A study of the blanket peat at Rookhope Head, upper Weardale, CO. Durham

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INTRODUCTION

Apart from the work recently carried out by Pamela Ward (Durham University M.Sc. student) on Bollihope Common and at Steward Shield Meadow no other palynological study has yet been undertaken on the peat deposits of Upper Weardale. It was hoped that by making such a study, not only would it be possible to provide an outline of the vegetational history and of human activity for the selected site, but also to establish whether peat formation began at more or less the same time as at the other two sites in Upper Weardale or whether instead it was contemporaneous with upland sites at similar altitudes in other parts of the Pennines.

THE SITE

(a) Description

A number of sites were considered but Rookhope Head was chosen because here there was a generous peat cover suggesting fairly continuous growth and, since there were few signs of erosion, it was thought that, through pollen analysis, a deep peat core would probably reveal an unbroken record of vegetational history. The site is situated near the easterly extremity of the physiographic area named by the British Association (1949) Upper Weardale, bounded in the north by the Northern Dales and in the south by the High Fells. The southern edge of the site is marked by the quiet moorland road leading through Rookhope Burn from Rookhope (4 miles) to Allenheads (1 mile) and to the north is the Durham/ Northumberland county boundary. The slope of the site is to the south and east and, except near the road where the peat gives way to a poor thin dry soil, it is very gentle, descending from near 1,775 feet across the 1,750 feet contour to about 1,668 feet. A large and apparently natural drainage channel called North Grain receives a number of smaller "tributaries" and passes over weathered bed-rock in a south-easterly direction. After heavy rain this watercourse carries a large volume of water causing a certain amount of erosion of its peat banks. Elsewhere little erosion appears to be taking place but peat growth over much of the area seems to have ceased because of considerable drying-out of the surface.

This is not thought to be due to any climatic change but to the regular heather burns and to numbers of drainage channels which tend to discourage Sphagnum but encourage young herbs on which the hill sheep can graze. In this connection, because the field work had to be completed during the lambing season, some restriction in the laying of the transect was encountered. Fortunately the peat which appeared, and later proved, to be the deepest lies on a slope to the north of North Grain in a rather wet area generally avoided by the sheep. By laying the transect roughly at right angles to the stream and against a steeper part of the slope towards the 1,750 feet contour this deep peat was encountered. In places there is evidence of peat cutting although this has not been carried out recently. Although three Red Grouse nests were found in the course of the work it is not thought that grouse shooting on a large scale is practised here.

(b) Climate

No climatic data specific to the Rookhope Head site is available and, because of the short period covered by the project, no attempt was made to collect any. Instead reference was made to various books dealing with the climate of the North East, in particular to that of the British Association (1949) and the Advanced Atlas by Watson (1968), and from these a good general picture for the area was built up. Although the annual precipitation is very variable it averages between 40 and 60 inches.

This is not particularly high but, since it occurs on between 225 and 250 days of the year, much of the surface of the site tends to remain permanently damp. This condition is helped by the generally low temperatures which for 220 days of the year do not rise above 42°F; there is thus a high precipitation/evaporation ratio which favours the accumulation of peat. Not only is the growing season short but the winters are long and severe with frosts occurring regularly between September and June, being most severe in January, February and particularly March. In addition there may be as many as 60 days between September and June when falls of snow occur with amounts of 2 feet or more occurring in March. The prevailing winds, which come mainly from the west and south-west, give a continual breeziness to this exposed site.

