age or perhaps at the end of the Neolithic period. Plunkett Dillon, taking a more rapid solutional rate, estimated the age of the pedestal/mound wall as being at least 2000 years.

Location 5. A continuation of the tumble wall at location 4 crosses the droveway and extends southwards past small round and rectangular enclosures which may represent house sites. A grike parallel to this part of the wall yielded small quantities of charcoal from *Taxus baccata* (yew) at a depth of 300 mm in a red-brown mineral soil. Palynological work by Rutherford (1982) at Faunarooska and Dereen South some 1-1.5 km south of this area demonstrated a mixed oak climax forest with an upper boundary at c. 2700 B.P., followed by open heath and grass with some weed and cereal pollen. This late Bronze Age date is of interest compared to palynological work in other parts of the Burren reported elsewhere in this publication and the evidence presented above for the age of the field boundary systems.

Poulawack (Site A3)

P. Gosling

Ringfort and Souterrain

The ringfort was the characteristic enclosed settlement form of the Early Historic Period (A.D. 400-1200) in Ireland. They generally consist of a circular or oval area, varying in diameter from c. 20-60 m internally, which is delimited by one, or more, earthen or stone enclosing elements. These can take the form of an earthen bank(s) and fosse(s), a stone rampart(s), and/or scarp(s), giving rise to the designations, uni-, bi-, and multi-vallate.

The entrance, frequently marked by a stout gateway, was usually situated on the eastern side, and the interior would have contained the buildings of the household. This most probably comprised the members of an extended family who farmed an estate of 40 ha upwards.

Some ringforts contain souterrains, or artificially-built subterranean chambers, beneath their interiors. Whether built of wood and/or stone (less frequently, tunnelled), these artificial caves appear to have been designed as refuges for people and property in times of danger, e.g. during cattle raids.

The Poulawack ringfort (grid ref. R 227 984) is a typical example of this type of monument, of which the Burren probably has about 500 examples. From it, one also gets a good view, northwards, of a number of other ringforts, including the very well preserved Cathair Chonaill ringfort.

Multiple Cist Cairn

This humble looking cairn (diameter 21 m, height 2.5 m; Fig. 13) was one of two monuments in the Burren chosen for archaeological excavation by the Harvard Archaeological Expedition to Ireland. Excavation in 1934 revealed that it contained 10 graves, including the remains of at least 16 people. These comprised 3 adults, 4 young adults, 5 children and 4 unspecified. The recent series of radiocarbon dates (conventional and AMS) have served to clarify the chronology of this complex site (Brindley and Lanting 1992a).

Within the cairn, two concentric stone revetments, probably representing at least two main phases of construction, were identified:

(i) an inner cairn (diameter: 10.5 m) delimited by a drystone revetment wall (height: 1 m) within which was a centrally placed double cist (Grave 8 and 8a) defined by wall of multiple, inclined slabs and roofed by a number of capstones. Grave 8 contained some human bone, a hollow scraper of flint, two tiny potsherds, and a boar's tusk. Grave 8a contained the disarticulated skeletal remains of four individuals; an infant of about one year, a young adult female, and a middle aged male and female. These were accompanied by a solitary shell of *Ostrea edulis*. Human bone from this grave has given dates of c. 4600 B.P. (3350 cal. B.C.) which serves to confirm a Neolithic age. Grave 5 was also considered by Hencken as primary, but the small potsherd contained in it has since been identified as Beaker pottery (Ryan 1981, 138). Human bone from this grave has been ^{14}C-dated to 3490±60 B.P., i.e. 2000 cal. B.C., which supports the idea that the grave is not primary. Graves 6-7 were evidently placed in the inner cairn as it was being built.

(ii) a concentric, outer ring of slabs set on edge (diameter: 13.4 m, height: 0.9 m) which was completely mantled by the cairn material. This contained Graves 1-4, though the possibility that Grave 1 could have been earlier than all the others, was considered by the excavator. The only finds from these graves were a bone point and a flint scraper from Grave 2.

From a palaeoenvironmental viewpoint, the excavations also indicated that the whole cairn, including the Late Neolithic central cist, was built directly on the limestone pavement.

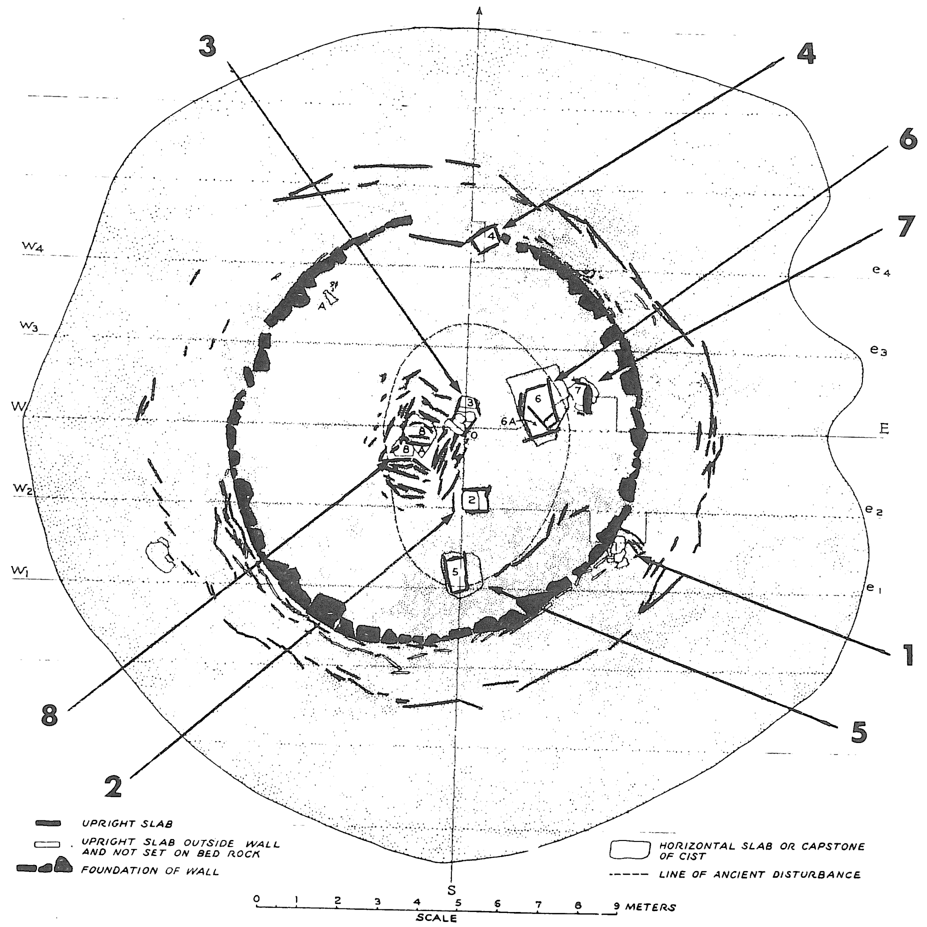


Fig. 13. Horizontal sectional view of the multiple cist cairn at Poulawack, central Burren (after Hencken 1935)

Ballyvaughan valley: overview of the archaeology (Area A4)

P. Gosling

Given the large concentration of megalithic tombs in the Burren, their absence from the Ballyvaughan Valley is notable. While the reasons for this have not, as yet, been the subject of detailed study, it may well have been related to its deep soils which probably supported relatively dense woodland in post-glacial times. As de Valera and Ó Nualláin (1961, 108-9) have commented, the distribution of the Burren tombs suggests that their builders preferred the upland plateaus (150-300 m O.D.) for settlement, probably because of the presence of open upland pastures.

There is, however, a loose group of five wedge tombs (c. 3850-3650 B.P.; Brindley and Lanting 1992b) at Berneens and Glenisheen, on the upper slopes (150-200 m O.D.) at the south end of the valley. It is perhaps more than coincidental that this area also boasts two undated prehistoric cairns as well as the find-spot of a Late Bronze Age gold collar known as the Glenisheen Gorget. The only other evidence for settlement activity here in the Bronze Age, are a number of fulachta fia near Mám Chatha, on the eastern side of the valley.

The most common archaeological monuments in this valley are medium sized circular enclosures (diameter: 20-60 m), of which about two dozen have been identified to date. The majority of these are probably ringforts. When compared to the dearth of evidence for prehistoric settlement, the presence of these enclosures suggests that the valley floor may not have been opened up for dense settlement until the Early Historic Period (A.D. 400-1200). This is further underlined by the presence of two probable early ecclesiastical sites, at Rathborney and Ballyallaban.

In view of the Burren's reputation as a stony place, it is interesting to find that some of the largest and most impressive enclosures in the Ballyvaughan Valley are constructed of earth, i.e. Dún Torpa, near Rathborney, and An Rath, at Ballyallaban. The former monument is a multi-vallate enclosure, suggesting that it may have been the residence of a chieftain, while the latter, with its water-filled moat, displays certain affinities with Anglo-Norman earthworks of the 13th century.

In medieval times (A.D. 1300-1600), the Ballyvaughan Valley formed the heartland of the O'Lochlainn clan who controlled the Burren uplands, and appear to have maintained a degree of independence from their overlords, the O'Brien dynasty of Thomond. The valley contains five of their late medieval castles (fortified tower houses), four of which are strategically located to control routeways. At least some of the valley's ringforts also continued to be occupied at this period, as the medieval gateway to Cathair Mhór testifies.

Investigations towards the reconstruction of the late-glacial environment at Lurga, S.E. Burren.
I. The sedimentary record and the pollen and macrofossil evidence (Site P1)

Aa. Paus, C.C. Huang, H.H. Birks and M. O'Connell

Introduction

Several late-glacial deposits have been identified, mainly in shallow basins, in the low-lying karstic landscape north of Tubber in the south-eastern Burren. One such deposit is that at Lurga (grid ref. R 420 965; 8° 52'W, 53° 01'N, 6.34 km south-west of Gort; Fig. 14) where, from a cutover bog, a 10-cm-diameter core (LGA II) from 140-323 cm below the present surface, yielded sediments that span the period from the end of glacial melt to the early Holocene. In addition, several 5-cm diameter cores were taken in close proximity to the main core, LGA II. Except where otherwise indicated, the measurements and analyses were carried out on material from the main core.

Methods

- **Pollen analysis**

Stratigraphical and pollen analytical investigations were carried out by Aa. Paus. Samples were analysed at 1-8 cm intervals. Because of low pollen concentration, the pollen sum in low (average: 554; range: 1128-126).

- **Physical investigations**

Whole core magnetic susceptibility measurements have been carried out on three 5-cm diameter cores. Single sample susceptibility measurements in both low and high fields have been carried out on 86 individual samples from core LGA II. In samples where marl dominated, susceptibility values were often very low and near the reliability limits of the instrumentation. The results of measurements in the low field are therefore only considered here. After carrying out the magnetic measurements, bulk (wet) density, dry density and loss-on-ignition were also measured. These investigations have been carried out by C.C. Huang.

- **Elemental analysis**

Elemental analysis was carried out on 46 samples from core LGA II by H. O'Donnell, Department of Geology, University College Galway.

Table 2. Main stratigraphical features in core LGA II, Lurga.

Depth (cm)	Deposit	Colour	Remarks
140-150	humified peat	brown	At base, *Betula* is rising sharply (early Holocene)
150-169	marl	grey	Early Holocene expansion of *Juniperus* recorded here
169-172.5	silty, calcareous gyttja	grey	Short transitional stratum. In pollen sample 170 cm *Artemisia* has declined
172.5-194	silty gyttja	greenish grey	Younger Dryas stadial, as defined on basis of pollen (PAZ 5). Lower boundary of stadial, however, placed at 197 cm (see next stratum)
194-197	silty calcareous gyttja	grey	Short transitional stratum
197-270	marl with three silty layers, the uppermost being the least pronounced	whitish grey; silt-enriched layers grey	Silt-enriched layers as follows: 207-212, 228-233 and 252-256 cm
270-291	silty gyttja with plant remains	grey to brown (see Remarks)	Four strata distinguishable as follows: 270-277: brownish grey, silty calcareous gyttja 277-283: grey brown silty gyttja; some plant remains 283-287: brown silty gyttja with abundant herbaceous plant remains 287-291: grey brown silty clayey gyttja with some plant remains Beginning of Late-glacial Interstadial recorded here
291-313	highly minerogenic silt/clay	blue-grey to brownish grey	Small variations in silt/clay proportions and colour. The silty clay with deep blue/grey colour between 294-297 cm gave exceptionally high χ_{lf} values
313-317	silt	brownish grey	
317-323	pebbles in sand	grey-blue	outwash from glacial melt

