Pollen Analysis: a technique for investigating early agrarian history

By J. W. FRANKS

THE fact that the remains of plants are preserved in deposits laid down under waterlogged conditions has been known since peat deposits have been worked; and amongst the remains so preserved are pollens. Pollen analysis is the study of the pollen content of sedimentary deposits. During the past fifty years it has developed rapidly. The technique is based on the fact that all the higher plants (trees, herbs, and ferns) release pollen and spores into the atmosphere. These pollen grains and spores, being very small, are carried about by air currents and become mixed before settling out of the air. In the process of settling they are known as the 'pollen rain', and it is one of the basic assumptions of pollen analysis that the composition of the pollen rain is proportional to the composition of the vegetation from which it is derived. This assumption is not strictly true: the forest trees do not produce equal amounts of pollen, and no satisfactory measure of the inequalities has yet been devised. Furthermore, we do not know exactly how pollens are incorporated and preserved in peats and sediments. Nevertheless, so long as these limitations are borne in mind, it is believed that pollen analysis can tell us something about the history of vegetation.

The pollen content of sedimentary deposits is investigated by applying a standard chemical treatment to digest small samples of the deposit, and mounting the resultant suspension of pollen grains on a microscope slide. The pollens are then identified and counted.[1] The results of the pollen counts are calculated as a percentage of the arboreal pollen or of the total pollen of each count. These calculations are then presented graphically as a pollen diagram (see Fig. II).

The science of pollen analysis first came into being as the result of work by the Swedish scientist von Post. In the early 1900's he produced the first percentage calculations of pollens preserved in peat deposits, thereby putting the study of past vegetation on a quantitative basis for the first time. Since von Post's pioneer work pollen-analytical studies have been used chiefly for the purpose of elucidating the history of vegetation since the last ice age, with the result that in N.W. Europe a regular pattern of development over the last 10,000 years has emerged (see Fig. I). It is against the background of this work that recent studies of man's influence on the vegetation must be

[1] Faegri and Iversen, *Textbook of Modern Pollen Analysis*, Copenhagen, 1950.

Approx. Age	*Pollen Zones*	*Name of Zone or Period*	*Type of Vegetation and Climate*	*Forest Destruction*
10th cent. A.D. 0 B.C. 3500	VIIB to recent	Post-atlantic	Mixed oak forest with little elm. Climate: Cool oceanic. Elm declined. ?Climatic deterioration.	Oak forests cleared. Norse land-takes. Esthwaite early clearances, not earlier than 2000 B.C.
6000	VIIA	Atlantic	Mixed oak forest, alder in the damper places. Climate: Warm oceanic.	
8000	VI V	Boreal	Pine-hazel woods with some birch, oak, elm, and alder. Climate: Warm dry.	
10000	IV	Pre-boreal	Birch-pine woods, with many herbs. Climate: becoming warmer.	
to 13000	I, II, and III	Late-Glacial	Climate: Cold.	

FIG. I

Table of Vegetation and Climatic Type in the English Lake District.

considered.[1] So far pollen analysis has suggested the following sequence in the development of vegetation prior to man's influence.

After the last glaciation temperatures increased and birch woodland expanded rapidly. At the beginning of this period, the pre-boreal, there were many herbaceous species, but they became more abundant as it progressed. From this we may infer the development of denser woodland. In the boreal period the birch woods were invaded by pine. This points to a decrease in rainfall. The hazel became an important component of the vegetation at this time, probably forming pure hazel woods. The oak, elm, and lime began to appear, fostered by the still increasing temperatures. Soon after the appear-

[1] J. Iversen, 'Land occupation in Denmark's Stone Age', *Danm. Geol. Unders.*, II, 1941, Nr. 66, pp. 1–68; and 'The influence of prehistoric man on vegetation', *Danm. Geol. Unders.*, IV, 1949, Bd. 3, Nr. 6, pp. 1–25.

ance of the trees of the mixed oak forest, ivy appeared, showing that the climate was becoming more oceanic.[1]

At the end of the boreal period a major change in the vegetation occurred. The alder, which had been present in small amounts since the pre-boreal, expanded rapidly. The amounts of birch and pine, until now the most important trees, declined sharply. This expansion of alder was almost certainly brought about by climatic change. At this time the mixed oak forest became established as an important unit of the vegetation. The period characterized by this type of vegetation is known as the atlantic.