(c) Geology

The whole of this part of western County Durham consists of Lower Carboniferous rocks known as the Bernicia series and these are nowhere overlaid, as in much of the east of the county, by Upper Carboniferous rocks bearing workable coal measures. This Bernicia series consists of up to 120 layers of grits, sandstones, fire clays and limestone with occasional narrow coal seams of no real commercial value. The geology of the area was well known by the lead miners who, long before any scientific survey had been carried out, were familiar with and gave a name to every stratum from millstone grit at the top to the denuded Silurian and Ordivician rocks upon which these Lower Carboniferous strata are resting and which stood out like islands in early carboniferous times. Vertical veins bearing galena, which yield lead together with other associated metals like silver, occur in the Lower Carboniferous rocks. These veins, varying unpredictably in thickness, were formed when molten mineralised solutions, forced from beneath through faults in the carboniferous rocks, crystallised out. Only at one place in the immediate vicinity, White Edge, is the millstone grit, which normally covers Lower Carboniferous rocks or separates them from Upper Carboniferous ones, still present.

(d) Vegetation

The Rookhope Head site, like the whole of upper Rookhope Burn, is treeless and no shrubs appear to grow there either. Vegetationally, apart from the narrow strip with shallow well-drained soil bordering the road, the whole site is a mosaic of dry and wet areas of peat. In the dry areas Calluna vulgaris (Ling) is dominant with the very occasional Erica tetralix (Cross-leaved heather) and Vaccinium myrtillus (Bilberry). In addition, where the Calluna has not recently been burnt, patches of Galium hercynicum (Heath bedstraw) and isolated Alchemilla vulgaris (Lady's mantle) are also to be found. In the wet areas are various species of Cyperaceae, chiefly Eriophorum angustifolium (Common cotton-grass), Carex nigra (Common sedge) and Scirpus caespitosus (Deer's-hair sedge), together with a number of hummock-forming and pool-dwelling species of Sphagnum including Sphagnum rubellum, S. papillosum, S. plumosum, S. cuspidatum and S. tenellum. Towards the county boundary are a number of partly filled peat cuttings where plants like Eriophorum vaginatum (Hare's-tail cotton-grass), Drosera rotundifolia (Common sundew) and Narthecium ossifragum (Bog asphodel) are assured of permanent bog conditions although none of these species appears abundant. Juncus effusus (Common rush) and Festuca rubra (Red fescue) occur frequently in the rather flush conditions which border the North Grain. The dry steep slope down to the road supports a number of heathland grasses like Nardus stricta (Mat grass), Deschampsia flexuosa (Wavy hair-grass), Agrostis tenuis (Fine bent-grass) and Anthoxanthum odoratum (Vernal grass). Juncus squarrosus (Heath rush), Luzula campestris (Field woodrush) and Galium hercynicum (Heath bedstraw) also grow here. At the road's edge are isolated specimens of Cirsium vulgare (Spear thistle), Prunella vulgaris (Self heal) and Bellis perennis (Common daisy). Only one fern, Asplenium lanceolatum (Lanceolate spleenwort), was found; this was growing in the crevice of some exposed rocks near the North Grain.

(e) History

Up to the present time there would appear to have been no prehistoric finds in the vicinity of Rookhope Head *but some interesting discoveries have been made not far away. That Mesolithic people wandered through this part of Durham there is no doubt for their microliths have been found scattered throughout Weardale and at sites as high as Cross Fell. Similar widely dispersed Neolithic remains have been uncovered including a ground basalt axe at Cowshill only 3 miles south-west of Rookhope Head. One of the most interesting Bronze Age discoveries in Britain was made in 1859 at Heathery Burn Cave, 1 mile south of Stanhope. The find consisted of the whole equipment of a, possibly very important, late Bronze Age family who, it is thought, had taken refuge when the invading Iron Age people from the south attacked their tribe, only to be drowned in their sleep when the mountain stream outside their cave rose suddenly in the night. Collectively this sizeable assembly of largely metal objects was very illuminating. It showed that this tribe had not only discovered how to smelt metal and then to work it into useful objects but that they had also domesticated horses, used wheeled vehicles and employed a light plough. During the Romano-British/ Iron Age period the picture is less clear. Before the Romans arrived it is known that what is now Durham County was within the area controlled by the powerful and largely pastoral Brigantee tribe. The centre of this culture was in the North Riding of Yorkshire which was later described by Tacitus as "the most populous state" in the whole of Britain. Narrow valleys like Rookhope*

