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# An interglacial deposit of Mindel-Riss age from Kilbeg, Waterford, Ireland

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The interglacial deposit I am about to describe lies at Kilbeg, near the large town of Waterford in south-east Ireland. The deposit consists of a series of detritus muds, peat, clay-mud and diatomite about 3.5 m. thick. It lies under about 10 m. of boulder-clay of the Riss glaciation and there is solid rock beneath it. The presence of the deposit cannot be detected from the surface. It was originally discovered in 1941 during a well-boring and a new boring was necessary to obtain samples for pollen analysis. A preliminary examination of samples from the original well-boring carried out by Mr. G. F. Mitchell and later by Mr. S. T. Andersen yielded three pollen-spectra which showed a closely similar flora to the Gort interglacial which Mr. Andersen was then studying in co-operation with Professor Jessen. Later I had an opportunity to study the Kilbeg flora in detail and to prepare a complete pollen-diagram. This is rather similar to the Gort diagram which Mr. Andersen has described. I will confine myself therefore to a short description of the Kilbeg diagram and then describe the flora of the deposit as seen from pollen and macrofossil determinations.

The first stage of the Kilbeg flora is dominated by *Betula* with frequent *Pinus*. It is of interest that *Quercus, Hedera* and *Ilex* are already present at this stage. They are accompanied by remnants of an arctic flora which must have survived from an earlier stage, e. g. pollen of *Hippophaë, Juniperus, Salix* and some herbs. This mixture of warmth-demanding and cold-demanding species is due to very rapid climatic improvement after a glacial period, so that immigration of warmth-demanding species is made possible. The earliest of these species to arrive invade sub-arctic plant communities which persist in a climate already unsuited to them because there is not yet any effective competition. The same situation is seen at Hoxne (West, 1956). The second stage is dominated by *Pinus*. In this stage *Quercus* reaches its maximum with 10% of the tree-pollen. Later it becomes rare. A remarkable feature of the Kilbeg interglacial is the very poor development of mixed oak-forest; *Ulmus* is very rare and *Tilia* absent. In the third stage *Alnus* appears and becomes common. It is then co-dominant with *Pinus;* and *Alnus, Pinus* and *Betula* together make up 70% of the tree-pollen. The accompanying species are significant. The two most important, *Taxus* and *Abies,* do not exceed 15% of the tree-pollen. *Picea abies, Ilex, Fraxinus, Corylus* and *Buxus* also occur. As the third stage draws to a close pollen of *Ericaceae*, chiefly *Rhododendron ponticum*, becomes

very prominent and amounts to 200% of the tree-pollen. An unconformity separates the period of abundant *Rhododendron* from the final period, which is represented by 80 cm. of diatomite. This has a flora of park-tundra type with a great preponderance of herb pollen, the only trees being *Pinus* and *Betula.* The flora includes such genera as *Helianthemum* and *Artemisia* which are characteristic of the Late-glacial period but, in addition, many species of the period are calcifuge plants with strongly Atlantic distributions at present. To illustrate this unusual aspect of the flora one may mention *Daboecia cantabrica* and *Eriocaulon septangulare* as some of the species which occur. The declining stages of the interglacial are absent at Kilbeg. A small interglacial deposit from this period at Newtown, not far from Kilbeg, has a flora entirely dominated by *Pinus* with a little *Salix* and *Betula.* One may reasonably suppose that a *Pinus* stage comes somewhere near the end of the interglacial.

The age of the Kilbeg deposit was determined partly on a stratigraphical, partly on a floristic basis. Stratigraphically the Last Interglacial is excluded because the deposit lies under boulder-clay of undoubted Riss age. For this reason GAMS (1954) must be wrong in attributing all European *Rhododendron* sites to the Last Interglacial. Floristically Kilbeg is fully Quaternary in character and has no traces of the Tertiary elements found in the Tegelian flora (FLORSCHÜTZ and van der VLERK, 1953). Furthermore *Azolla filiculoides* occurs. As there is development of a warm, fully interglacial flora the choice of date seems to lie between the Cromerian and Mindel-Riss interglacials. There are no resemblances between the Kilbeg diagram and that from Cromer (THOMSON in WOLDSTEDT, 1950), except that both have very low *Corylus* values. The high *Picea* values at Cromer and the complete absence of *Abies* seem to constitute a fundamental difference from Kilbeg. In contrast, *Abies* is prominent at English Mindel-Riss sites (PIKE and GODWIN, 1953, WEST, 1956, DUIGAN, 1956) and there are indications in them of oceanic climate at the end of the interglacial. As opposed to this, mixed oak-forest is strongly developed in England at this period but is only feebly represented at Kilbeg. On the continent pollen-diagrams from the Netherlands of the Mindel-Riss period are characterised, according to FLORSCHÜTZ and van der VLERK, by a rather monotonous vegetation, dominated in the temperate period by *Alnus* and *Pinus.* It will be recalled that the Ohe type of interglacial (SELLE, 1955) shows the same feature together with abundant pollen of *Ericaceae.* SELLE thinks the Ober-Ohe type of interglacial may be of Mindel-Riss age, but he does not feel certain about it and prefers to place it in a separate category. The Netherlands and Ohe type diagrams are fundamentally similar to Kilbeg, though the Kilbeg flora is more varied and allows more satis-