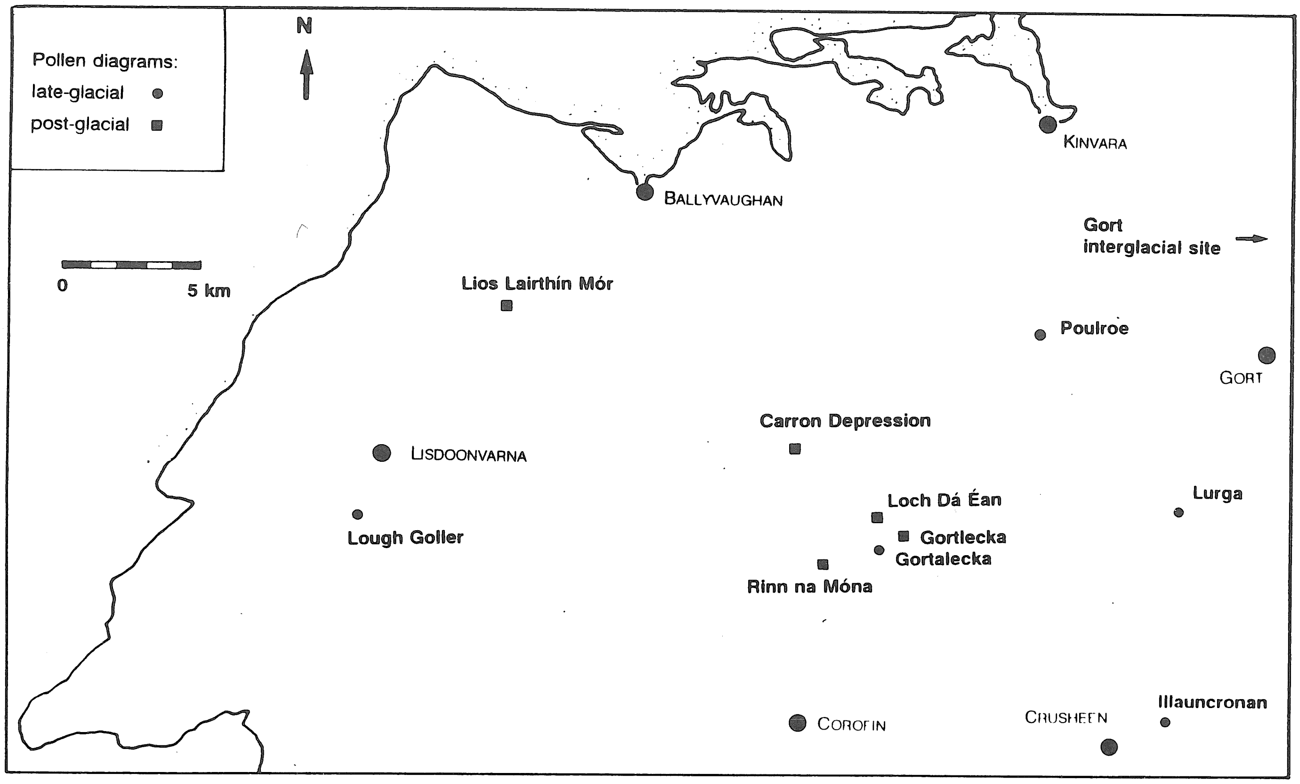


Fig. 14. Map showing the location of sites in Co. Clare from which late-glacial and post-glacial pollen records have been published. The Gort interglacial site (Jessen *et al.* 1959) lies 9 km north-east of the town of Gort.

- **Macrofossil investigations and radiocarbon determinations**

Macrofossil analysis were carried out by H.H. Birks on material from six levels in core LGA II. The sediment was poor in plant macrofossils so that detailed analysis was not justified. Sufficient material was, however, obtained for four ^{14}C AMS dates which were funded by the Norwegian Research Council for Science and Humanities (NAVF). In addition, a single conventional date was obtained from the early Holocene peat.

Results

The main stratigraphical features are presented in Table 2. While the tripartite stratigraphy which is typical of Irish late-glacial deposits from calcareous sites - silt/clay at the base, the greater part of the sequence consisting of marl, and a silt/clay layer at the top (Younger Dryas) - is recorded here, a number of minor but nevertheless noteworthy additional features were recorded. These include a layer with much plant remains (not identified but probably from aquatics) immediately above the minerogenic basal sediments and three silt-enriched layers within the Interstadial marl, i.e. the Allerød period *sensu* Jessen (1949). At Lurga and also in all the late-glacial deposits noted in similar shallow basins within the general vicinity of Lurga, the lower Holocene sediment, i.e. the sediment above the Younger Dryas clay/silt, consists of a c. 20-cm-thick layer of marl overlain by peat in which there is no further marl deposition.

- **Reconstruction of late-glacial vegetation and environment at Lurga**

The main data relating to core LGA II, Lurga, are presented as follows: percentage pollen diagram in Fig. 15; composite percentage pollen diagram and plant macrofossil concentration diagram in Fig. 16; and, physical and chemical measurements in Fig. 17.

The reconstructions which follow are made within the framework for subdivision of Irish late-glacial sequences as set out in Andrieu *et al.* 1993. In this scheme the late-glacial is divided into three main informal divisions refer ed to as Pre-interstadial, Interstadial (subdivided into earlier and later Interstadial) and Stadial, i.e. the Younger Dryas event (Table 3). These are based on biostratigraphic criteria and, while regarded as representing broadly synchronous developments, have not as yet well defined chronological boundaries (see Radiocarbon Dating below).

Table 3. Overview of late-glacial sub-divisions. In the case of the chronozones the lower boundary age, in conventional ^{14}C years B.P., is given in brackets.

Periods/ Zonation (Jessen 1949)	**Chronozones (Mangerud *et al.* 1974)**	**Regional PAZs (Watts 1977; Andrieu *et al.* 1993)**	**Local pollen assemblage zones at Lurga**	Lateglacial/Early Holocene sub-divisions
		Betula peak	*Betula* peak	
Post-glacial	Holocene	*Juniperus-Filipendula*	*Juniperus-Filipendula*	Early Holocene
	(10 ka)	Gramineae-*Rumex* peak	not recorded	
Younger *Salix herbacea* (zone III)	Younger Dryas (11 ka)	*Artemisia*	*Artemisia*-Cyperaceae-*Thalictrum*	Younger Dryas Stadial
Birch or Allerød (zone II)	Allerød (11.8 ka)	Gramineae	Gramineae-Cyperaceae-*Helianthemum*	Late Interstadial
	Older Dryas (12 ka)			
	Bølling	*Juniperus-Empetrum*	*Juniperus-Empetrum*	Early Interstadial
Older *S. herbacea* (zone I)	(13 ka)	*Rumex-Salix*	*Rumex-Salix-Empetrum*	
		Pinus-Artemisia-Gramineae	*Pinus-Artemisia*-Gramineae	Pre-interstadial

Pre-interstadial period

LGA II-1: *Pinus-Artemisia*-Gramineae PAZ (spectra 312-292 cm)

In addition to the taxa in the PAZ name, Ericaceae and *Alnus* are important and *Ophioglossum* attains 18% at 308 cm. Pollen concentration is very low (average terrestrial pollen concentration is 2480 grains cm^{-3}).

This pollen assemblage, recorded from what is often regarded as 'sterile clay' (silt/gravel transition is at 317 cm), may be regarded as consisting of a mixture of reworked, i.e. secondary, long distance-transported and locally produced, palynomorphs. Thermophilous taxa such as *Alnus*, Ericaceae and *Corylus* (does not exceed 2.5% and not shown in Fig. 15) almost certainly represent pollen that have survived in the clays from earlier interstadials or interglacials. They are regarded as reworked. The evaluation of records for some of the other taxa is more difficult. *Pinus*, for instance, may be, in part at least, of secondary origin but is more likely due largely to long-distance transport from sources in southern and eastern Europe (cf. Huntley and Birks 1993). Gramineae and *Artemisia* also fall into this category but, in these cases, there is the possibility that pollen of local origin are also represented. A sparse and discontinuous vegetation cover, which included mainly Gramineae and *Artemisia* species, probably existed locally and also within north-west Europe generally (cf. Andrieu *et al.* 1993; Paus 1989) at this time. It should be borne in mind that, since overall pollen production was probably low, the representation of locally occurring plants and also long-distance-transported pollen such as *Pinus* will be exaggerated in the percentage diagram.

The rise in *Pediastrum* in the uppermost spectrum (292 cm) suggests a rise in productivity in the aquatic environment and is probably due to amelioration in thermal conditions, especially summer temperatures.

Early interstadial period

LGA II-2: *Rumex-Salix-Empetrum* PAZ (spectra 290-274 cm)

Several changes are recorded at the base of LGA II-2. Cyperaceae, *Rumex* and especially *Botryococcus* expand, Gramineae continues to be well represented and *Pinus* and Ericaceae decline. The base of the PAZ coincides with a well defined lithological change from a highly minerogenic to a relatively organic-rich sediment which shows maximum loss-on-ignition values for the late-glacial part of the profile (Fig. 17). The high *Botryococcus* and *Pediastrum* values, as well as a sharp increase in organic content of the sediment, suggest a further rise in productivity within the lake while the changes in the representation of terrestrial herbs (*Rumex*-type, Cyperaceae and Gramineae increase, *Artemisia* decreases) suggests amelioration also in terrestrial conditions. The continued, though reduced, presence of reworked pollen (cf. Ericaceae p.p. curve), records for *Saxifraga oppositifolia* at 290 and 282 cm (cf. *Saxifraga* curve in Fig. 15) and the high concentration of chemical elements indicative of erosion of unweathered soils (cf. Fig. 17) suggest that soils in the catchment continued to be unstable, presumably due to severe frost action. However, the initiation of curves for relatively thermophilous aquatic taxa such as *Typha/Sparganium* (but *T. latifolia* not specifically identified in this zone) and *Myriophyllum* at 286 cm suggests a further amelioration in the thermal environment which probably involved an increase in summer temperatures. Macrofossils recorded in sample 283-285 cm included *Salix herbacea* leaves and leaf fragments which confirm the local presence of this species. Noteworthy also is the expansion of the *Salix* pollen curve from 2% at 286 cm to 17% at 282 cm which also strongly suggests local establishment and expansion involving probably low shrub willows.

From 282 cm to the top of the zone (274 cm) the pollen assemblage takes on a somewhat different character in that the reworked and long-distance transported taxa are now poorly represented, *Salix* is well represented, *Empetrum* expands and reaches 10%, *Betula* also increases but stays under 6.7% and *Dryas* is well represented (*Dryas* leaf fragment recorded in sievings of the pollen sample from 280 cm). The concentration of terrestrial palynomorphs expands dramatically to 18 500 grains cm^{-3}. These changes suggest the development of shrubby vegetation (see also above) though the herbaceous element also continued to play an important role (cf. *Rumex*-type, Gramineae and Cyperaceae curves).

The vegetation development reconstructed above suggests soil stabilization presumably as a result of an amelioration in temperature, probably during both winter and summer. The elemental analysis, which shows a sharp fall in the concentration of potassium and iron, supports the idea of soil stabilization. It should be noted, however, that in sediment corresponding to the upper part of zone LGA II-2, the cold-climate arctic form of the mollusc *Pisidium obtusale lapponicum* was recorded (see Evans and Griffiths, this volume). Vegetation development was probably still restrained by climate rather than by factors such as inadequate soil development or absence of propagules.

LGA II-3: *Juniperus-Empetrum* PAZ (spectra 270-238 cm)

This zone is characterised by high *Juniperus* values, a decline in *Salix* and especially *Rumex*-type, and increased *Helianthemum* and *Plantago maritima* in the upper part of the zone. In the middle of the zone there is a pronounced decline in *Juniperus* and an increase in herbaceous taxa including Gramineae, Compositae (both Tubuliflorae and Liguliflorae) and *Dryas*. *Gypsophila fastigiata/repens* achieves 1.9% (see D1, Fig. 15).

Scrubby vegetation in which *Juniperus* has a major role dominates for most of the zone. Other woody species include *Empetrum* and *Betula*. High pollen concentrations suggest high pollen productivity, presumably in response to substantial climatic amelioration. The changes in the pollen spectra at D1 (see above), which coincides with increased silt/clay and also a small increase in the chemical erosional indicators (Fig. 17), suggest a climate change that was unfavourable for *Juniperus* and led to increased soil erosion.

Macrofossil analysis has been carried out on samples from 249-251 and 237-239 cm, i.e. from immediately above the feature marked D1 and from the top of the zone. In the lower sample, remains of *Betula nana*, *Dryas* and *Juniperus* have been recorded. In the upper sample, in addition to the already mentioned species, fruits of tree birch and catkin scales of *B. pubescens* were noted. This serves to confirm the local presence of *B. nana*, *Dryas* and *Juniperus* in the upper part of the zone and, in addition, the local presence of tree birch (*B. pubescens* is the only tree birch known from the Irish late-glacial (Godwin 1975)) at the top of the zone. It is noteworthy that the peak in *Betula* pollen coincides with the presence of tree birch which agrees with the relationship observed elsewhere (cf. Birks 1994) between high *Betula* pollen values and the presence of tree birches.

The developments at the top of the zone not only involve partial replacement of *Juniperus* by *B. pubescens* but also the expansion of *Hippophae*. *Hippophae* is normally regarded as playing a role in the early successional sequence from low shrub to tall shrub and woodland vegetation (Reynaud 1975), but it can also tolerate relatively unstable habitat conditions, such as in sand dunes. In this instance, neither the lithology nor the chemical analysis suggests soil instability so the vegetation developments are probably largely attributable to succession.

Later interstadial period

LGA II-4: Gramineae-Cyperaceae-*Helianthemum* PAZ (spectra 236-198 cm)

Gramineae and Cyperaceae have largely replaced *Juniperus* and *Betula* as the main pollen contributors in this zone. There is, however, considerable movement in the *Juniperus* and, especially, the *Betula* curve throughout the zone.