Burn were probably of less use than the more extensive lowland sites where they felled forests to provide grazing for sheep, cattle and ponies. The effect of the Romans on the immediate area from the time Agricola invaded Durham in A.D. 77 until, as a result of increasingly fierce attacks by the Picts, Scots and Saxons, the last of the Roman armies withdrew in about A.D. 388, is virtually unknown. It is said that a ditch and fortified rampart called Scots Dyke, extending from near the head of the Wear to the Tees near Gainford, was constructed by the retreating Brigantees in a vain attempt to halt the Roman advance. The main roads built by the Romans were some 18 miles to the east, linking the permanent military forts at Piercebridge, Binchester, Lanchester and Ebchester, and over 20 miles to the south, from Binchester south-west to Bowes and thence westwards across the Pennines. It is not known whether any of the offshoots or vicinal ways penetrated valleys like that of the Wear but it seems quite likely for not only have Roman coins been found throughout the valley but two Roman altars have been discovered, the one on Bollihope Common and the other at Eastgate. Excavation of a Roman fort at South Shields revealed dozens of granaries and it seems likely that they cleared large areas of forest growing on the lighter soils surrounding the forts in order to grow corn. They would also have encouraged the Britons to do the same on the slopes above the settlements in the forest-choked valleys. It is also thought that the Romans used lead ores and it is possible, although there is no evidence to support this theory, that small scale exploitation of lead-rich valleys like Rookhope Burn began during this period. After the departure of the Romans the people of the North East, whether semi-Romanised or primitive Celtic, confronted by raiders on all sides, scattered. This would have resulted in a reduction in the intensity of cultivation as people returned to a pastoral living and, where grazing pressures permitted, much of the land would have returned slowly to scrub and some sort of forest by a succession of plant communities. Very little is known of the period following the departure of the Romans but it seems very unlikely that the inhabitants of Rookhope Burn, or indeed of any other valley, escaped the ravages of the "Yellow Plague" which for 20 years from 664 visited and revisited the whole of Northumbria. Only 1 in 30 of those infected recovered and whole districts were depopulated. As a result many who had by then been converted to Christianity returned to idolatry. By the early 11th century it is believed that there were still only just over one million people in the whole of Britain, most of them living in small villages and hamlets. Land to the north of the Tees was neither shired nor divided into hundreds and the open system of agriculture would seem to have altered little during the previous 700 years. In the vicinity of most villages there was a good deal of "waste" land including rough pasture for sheep and cattle, plentiful woodland which provided timber for buildings and for fuel and, on high ground, moorland with unworkable peat bogs. The only fences were temporary ones, erected to exclude animals from ploughed areas. Rookhope, if it existed then, could easily have been such a village. The punitive devastation and laying waste of land which followed the burning to death in Durham of the Norman "Earl of Northumbria beyond Tees" probably passed Rookhope by but to what extent it was affected by the feudal repression which followed is not known. It seems fairly certain that it did not escape the ravages of the plague which returned early in the 14th century. In the middle of the 17th century land began to be enclosed by stone walls or, where these could be grown, by hedges. These enclosures, which were aimed at more complete and efficient land use, were enforced by Act of Parliament and included much land previously known as "wastes". By 1810 a quarter of a million acres of waste land in Durham and Northumberland had been enclosed. This included "50,000 acres of a great common in Hexhamshire and Allendale", north and west of Rookhope Head. Many trees on these wastes would have been felled and, although much of this land was used as pasture, some was apparently ploughed and cultivated at least for a while. The first documents referring to lead mining in the Weardale valleys date to the 12th and 13th centuries but for 300 years after that mining activity was small. Sometimes lead-bearing seams were exposed by a process known as hushing when water in a dammed stream was suddenly released and, so great was the flow, the worthless superficial layers were removed. A large man-made reservoir, Corbitmere Dam, is situated beneath the stone farm-house at Rookhope Head. A network of channels have been constructed to direct water falling on the surrounding high ground into it. It was probably once equipped with a sluice gate, now missing, which enabled water to be released for hushing and perhaps for washing the crushed ore further down the valley. In the Burn there are also many old levels driven horizontally into the hillsides to reach the lead which used to be brought out in wooden trucks running along wooden rails. In addition to the hushes and levels countless shafts and spoil heaps also bear witness to the activity of these lead miners particularly since the early 17th century when the reverberating furnace for smelting and refining was invented. This resulted in a rapid expansion of the industry with silver also being extracted from the lead ore. A peak was reached in 1860 by which time a horizontal chimney had been constructed from the Rookhope Smelt Mill on to Redburn Common 1½ miles away. This chimney, and a similar one at Allendale, was constructed, not only to carry away the poisonous gases and the smoke from the burning wood or, when available, coal used for smelting, but also to enable later collection of metals which had escaped and condensed in it. Although from the mid 19th century lead mining declined rapidly the main