The end of the atlantic period was marked by the decline of the elm. This was followed by a series of clearances which destroyed the mixed oak forest and produced the present vegetational landscape. That these clearances were man-made has been shown by the pioneer work of Scandinavian scientists. The initiative was taken by Iversen, whose work on early forest clearances was the first attempt to investigate the problem by pollen-analytical methods, and is still the outstanding work in this field.[2] Iversen demonstrated, by means of pollen analyses from several Danish sites, the temporary clearances of the atlantic mixed oak forest by axe and fire, and he worked out the details of clearance, occupation, and regeneration on these sites. He emphasized the importance of certain pollens as indicators, particularly the ivy and mistletoe. The climatic requirements of these plants are strictly defined and well known, so that their occurrence throughout the whole of the clearance period suggests that climate was not the primary factor in bringing about these changes.

Since then Iversen, together with Troels-Smith and others, has shown that it is possible to clear considerable areas of high forest using only the Neolithic wooden-hafted polished stone axe and a primitive burning technique still in use in Finland. Crops have been grown on the land so cleared.[3]

Iversen's work on forest clearance in Denmark has established for that country a clear picture of the course of events when the Neolithic farmers attacked the virgin forests of the atlantic period. First came the steep decline in the mixed oak forest, together with the first appearance of the narrow-leaved plantain. The depression of the mixed oak forest was followed by an expansion of birch and hazel. Immediately after the clearance fire, traces of which are found as charcoal stratified into the deposits, birch became more abundant than at any time since the pre-boreal. However, it was soon shaded

[1] D. Walker, 'Skelsmergh Tarn and Kentmere, Westmorland', *New Phytologist*, LIV, 1955, No. 2, pp. 222–54.

[2] J. Iversen, 'Land occupation in Denmark's Stone Age', *loc. cit.*

[3] The experiment at Draved in S. Jutland. There is no published account.

out by the regenerating mixed oak forest. Hazel declined more slowly, but was nevertheless suppressed by the mixed oak forest. The great expansion of birch after the clearance fire can be explained by its efficient seed dispersal and by the extremely favourable conditions created for the germination of its seeds by the removal of the undergrowth.

The interpretation of the pollen diagrams receives confirmation from several other circumstances. First is the presence of a charcoal layer stratified in the deposits. Second is the fact that at the level of clearance the absolute frequencies of arboreal pollen fall very low and then slowly recover.[1] Finally, there is the striking evidence yielded by the non-arboreal pollen content of the deposits. Just above the charcoal layer the non-arboreal pollen increases suddenly, as would be expected from Iversen's hypothesis. But especial importance is attached to his identifications of the species contributing to this total. Firbas had previously suggested that it was possible to distinguish the pollen of cereals from that of other grasses on the basis of size;[2] by this method cereal pollen was identified from the deposits. Pollen of the plantains and mugwort was found in some quantity in the same deposits. Mugwort remained a serious weed in Denmark until deep ploughing became a regular practice. The occurrence of weeds in large numbers confirms Iversen's hypothesis of a community practising tillage only in the most rudimentary form.

Although the significance of Iversen's work was realized in this country, no attempt was at first made to study the effect of human influence on vegetational development in detail. References to forest clearance have appeared in British literature, but no detailed studies have been attempted. Some work was done by W. Pennington on the past vegetation of the Windermere region, the results of which were published by Pearsall and Pennington in a paper on the Ecological History of the English Lake District.[3] In this paper they surveyed the archaeological background of the region, and from the evidence of the Windermere pollen diagrams deduced stages in the historical development of the vegetation. These included: the clearing of the valley alder swamps by the Norsemen; the destruction of the low-level oak woods; the great expansion of the grasses due to the above and to monastic sheep-farming; and the extension of pine. In an earlier work Pennington had proposed

[1] Absolute tree pollen frequency is calculated on the basis of the number of pollen grains per unit area of the microscope slide, samples of comparable size being used. It is of only limited value as too many uncontrollable factors are involved.