At the base of the zone, grass and sedge-dominated communities have probably largely replaced birch, juniper and crowberry (*Empetrum*). The substantial contributions by other herb taxa such as *Helianthemum*, *P. maritima* and Compositae suggest species-rich communities. The greatest decline in *Betula* (cf. D2, Fig. 15) takes place just below a silt/clay-enriched layer and coincides with a small increase in the concentration of the chemical erosional indicators. There appears to have been a shift in climate which initially affected the woody vegetation and later led to soil erosion. It should be noted, however, that the concentration of Gramineae and Cyperaceae increases so that total pollen input by grasses and sedges may not have been adversely affected.

In the middle part of the zone, *Betula* and, to a lesser extent, *Juniperus* recovers and the *Hippophae* curve is re-established. Herbaceous pollen continues to be well represented which suggests that the expansion of woody vegetation was limited.

In the upper part of the zone, the main features include a sharp decline, followed by a minor recovery, in the *Betula* curve (cf. D3, Fig. 15) and a moderate expansion of *Juniperus* and *Pinus*. Changes of note in the non-woody taxa include increases in Cyperaceae, *Filipendula*, *Botrychium* and a substantial curve for *Selaginella* microspores. The sporadic records for *Gypsophila fastigiata/repens* here and elsewhere in the zone are also noteworthy insofar as these records suggest continental and/or alpine-type climates (cf. Webb and Moore 1982).

Macrofossils from 210-212 and 198-200 cm include leaves, fruits, and catkin and bud scales of *B. nana*, *Juniperus* and *Dryas* leaves, and megaspores of *Selaginella* (Fig. 16). From 198-200 cm, fruit/seed of *Campanula rotundifolia*, *Linum catharticum* (also 210-212 cm) and *Pinguicula* sp. were recorded. These data, taken together with the pollen evidence, suggest open, herb-rich communities characteristic of both dry (cf. *C. rotundifolia*, *Helianthemum* and *Plantago*) and wet habitats (cf. *Selaginella*, *Pinguicula* and *Filipendula*), and also low shrub communities which included *Juniperus*, *Dryas* and *B. nana*. The increase in the percentage *Pinus* representation may only be partly an artifact of the percentage method of calculation (concentration values for *Pinus* also rise). It is likely that there was an increase in long-distance-transported *Pinus* pollen. This would suggest changes in wind circulation patterns which may have involved increased frequency of easterlies and south-easterlies in early summer.

While the changes described above suggest that conditions were generally unfavourable for woody vegetation, there is little evidence for increased soil instability. The change in lithology at 207-212 cm, which suggests increased silt/clay input, is the least pronounced of the three silt/clay layers recorded within the interstadial marls, and the increase in the concentration of erosional indicators in this part of the profile is also minimal (Fig. 17). While the vegetation development, especially about D3, suggests some downturn in climate, it appears that this downturn did not lead to substantially increased soil instability within the catchment. It has been argued elsewhere that, in the period immediately preceding the Younger Dryas, Ireland may have experienced a moderate climatic upturn (Andrieu *et al.* 1993). This is based mainly on an expansion in woody taxa in several profiles especially in western Ireland (cf. *Juniperus* and *Betula* curves in this profile).

Younger Dryas Stadial

LGA II-5: *Artemisia*-Cyperaceae-*Thalictrum* PAZ (spectra 196-174 cm)

In this zone herbaceous taxa dominate. Apart from the taxa after which the zone is named, the substantial representation of Caryophyllaceae, *Saxifraga* (*S. oppositifolia* is recorded in three spectra at values 0.9-2%), and *Selaginella* in the lower part and *Dryas* in the upper part of the zone is noteworthy. *Rumex*-type and *Ophioglossum* are well represented throughout and also *Pinus* and *Salix*. The *Pinus* curve probably represents long-distance transport (average pollen concentration is very low at 6400 grains cm^{-3}) rather than re-worked pollen but *Salix* species, consisting probably of dwarf shrub species such as *S. herbacea* and *S. polaris*, appear to be the main woody elements in a herb-dominated vegetation.

The highly minerogenic sediment, the increased concentrations of erosional indicators (cf. curves for K, Fe, Al, Mg and Na) and high values for whole core (unpublished data) and single sample magnetic susceptibility (Fig. 17) suggest sustained erosion of largely unweathered soils. This, in turn, suggests severe frost action though the thermal environment in the late-glacial lake remained favourable for algae, especially for *Pediastrum*.

Early Holocene

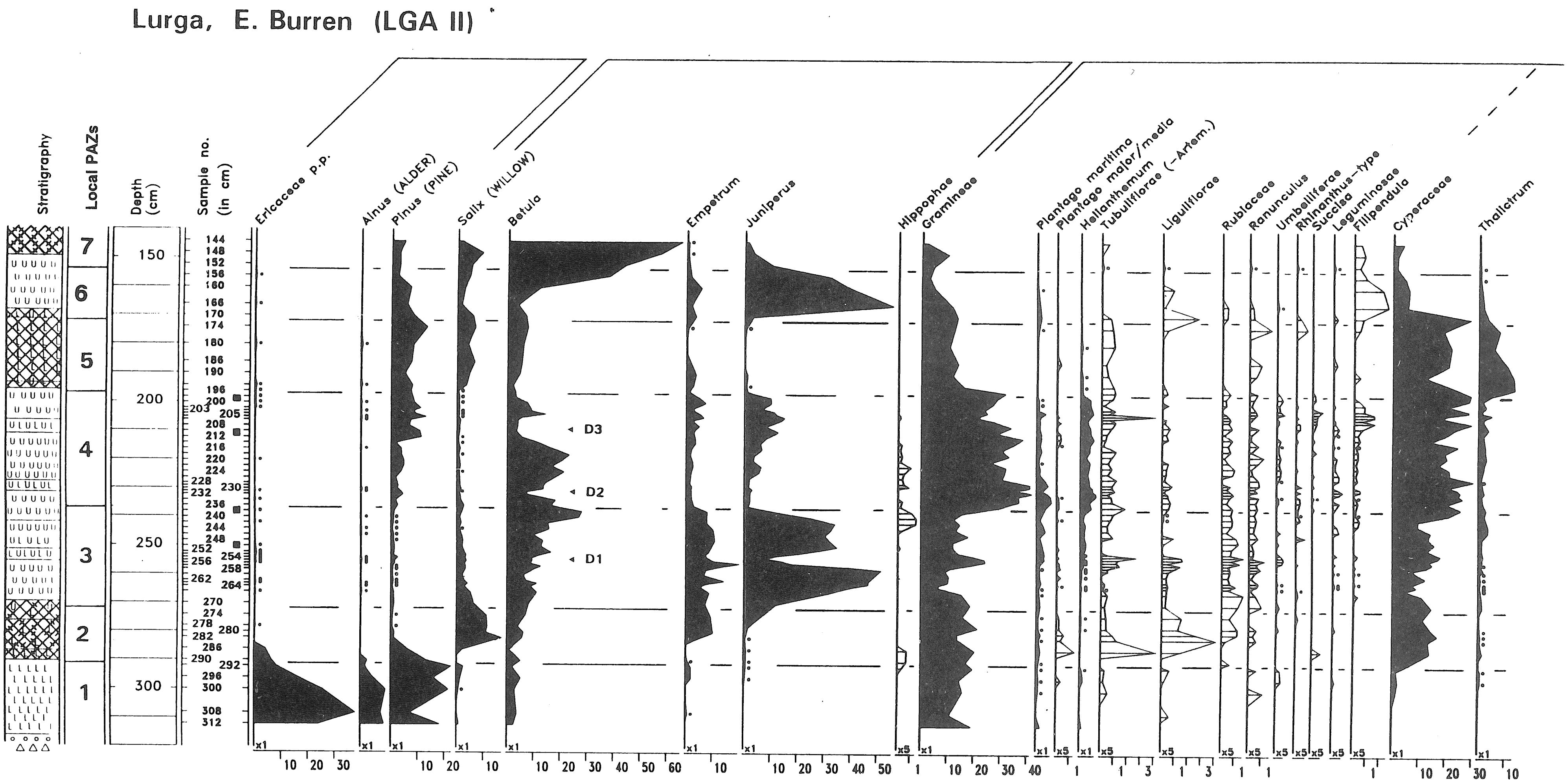
LGA II-6: *Juniperus-Filipendula* PAZ (spectra 170-156 cm)

LGA II-7: *Betula* peak zone (spectra 152-144 cm, i.e. top of profile)

At the base of zone LGA II-6, Cyperaceae peaks, the Gramineae curve rises slightly and *Artemisia* and Caryophyllaceae fall to low values. Subsequently, *Juniperus* expands sharply to reach 56% at 166 cm where *Filipendula* achieves 2.6%, its highest value in the profile. A steep rise in *Betula* is then initiated which continues into the following zone (LGA II-7). This suggests the replacement of *Juniperus* shrub by tree birch (a tree birch fruit recorded in sample 156-158 cm, Fig. 16). This development is paralleled by an expansion in the fern population (cf. rise in the *Dryopteris*-type curve and occurrence of Polypodiaceae sporangia). It is also noteworthy that the chemical erosional indicators decline sharply in LGA II-6 which suggests rapid soil stabilization after the unstable conditions of the Younger Dryas period.

The lithological change from marl to peat that is recorded near the base of LGA II-7 suggests a lowering of water-table level. This may be simply the result of sediment accumulation or it may be caused by changes in precipitation and evapotranspiration in the early Holocene. The possibility that the development of a karst hydrology is also involved cannot be excluded, especially since a comparable lithological sequence has been noted at several sites in the locality.

Fig. 15. Percentage pollen diagram from Lurga (core LGA II). A small number of curves for minor taxa with infrequent records have been omitted (1 of 2 parts).