Rookhope mine was modernised and remained profitable until the end of the century. More recently it has been acquired by Imperial Chemical Industries who are extracting fluorspar. In 1821 during the expansion of lead mining in the area Mackenzie and Ross (1834) state that there were 7,341 people comprising 1,337 families living in the parish of Stanhope, which included Rookhope, and of these close on 1,000 families obtained a living from lead mining and 155 from agriculture. At about the same time Leland says much of the area (Stanhope) "be not very fertile in corne, yet ys there very fine gresse in the dale selfe". He goes on to mention the scarcity of trees, except near the stream, and the cheerless hills supporting a coarse reedy vegetation affording subsistence for a few sheep. The scene would seem to be similar to much of Rookhope Burn today with dry stone walls to the enclosures and nowhere a hedge to be seen. At that time there were 13 farms, probably including one at Rookhope Head, and 3 corn mills in the area covered by Eastgate, Westgate and Rookhope. The advent of the railway during the mid 19th century placed further demands on Rookhope Burn although these were far less than in the main valley. From that time large quantities of limestone were taken to the blast furnaces of Consett and Middlesbrough. A small number of disused quarries show that Rookhope Burn was to some extent exploited in this way.

FIELD WORK

(a) Transect

When the preliminary survey had been completed a transect was staked out across the small stream called North Grain (see 6" map). The first stake (+1) was pushed into the peat on the higher side of the stream and from that point a tape was used to measure 10 metres, at which point another stake (+2) was inserted. The next stake (+3) was placed 10 metres from the previous stake and, using the eye, it was lined up with the first two. The same procedure was adopted for all the other stakes on the higher side of the stream, the last stake (+50) being placed at a point 15·3 metres from a ditch which ran along the northern edge of the site and which formed the Durham/Northumberland boundary. Since a Red Grouse was nesting where stake +49 would normally have been positioned a 20 metre interval was left between +48 and +49. So that the transect could later be drawn accurately on a 6" map of the area a compass reading (173°) was taken along the line of stakes from the boundary, and the tape was used to measure the distance along the boundary in a westward direction to a point (299 m) where it turned sharply towards the south. Meanwhile a helper was positioning stakes on the lower side of the stream (-1 to -25) but since only one tape was available the intervals between the stakes were measured by pacing, the intention being to check the distances during the subsequent levelling operation. Again the presence of a Red

Grouse's nest necessitated a 20 metre interval, this time between stakes -6 and -7. Because stake -11 was at the head of an erosion channel which ran towards the road, and which exactly followed the line of the transect, the remaining stakes were aligned so that they ran in the same direction as the main part of the transect, and therefore parallel to it, but 3 metres to the side. For this operation and for the positioning of all the remaining stakes the tape was used. When the transect was complete other compass readings were taken from stake -25 along the line of stakes (350°), on the Groove Rake Mine (126°), and on the deserted farm-house at Rookhope Head (234°). A discrepancy of 3° was noted between the reading along the transect from +50 and that from -25. This was traced to stake +1 from which point the transect had been laid in opposite directions simultaneously. It would appear that this had resulted in each section of the transect, although straight in itself, being at a 3° angle to the other.

