THE STRATIGRAPHIC POSITION AND AGE OF THE GORTIAN INTERGLACIAL DEPOSITS

W. P. WARREN

ABSTRACT

The Gortian Interglacial, first so called by Watts (1964), is problematic. Though it has been correlated on a palynological basis with the Holsteinian of western Europe and the Hoxnian of Britain and has been referred to a "penultimate interglacial" (Jessen and Farrington 1959), no evidence of a later interglacial has yet come to light in Ireland. It is suggested that the palynological basis of this correlation and the stratigraphic interpretation upon which it is partly based are questionable, and that an objective stratigraphic treatment of the relevant geological data must place the Gortian deposits in the last interglacial.

INTRODUCTION

G. F. Mitchell (1976) has referred to geologists who, spurred by the ever-increasing abundance of Gortian deposits, ask "Are you sure your so called Gortian deposits are not really younger, and perhaps of Ipswichian age?" (p. 54). As one of those who has frequently asked whether palynologists could be sure that the Gortian is not last interglacial (as distinct from drawing any correlation with the Ipswichian of Britain), and as I have, in discussion, over the past number of years, frequently had cause to advocate a strict stratigraphic approach to the question of Irish interglacials, I propose here to outline the position of the geologist who for years has accepted the palynologists' interpretation in good faith, but increasingly finds any attempt at stratigraphic correlation bedevilled by the question of the age and the stratigraphic position of the Gortian Interglacial.

The interglacial site at Gort was discovered by G. H. Kinahan (1865). It was subsequently rediscovered by A. Farrington and analysed by Jessen, Anderson and Farrington (1959). In the meantime other interglacial deposits have been discovered and reported upon. These occur at Kilbeg and Newtown, Co. Waterford (Watts 1959), Baggotstown (Watts 1964) and Kildromin (Watts 1967) in Co. Limerick, Ardcavan (Mitchell 1948) and Shortalstown (Colhoun and Mitchell 1971) in Co. Wexford, Fenit in Co. Kerry (Mitchell 1970) and Benburb in Co. Tyrone (Boulter and Mitchell 1977). Of these the Ardcavan deposit, first thought to be a post-Gortian interglacial deposit, was subsequently discovered to be a postglacial deposit (Mitchell 1972), the deposit at Shortalstown which is very much incomplete and probably not *in situ*, is thought to be a post-Gortian remnant (Colhoun and Mitchell 1971, Mitchell 1976), the deposits at Fenit and Newtown may be interstadial (Watts 1967) and the Benburb deposit has not yet been fully analysed. In addition,

an upper organic bed lying 3.8 m above the main Baggotstown interglacial deposit was suggested by Mitchell (1976) to belong to a later interglacial.

THE INTERGLACIAL DEPOSITS AT GORT

The Gortian type site is exposed in a stream section at Boleyneendorrish, 9 km north-east of Gort, Co. Galway. The interglacial deposit is a polleniferous lacustrine mud-with-sand overlying a thin layer of hillwash resting on Devonian sandstone. It is overlain by up to 8 m of till, which Farrington (in Jessen *et al.* 1959) subdivided into two litho-facies. Palynologically, the deposit clearly indicates the passage of an interglacial period. It began with a "Herb – *Salix* – *Betula nana* zone" (Watts 1967, p. 345) and developed a climax phase indicated by a *Quercus* maximum – Zone G5, the *Pinus-Quercus* Zone of Watts (1967) and the IGWC Phase of Mitchell (1976). The deposit at Gort terminates below the level at which a late-interglacial flora may subsequently have developed, but the overlying till may be regarded as evidence that the interglacial came to a close.

Two methods were used by Jessen *et al.* (1959) to identify the interglacial represented by this deposit, litho-stratigraphic interpretation and bio-stratigraphic (palynological) correlation. The two methods were not, however, applied independently of one another; each was used to bolster the other, rather than as separate, corroborating evidence.

STRATIGRAPHY

The litho-stratigraphic interpretation was based (a) on Farrington's (in Jessen *et al.* 1959) examination of the site, and (b) on a comparison with the stratigraphic position of the interglacial deposit at Kilbeg, Co. Waterford. At Gort, Farrington (in Jessen *et al.* 1959) attributed the two till litho-facies that overlie the organic deposits to two separate glaciations on the basis of their differing lithologies; he associated an inferred north-west–south-east ice movement with a Riss-equivalent (Munster General, now Munsterian) glaciation and north-east–south-west movement with a later Wurm-equivalent (Midland General, now Midlandian) glaciation. These were associated with the lower and upper till facies respectively. Thus it was concluded that the interglacial deposit must be older than "Last Interglacial or Riss-Wurm" (Jessen *et al.* 1959, p. 68).

The Kilbeg interglacial deposit (Watts 1959) is very similar to that at Gort. It has a dominant *Pinus-Alnus* presence, a weak mixed oak forest development and a very distinct *Picea, Abies, Taxus, Buxus, Rhododendron* assemblage. It is overlain by 5 m of non-calcareous till and directly underlain by solid rock. The penultimate interglacial age of the Kilbeg deposits as determined by Mitchell (1948, 1953) was offered by Jessen *et al.* (1959) as corroborating stratigraphic evidence of an older age for the Gort deposits. Mitchell (1948) based his Mindel/Riss age for the Kilbeg

deposit on the occurrence of an interglacial deposit of presumed last interglacial age, at Ardcavan, which overlay the till that was thought to cover the Kilbeg interglacial deposit. However, Mitchell (1972) has since determined that the Ardcavan deposit is a slumped post-glacial deposit, thus removing the stratigraphic basis for the older age of the Kilbeg deposit. Watts (1959) also regarded the Kilbeg deposit as of penultimate interglacial age and discounted a last interglacial age on the grounds that "Kilbeg lies well to the south of the end-moraine of the Weichsel glaciation which runs across south-central Ireland. It is covered by a boulderclay." (Watts 1959, p. 123). Ultimately, the Ardcavan deposit (Mitchell 1948) must have been the basis of this interpretation, for there was no other evidence whatever of an interglacial period post-dating the Kilbeg deposit.