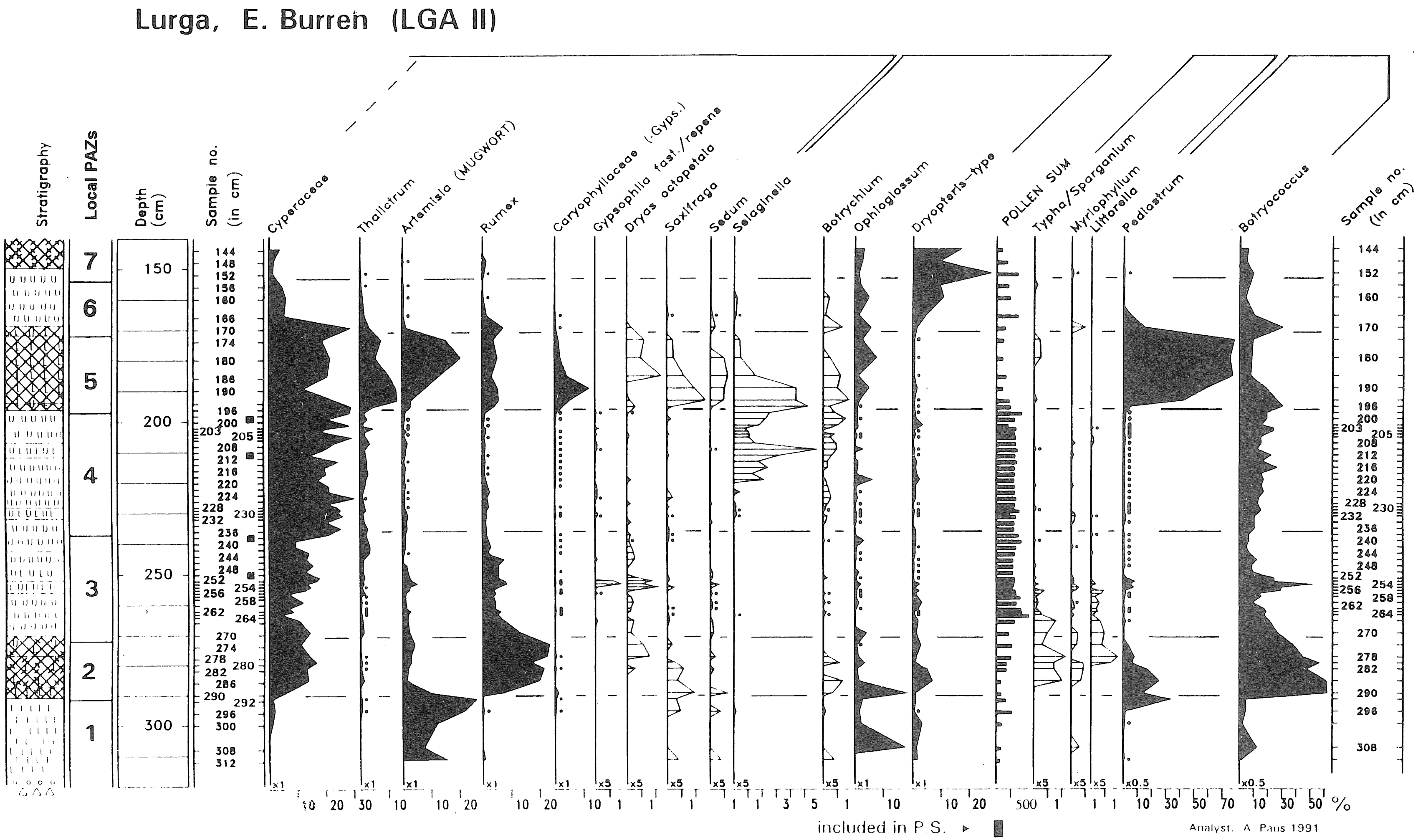
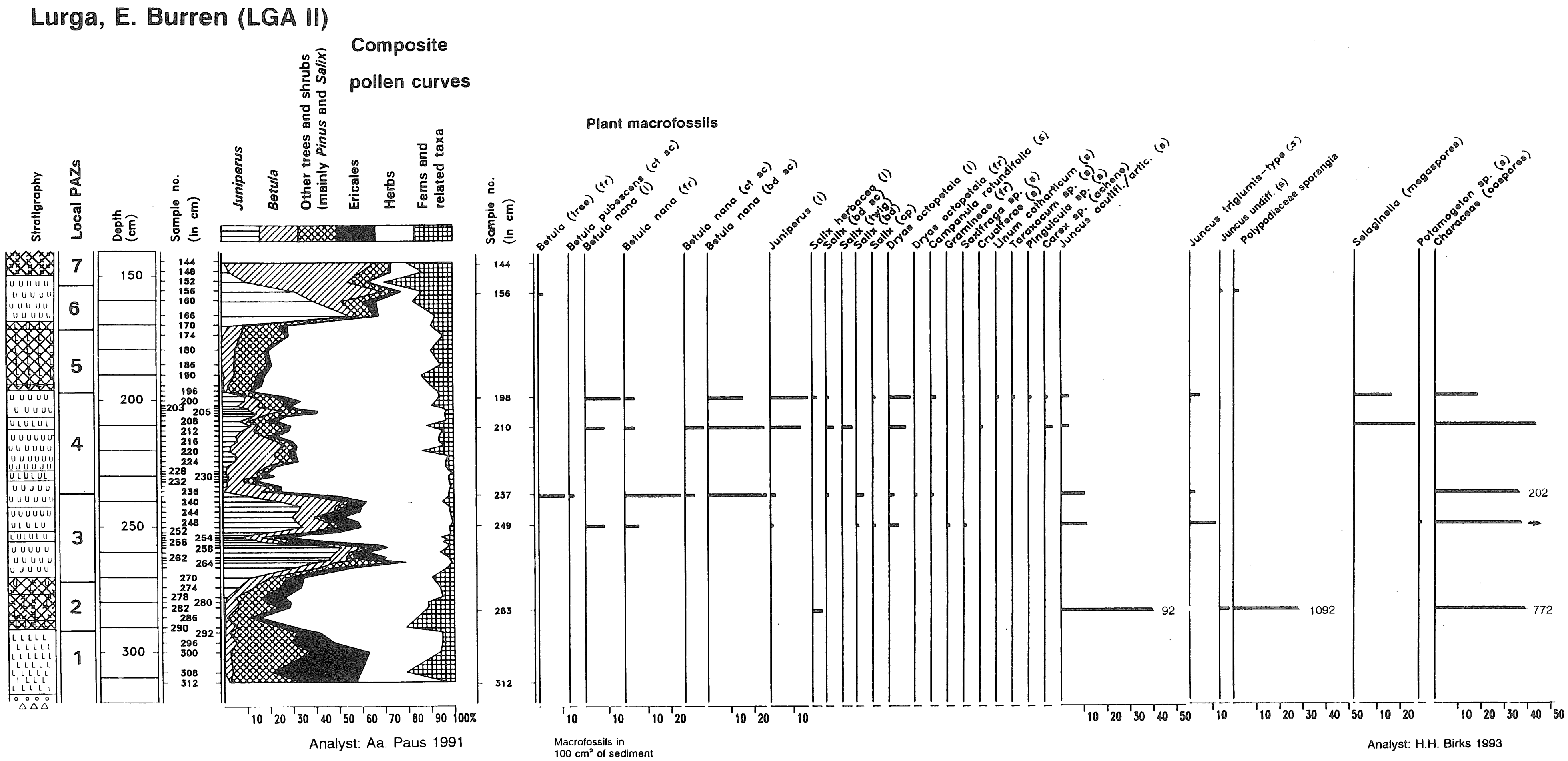


Fig. 15. Percentage pollen diagram from Lurga (core LGA II). A small number of curves for minor taxa with infrequent records have been omitted (2 of 2 parts).

Fig. 16. Composite percentage pollen diagram and plant macrofossil concentration diagram, core LGA II, Lurga. Horizontal scale represents numbers per 100 cm³ of sediment; a horizontal arrow indicates very large numbers (cf. Characeae oospores). Abbreviations are as follows: bd sc, bud scale; cp, capsule; ct sc, catkin scale; fr, fruit; l, leaf; and s, seed.



Lurga, E. Burren (LGA II)

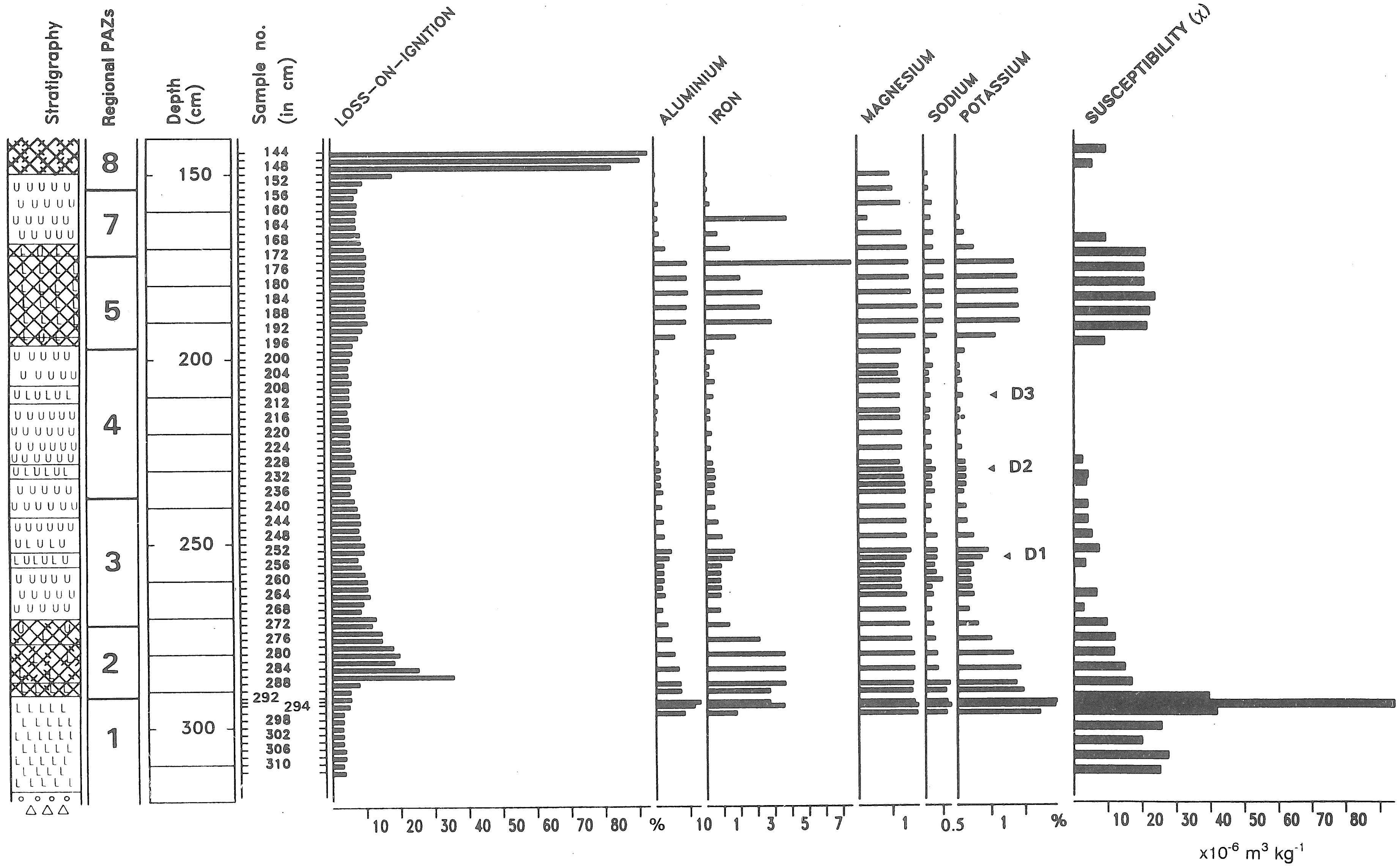


Fig. 17. Loss-on-ignition (LOI) as a percentage of dry weight, concentration of selected chemical elements as a percentage of the oxide in the mineral fraction and mass specific magnetic susceptibility (χ), profile LGA II, Lurga.

- **Radiocarbon dating**

The ^{14}C dates are presented in Table 4. The conventional ^{14}C date, 7990±120 B.P., obtained from near the base of the peat is, on the basis of the pollen assemblage (*Corylus* is not recorded), at least 1000 years too young. Penetration of roots from higher, and hence younger levels, may have resulted in this 'young' date.

The levels from which material for AMS dates was obtained are indicated by closed squares in the Sample No. column in Fig. 15 (see also Table 4). The AMS dates, 10 485±65 and 11 005±75 B.P., from the upper part of LGA II-4 (later Interstadial) are also rather younger than expected if a date of c. 11 000 B.P. is accepted for the beginning of the Younger Dryas. AMS dates from Ballybetagh, however, suggest that the onset of the Younger Dryas event at that site dates to c. 10 600 B.P. (Cwynar and Watts 1989). This corresponds closely with the ^{14}C results from Lurga. On the other hand, AMS dates from Illauncronan, 7.6 km to the south, suggest that the lower boundary of the Younger Dryas event dates to shortly after 10 960±90 B.P. (Molloy, O'Connell and Andrieu, unpublished). It is unlikely that the onset of the Younger Dryas, which represents a major climatic deterioration, would be substantially diachronous at two sites within such close proximity of each other. It is doubtful, therefore, that the lower boundary of the Younger Dryas at Lurga is as young as the dates from core LGA II appear to suggest.

As regards the two lowermost dates, 12 600±370 and 11 735±70 B.P., these are inverted. The σ value attaching to the former date is such, however, that if a 2σ range is taken for both dates the ranges overlap. If one accepts the second date as valid (this also has a small standard deviation) then the zone LGA II-3/4 boundary, which represents the main climatic shift within the Interstadial is considerably younger than 12 000 B.P., the date usually given for the main climatic deterioration within the Interstadial in Ireland and Britain (cf. Watts 1985; Cwynar and Watts 1989; Walker and Harkness 1990). AMS dates from Illauncronan suggest that the zone ILC I-3/4 boundary at that site dates to c. 12 000 B.P. It should be noted, however, that the pollen stratigraphy is rather different from that associated with the LGA II-3/4 boundary (see Andrieu *et al.* 1993) and so may be reflecting processes and influences other than a climatic deterioration which appears to be reflected at Lurga.

Table 4. Radiocarbon dates from Lurga, S.E. Burren. AMS dates (TUa- series) are from macrofossils extracted from core LGA II. In the AMS samples, $\delta^{13}C$ has been estimated to be -27.7‰ (Trondheim Radiocarbon Dating Laboratory, pers. comm.).

^{14}C lab no.	Depth (cm)	Material dated	Age (B.P.)
Gd-6692	156-160 (LGA Ic)	Peat from above transition from marl to peat. Lowermost peat (1 cm) not included.	7990±120
TUa-660	198-200	Terrestrial plant remains including *B. nana* lv. and fr., and *Juniperus* and *Dryas* lv.	10 485±65
TUa-661	210-212	Terrestrial plant remains including *B. nana* lv., fr. and sc, *Selaginella* megaspores, and *Juniperus* and *Dryas* lv.	11 005±75
TUa-662	237-239	Terrestrial plant remains including *B. nana* lv., fr. and sc, and *B. pubescens* fr.	12 600±370
TUa-663	249-251	Terrestrial plant remains including *B. nana* lv., fr. and sc., and *Dryas* lv.	11 735±70

fr.: fruit; lv.: leaves; sc.: scales

Investigations towards the reconstruction of the late-glacial environment at Lurga, S.E. Burren.
II. Mollusc and ostracod evidence (Site P1)

J.G. Evans and H.I. Griffiths

For the mollusc and ostracod analyses, a 5-cm diameter core, LLM I(A), was used. This core was taken within 50 cm of the main core, LLM II, using a Livingstone sampler. Alternate 5-cm thick samples were analysed from between 160 and 300 cm. Additional samples were analysed for molluscs (160-165, 210-215, 220-225, and 275-280 cm).

The molluscan fauna is a very impoverished lacustrine one, consisting mainly of *Lymnaea peregra*, with five species of *Pisidium*, mainly *P. nitidum* (Fig. 18). The low species diversity almost certainly reflects the immediate location rather than the basin as a whole. Many more species are known from the Woodgrange (=Allerød, *sensu lato*) period in Ireland.

In the lower part of the sequence, *Pisidium* are relatively abundant in comparison with *Lymnaea peregra*, probably indicating a stable muddy substratum in the lower or eu-littoral. The presence of the cold-climate arctic form, *P. obtusale lapponicum*, is noteworthy. Higher up, both in the Woodgrange deposits and the early Holocene, the fauna is predominantly *L. peregra*. The reduction in *Pisidium* is possibly due to the formation of marl which clogged the filter-feeding apparatus of the organisms. The absence of a rich phytic fauna indicates a paucity of plant remains and a location away from the upper littoral. The absence of fauna in the Younger Dryas deposits may be as much due to lack of preservation as to a real absence at this time.