(b) <u>Levelling</u>

To measure the changes in level from stake to stake along the whole transect an automatic leveller was used. Basically this consisted of a tripod equipped with a circular spirit level incorporating a telescope with three horizontal graticules. Starting at the end of the transect stake +50 was removed and the tripod placed exactly over the hole. The telescope was then adjusted until level and the distance between the ground level and the eye-piece was measured. A helper then held a 2 metre pole, calibrated in centimetres, vertically against stake +49 while it was viewed through the telescope and the height of the pole corresponding to each of the three telescope graticules was noted. The helper then held the pole erect against stake +48 while a further set of readings were taken from +50. This was repeated for other stakes until the distances between telescope and pole became too great so that slight movements of the pole in the wind were magnified by the telescope making accurate readings impossible. The stake which had been removed was then replaced and the tripod set up as before at the stake (+44) immediately before the one (+43) where the helper was standing. From that point it was possible to obtain graticule readings for a further batch of stakes before the tripod again had to be resited. This operation was repeated until from stake -18 the slope of the land increased appreciably so that in attempting to view the pole when more than 10 metres away the graticules were above the level of the top of the pole even though it could be extended; it was therefore necessary to set up the tripod at each of the remaining stakes in turn. Later by comparing the middle graticule reading with the height of the telescope above the ground when that reading was taken the change in ground level between tripod and the appropriate stake was calculated. Similarly for any stake the number obtained by deducting the lower from the upper graticule reading was the distance in metres from the telescope to that stake. Although the latter operation was only necessary for stakes +1 to -11, the tape having been used when positioning the rest, later examination of the figures revealed larger differences between estimated (paced) and calculated distances than could reasonably be accepted. It was felt that this was attributable in part to the extremely strong wind which was blowing while this work was being carried out. The stakes had however appeared to be equally spaced and, since the length of the whole transect when drawn and then measured on the map (772 m) only differed in length by 12 metres (a 1·6% discrepancy) from the total length of the transect where 10 metre (and 2 X 20 m) intervals were assumed throughout, it was not considered necessary to revisit the site to repeat the work. The relevant figures are given in the appendix.

(c) Sampling

Initially sampling was carried out to ascertain the stratigraphy and the depth of the peat at every fourth stake (i.e. at 40 m intervals) for the whole length of the transect. Later intermediate samplings were made wherever a sudden change in the stratigraphy or depth of the peat had been noted. The Hiller sampler used for this purpose was pushed alternately into two separate holes on either side of the stake. In this way consecutive samples were not taken from the same hole and the chances of contamination of a sample were minimised. The stratigraphy of each sample was noted, a steel tape being used for the measurements, and the sampler was cleaned before reuse; humification was assessed according to the Von Post scale. When, near the bottom, the peat became too stiff for the Hiller, or when the sampler reached the underlying rock, a sample of the remaining deposit was obtained by pushing down an auger to the lowest level of the last sample taken and then turning it until the rock was reached. The auger was then pulled up and a sample from its centre was examined. It was possible to use this information together with that previously obtained to construct a profile (see diagram) which showed clearly the relationship between the surface topography, the depth of the peat and the rocky substratum. Because of the considerable length of the transect (760 m), and the large change in level (32·16 m) between its extremities when compared with the deepest peat found (4·33 m), it was not possible to construct a realistic profile which also showed the stratigraphy. The stratigraphy was therefore shown separately as a series of columns on a much larger scale but suspended beneath the appropriate part of a line, on the same scale as the profile, representing the peat surface. Dotted lines were used to join the bases and other comparable parts of adjacent columns to give some indication of the possible origin and development of peat but in no way to indicate actual changes in level. It was decided for the purpose of pollen analysis to obtain a complete core from the deepest peat discovered since, although had time permitted further transects in the form of a grid across the blanket bog might possibly have revealed slightly deeper and older deposits, for the purpose of this investigation it would provide a reliable indication of the age of the deposit and of the vegetational history of the area. Accordingly a point about 2 metres from the upper side of stake +17 was chosen to avoid the trampling, disturbance and possible contamination caused by the earlier sampling at +17. This proved to be a fortunate choice since here the depth of the peat (432 cm) was greater than had previously been found. A Russian sampler was used in a similar way to the Hiller to obtain the core, each labelled 50 centimetre sample being quickly and carefully transferred to a length of half-round plastic guttering which was immediately sealed in a polythene bag. Between samplings the whole of the chamber of the sampler was thoroughly cleaned using a fresh paper towel. Finally two bottom samples were obtained using the auger as previously described.