Thus, in so far as the type site is concerned, the stratigraphic position of the Gortian rests on two assumptions for which there is no stratigraphic evidence whatever; (1) that the two till facies overlying the interglacial deposit at Gort represent two separate glaciations, and (2) that the South of Ireland End Moraine is the end-moraine of the last glaciation.

PALYNOLOGY

The palynological basis upon which Jessen *et al.* (1959) attributed the deposits at Gort to the penultimate interglacial was not entirely one of positive correlation, rather, it was largely a result of a series of negative correlations with pollen diagrams of other interglacial periods. A positive correlation with the last interglacial deposit at Histon Road, Cambridge (Ipswichian) as described by Walker (1953) was ruled out on account of the discrepancy between the mode of occurrence and relative amounts of *Carpinus, Corylus, Picea* and *Abies* pollen in each. The abundance of *Carpinus* and *Corylus* remains in the lower part of the deposit at Histon Road was set against low *Corylus* values and almost non-existent *Carpinus* at Gort. The later dominance of *Pinus* and low *Quercus, Picea* and *Abies* values at Histon Road was mentioned. But *Pinus* in the composite Ipswichian pollen diagram (Turner 1970) is strong and, although *Abies* is absent from the Ipswichian diagram, the levels of *Picea* and *Quercus* are not totally at variance with those at Gort. With regard to these taxa there is as much accord as discord between the Gortian and the Ipswichian (cf. Walker 1953, Jessen *et al.* 1959, Godwin 1975). The important points of dissimilarity were expressed as between Gort and ". . . most continental pollen diagrams of Eemian age." (Jessen *et al.* 1959, p. 52) rather than between Gort and the British interglacial site. These are the high frequency of *Carpinus* and *Corylus* (in their lower parts) and the late appearance of *Picea* and *Abies* in the continental pollen diagrams of Eemian age. Jessen and Milthers (1928), Vlerk and Florschultz (1953), Woldsted (1947) and Selle (1953) were referenced. It should be noted, the other discrepancies notwithstanding, that *Picea* enters the Ipswichian pollen diagram as

early as the base of Zone II (West 1968). It should also be noted that there is some question as to whether the disparate elements which go to make up the Ipswichian palaeontological sequence can logically fit into one interglacial (Sutcliff and Kowalski 1976). There is also doubt as to other aspects of the British Quaternary Stratigraphic succession, particularly the existence of a Wolstonian litho-stratigraphic unit and the age of the Hoxnian Interglacial deposits (Bristow and Cox 1973). In this review reference to the established British Quaternary climate units (Mitchell *et al.* 1973) is made only in the context of an outline of the evolution of the established Irish succession, which is also in many respects without stratigraphic foundation and is therefore largely meaningless.

The deposit at Gort was thought not to be older than the Hoxnian in England, for, while *Abies* is common at both Hoxne and Clacton it was said to be absent from all known deposits of the earlier (Cromerian) interglacial and Jessen *et al.* (1959, pp 53-54) thought "Its *(Abies)* absence from England, however, is incompatible with an immigration to Ireland". However, it has since been established that *Abies* occurs at at least six Cromerian sites (Duigan 1963).

The final correlation with the deposits at Hoxne and Clacton was based on factors in common with these sites and with European sites also correlated with Hoxne (West 1956). These are listed as: "(1) general dominance of *Pinus* and *Alnus*, (2) an early appearance of *Picea*, (3) a slow rise of *Corylus*, (4) a period with high values of *Abies*." by Jessen *et al.* (1959, p. 53) who go on to point out: "The Hoxne diagrams, however, contain more *Quercus, Ulmus* and *Corylus* than found at Gort".

There are further discrepancies between the pollen diagrams from Gort and Hoxne which were not specifically outlined by Jessen *et al.* (1959) and there are some points of similarity between those from Gort and Ipswich which have not been considered. These, as they apply to the site at Gort only, are outlined below.

(1) The extreme oceanic ericaceous (particularly *Rhododendron)* assemblage which typifies the upper part of the Gortian diagram has no equivalent at Hoxne.
(2) *Pinus* is much more dominant at Gort than Hoxne. This is a corollary of the low level of mixed oak forest development at Gort.
(3) Strong *Pinus* presence along with low *Quercus* levels are strongly characteristic of both the Gortian and Ipswichian deposits.
(4) Whereas it is true that there is a distinct discrepancy between the *Carpinus* levels at Ipswich (50% – 70% of the arboreal pollen according to Walker 1953) and the level attained by this pollen at Gort (0.1% – 0.2% of the land pollen), this discrepancy occurs also between Gort and Hoxne where *Carpinus* reaches a level of 10% of the land pollen. The very low percentage of *Carpinus* in the deposit at Gort suggests that it may have been wind transported.

CONCLUSION

The non-occurrence of *Carpinus*, or its occurrence in very small quantities at Gort is not indicative of either interglacial, and, as *Picea* enters the Ipswichian