It should be borne in mind that to make a comprehensive study of the molluscan fauna of lake marls, it is necessary to analyze several cores across the basin to get a full picture. This was not possible in this instance.

The ostracod fauna within the cores is extremely rich, although of a low species diversity. Ostracod valve counts are based upon calculations made from the operation of a randomised sampling regime.

The ostracod fauna is predominantly composed of the bottom-dwelling species *Limnocythere sanctipatricii*, *Pseudocandona* cf. *marchica* and *Candona candida*, augmented by the phytic species, *Cyclocyris ovum* and *Herpetocypris reptans*. In addition, *Potamocypris villosa* is present in the Holocene sediments immediately above the Younger Dryas and *P. fallax* is recorded during the Woodgrange period. Throughout the sequence, the ratios of juvenile valves to those of adults indicate *in situ* preservation of benthic taxa, but suggest some small degree of sortage of phytic taxa.

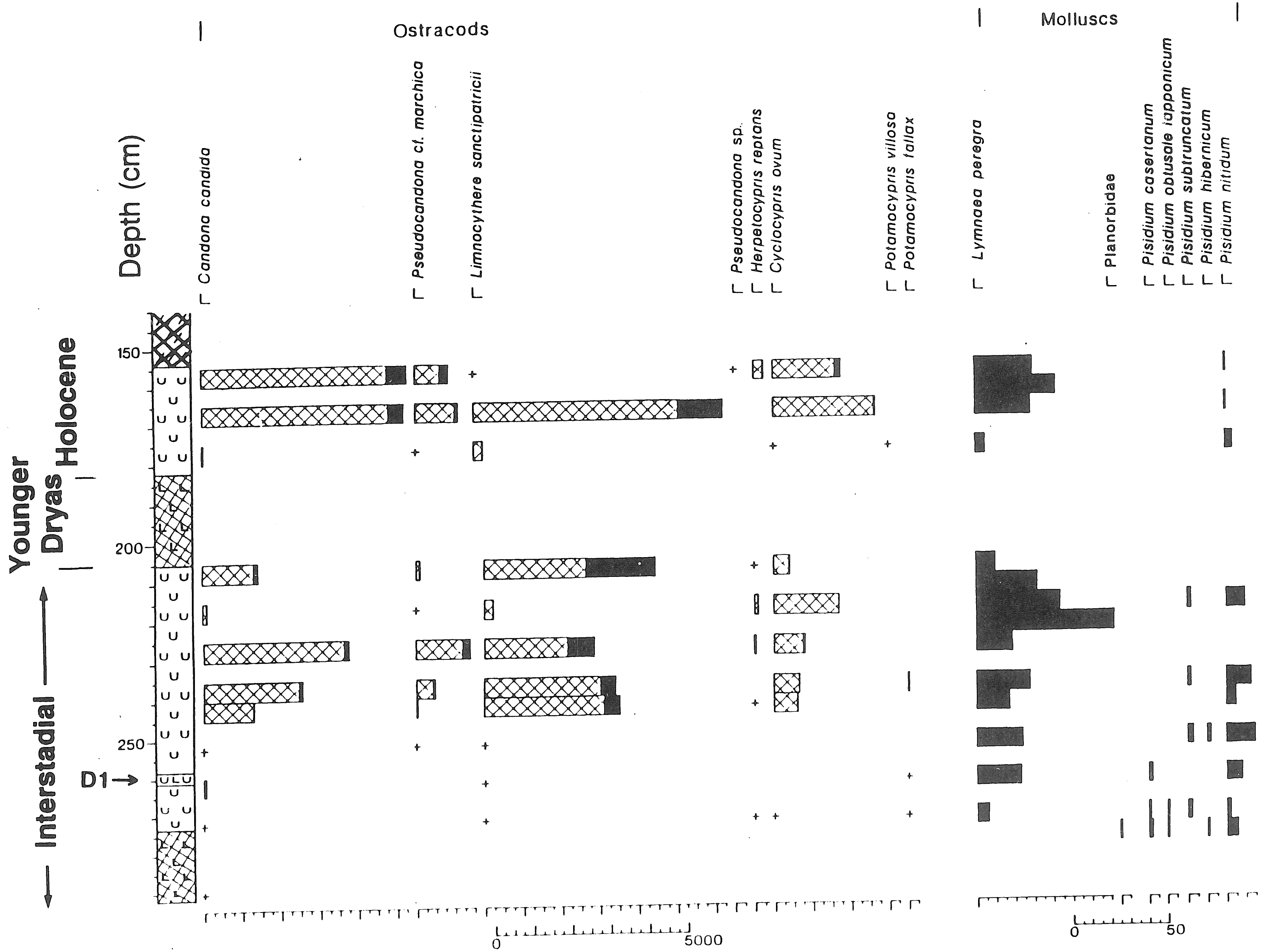


Fig. 18. Ostracod and mollusc counts (per c. 100 cm^3 of sediment), core LGA I(A), Lurga.

The benthic species are typical of the shallow eu-littoral of cool water-bodies. All species are present in Great Britain and Ireland today, with the possible exception of *P.* cf. *marchica*, which has a continental distribution. It is of interest that the faunal succession following the Younger Dryas is essentially identical to that of the Woodgrange period, however, as with the molluscs, ostracods are absent from the Younger Dryas deposits.

In September 1993 a 10-cm-diameter core was taken at the site. Further investigations of the late-glacial and early Holocene mollusc and ostracod fauna are at present being carried out on material from this core.

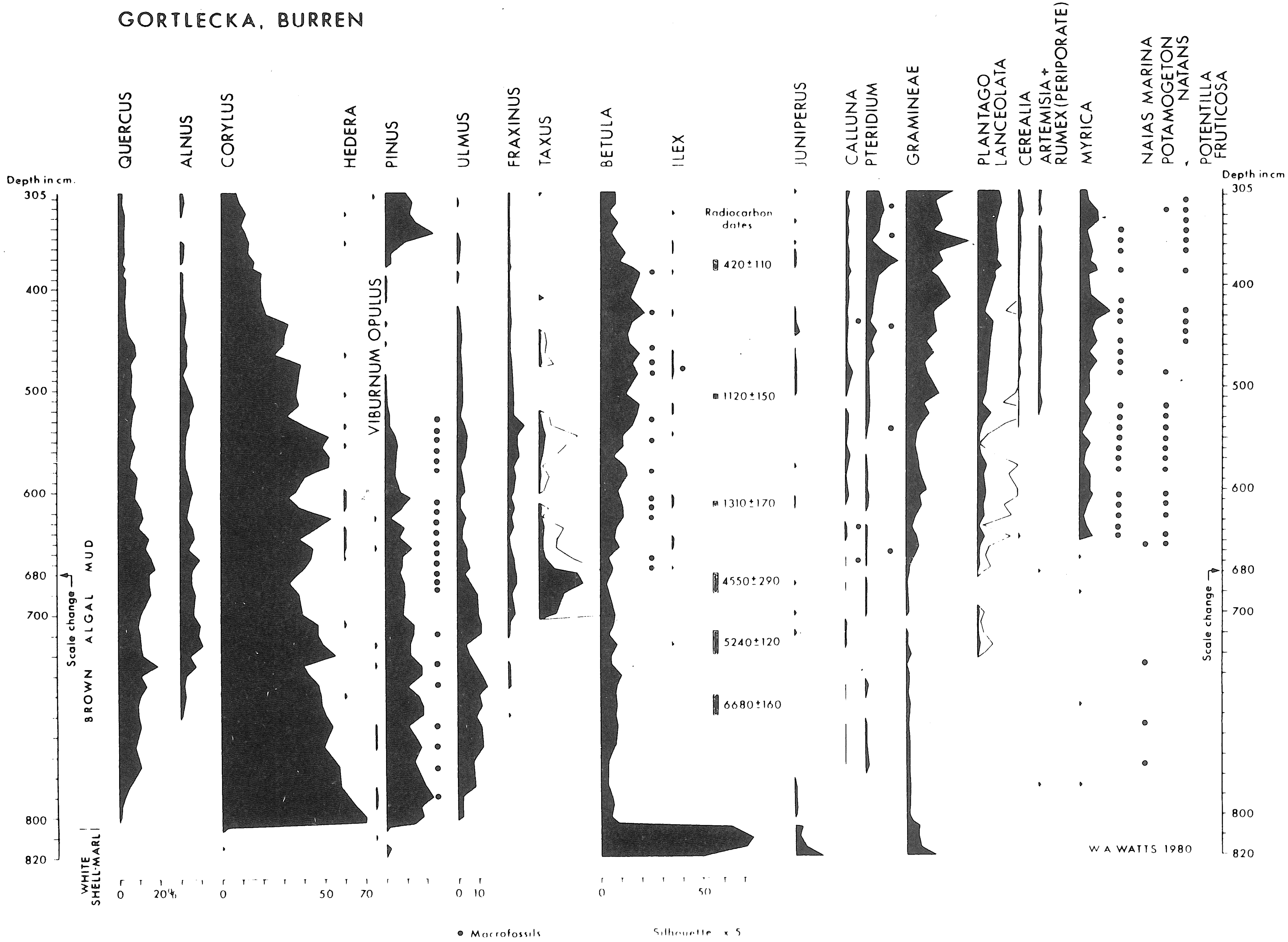
Holocene vegetation history at Mullagh More (Sites P2 and P3)

W.A. Watts

The Burren, especially the eastern lowland from Ennis to Galway Bay is relatively rich in late-glacial and earlier Holocene sediments. Difficulties arise in the study of the later Holocene where few peats or cutover bog do not provide satisfactory sediments for study. The difficulty was overcome at Gortlecka (grid ref. R 326 955) and Rinn na Móna (Loch na Brón in Robinson's (1977) map; grid ref. R 297 943), both near Mullagh More (Fig. 14), where small permanent lakes were cored from a raft to obtain younger records.

The pollen diagrams (Figs. 19 and 20) are rich in information and Gortlecka has sufficient radiocarbon dates to provide a satisfactory time scale. The main points to notice are the early abundance and disappearance of pine *(Pinus)*, the abundance of yew *(Taxus)* as pine declined at about 5000 B.P. when the elm *(Ulmus)* fall can be seen. Yew subsequently became rare. In the last thousand years grass (Gramineae), heather *(Calluna)* and bracken *(Pteridium)* record clearing of woodland or scrub for agriculture. It seems likely that the Burren has been forested throughout the Holocene, though rock outcrops, cliffs and boulders will always have provided habitat for artic-alpine and other herbs. Macrofossils were collected at Gortlecka. The presence of the submerged aquatic *Naias marina*, now extinct in Ireland and with only one remaining station in Britain, points to an earlier Holocene of warmer summers and cooler winters, relating to well-documented changing patterns of solar radiation. For further details and regional context see Watts (1984, 1985).

Fig. 19. Pollen diagram from Gortlecka, Mullagh More.



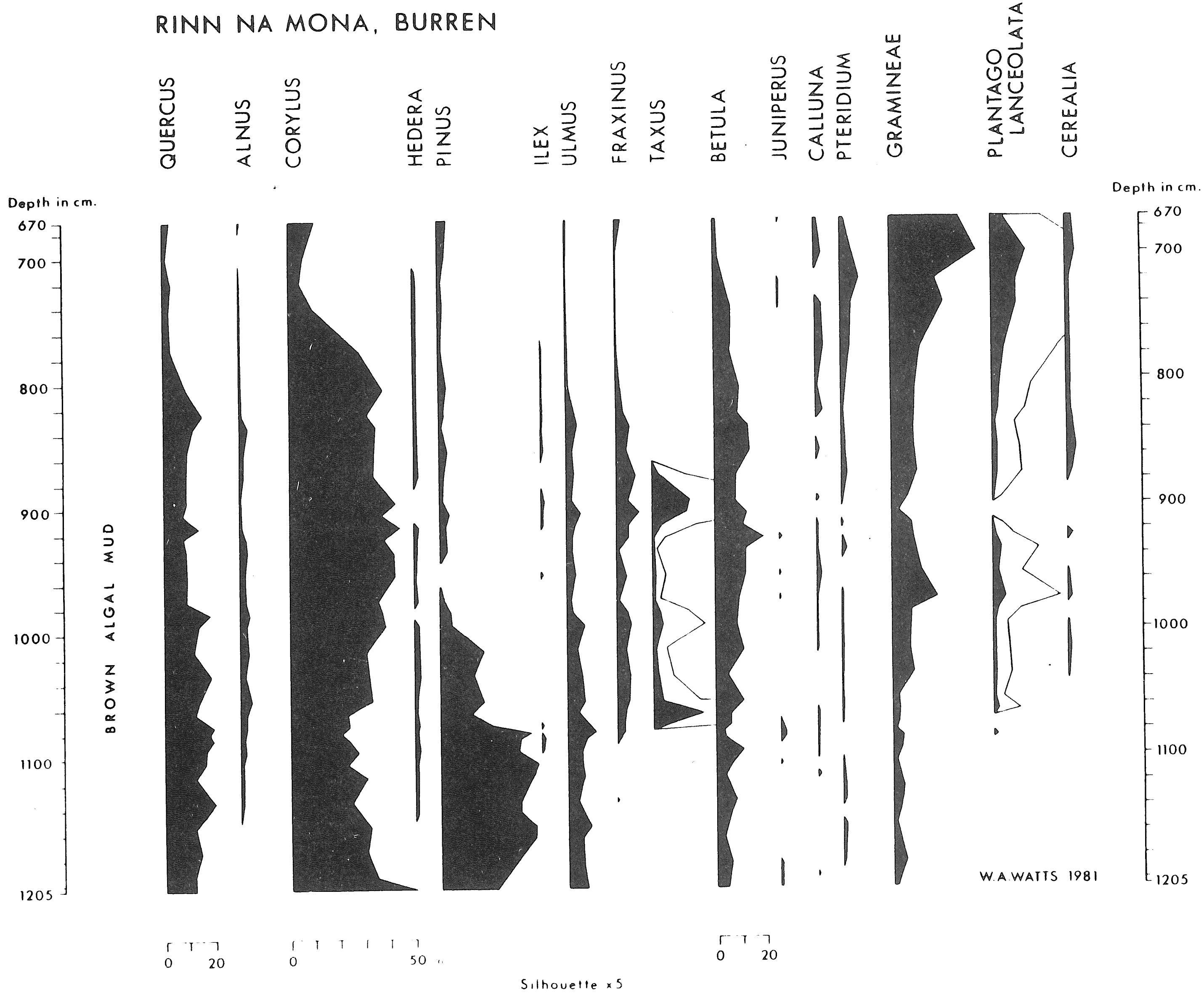


Fig. 20. Pollen diagram from Rinn na Móna, south-west of Mullagh More.