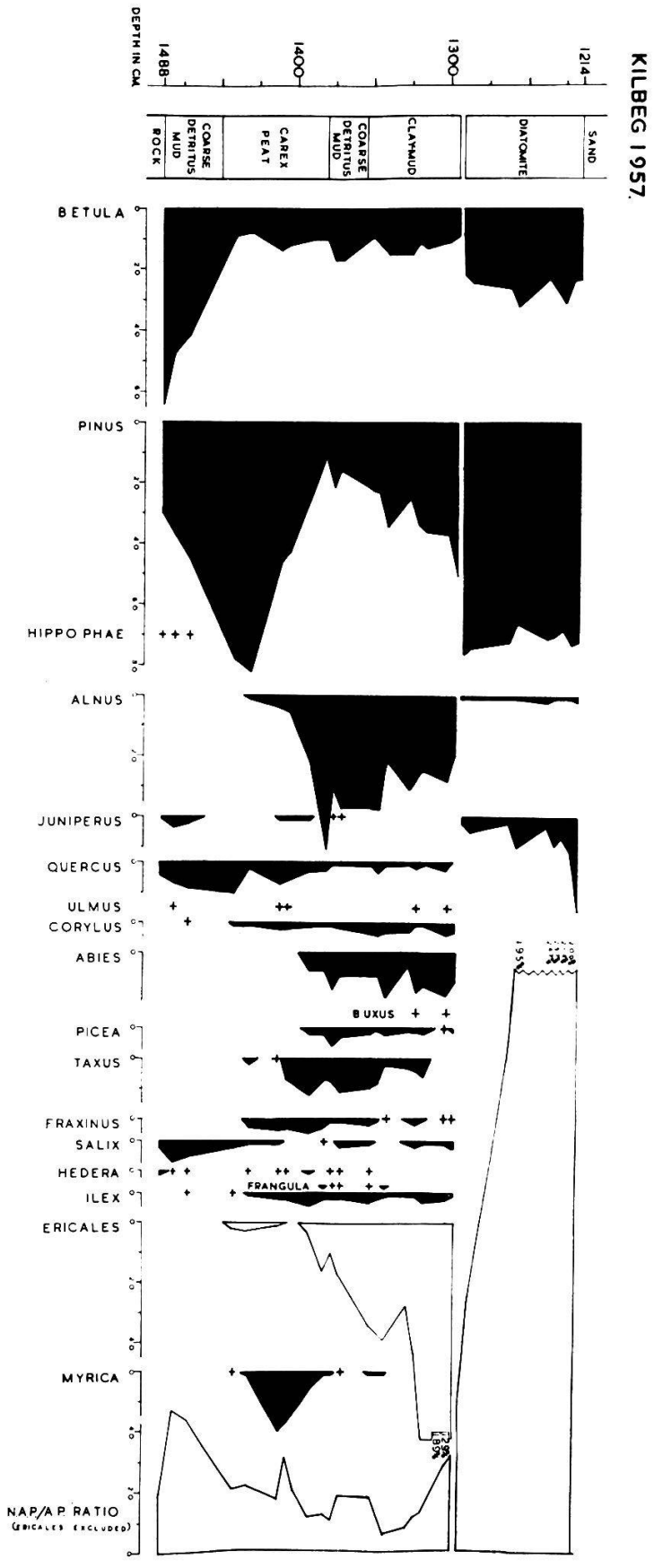


Fig. 1. Pollen-diagram from the Kilbeg Interglacial. The diagram is based on twenty-seven spectra. In each spectrum 300 'tree' pollen were counted. Curves for 'tree' pollen are blackened in the diagram

factory zonation. In addition to the similarity due to Alnus-Pinus dominance *Abies* is also present in them and Quercetum mixtum is poorly developed. To sum up, I consider the Kilbeg flora to be of Mindel-Riss age because it is totally different from the Cromer flora and because it shows important similarities to certainly dated Mindel-Riss floras from England and the Netherlands.