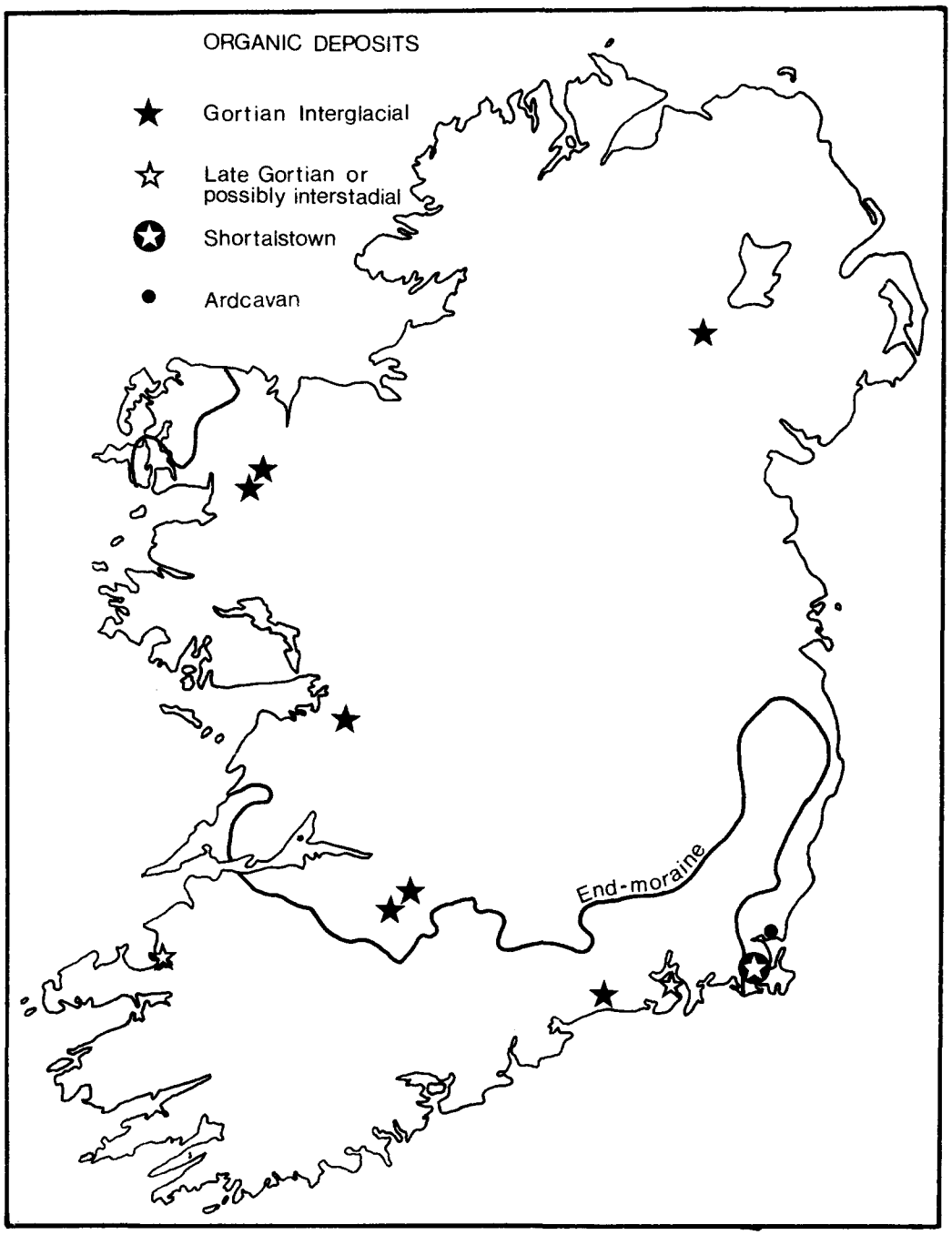

Figure 1. Location of sites referred to in the text.

diagram as early as lower zone II, the correlation between the deposit at Gort and that at Hoxne must now rest on the occurrence of *Abies* pollen in large quantities in each. Jessen *et al.* (1959) were obviously somewhat uneasy as to the validity of their correlation when they remarked (p. 53) "The pollen diagram from Gort is certainly influenced by its extreme western location, but this fact cannot quite explain the differences from the English pollen diagrams". Further, stratigraphically, at Gort there is no reliable evidence that the interglacial deposit is not last interglacial in age. Objectively, there is no reason why the two overlying tills, albeit indicating different ice-flow directions should not have been deposited in a single glaciation.

OTHER GORTIAN SITES

The deposit at Kilbeg, Co. Waterford, has been described above and is clearly Gortian. Other clear Gortian sites have been described at Baggotstown, Co. Limerick (Watts 1964) and at Kildromin, Co. Limerick (Watts 1967). Both of these deposits display all of the Gortian characteristics outlined by Jessen *et al.* (1959) *(vide supra).* They both lie within the South of Ireland End Moraine and are overlain by a till, while a stony clay including erratics underlies the Kildromin deposit and may be a till. At Baggotstown a thin (30mm) layer of organic mud lies above the level of the main interglacial deposit. It is sandwiched between two identical till units neither of which shows any evidence of weathering or soil development. This mud contains pollen of an interglacial character, 50% *Alnus,* 15% *Pinus* and smaller percentages of *Quercus, Corylus, Ilex, Taxus* and *Juniperus,* but contains no *Abies* or *Betula.* Very recently another interglacial deposit has been discovered at Benburb, Co. Tyrone (Boulter and Mitchell 1977), preliminary examinations of which reveal, *inter alia, Taxus* 29%, *Pinus* 16%, *Picea* 16%, *Abies* 11%, *Ericaceae* 11% and *Alnus* 5%, which seem to indicate that it is a Gortian deposit. Deposits at Newtown, Co. Waterford (Watts 1959) and Fenit, Co. Kerry were described as interglacial deposits (Mitchell 1970), but there is some doubt as to the status of the climate unit that they represent (Watts 1967). There are at least three other localities at which Gortian deposits have been identified but none of these have yet been fully examined. They occur at Burren (Watts 1970, Godwin 1975) and Derrynadivva (Synge 1977b) Co. Mayo and Ballykeerogue More, Co. Wexford (Watts 1970).

The two Co. Limerick deposits (Kildromin and Baggotstown) assume an added importance in that they have been used, along with the type site at Gort and the Kilbeg deposit as the basis upon which a complete Gortian pollen sequence has been attempted by Watts (1967) who proposed a subdivision of the Gortian Interglacial into six zones.