Lios Lairthín Mór (LLM II), N.W. Burren: history of vegetation and land use from 3200 B.P. to the present

M. O'Connell and Lj. Jeličić

Introduction

The peat body that lies to the east of Slieve Elva and west of Corkscrew Hill on a shale outlier has provided a record of vegetation and land use that extends from recent times to c. 3200 B.P., i.e. the later Bronze Age. The sampling site where core LLM II was taken consists of a hummock-like body of peat c. 50 m in diameter that lies immediately to the north of Lios Lairthín Mór ringfort at c. 270 m O.D. (9° 13'W 53° 5'N; grid ref. M 180 042; Fig. 21). For a more complete description of the investigations carried out at this site consult Jeličić (1991) and Jeličić and O'Connell (1992).

The extent of different soil types within 0-1 km, 1-2 km and 2-6 km radius bands of the sampling site, based on the soil map of Finch (1971), is presented in Table 5. The radii were chosen bearing in mind the distribution of the natural landscape units and possible pollen dispersal patterns in this wind-exposed landscape. Though soil erosion in a karstic landscape may produce substantial change over a relatively short time interval (cf. Drew 1983), the present soil distribution patterns are considered to provide the best available indication as to former edaphic conditions and hence to the potential natural vegetation and land use in the area represented by the pollen record. Noteworthy is the extent of rendzinas and the more or less complete absence of soils suitable for tillage in the vicinity of the site.

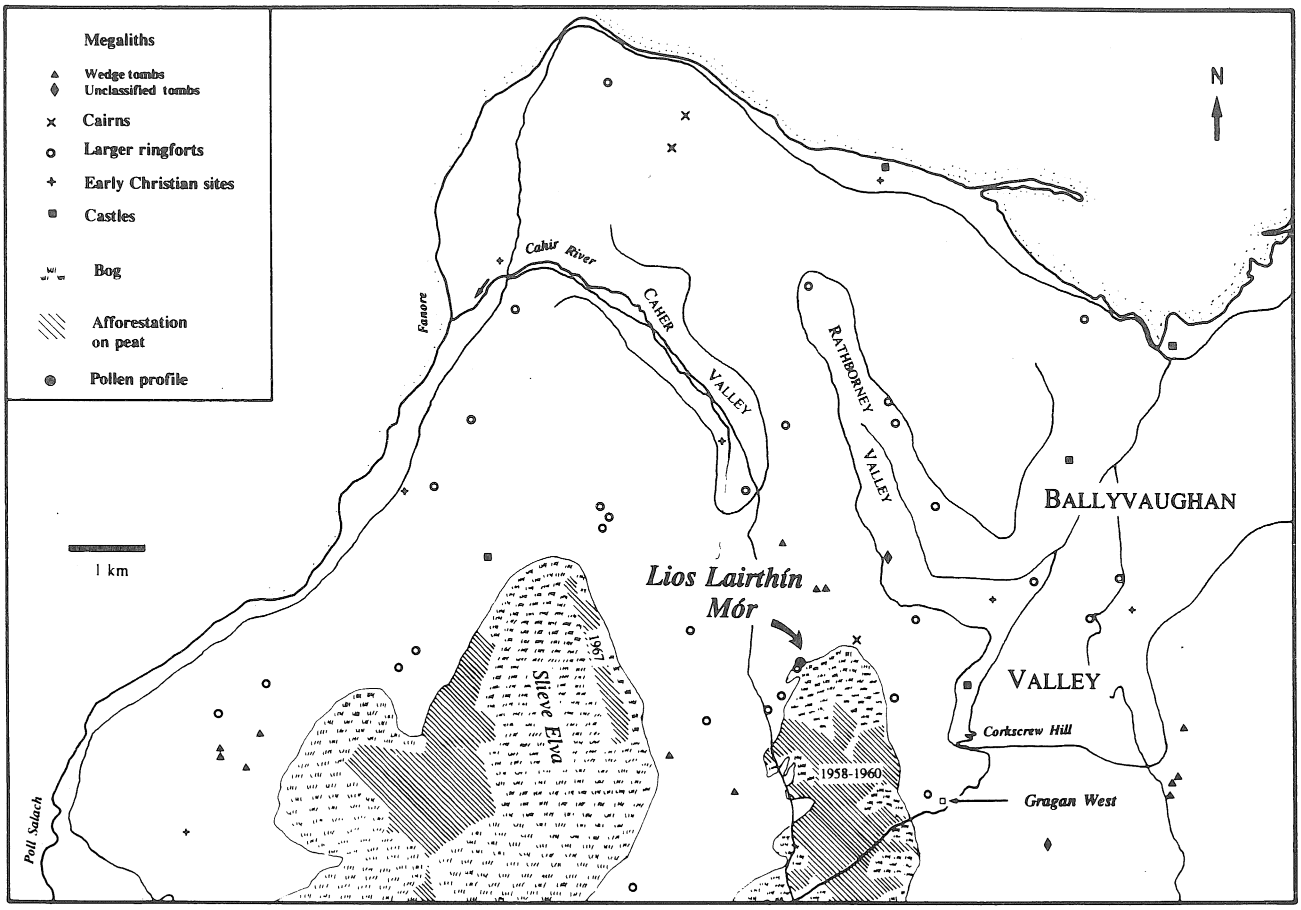


Fig. 21. Map of the north-west Burren showing the location of the pollen profile, Lios Lairthín Mór (LLM II), and landscape features including archaeological field monuments. The lines delineating the three valleys correspond approximately to the 150 m contour.

Table 5. Main soil types, expressed as percentages of total area, in three radius bands of the sampling site at Lios Lairthín Mór.

Radius band (km)	Peat	Burren rendzina	Kilcolgan rendzina	Brown earths	Podzols
0-1	35	65	-	-	-
1-2	16.4	80	-	-	2.6
2-6	14 + gleys: 10	59	6	7	4

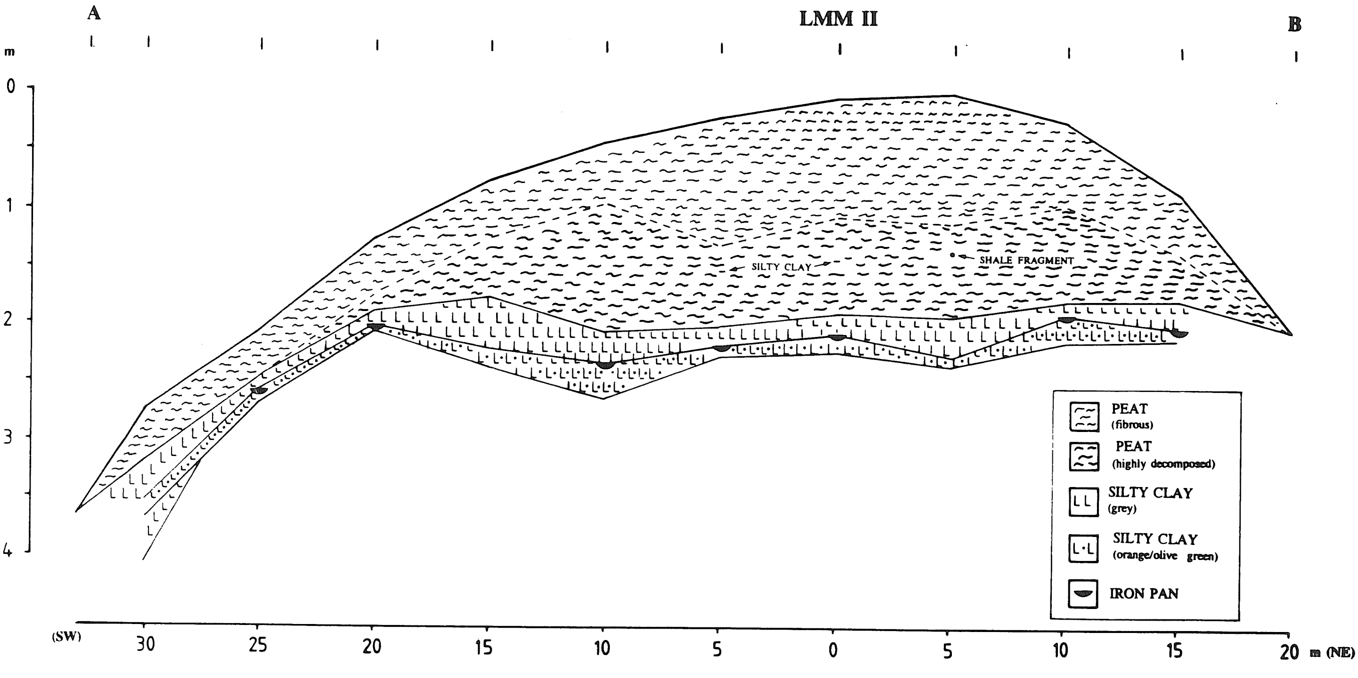


Fig. 22. Stratigraphy of the peat body where the core LLM II was taken. The end points are at sinkholes where the limestone bedrock is exposed.

Results

Stratigraphy

Results of stratigraphical investigations are presented in Fig. 22. Peat is underlain by silty clay, the total thickness of which was not ascertained because of difficulty of penetration with increasing depth. A well developed ironpan was recorded at most points. An orange to vivid orange silty clay with shale fragments in varying frequency is present beneath the ironpan. This is interpreted as the B_2 horizon.

A diffuse transitional zone of variable thickness separated the peat from the underlying silty clay. Near the centre of the sampling area, the lower peat was amorphous and highly decomposed while, in the upper peat, fibrous remains of *Eriophorum vaginatum* and *Sphagnum* leaves were common. Within the lower amorphous peat, *a silty clay layer, 3 mm thick, was recorded at 140 cm in LLM II,* and a similar layer, 5 mm thick, was noted at 132 cm in the core at 5m (SW).

Trial corings in the adjoining main area of blanket peat at c. 80 m to the north-east of the sampling site showed peat of over 1 m thickness overlying a silty clay deposit, the upper 15 cm of which was grey in colour and beneath which was a fine dark blue, apparently unweathered, silty clay. The lack of podzolization suggests that peat initiation began here much earlier than at the sampling site.

Chronology

A plot of age (^{14}C years B.P.) *versus* depth is given in Fig. 23. The three uppermost ^{14}C dates are too young (two uppermost dates are indistinguishable in age from present and are omitted) and are rejected in favour of a chronology based on pollen and historical evidence. On these criteria, the PAZ boundaries 5a/5b and 5b/6 are assigned dates of c. A.D. 1800 and 1900, respectively, and the boundaries 3/4 and 4/5a are assigned dates of c. A.D. 1650 and 1750, respectively, mainly on the basis of the likely peat accumulation patterns in this part of the profile and also on the pollen and historical evidence.

Macrofossil analysis

Macrofossil remains and sand particles noted in the residue from the samples prepared for pollen analytical have provided a good guide to local peat and karst development (Fig. 24). At 120 cm and below, *Juncus* seeds are recorded in considerable quantity in most samples with the notable exception of 3 of the 4 samples in PAZ 2. Above 116 cm, sand is no longer recorded. In the upper part of the profile, acidophilous taxa predominate, including *Eriophorum* cf. *vaginatum*, *Sphagnum* sect. *Acutifolia* (leaves and occasional branches with leaves), *Hypnum cupressiforme sensu lato* (*H.* cf. *jutlandicum*), *Pleurozium schreberi* and other pleurocarpous moss leaf fragments.