[2] F. Firbas, 'Der Pollenanalytische Nachweis des Getreibaus', *Zeitschrift für Botanik*, Bxxxi, 1939.

[3] W. H. Pearsall and W. Pennington, 'The Ecological History of the English Lake District', *Journ. Ecol.*, xxxiv, 1947, No. 1, pp. 137–47.

a time scale for the region based on rates of sedimentation.[1] When applied to the pollen diagrams this gave the age of the supposed Norse clearance as about A.D. 1400. This date applies to the height of the clearance, but the historian will be quick to point out that there is a considerable margin of error. The fact is that pollen analysis can only determine sequences in the history of vegetation; for the chronology of those sequences, additional evidence must be sought from archaeological or other techniques.

In Pennington's work only a small proportion of the non-arboreal pollens were identified, so that the evidence for the deductions made was rather slender. Nevertheless, later work has in the main supported the ideas put forward in his paper. In general, however, when British workers have used pollen analysis in connection with archaeological investigations, they have used it chiefly as a dating tool.[2] In the course of a general pollen-analytical investigation of the vegetational development of the Esthwaite basin in the English Lake District, I have devoted special attention to the effects of early forest clearance. During the routine investigations a well-marked clay band was seen to be associated with changes in the pollen diagram that suggested forest clearance. An analysis of the deposits was made, using as the standard count 1,000 grains of arboreal pollen (as against the usual 150), to give greater statistical accuracy. The pollen diagram (Fig. II) shows the result of this analysis. For convenience of interpretation the diagram has been zoned into six arbitrary phases, each characterized by its own type of vegetation. The sequence of changes shown by these phases can be seen to represent a double cycle of a weakening of the mixed oak forest followed by its regeneration.

These changes may be regarded as stages in the utilization of the area by man. Their interpretation rests largely on the appearance and disappearance of the plantains, and upon comparison with earlier accepted clearance diagrams.

PHASE

I. Typical atlantic mixed oak forest.
II. Small depression of the mixed oak forest.
III. Regeneration of the mixed oak forest.
IV. Major depression of the mixed oak forest and birch.
V. Appearance of herbaceous types in large numbers.
VI. Regeneration of the woodland with more birch than formerly.

[1] W. Pennington, 'The bottom deposits of the N. Basin of Windermere, Diatom Succession', *New Phytologist*, XLII, 1943, No. 1, pp. 1–27.

[2] J. G. D. Clark, *The Excavations at Star Carr*, Cambridge, 1955; H. Godwin, 'The Meare Pool region of the Somerset Levels', *Phil. Trans. Roy. Soc.*, Ser. B, CCXXXIX, 1956, No. 662, pp. 161–90; H. Godwin, 'The age and origin of the Breckland heaths', *Nature*, CLIV, 1944, p. 6.