It is striking that at each of the four well preserved sites the interglacial deposits are truncated at the level at which an extreme oceanic post-climax vegetation is indicated. This is Zone G6, the *Taxus – Abies – Rhododendron* zone, of Watts (1967). There is no indication at any of these sites of a gradual cooling towards the end of the interglacial such as Mitchell's (1976 p. 39) interglacial model would

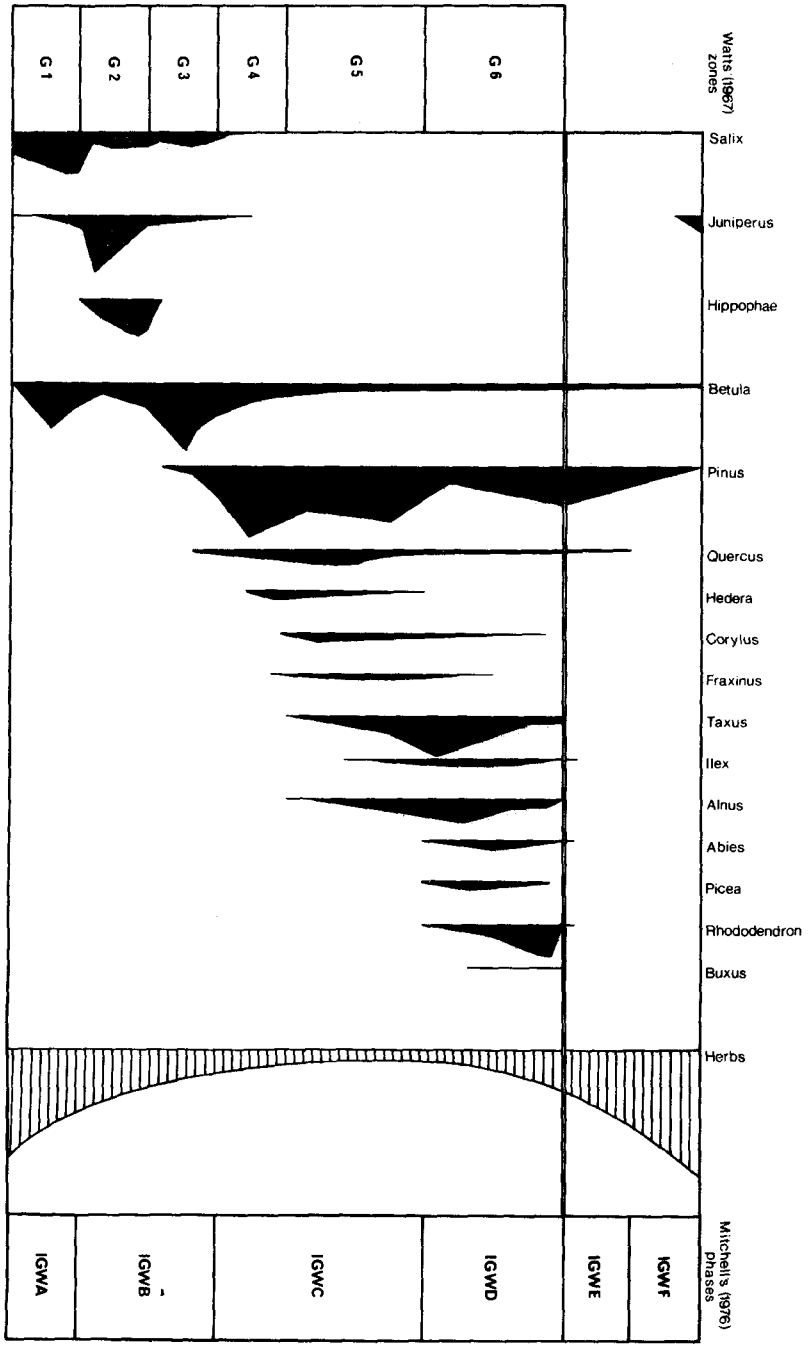

Figure 2. A schematic pollen diagram for the Gortian Interglacial, showing its subdivisions according to Watts (1967) and Mitchell (1976).

suggest. Watts (1967), having considered the evidence of later organic deposits at Newtown, Kilbeg, Fenit and Baggotstown perferred to allow the interglacial pollen diagram remain truncated in Zone G6 rather than terminate it with reference to the diagrams for these sites, which may indicate either late interglacial or interstadial conditions, for in no case is a conformable transition from Zone G6 to a later zone seen, and at two sites (Fenit and Newtown, which he allows may be either interglacial or interstadial) the *Pinus* dominated deposits exist in total isolation as organic deposits. Mitchell (1976) proposed a somewhat more contracted zonation system for the Gortian using a different notation system. He too identified six subdivisions, but his Ebbing-phase (IGWE) and Finished-phase (IGWF) are both based on the upper organic stratum at Kilbeg, which overlies unconformably the main interglacial deposit. The two zonation systems are illustrated in Figure 2.

The stratigraphic position of the deposits at Baggotstown, Kildromin and Benburb is revealing in that they all lie within the supposed end-moraine of the last glaciation, and, the upper deposit at Baggotstown notwithstanding, there is no evidence of more than one post-Gortian glaciation at each site. Stratigraphically, therefore, at three localities the deposits of the Gortian interglacial are directly, albeit, of necessity, unconformably overlain by a till of undisputed last glaciation age. And, although the interglacial deposit at Gort is overlain by two tills, there is no reason why they should not have been deposited during a single glaciation.

Though the Gortian has been assumed to be a Hoxnian equivalent since Jessen *et al.* (1959) and Watts (1959) arrived at this conclusion, Watts (1970 p. 28) has redefined the basis of the correlation as follows: "The Gortian resembles the Hoxnian in several important respects, (1) the abundance of *Hippophae* (sea-buckthorn) in the protocratic stage, (2) the association of abundant *Taxus* (yew) *Alnus* (alder), *Abies* (silver fir) and sparse *Picea* (spruce) in the telocratic stage; *Rhododendron ponticum* (rhododendron) is common at this stage in Ireland but is not recorded in Britain, (3) the presence of *Azolla filiculoides* at several sites." Jessen *et al.* (1959), however, specifically disregarded the *Hippophae* element as being indicative of any one interglacial. And the use of *Azolla* as a key assumes a coincidence of extinction in Britain and Ireland and therefore begs the question of a correlation. The only potentially reliable basis for comparison is one between the distinctive telocratic assemblages. There is a corresponding *Taxus* presence and high *Abies* content, but although they share common *Alnus* and *Picea* these taxa are also common in the equivalent phase of the Ipswichian and moreover the very distinctive ericaceous assemblage of the Gortian telocratic phase has no comparison in the Hoxnian. In effect the correlation between the Gortian and the Hoxnian rests on their common *Abies* and *Taxus*. It bears mention that the so called Tertiary relic *Pterocarya* which is common to many Continental Holsteinian and British Hoxnian sites (Turner 1975) does not occur in any known Gortian deposit. The occurrence of *Pterocarya* in Zone III was regarded by Turner (1975, p. 212) as: "One of the most important features for correlation of the Holstenian interglacial period across Europe . . .". It is also important to note that *Azolla filiculoides* occurs in the post-

Holsteinian, Domnitz Interglacial (Erd 1970), so that there is no reason to suppose its extinction in Europe was synchronous.