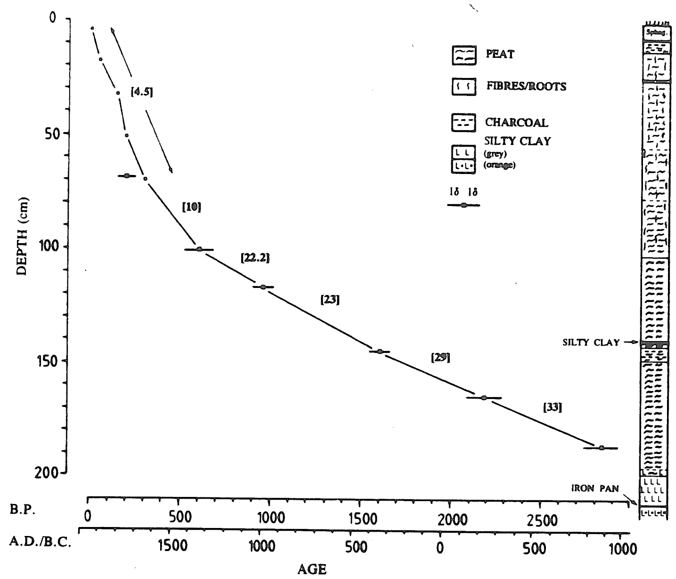


Fig. 23. Age-depth curve for profile LLM II (dates not calibrated). Values in square brackets are the estimated peat accumulation time over the particular segments in ^{14}C years per cm.

The significance of these findings are as follows:

1. The transport processes involved in the deposition of sand particles in the lower peat are not known but aeolian processes are unlikely. Transport by water may be involved, which, if true, would suggest that the sink holes around the periphery of the sampling site are karstic features that have developed in the last c. 1000 years (see below).
2. A decline in minerogenic influence appears to have taken place at the base of LLM II-2 (cf. peak in *Calluna* at 144 cm; *Juncus* not recorded for first time). In the upper part of this zone, sand is again recorded and a distinct silty clay layer is present at 140 cm. The sand consists of a mixture of calcite and quartz particles, presumably of local origin, the latter deriving from drift (cf. Farrington 1965). The precise significance of the silty clay layer, which appears to be confined to the central part of the peat body (Fig. 22), is difficult to ascertain. It is not tephra nor does it appear to be aeolian in origin. In the same level, *P. lanceolata* rises again sharply suggesting increased farming activity. It may be connected with the construction of the nearby ringfort, Lios Lairthín Mór. The silty clay was probably transported by water from the adjoining higher ground at a time when the present karstic drainage patterns had not yet developed. Unfortunately, there is no independent evidence to date the construction of the ringfort but construction or re-occupation at c. A.D. 440, i.e. the estimated age of the sample at 140 cm, is not unlikely.
3. In subzone LLM II-3c (c. A.D. 1200-1650), acidophilous vegetation becomes firmly established locally (cf. presence of *E. vaginatum* and *Sphagnum*). From 103 cm upwards, there is a decline in peat decomposition and the peat accumulation rate probably doubles. It is assumed that the present-day drainage patterns were now in place.

Lios Lairthín Mór, N.W. Burren (LLM II)

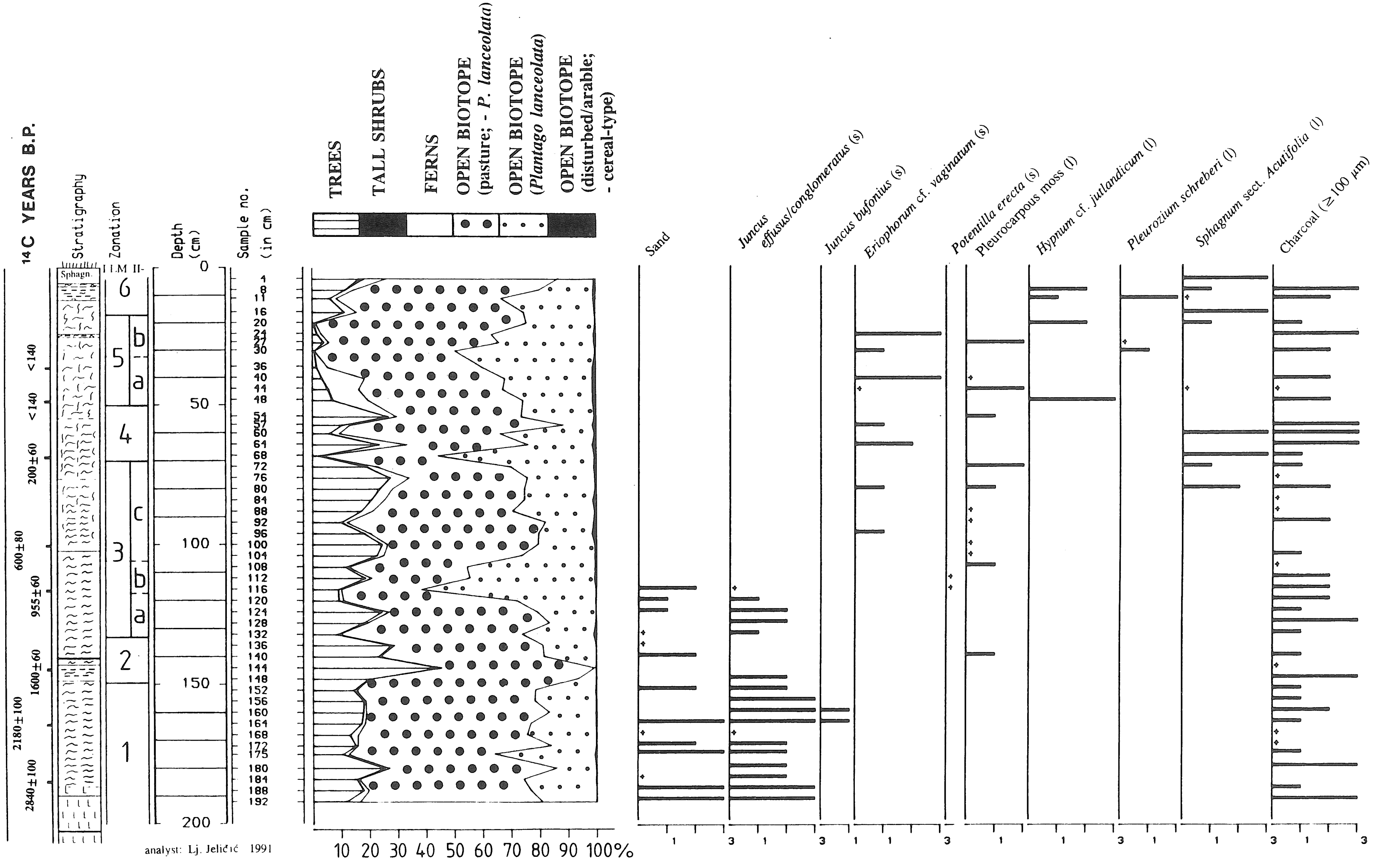


Fig. 24. Composite percentage pollen curves and results of analyses of the coarse fraction (> 100 μm) from the pollen samples, core LLM II, Lios Lairthín Mór. The horizontal scale is as follows: +: rare; 1: occasional; 2: frequent; 3: abundant; (s): seed/fruit; (l): leaves

Surface samples. Pollen spectra from LLM SS1 and LLM SS2 are presented in Fig. 25, together with a spectrum from within a *Helianthemum canum* community near Black Head (BH) (data from Proctor and Lambert 1961).

The main features of these results are as follows:

1. Arboreal pollen (AP) representation is low, partly the effect of the high Gramineae values reflecting local bog species such as *Molinia caerulea.* The high *Pinus* values, much in excess of *Corylus*, are noteworthy. The *Pinus* pollen is due largely to long distance transport while *Corylus* pollen production is probably adversely affected by strong winds.
2. In the herb component, *P. lanceolata* values are relatively high (maximum 8.7%) but fall far short of the values common in profile LLM II. In the surrounding pastures at Lios Lairthín Mór, *P. lanceolata* is not frequent. The species may be over-represented in the pollen record. Though *Dryas octopetala* is abundant in much of the region to the west and north-west of the sampling site (but not noted within c. 200 m of the site) its pollen is not recorded in any of the surface samples.

Pollen profile LLM II. The main conclusions that can be drawn from the fossil pollen record (c. 3200 to 0 B.P., i.e. 1250 B.C. (non-cal.) to A.D. 1950) regarding the vegetation history of the N.W. Burren are as follows (see Fig. 26):

1. *Corylus* (hazel) was the main woody species in the N.W. Burren and, apart from the later eighteenth and nineteenth centuries, when woody species were almost totally cleared, it constituted a more important element in the landscape than at present.
2. Small populations of *Quercus* (oak), *Fraxinus* (ash), *Betula* (birch), *Alnus* (alder) and possibly *Ulmus* (elm) were also present until at least the mid seventeenth century (base of LLM II-4).
3. Exceptionally high values of *P. lanceolata* (ribwort plantain; mostly in excess of 20% total terrestrial pollen) suggest intensive farming where the land-use practices which were particularly favourable to *P. lanceolata.* Values of *P. lanceolata* such as those recorded here are quite exceptional and suggest a vegetation cover in which ribwort plantain was the dominant species. As far as the authors are aware, present-day analogs of these *P. lanceolata*-rich plant communities do not exist nor, presumably, the land-use practices that gave rise to these communities.

Surface pollen spectra, N.W. Burren

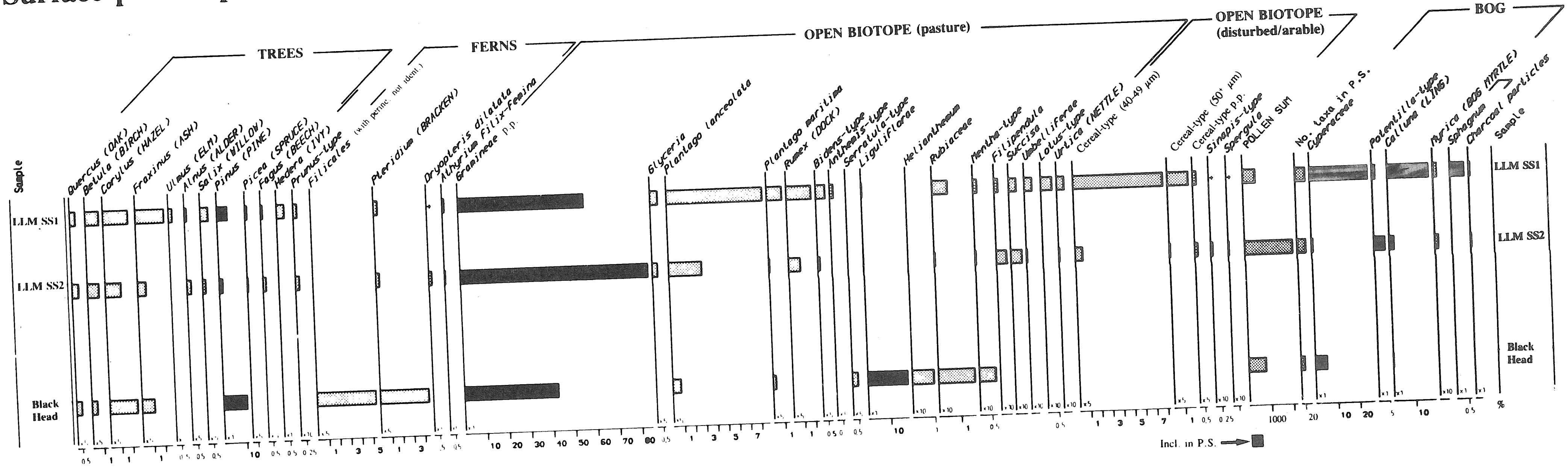


Fig. 25. Percentage pollen representation in surface samples from Lios Lairthín Mór (SS1 and SS2) and Black Head (BH). Where the horizontal scale is magnified, the histograms are stippled.