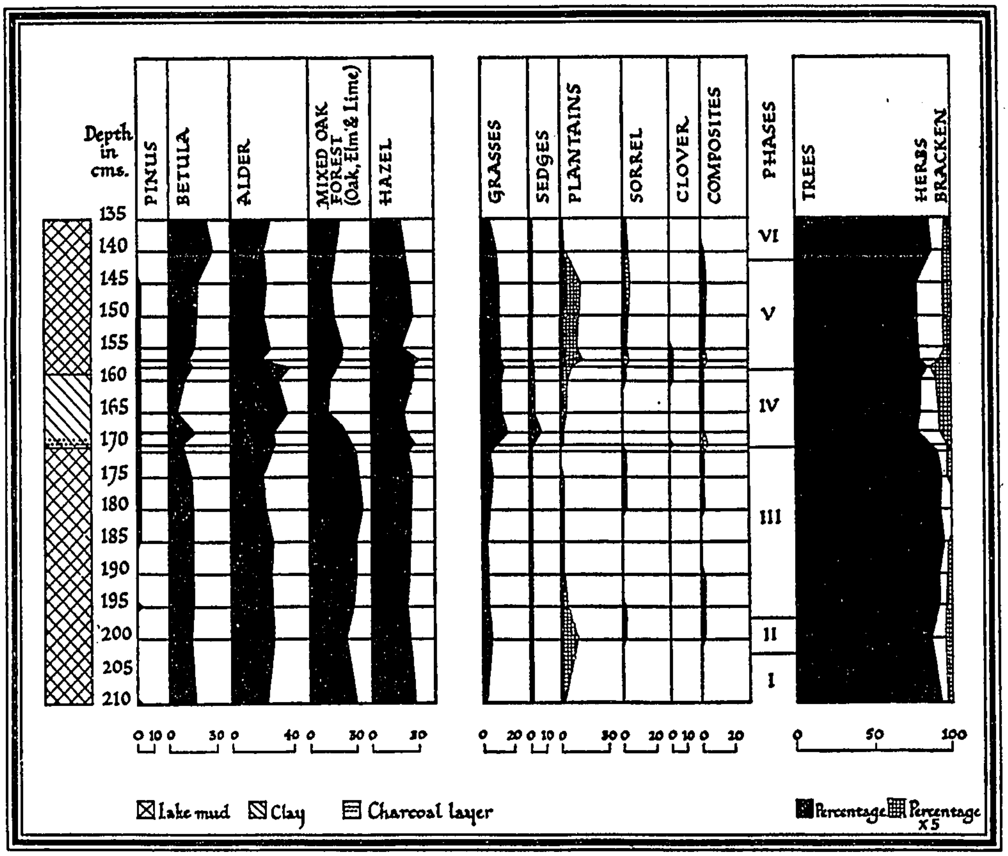

FIG. II.

The early part of the diagram (phase I) is typical of the atlantic period, in which no trace of human activity can be found. At 200 cms. there is a small depression of the mixed oak forest (phase II). This, taken in conjunction with the prolific growth of plantain, grasses, and bracken, provides some evidence of human activity; but compared with the later clearance, this appears as a very short-lived attack on the mixed oak forest, for the latter immediately returns to its former importance. The plantains, grasses, and bracken decline, and by phase III the mixed oak forest has returned. The following phases, IV, V, and VI, can be considered as representing successively the clearance, utilization, and abandonment of the area by man.

Phase IV, which begins with the decline of ash and birch, is interpreted as representing the period during which the forest was actually cleared. Later the oak was considerably reduced, and the non-arboreal components of the vegetation became of greater importance. At this time the absolute frequency of pollen fell.[1] Amongst the non-arboreal components of the vegetation, the

[1] See footnote, p. 5, on absolute pollen frequencies.

grasses and bracken predominated; the large numbers of other herbaceous types associated with the occupation phase were not represented. The delimitation of the clearance phase, judged from the pollen diagram, corresponds almost exactly with the stratigraphic horizon formed by the clay band. It seems probable that this clay band was produced by the increased erosion that followed large-scale human interference with the vegetation cover.

Phase V, the phase of occupation or utilization, began with an increase in the amount of birch, which continued throughout the phase. There was also a slight increase in oak and hazel, but the oak immediately declined. The increase in birch is explained by its superior powers of dispersal and the extremely favourable conditions for the germination of its seeds existing after the clearance fire. There is considerable evidence to support the hypothesis of such a fire. First, small particles of charcoal have been observed in the lower part of the clay layer, and secondly, occasional moss spores resembling these of *Funaria* (a species often growing on burnt areas) have been found immediately above the clay layer. The grasses declined slightly at the beginning of this period but quickly rose to a new maximum. At the same point the plantains reached their highest frequency. Sorrel rises to its maximum slightly later. The behaviour of bracken during this period is of particular interest. It can be seen from the pollen diagram that bracken decreased steadily throughout the occupation phase. This may perhaps have been due to treading by cattle. It is during this period that the greatest numbers of herbaceous types occur. They suggest that either the dense woodland earlier destroyed was being replaced by a more open type of woodland, or that extensive clearings had been made.