SHORTALSTOWN AND ASSOCIATED (?) DEPOSITS

A disturbed interglacial estuarine deposit at Shortalstown (Colhoun and Mitchell 1971) was thought to be a post-Gortian interglacial deposit. It contains high percentages of *Betula, Pinus, Ulmus* and *Quercus* with smaller amounts of *Hedera, Alnus, Corylus* and *Picea* and probably represents the climax phase of an interglacial. It was ascribed a post-Gortian Interglacial age on account of its relatively high *Ulmus* content (up to 7%) and was correlated with Zone e (Jessen and Milthers 1928) or early Zone II (West 1968) of the British Ipswichian Interglacial. According to Colhoun and Mitchell (1971, p. 224) and Mitchell (1976, p. 55) "Pollen of *Ulmus* is almost unknown from Gortian deposits . . .", yet *Ulmus*, though in much smaller amounts, occurs in all of the fully reported and clear Gortian sites – at Gort, Kilbeg, Baggotstown and Kildromin. Furthermore, the Shortalstown pollen diagram correlates probably as well with the early part of the Hoxian, e.g. Zone Ho II a of Turner (1970) which also contains considerable amounts of *Ulmus*. The correlation with the Ipswichian, therefore, must rest on the assumptions that the Gortian equates with the Hoxnian and that the east coast Gortian flora cannot have had Hoxnian elements that are rarer in the Gortian deposits elsewhere.

Mitchell (1976) also suggested that the upper polleniferous mud at Baggotstown, which is separated from the main interglacial deposit by 3.8 m of till, represents a post-Gortian interglacial. His suggestion is based on the assertion that the upper deposit is unlikely to be a disturbed layer of the lower one "because the pollen count it represents cannot be matched in the lower phase" (Mitchell 1976, p. 55). Watts (1964), however, stated that this thin organic strip is not distinctive of any particular interglacial period, and, though he considered the possibility that it might be Eemian, he remarked on its proximity to the surface (1.35 m) and on the similarity between the tills on either side of it. A number of other points should be added with regard to this deposit. (1) Watts (1964) remarked on the poor state of preservation of its contained pollen. (2) Owing to the method of sampling (see Watts 1964) there is considerable uncertainty as to both the interval and the sequence of sampling of the lower deposit and only the broadest comparisons can be made between this deposit and any other. (3) It is impossible to tell whether the upper deposit is in its primary position or not, but the indications (its stratigraphic position in relation to the tills and the lack of a pre-climax vegetation in the pollen-bearing muds which are separated from the lower till by a thin smear of sterile mud) are that the pollen is probably redeposited. (4) With point 2 in mind, the simplest interpretation is that the upper deposit is a redeposited fragment of the lower. It would fit in the lower part of stratum G (Watts 1964), or somewhere between F and G where *Alnus* is strong but *Abies, Pices* and *Rhododendron* are still weak, as is *Betula*.

The only conclusion that can validly be drawn in relation to these two deposits is that they represent fragments of interglacial sequences which, owing to their lack of context, cannot be identified.

OTHER EVIDENCE OF INTERGLACIAL CONDITIONS

The only other stratigraphic evidence suggestive of interglacial conditions are the raised beaches that are frequently seen to underlie glacial tills, particularly along the southern coast line, and the occasional exposure of weathered till underlying fresher deposits, but as no true palaeosols have been identified in such tills they will not be discussed here. To-date only one beach level has been recognised, although the platform on which it is usually seen to lie displays two levels of marine erosion (Farrington 1966). The beach is the Courtmacsherry Raised Beach of Wright and Muff (1904) and the 6 – 8m raised beach of Synge (1977), and, because of its stratigraphic position immediately below the uppermost glacial deposits, which provide evidence of no more than one glaciation, it is regarded by Bowen (1973) as a deposit of the last interglacial. Bowen (1977) suggests an Ipswichian (last interglacial) age on the basis of a biostratigraphic correlation of mammilian assemblages in Gower (South Wales) and Ilford with Thames Valley. Synge (1977a) has suggested a late Midlandian date, while Mitchell (1972) regards it as belonging to the penultimate interglacial and as coeval with the Gortian deposits. Mitchell (1972, 1976) suggests that there is possible evidence for a later beach at Cahore, Co. Wexford.

The Courtmacsherry Raised Beach invariably is seen to underlie deposits of cold climate conditions, and, whereas Orme (1966) and Synge (1977a) suggest that it was deposited, in part at least, under periglacial conditions, there is no conclusive evidence of this in the sediments themselves. Classically, on the south coast the beach assumes a stratigraphic position below, in turn, an autochthonous head and a till, as, for instance, at Whiting Bay (Wright and Muff 1904). And, occasionally, an upper head is seen resting on the till unit, as at Ballycotton Bay (Wright and Muff 1904). The upper head is rarely more than 1m thick. At its type-site the stratigraphic sequence is as follows (Wright and Muff 1904).

Upper head (rubble and soil)	0.6m
Boulderclay	3.0m
Lower head or rubble-drift	1.5m
Stratified pebbly raised-beach sand lying among sub-angular blocks of rock	0.5m
Water-worn rock-platform	

At Ross Behy in west Kerry the beach is overlain in turn by head and till (Warren 1977). At Dingle it is overlain by head (Bryand 1966). At Fenit Mitchell (1970) recognised a complicated sequence involving a lower head, middle till and outwash and upper head resting on the beach. Warren (1977) regarded this as a single

head deposit incorporating varying amounts of re-worked till.