Other features worthy of note include:

1. *Zone LLM II-2: (A.D. 200-580).* A lull in activity is recorded here during which woody species and, in particular, hazel scrub regenerated. This event may be of regional significance in the Burren (cf. Jeličić and O'Connell 1992) and may be equated to the 'late Iron Age lull' identified by Mitchell (1965) in his Littleton Bog profile. If the regeneration is the result of a decline in human activity, as appears to be the case, it may be concluded that the present open aspect of the NW Burren is largely the result of farming activity rather than factors such as absence of soil cover or severe wind exposure.
2. *(i) Subzone LLM II-3a: (c. A.D. 580-1000).* A substantial decline in occurs in woody vegetation. Hazel scrub and other canopy trees now play a rôle similar to that at present. The *Taxus* and *Pinus* record more or less ceases, suggesting extinction of both yew and pine, possibly in the Burren generally, at about A.D. 600. The elm population is also greatly reduced. A recent archaeological excavation at Gragan West (Fig. 21) has yielded small amounts of charcoal of oak, willow/poplar, hazel, alder and possibly elm from an early Christian context (Cotter, pers. comm.). This supports the pollen evidence for a local presence of these trees and shrubs. Farming appears to be almost exclusively pastoral based.
(ii) Subzone LLM II-3b: (c. A.D. 1000-1200). P. lanceolata achieves the quite exceptional average value of 50%, *P. maritima* is in the range 1.5-3.5% and the *Artemisia* curve is initiated and continues more or less uninterrupted to the top of subzone 5a. A substantial increase in farming activity has taken place at probably both local and regional levels and, for the first time in this profile, arable farming has now assumed some importance, though probably in the region as a whole rather than locally (note: Corcomroe Abbey established 1194/5).
(iii) Subzone LLM II-3c: (c. A.D. 1200-1650). In the lower part of the subzone, arable farming is probably more important than at any time in this 3200 year record (cf. *Artemisia* and cereal-type curves). The scrub regeneration phase, admittedly minor, recorded at 100 (A.D. 1350) and 96 cm may be the result of adverse political developments such as the Bruce Invasion (1315-1318), and population declines caused by the Great European Famine of 1315-1317, the Black Death (1348-1350) and the succeeding epidemics (Barry 1988). A shift towards wetter conditions (cf. substantially higher Cyperaceae and increase in *Filipendula*), may also be involved.
In the mid/upper part of subzone LLM II-3c there is some evidence for a recovery in economic well-being. This may coincide with the construction of tower houses in the fifteenth or more probably in the sixteenth century (three in the Ballyvaughan valley alone, Fig. 21).
3. *LLM II-4: (c. A.D. 1650-1750).* The curves of *Fraxinus* and *Ulmus* cease and high peaks are recorded in *P. lanceolata* (55%) and Gramineae (68%). Tall canopy trees, such as ash and elm, have

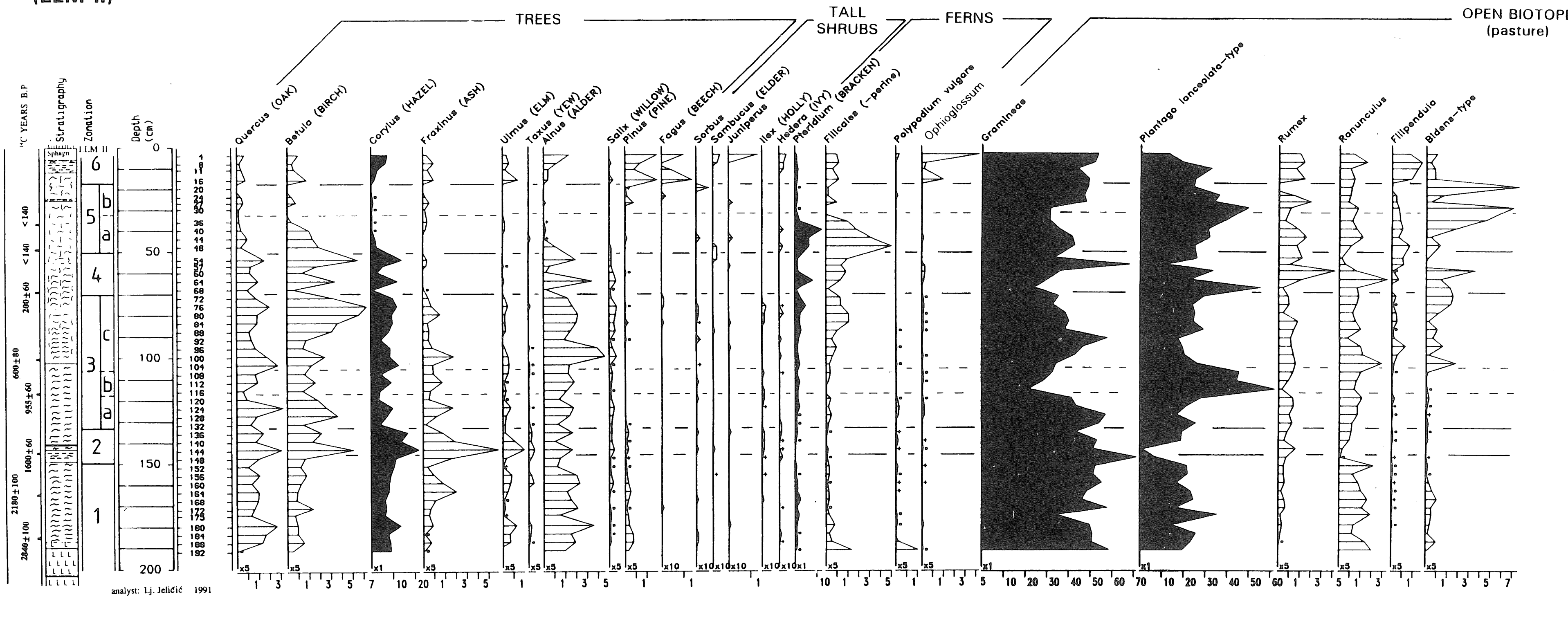
probably become extinct in the region and perhaps in the Burren generally. Changes in the upper part of the profile (cf. increased representation in Gramineae, *Filipendula* and Rubiaceae and *Rhinanthus*-type pollen) suggest increased importance of meadows as against permanent pasture.

4. *LLM II-5: (c. A.D. 1750-1900).* This zone is characterised by extremely low AP values (0 to 7% in subzone LLM II-5b). This reflects the more or less total clearance of hazel scrub and most woody species over large parts of the Burren and certainly within the north-west region. This is also attested to by cartographic, photographic and written evidence.
5. *LLM II-6: (post A.D. 1900).* Arboreal pollen curves and especially *Corylus* recover gradually in this PAZ. This reflects the regeneration of scrub, involving mainly hazel, and the planting of pine, beech and horse chestnut. There is a decline in *P. lanceolata* and a rise in *Filipendula* that may be in response to declining grazing pressure and perhaps also to the use of artificial fertilizer.
6. The record of the typical Burren species is abysmally poor. There are no records, for instance, for *Dryas octopetala* (some *Dryas* pollen may be included in the Rosaceae (undifferentiated) curve) nor *Geranium* (*G. robertianum* and *G. sanguineum* are present locally). Only a single pollen of *Gentiana verna* has been recorded (132 cm). Analysis of surface samples (see above) suggests that the more unusual elements of the Burren flora may be more or less completely silent in the pollen record. In view, however, of the strong palynological evidence for an open landscape, it is assumed that, like today, many of the typical Burren species formed a conspicuous element of the flora in the study region over most of the period represented in the profile.
7. The available archaeological record supports the pollen analytical evidence for intensive human activity in the north-west Burren during the period in question. It appears to be human activity, rather than wind exposure or edaphic factors, that was the main factor controlling scrub/woodland development and hence the extent of the Burren flora.

In Fig. 27 the pollen record from Lios Lairthín Mór area is compared with the later post-glacial records from sites in the Mullagh More area of the south-east Burren. While the south-east Burren was more wooded, with *Corylus* playing an important role for much of the later Holocene, it is also clear that similar overall trends can be seen in the records from there two areas (see Jeličić and O'Connell for full discussion). Investigations by W. Dörfler, at present in progress, will provide a more or less complete post-glacial regional pollen record for the north-west Burren.

Fig. 26. Percentage pollen diagram, profile LLM II, Lios Lairthín Mór. A small number of curves for minor taxa with infrequent records have been omitted (2 of 2 parts).

Lios Lairthín Mór, N.W. Burren (LLM II)



Lios Lairthín Mór, N.W. Burren (LLM II)

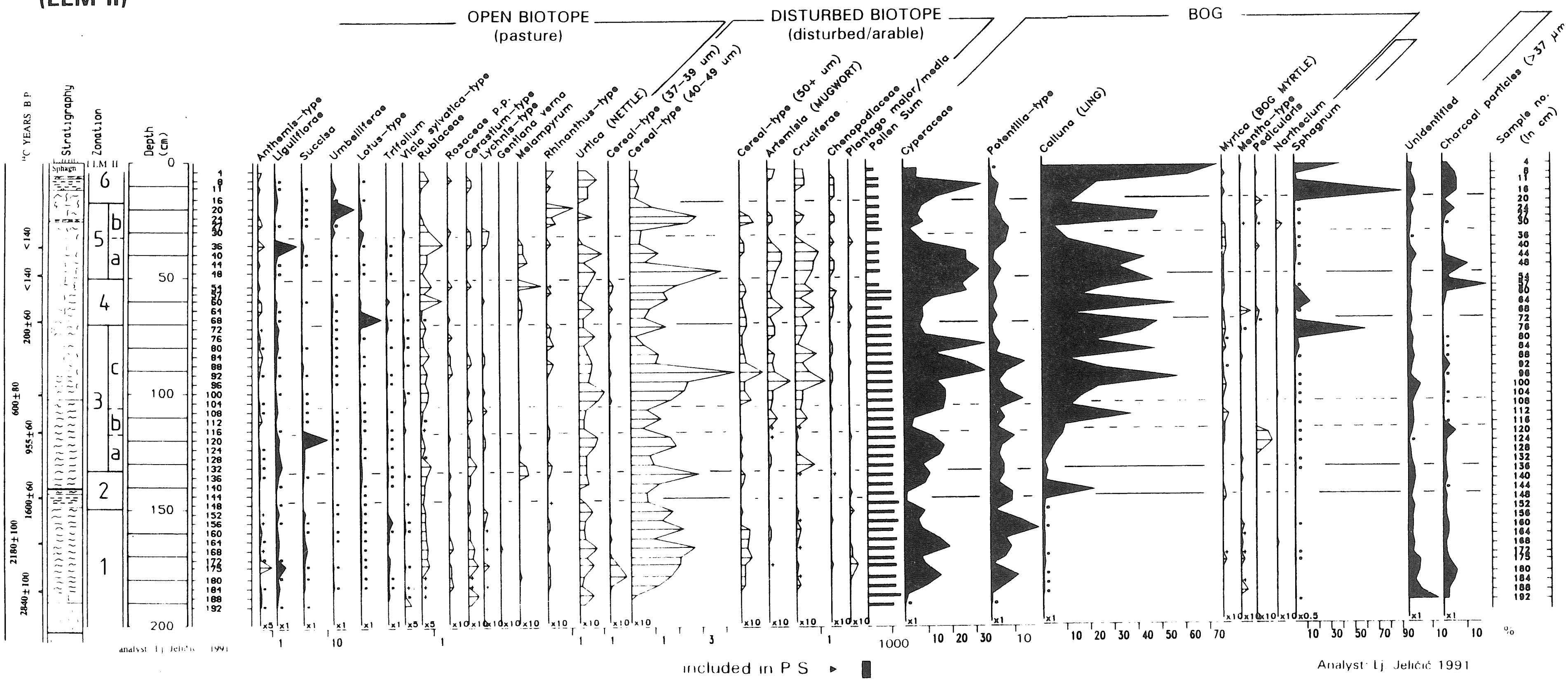
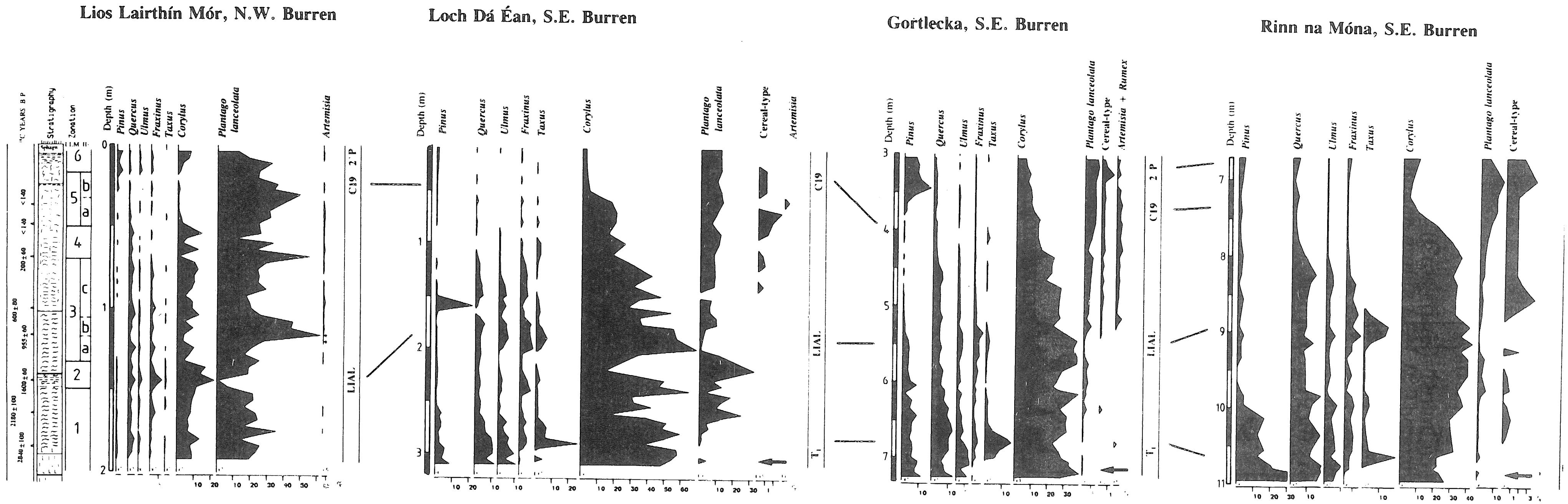


Fig. 26. Percentage pollen diagram, profile LLM II, Lios Lairthín Mór. A small number of curves for minor taxa with infrequent records have been omitted (1 of 2 parts)

Fig. 27. Selected curves from Lios Lairthín Mór (LLM II) and the upper part of profiles from the south-east Burren (Loch Dá Éan after Feighan (1985), and Gortlecka and Rinn na Móna after Watts (1984; see Figs. 19 and 20)). The position of the Elm Decline (c. 5100 B.P.) is indicated by an arrow and lines are used to show possible correlations between the various profiles. Abbreviations are as follows: T_1: first *Taxus* expansion; LIAL: late Iron Age lull (the 2nd post glacial expansion of *Taxus* is normally recorded here); C19: 19th century decline in *Corylus*, and 2°P: the secondary rise of *Pinus* due to plantations.



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