It is of interest to consider what sort of climate there was at Kilbeg in the *Alnus-Pinus* period. Some of the species which occur are useful as climatic indicators. The period can have had only light winter frosts at the most, since both *Ilex* and *Rhododendron* are intolerant of severe cold. The abundance of *Ilex* is remarkable. It forms a continuous curve throughout the *Alnus-Pinus* period and makes up 4% of the tree pollen in some spectra. I know of no such consistently high *Ilex* values for any other period, though in one postglacial diagram from Ireland (MITCHELL 1951) it reaches values as high as 8% in two spectra; but in that diagram the pollen-curve is not continous. I take the abundance of *Ilex* to indicate a climate at least as favourable as the present Irish one and possibly even somewhat warmer. *Rhododendron* flourishes at present in Ireland as an introduced plant and even invades the native vegetation. In its native stations, as, for example, in the Caucasus, it grows in a climate closely similar to the climate of the west Irish coast in average winter temperatures and total annual rainfall, but with higher average summer temperatures. One may conclude that winter temperatures in the interglacial were at least as mild as at present in Ireland and that summer temperatures may have been a little higher. The climate was also a very humid one. This is seen in the rather frequent occurrence of spores of the *Hymenophyllaceae,* probably *Hymenophyllum tunbridgense.* The three members of this family in the present Irish flora only grow in a permanently moist atmosphere. The two *Hymenophyllum* species are particularly characteristic of the oakwoods of south-west Ireland where they are abundant in the rich bryophyte flora which covers the ground and forms a thick epiphytic mat on tree-trunks. Taken together, the presence of *Ilex, Rhododendron* and *H. tunbridgense* indicates a mild oceanic climate with relatively frost-free winters, a climate not very different from that of the more oceanic parts of Ireland at present and possibly slightly warmer.

To complete the picture of the interglacial flora I wish to compare it with the modern Irish flora in three respects; firstly, to see if any plant communities comparable with modern ones could be identified; secondly, to describe the plant-geographical relationships of the interglacial flora in terms of modern distributions and finally to see whether any taxonomic units below the specific level could be identified. To do this a large number of determinations is necessary. It proved

possible to identify over 100 species from either macrofossils or pollen. The analysis of the flora is based on these determinations.

It is evident that the arboreal communities of the interglacial period have nothing in common with the Post-glacial. In the *Alnus-Pinus* period four species, *Abies* sp., *Picea abies, Rhododendron ponticum* and *Buxus sempervirens* are now totally absent from Ireland and, with the exception of *Buxus,* from much of north-west Europe. The abundance of *Taxus* and *Ilex* contrast with their more subordinate position in the post-glacial. Even in the earlier *Pinus* period, *Pinus* reaches values which are unknown in the Irish post-glacial. Although the arboreal communities are very different from post-glacial ones there is evidence of the occurrence of two communities which are characteristic of Ireland today. A common type of vegetation in present-day Ireland is a dry-heath community which occurs where thin soil covers acid rock. Such communities are dominated by *Ulex europaeus* and *U. gallii* accompanied by *Calluna, Erica cinerea, Hypericum pulchrum, Potentilla erecta, Galium saxatile, Teucrium scorodonia* and other species. Macrofossils of *Calluna,* the *Teucrium,* the *Hypericum,* the *Potentilla* and pollen of the Rubiaceae occurred in the Alnus-Pinus stage. It seems possible that a dry- heath community similar to the modern one may have occurred. This type of community is confined to oceanic areas of western Europe. In the treeless diatomite stage at the end of the interglacial an aquatic flora occurs which can be matched in Ireland now. Macro- or microfossils of *Isoëtes lacustris, I. echinospora, Pilularia globulifera, Elatine hexandra, Eriocaulon septangulare, Littorella uniflora, Potamogeton natans* and *Myriophyllum alterniflorum* and *M. spicatum* occur together. This type of flora is very distinctive and occurs in extreme oceanic areas of western Ireland in small lakes in rock-basins with very acid water and sandy or stony margins. The only species normally occurring in this community which was not found was *Lobelia dortmanna,* and of course one cannot draw conclusions from absences. I consider therefore that two plant communities characteristic of present-day Ireland also existed in the Mindel-Riss interglacial.