The raised beach, where levelled (Farrington 1966, Synge 1977a), invariably falls within the range 6-8m Mean Sea Level (MSL) – Mean Sea Level as estimated by Synge (1977a) approximates to British OD and is 2.554m above Irish OD – there is nowhere evidence of more than one beach level and, considering the uniformity of the stratigraphic sequence under which it lies and its mode of deposition, it is logical to regard the beach as an isochronous unit. By any objective stratigraphic criteria the raised beach, as the uppermost deposit indicative of high sea-level and, in all likelihood, interglacial conditions, must be regarded as last interglacial in age, unless and until evidence of later interglacial conditions is found at a higher stratigraphic level.

At Fenit in Co. Kerry polleniferous peats and silts, regarded as late Gortian by Mitchell (1970, 1976) directly overlie the raised beach which stands at 6m (MSL). The peat, which is likely *in situ*, reflects an open pine-wood with grasses and heather in its 52% *Pinus*, 38% *Gramineae* and 8% *Calluna* pollen content, and does not of itself represent an interglacial flora. The silt contains derived pollen which include small amounts of *Abies* and *Rhododendron* along with more substantial amounts of, *inter alia, Alnus, Ilex* and *Taxus*, which are probably derived from a Gortian deposit. In probability this is, as Mitchell (1970) interpreted it, a late Gortian/early glacial solifluction deposit. Its association with the raised beach suggests not only that that the beach is probably Gortian in age (Mitchell 1970, 1976) but the converse – that the Gortian is of an age with the raised beach. Within its local stratigraphic context this association is suggestive of a last interglacial age for the Gortian. The expression 'last interglacial' is here used to indicate the interglacial immediately preceding the most recent glaciation as exemplified in the uppermost and most recent glacial deposits that have an almost ubiquitous distribution in Ireland (*cf.* Bowen 1973) and are widespread in northern Europe. Kukla (1977) suggested that this interglacial be correlated with the most recent one indicated by Oxygen Isotope analysis of deep-sea sediments, stage 5e dated to ca 125,000 B.P. by the uranium/thorium method.

DISCUSSION

Whereas in Britain and on the continent palynologists generally are agreed that there is palaeobotanical evidence of three distinct interglacials (West 1968, Godwin 1975, 1977), in Ireland there is certain evidence of no more than one. However, *inter alios*, Kukla (1977) suggested that there is clear evidence of eight completed glacial cycles in retrieved deep sea sediment core representing the last 700,000 years and points to evidence of serious mis-correlation between both the glacial and interglacial sediments in Northern Europe. The two deposits that it has been suggested (Mitchell 1976) may refer to a separate, later interglacial in Ireland hold out this possibility chiefly because there is insufficient evidence to recognise in them the

characteristics of any one interglacial. Mitchell (1976) has raised the possibility that the plethora of Gortian deposits might conceivably suggest, in the absence of a distinctively different interglacial pollen assemblage, that there may have been two or more successive interglacials which developed characteristically similar vegetation patterns. However, he discounted this possibility on the principal that, since a consistent pattern of vegetational development is reflected, in both western continental Europe and Ireland, in Gortian/Holsteinian and Littletonian/Flandrian pollen diagrams, a similar pattern should come to light in respect of a yet undiscovered Irish interglacial and the Eemian/Ipswichian which is characterised by large amounts of *Carpinus* which Mitchell (1976) regards as the key Eemian/Ipswichian pollen.

This approach, irrespective of the acceptability of its major premise assumes that interglacial bio-stratigraphic units can be used as time-stratigraphic units which can be correlated on a wide scale. This is questionable, not only because of the doubts which arise in relation to the stratigraphic position and conventional correlation of the Gortian, but because very significant elements of the most commonly occurring and most recent biostratigraphic unit in Britain (the Flandrian) do not occur in its stratigraphic equivalent in Ireland (the Littletonian). These are *Carpinus* and *Fagus* which are key pollen of the Flandrian Zone VIII, along with *Tilia* which is normally strong in the Flandrian in Britain (West 1968, Godwin 1975). One must therefore consider the possibility that key pollen of the interglacials in Britain may not occur in equivalent interglacials in Ireland, and conversely, that the presence in Ireland of evidence of any one taxon need not assume its concurrent presence in Britain. This is made abundantly clear by the common occurrence of *Rhododendron* in Gortian deposits in spite of the absence of any evidence of this shrub in any of the British interglacials. It also illustrates the weakness of the argument – that because of the absence from the Cromerian deposits of *Abies* its common occurence in the Gortian precludes the correlation of these two interglacials (see Jessen *et al.* 1959). Furthermore, this argument must now rest on differing amounts of *Abies* remains in Gortian and Cromerian deposits (cf. Duigan 1963).

The palaeobotanical correlation between the Hoxnian and Gortian is specious, but other possibilities cannot be entirely ruled out. It is argued here that a complete Irish stratigraphy should be established before correlation is attempted between Quaternary bio-stratigraphic units of this country and those of any other. Good stratigraphic practice will not permit such units, belonging to areas of differing climatic regimes and physiographic conditions, to be treated as time-stratigraphic units on the basis of the occurrence of taxa that have neither evolved nor become extinct, *sensu stricto,* within the time-scale of the Quaternary. Watts referred to the stratigraphic recommendations of van der Vlerk (1954), but in accepting the fundamental correlation between Gort and Hoxne, without reference to reliable stratigraphic parameters, he is at variance with these recommendations.

Using the stratigraphic guidelines laid down by the American Commission for Stratigraphic Nomenclature (1961) without reference to stratigraphic considerations

outside this island one cannot identify evidence of more than two glaciations and one interglacial in Ireland (although botantists tend to regard the current climate unit as an interglacial (Godwin 1975, 1977), it must, for obvious stratigraphic reasons, be regarded geologically as post-glacial). At Gort, Baggotstown, Kildromin and Benburb the interglacial deposits lie inside the so called End Moraine and the tills overlying them lie in the same stratigraphic position as those overlying the Gortian deposit at Kilbeg, outside the moraine, thus suggesting that, as Bowen (1973) has already proposed, this is not the end moraine of the last glaciation.