LABORATORY WORK

(a) Preparatory Work

One object of this project was to obtain evidence of forest clearance and land usage in the area and, in this connection, it was thought that detailed study of the top half of the deposit would prove most profitable, the remainder of the core being used to establish the age of the deposit and the early vegetational development before extensive human interference began. With this in mind the first 200 cm were cut up into 1 cm lengths and, from the remainder, 1 cm lengths were taken at 8 cm intervals. To accomplish this first a pen-knife and then a single-edged razor blade were used but much of the peat was so loosely packed and unhumified that neither blade did much more than crush and tear it. In an attempt to overcome this a pair of sharp dissecting scissors were introduced and these proved to be ideal since, by moving in opposite directions, the blades not only cut the peat but kept it steady. To reduce the risk of cross contamination which would have seriously reduced the value of the work all cutting surfaces were wiped clean with a fresh paper tissue between each cut. As each centimetre was separated from the main part of the sample it was removed and held lightly between the fingers while the whole of its outer surface, which had been in contact with the chamber of the sampler and was therefore probably contaminated, was carefully cut away and discarded. That which remained was then placed in a small labelled glass tube with an airtight, clip-on, polythene cap. Before touching the next sample care was taken to ensure that the fingers were clean. The small tubes and the remainder of the 50 cm samples were then set aside in a cool place away from the sunlight until needed.

(b) Pollen Extraction

One centimetre samples were processed in batches of 4, one half of each sample being retained in its tube in case a repeat was made necessary by the loss of the other half during the extraction process. In the first instance samples 128 cm apart were taken but subsequently those at 64 cm, 32 cm and 16 cm intervals were processed; in addition it had been hoped to include selected intermediate samples (i.e. at 8 cm intervals) but the limited time prevented this. Particular care was taken throughout to avoid cross contamination, and to minimise the risk of other contamination by thoroughly cleansing apparatus before use and by covering samples which were awaiting treatment. From the various methods of pollen extraction available that described by Faegri (1953), and outlined below, was used. For the first stage in the extraction process each sample was broken down for from 5 to 10 minutes in a 10% solution of sodium hydroxide. Large fragments were then removed by passing the sample through a sieve from which they were transferred to a labelled Petri dish to await later examination. Meanwhile the filtrate (i.e. micro-debris in