The final stage in this cycle (phase VI) is the regeneration of the forest. This was characterized by a further extension of birch, and to a lesser extent of oak. This part of the diagram differs considerably from Danish examples where regeneration was complete. It seems probable that the difference can be at least partly explained by the location of the Esthwaite basin in a mountain region, with the consequent leaching of soils. It may well be that at the time of the clearance the oak woods were maintaining themselves with difficulty on the upper slopes, and that the introduction of an adverse factor such as grazing had a far-reaching effect on the vegetation.[1]

In the foregoing pages the changes in the vegetation reflected in the pollen diagram have been attributed to man's interference. The possibility that they were brought about by climatic influences has been rejected for the following reasons.

[1] Cf. W. H. Pearsall, 'Woodland destruction in Northern Britain', *The Naturalist*, 1934, pp. 23–8, on "zones of tension."

First, to bring about changes of the suddenness and magnitude of those shown in the pollen diagram a major climatic change would have to be postulated. Moreover, it is difficult to imagine climatic conditions which would favour alder and the even more demanding hazel at the expense of birch and oak. Such changes would of necessity affect the whole region, yet in the Esthwaite basin the elm and lime remained unaffected throughout the period. This suggests that they were growing outside the area of clearance and that we are here not dealing with a regional climatic change.

Furthermore, a forest in which alder is replacing birch is not a habitat in which high percentages of grasses, plantains, and bracken would be expected.

The remaining possibility is that some factor other than climatic was responsible for the surface on which erosion took place. When the assemblage of plants recorded is considered, the interpretation which best fits the facts is that these changes represent the product of human activity in the region, and most probably of a clearance fire, as suggested by the charcoal fragments found in the clay.

Archaeological investigations in the Lake District provide evidence for a considerable occupation of upland sites. This evidence comes largely from burial sites and stone circles, dating from late Neolithic times onwards.[1] There is also the important site of the Great Langdale Stone Axe Factory, the date of which is placed at around 1900 B.C.[2] The culture here appears to have remained at Neolithic level until Romano-British times and perhaps even later. It is thought that the Neolithic people of this district were cattle raisers, perhaps grazing their cattle in the upland woods, thus depressing the growth of trees and encouraging that of herbs. This type of occupation might well explain the earliest depression of the mixed oak forest (phase II). It has already been mentioned that the upland woods at this time may have been a 'zone of tension', and a factor such as grazing could well have been decisive in preventing regeneration.

It is at once apparent, however, that this is not the type of clearance characteristic of the major clearance, phase IV. The evidence shows that this belongs to a valley occupation and is a real clearance rather than an effect of grazing pressure. In this respect it is interesting to note the absence of any pollen which can with certainty be identified as cereal. The lack of cereal pollen, together with the herbaceous assemblage recorded, gives good

[1] R. G. Collingwood, 'An introduction to the prehistory of Cumb. Westm. and Lancs. N. of the sands', *Trans. Cumb. and Westm. Antiquarian and Archaeological Soc.*, N.S. XXXIII, 1933, pp. 163–200.

[2] C. Fell, 'The Great Langdale Stone Axe Factory', *ibid.*, N.S. L, 1951, pp. 1–14.

grounds for supposing that the clearance was made for pasture rather than for cultivation. It is noteworthy in this connection that there is no great rise in the quantity of mugwort at the end of the occupation phase such as takes place after clearances for cultivation. The virtual absence of nettle pollen strongly suggests that the clearance was made and maintained for pasture, and not for cultivation by a people permanently domiciled in the district, for pollen of this plant is only found in large quantities in diagrams from the vicinity of settlements. R. G. Collingwood points out that there is no evidence to show where the earliest settlers in the Lake District dwelt, and he therefore considers that their settlements were of a temporary nature.[1]

In the absence of radio-carbon dating and specific archaeological evidence, it is difficult to ascribe the clearance to any particular period, beyond saying that it is pre-Viking, i.e. not a part of the permanent clearance, which began with the Norse land-takes in the tenth century A.D. The pattern of clearance, however, shows considerable affinities with Danish Neolithic clearances. Nevertheless, any attempt to place this diagram in the Neolithic period on the basis of comparison with Danish diagrams would be fraught with danger, for the effect of Neolithic culture on the vegetation of this country is not known. Added to this there is the fact that the density of population in Neolithic Denmark was undoubtedly much greater than in the Lake District.