The Courtmacsherry Raised Beach, at Courtmacsherry, Rose Behy and Fenit in particular, can, according to these basic stratigraphic principles, only be last interglacial in age. This places much of the superjacent sediments of the so called Munsterian Glaciation firmly within the last glaciation and makes a strong case for a complete redefinition of the major Irish Quarternary glacial climate units, the Midlandian and Munsterian which have never been properly defined stratigraphically and for which there are no formal type sites.

In effect most of the Munsterian deposits of the south of Ireland must now be regarded as Midlandian in age (if that term is to be retained) and only demonstrably pre-Gortian glacial deposits can be regarded as belonging to an earlier glaciation. If, however, the Gortian can be proved on a stratigraphic basis to be penultimate interglacial in age, and the Fenit organic deposit is accepted as late Gortian then there will be some basis for reconsideration of this positon.

It is necessary now to establish a simple stratigraphic profile for the Irish Quarternary on the basis of what is known. Type sites must be designated and unit names applied to the deposits and the inferred events. Alterations, such as should have been made when the Ardcavan Interglacial was dismissed, can then be made and the column adjusted as our knowledge improves. A broad sequence is outlined in Table I, but it is felt that the nomenclature, which needs drastic change, and the question of type sites, which often do not exist in relation to some of the current Quaternary stratigraphic units, should be further discussed at an informal level before being formally established.

Finally, in Britain, Bristow and Cox (1973) have made a good case for a younger age than the penultimate interglacial for the Hoxnian by means of a detailed stratigraphic investigation of the Quarternary deposits of East Anglia. Certainly, the inadequacy of long-distance bio-stratigraphic correlation without a thorough knowledge of the local stratigraphy is demonstrated in their paper which elicited the suggestion (West in discussion in Bristow and Cox 1973) that many of the Holsteinian sites on the continent might be Cromerian in age. If this possibility is followed to its logical conclusion then, conversely, the age of the Cromerian is also in doubt and the age of the Hoxnian must to some degree rest on its correlation with the Gortian which stratigraphically is last interglacial.

CLIMATE UNIT	LITHO-STRATIGRAPHIC UNIT	BIO-STRATIGRAPHIC UNIT
LITTLETONIAN		Littleton Bog
NAHANAGAN STADIAL	Nahanagan Moraine	
WOODGRANGE INTERSTADIAL		Woodgrange mud
GLACIAL	Midlandian Tills Ballyvoyle Till Garryvoe Till Ballycroneen Till	? Derryvree Interstadial mud ?
GORTIAN INTERGLACIAL	Courtmacsherry (6–8m) Raised Beach	Newtown Peat Fenit (Ballymakegoge) peat Gort muds
GLACIAL	Baggotstown Till	

Table 1. Suggested stratigraphic model for the Irish Quaternary, without some unit designations.

As implied by Rose (in discussion in Bristow and Cox 1973) the Saalian Glaciation in Britain may not have been everywhere as extensive as the Devensian, so that Devensian deposits may rest unconformably on Hoxnian Interglacial deposits. This hypothesis, when applied to Ireland raises once more the possibility originally raised by Mitchell (1976) that the last two Irish interglacials may have

been so similar as to be indistinguishable one from another. The existence of extremely weathered lower tills in Ireland, e.g. the Cuan Lathaí till at Ross Behy in Kerry (Warren 1977) may tend to corroborate this interpretation, but such hypotheses cannot be developed any further without a much more detailed knowledge of the total Irish Quaternary stratigraphy.

CONCLUSIONS

The conclusions to this review are simple in that they are based on a necessarily conservative stratigraphic interpretation of the Quaternary deposits. They are:–

1. On the basis of any objective stratigraphic approach the Gortian Interglacial must be the last interglacial.
2. The correlation between the Gortian and Hoxnian is open to question.
3. A Gortian penultimate or older interglacial age based on such a correlation is untenable because (a) objective stratigraphic considerations place the Gortian in the last interglacial, (b) the age of the Hoxnian and its stratigraphic position are very much in question and (c) because of the short time-scale involved these biostratigraphic units cannot be used as reliable time-stratigraphic units linking the stratigraphy of southeast England with western and southern Ireland.

REFERENCES

AMERICAN COMMISSION ON STRATIGRAPHIC NOMENCLATURE, 1961. Code of Stratigraphic Nomenclature. *Bull. Am. Ass. Petrol. Geol.*, 45, 645–665.

BOULTER, M. and MITCHELL, W.I. 1977. Middle Pleistocene (Gortian) deposits from Benburb, Northern Ireland. *Ir. Nat. J.*, 19, 2–3.

BRISTOW, C.R. and COX, F.C. 1973. The Gipping Till: a reappraisal of East Anglian glacial stratigraphy. *J. geol. Soc.*, 129, 1–37.

BOWEN, D.Q. 1973. The Pleistocene Succession of the Irish Sea. *Proc. geol. Assoc.*, 84, 249–272.

———— 1977. The coast of Walis, *In* KIDSON, C. and TOOLEY, M.J. (eds). *The Quaternary of the Irish Sea*. Seel House Press, Liverpool, 223–256.

COLHOUN, E.A. and MITCHELL, G.F. 1971. Interglacial marine formation and lateglacial freshwater formation in Shortalstown townland, Co. Wexford. *Proc. R. Ir. Acad.*, 71, B, 221–245.

DUIGAN, S.L. 1963. Pollen analysis of the Cromer Forest Bed series in East Anglia. *Phil. Trans. R. Soc.*, B, 246, 149–202.

ERD, K. 1970. Pollen-analytical classification of the Middle Pleistocene in the German Democratic Republic. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 12, 129–145.

FARRINGTON, A. 1966. The Early-Glacial Raised Beach in County Cork. *Scient. Proc. R. Dub. Soc.*, A, 2, 197–219.