10% sodium hydroxide solution), which had been collected in the tube, was centrifuged and, when the supernatant had been discarded, the contents of the tube were washed in distilled water and centrifuged again. When the supernatant had again been discarded the sample was ready for acetolysis by which the bulk of the debris, mainly cellulose, was substantially reduced. First, to remove any water present, the sample was washed in glacial acetic acid and, after centrifuging, the supernatant was discarded. A mixture of 10 cc acetic anhydride and 1 cc concentrated sulphuric acid was then added and the sample heated in boiling water in a water bath for 1 minute. After centrifuging and discarding the supernatant the tube's contents were, as before, washed firstly in glacial acetic acid and then in distilled water. The latter was gently heated and a few drops of sodium hydroxide were added to assist subsequent staining. After the last centrifuging and the discarding of the supernatant the tube was left inverted to allow water to drain away. Additionally a piece of paper tissue was used to wipe dry as much of the inside of the tube as possible. When this had been done a small amount of melted glycerine jelly containing safranin was added to the sample which was stirred with a teat pipette. After thorough mixing the pipette was used to transfer one drop on to a clean microscope slide and a cover slip was added. Initially four slides were made for each sample but this often proved insufficient because of the scarcity of the pollen and as many as nine slides had to be prepared for one level. The slides were labelled and set aside for counting. Hydrofluoric acid treatment, as described by Faegri and Iversen (1964), was only necessary for the bottom two samples where significant amounts of sand (silica) were present. Unfortunately the lower of these two samples was lost by the breaking of a centrifuge tube during the extraction process and because neither of these bottom samples had been large it had not been possible to halve them to provide a reserve sample for such an eventuality.

(c) Counting

A binocular microscope with X 7 eye-pieces, X 40 (0·65 mm) objective and vernier stage was used for counting. When necessary closer examination of pollen grains was carried out with a X 100 (1·30 mm) oil immersion objective. The pollen although sparse was generally in good condition but the presence of a large quantity of micro-debris not only made the work of counting time-consuming but also more than usually fatiguing because sufficient grains were partly hidden by debris to necessitate quite frequent use of the oil immersion lens. As a result it proved impossible to complete the counting of the majority of the slides in less than 1½ hours and some took considerably longer. Grains which were badly damaged, distorted, or hidden from view to a sufficient extent to make identification at best uncertain, were ignored. Where more than one half of a grain was present and it could be safely identified it was included in the count. Cereals were differentiated from grasses on the basis of size, grains greater than 40 μ in length, where the average size of Corylus grains on that slide was 25 μ, being classed as cereals. They were measured by substituting another X 7 eyepiece containing a graticule the calibrations on which were compared with a 1 mm length engraved in hundredths on a blank slide. Frequent reference was made to a herbarium collection and to the pollen key of Faegri and Iversen (1964). A second opinion by an experienced palynologist was sought in the case of difficult grains, the position of each having been noted by recording the horizontal and vertical reading on the stage vernier. Square 22 mm cover slips were used and vertical traverses were made at 1 mm intervals. Since the field of view, estimated using the graticule, was 288 μ slightly under 29% of each slide was counted. Counting was continued until either 150 trees or a total of 500 pollen grains (excluding spores) had been counted. Numbers were expressed as percentages of total tree pollen and presented in the form of pollen diagrams.

DISCUSSION

Radio-carbon dating methods were not employed and an attempt was made to establish chronologically a vegetational history of the area based mainly on the results of pollen analysis and using the zonation scheme devised by Godwin (1956). Where possible study of the stratigraphy and macro-remains was used to confirm or supplement the information already obtained.