The major contribution of the Esthwaite site to the picture of early forest clearance is that it provides evidence for the occupation of a valley site in the period between the initial Neolithic colonization of *c.* 2000 B.C. and the permanent clearance beginning *c.* A.D. 900.

Whilst the sketch of previous pollen-analytical work presented in this paper is by no means complete, it is hoped that sufficient of the background has been drawn in to enable the non-specialist to appreciate the value of these studies for early agrarian history. The brief account of my investigations in the Esthwaite basin is necessarily incomplete, and will appear in greater detail elsewhere. Although the site has known archaeological correlations, the results do show the potentialities of such detailed studies. How much more valuable, then, would be investigations carried out with full co-operation between botanist and archaeologist or historian. Besides working out an agreed date for early settlements, we might then attempt a detailed study of the plants associated with man, and might gain much consequent insight into farming methods and the problems which confronted early man.

[1] R. G. Collingwood, *op. cit.*

Notes and Comments

THE BRITISH AGRICULTURAL HISTORY SOCIETY

A one-day conference was held jointly with the Association of Agriculture at the London University Institute of Education on the 1st of December 1956. The chair was taken by the President, Sir James Scott Watson, and about forty people attended. Three papers were read, the first by Mr F. G. Payne of the Welsh Folk Museum on 'The Plough in Britain', the second by Miss M. E. Marston of the University of Nottingham on 'The History of Plant Propagation in England', and the third by Mr G. E. Fussell on 'Grasses and Grassland Cultivation, 1500–1900'.

THE AGRARIAN HISTORY

The project for an Agrarian History of England, announced in these pages a year ago, is gathering momentum. It is being assisted by a grant of £6,000 generously contributed by the Nuffield Foundation towards the expenses of the pilot volume. This, the first volume to be put in hand, will cover the period from approximately 1500 to 1640. It will be edited and in part written by Dr Joan Thirsk, senior research fellow in agrarian history at University College, Leicester; and in order to help the work, a new post of research assistant has been created in the department of English Local History at the College. Miss L. M. Midgley, M.A., hitherto editor of the Victoria County History of Staffordshire, has been appointed to the post. Meanwhile sub-committees are being set up to plan the work on several other volumes.

A NEW JOURNAL OF FOLK LIFE

We welcome the arrival of *Gwerin* as a new contemporary in a closely related field. There has long been need for a journal devoted to folk life, and *Gwerin* has made its appearance at a timely moment when interest in folk-life studies is rapidly increasing. Dr Iowerth Peate, the Keeper of the Welsh Folk Museum, who edits the new journal, has striven for some years to bring it into being by gathering together support both in the British Isles and overseas, and the first issue does his efforts great credit. It is pleasingly produced and sells at the modest price of 6s. for 48 pages. It will be published twice a year.

In his editorial notes Dr Peate explains that

(*continued on page* 30)

NOTES ON CONTRIBUTORS

J. W. Franks, B.Sc., Ph.D., formerly a research scholar in the department of botany at University College, Leicester, is now Assistant Keeper in Palaeobotany in the department of palaeontology at the British Museum.

K. J. Allison, B.A., Ph.D., formerly Dean research scholar in the University of Leeds, has published a study of the lost villages of Norfolk, and is now continuing his research into the agrarian history of the county.

Malcolm Gray, M.A. (Aberdeen), is lecturer in economic history at the University College of North Wales, Bangor, and author of *The Highland Economy, 1750–1850*. He has also published several articles on the subject in the *Economic History Review* and elsewhere.

W. H. Chaloner, M.A., Ph.D., is a senior lecturer in history and economics in the University of Manchester.

R. E. F. Smith is a member of the department of economics and institutions of the U.S.S.R. in the University of Birmingham.