GODWIN, H. 1975. *History of the British Flora a factual Basis for Phytogeography*. Second edition, Cambridge University Press, 541pp.

———— 1977. Quaternary History of the British flora. *In* SHOTTON, F.W. (ed.) *British Quaternary Studies recent advances*. Clarendon Press, Oxford, 107-118.

JESSEN K., ANDERSEN, S. Th. and FARRINGTON, A. 1959. The Interglacial Deposit near Gort, County Galway, Ireland. *Proc. R. Ir. Acad.*, 60, B, 1–77.

———— and MILTHERS, V. 1928. Stratigraphical and Palaeontological studies of interglacial freshwater deposits in Jutland and north-west Germany. *Danm. geol. Unders.*, II R., No. 48.

KIDSON, C. 1977. Some problems of the Quaternary of the Irish Sea. *In* KIDSON, C. and TOOLEY, M.J. (eds) *the Quaternary History of the Irish Sea*. Seel House Press, Liverpool, 1–12.

KINAHAN, G.H. 1865. Explanation to accompany sheets 115 and 116. *Mem. geol. Surv. Ireland*.

KUKLA, G.T. 1977. Pleistocene Land – Sea Correlations I. Europe. *Earth-Sci. Rev.* 13, 307–374.

MITCHELL, G.F. 1948. Two interglacial deposits in south-east Ireland (Studies in Irish Quaternary deposits, No. 7). *Proc. R. Ir. Acad.*, 52, B. 1–14.

———— 1953. Further identifications of macroscopic plant fossils from Irish Quaternary deposits, especially from a late-glacial deposit at Mapastown, Co. Louth. (Studies in Irish Quaternary Deposits: No. 8). *Proc. R. Ir. Acad.*, 55, B, 225–281.

———— 1970. The Quaternary deposits between Fenit and Spa on the North Shore of Tralee Bay, County Kerry. *Proc. R. Ir. Acad.*, 70, B, 141–162.

———— 1972. The Pleistocene history of the Irish Sea: second approximation. *Sci. Proc. R. Dubl. Soc.*, A, 4, 181–199.

———— 1976. *The Irish Landscape.* Collins, Glasgow, 277pp.

MITCHELL, G.F., PENNY, L.F., SHOOTON, F.W. and WEST, R.G., 1973. A correlation of Quaternary deposits in the British Isles. *Geo. Soc. Lond.*, Special Report No. 4, 99pp.

ORME, A.R. 1966. Quaternary Changes of Sea Level in Ireland. *Trans. Inst. Br. Geogr.*, 39, 127–140.

SELLE, W. 1953. Gesetzmässigkeiten im pleistozänen und holozänen Klimaablauf. *Abh. naturw. Ver. Bremen*, 53, 259.

SUTCLIFF, A.J. and KOWALSKI, K. 1976. Pleistocene rodents of the British Isles. *Bull. Br. Mus. Nat. Hist. (Geol)*, 27, 31–147.

SYNGE, F.M. 1977a. The coasts of Leinster (Ireland). *In* KIDSON, C. and TOOLEY, M.J. (eds). *The Quaternary History of the Irish Sea.* Seel House Press, Liverpool, 199–222.

———— 1977b. 6: Plains of Mayo and the Midlands. *In* FINCH, T.F., SYNGE, F.M. and ORME, A.R. *Western Ireland.* Guidebook for Excursion C16 INQUA X Congress (BOWEN D.Q. ed.), Norwich, 37–45.

TURNER, C. 1970. The middle Pleistocene deposits at Marks Tey, Essex. *Phil. Trans. R. Soc.*, 257, 373–440.

———— 1975. The correlation and duration of Middle Pleistocene interglacial periods in Northwest Europe. *In* BUTZER, K.W. and ISAAC, G. Ll. (eds). *After the Australopithecines.* Mouton, The Hague, 259–308.

VAN DER VLERK, I.M. 1959. Problems and principles of Tertiary and Quaternary stratigraphy. *Q. Jl. geol. Soc. Lond.*, 65, 49–64.

———— and FLORSCHUTZ, F. 1953. The palaontological base of the subdivision of the Pleistocene in the Netherlands. *Verh. K. ned. Akad, Wet. Afd. Naturk.* 1, 20.

WALKER, D. 1953. The Interglacial deposits at Histon Road, Cambridge. *Q. Jl. geol. Soc. Lond.* 108, 273–282.

WARREN, W.P. 1977. North East Iveragh. *In* LEWIS, C.A. (ed) *South and South West Ireland.* Guidebook for excursion A15 INQUA X Congress, (BOWEN, D.Q. ed.) Norwich 37–45.

WATTS, W.A. 1959. Interglacial Deposits at Kilbeg and Newtown, County Wexford. *Proc. R. Ir. Acad.*, 60, B, 79–134.

———— 1967. Interglacial deposits in Kildromin townland, near Herbertstown, County Limerick. *Proc. R. Ir. Acad.*, 65, B, 339–348.

———— 1970. Tertiary and Interglacial floras in Ireland. *In* STEPHENS, N. and GLASSCOCK, R.E. (eds) *Irish Geographical Studies in honour of E. Estyn Evans.* Dept. Geogr. Queen's Univ. Belf., 17–33.

WEST, R.G. 1956. The Quaternary deposits at Hoxne, Suffolk. *Phil. Trans. R. Soc.*, B, 239, 265–356.

———— 1968 *Pleistocene Geology and Biology.* Longmans, London, 377pp.

WOLDSTED, P. 1947. Über die stratigraphische Stellung einiger wichtiger Interglazialbildungen im Randgebiet der nord-europäisochen. Vergletscherung. *Z. dt. geol. Ges.*, 99, 96.

WRIGHT, W.B. and MUFF, H.B. 1904. The Pre-Glacial Raised Beach of the South Coast of Ireland. *Scient. Proc. R. Dubl. Soc.*, N.S. 10, 250–324.

W.P. WARREN, B.A., Ph.D.,
Geological Survey of Ireland,
14 Hume Street,
Dublin 2.

Manuscript Submitted
November 1977