Of the 100 or so species identified in the Kilbeg flora 12 no longer occur in Ireland. Five of these occur in Britain and have simply failed to penetrate to Ireland in the post-glacial, or, like *Betula nana,* reached Ireland but have become extinct once more. The remaining seven species are *Picea abies,* a species of *Abies, Rhododendron ponticum, Azolla filiculoides, Eleocharis ovata* and *E. cf. carniolica* and an intriguing species of *Erica* which also occurs in the Gort interglacial. Although seeds, capsules and flowers of this species are available it has proved impossible to identify it with any *Erica* species in the European flora and the species may simply be extinct. Of the remaining species the

great majority are common and widespread plants in temperate Europe. A group of 20 species occurs with them which have now got restricted distributions on the Atlantic seaboard of Europe. One may mention as examples *Anagallis tenella, Erica tetralix, Teucrium scorodonia* and *Hypericum pulchrum.* These exemplify species which have a wide distribution in Atlantic Europe and to some extent also in the Mediterranean area but are almost entirely absent from central, eastern and northern Europe. Some members of this group are among the most interesting species in the present Irish flora and have an extreme western distribution even in the context of the Atlantic flora in general. For example, macrofossils of the two heaths, *Daboecia cantabrica* and *Erica mackaiana* occur at Kilbeg and *Daboecia* is also at Gort. Both plants have similar modern distributions, occurring in very limited areas of western Ireland, and having the remainder of their distribution in north-west Spain and Portugal and south-west France. Finally *Eriocaulon septangulare,* whose main area of distribution now is in North America, and which also occurs in west Ireland and a few very limited areas in west Scotland, was found abundantly in the interglacial. The find is of very great interest, since the peculiar distribution of the species has led to much speculation as to its cause. I will discuss this species in more detail later but enough has been said to show that, with a few notable exceptions, the flora of the Mindel-Riss interglacial in Ireland was closely similar to the present flora and that, significantly, in view of what has been said about climate, species of Atlantic distribution are prominent in the flora. Further, the plant-geographical groupings seen in the modern flora appear to be long-established.

In the case of three species information of evolutionary interest was obtained. A sporangium of *Polypodium vulgare* containing spores was found. The annulus of the sporangium had 12 indurated cells. This number of indurated annulus cells is characteristic of the tetraploid form of the species, in which diploids and hexaploids are also known (Manton, 1950). Similarly a seed of *Nasturtium* proved to belong to *N. microphyllum,* the allotetraploid of the *N. officiale* group, which is distinguished in part on seed characters. To return to *Eriocaulon,* I was much interested in this species because I knew that Jessen (1948) had carried out measurements on pollen of the species from American and Irish localities and had found a size difference, American pollen averaging 24 $\mu$ and Irish pollen 32 $\mu$. A similar size for American pollen had been recorded by Erdtman (1943). I carried out a series of measurements also and obtained much the same result as Jessen; It was evidently of great interest to see with which size group the fossil agreed more closely. Fortunately the fossil was rather frequent. While emphasising that pollen of *Eriocaulon* is easily distorted because of its peculiar

symmetry great care was taken to measure only those grains which appeared undamaged. It was found that the fossil agreed very closely in size with modern Irish material. Noting this agreement and the fact that the species in the interglacial period occurred in the same sort of plant community as now, it seems reasonable to suggest that an Irish biotype of the species, of limited ecological amplitude, has had a long history of separation from the main American population and has existed in Europe for a considerable time. This is a conclusion which has been reached from plant-geographical considerations by, amongst others, DEEVEY (1949).

One final piece of information is available about this interglacial. We know from a well-developed raised beach around the south coast of Ireland that the level of the ocean was constant for a very long period at a level about 2 m. above present sea-level. I should mention that this beach is the oldest satisfactorily-dated glacial feature in Ireland. Part of the interest of finding traces of a «late-glacial» flora at the beginning of the Kilbeg interglacial and, more importantly, of the Gort interglacial also, is that this is the first entirely satisfying evidence for a Mindel glacial period in Ireland. So far only the most tenuous traces of a Mindel glaciation have been found and no boulder-clays of the period have been satisfactorily identified.

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Diskussion. K. FAEGRI: Made a plea for distinct indication in the digrams between pollen types that are included in the 100% sum, and those that are not. Also, the level of individual samples should be indicated by horizontal lines in the diagram, and the main percentage levels by vertical lines.