(a) Stratigraphy

Unfortunately the stratigraphy was generally poor with few clearly defined horizons and a number of places where different sorts of peat merged gradually and unobtrusively with one another. This was no doubt because growth had, in the main, been rapid and more or less continuous. It was however possible to divide the deposit into a lower highly humified peat and an upper one which was less well humified. The horizon separating them (260 cm), which was fairly sharp, was tentatively identified with the climatic deterioration which took place between the Sub-Boreal and Sub-Atlantic period and is believed to have occurred at about 500 B.C. In addition, as is explained in the discussion of the pollen analysis, what appeared to be a fairly sharp elm decline (377 cm) enabled the lower humified peat to be subdivided into Atlantic at the base and Sub-Boreal overlying it. The rate of peat accumulation during the cool wet Sub-Atlantic has been rapid, particularly from the middle of this period, which is represented by almost fresh Sphagnum peat, until relatively recently when probably burning and draining have caused considerable drying out of the surface in some places. On average growth during the whole of the Sub-Atlantic has been at a rate of 1 cm every $9\frac{1}{2}$ years but it is thought that in places this rate was greatly exceeded. By contrast during the warm dry Sub-Boreal peat accumulated slowly and, it would appear, at a fairly uniform rate. This has been calculated at 1 cm every 20 years, Because this Sub-Boreal peat and the Atlantic peat beneath it appeared to be equally highly humified it seems probable that each was formed at about the same rate. If this assumption is correct then the first 56 cm of the deposit represents roughly 1,100 years of growth from which it can be concluded that it began to form at about 4,100 B.C. This compares favourably with the findings of Conway (1954) and Tallis (1964) in respect of a number of upland sites in the Southern Pennines, and those of Johnson and Dunham (1963) for Moor House.

(b) Pollen Analysis

As previously mentioned pollen analysis showed a marked Primary Elm Decline (377 cm) and it was decided that the peat below this pollen horizon had been formed between roughly 4,100 and 3,000 B.C. Although, as already described, the bottom sample was lost during extraction, further reference to the pollen analysis showed that the sample taken 8 cm from the bottom yielded a higher pollen count for Alnus and lower ones for Pinus and Betula than would be expected near the Boreal Atlantic

Transition. This would seem to confirm the age previously suggested for the deposit.

It would appear that, at the time when the deposit began to form, the area was covered by three distinct types of vegetation. Firstly, possibly along the margins of a natural drainage channel in the region of stakes +18 to +13, there would appear to have been the beginnings of a bog with Calluna growing on the drier parts, Sphagnum where it was very wet and, in the intermediate areas, Eriophorum. It was apparently here, in this small community, that peat began to form very slowly. The second type of vegetation, probably covering a very large area around the bog, was a fairly continuous mixed-oak forest (Quercetum mixtum) containing a high proportion of Alnus and the occasional Salix indicating extensive wet areas, and significant numbers of Ulmus and the odd Tilia suggesting areas of base-rich soil. The few remaining Betula and Pinus were probably growing on areas of dry shallow soil. Not only pollen but also twigs and leaves from many of these trees would have fallen or have been blown on to the peat bog to be incorporated into its structure. A third type of vegetation was probably to be found where, in the warm wet climate (climatic optimum), it was too wet to enable trees to regenerate but where peat had not yet started to accumulate. This vegetation appears to have consisted mainly of grasses, possibly including Phragmites which thrives in wet conditions, and Ranunculaceae. It is not known where the Rosaceae and Potentilla were growing but, since both increased greatly after the elm decline, they may have been growing among the trees wherever there was sufficient light. At that time, the latter part of the Mesolithic period, although the odd Plantago, Rumex, and Pteridium occurred, there is no real sign of human interference.

As the end of the Atlantic period approached it may well have become slightly less wet. Regeneration of trees in areas which had previously been too wet would then have been possible. This would certainly explain the increase of trees and decrease of grasses just before the elm decline.

While this deposit (B - see profile) began to form in the region of stakes +18 to +13 it would appear that a moderately humified Sphagnum peat was accumulating, perhaps more rapidly, in a poorly drained and shallow depression extending northwards from stake +41. Further pollen analysis would be needed to confirm this but it must surely be significant that both deposits (B and C) are overlain by the same apparently continuous layer of highly humified Sphagnum, Eriophorum and Calluna peat (D).

After the elm decline the herb pollen increased. Nomadic Mesolithic people are normally associated with this phenomenon and various archaeological finds show that they were nearby. They probably wandered through the forest gathering the leafy branches of elm, and possibly oak, with which to feed their cattle and, in so doing, they would have allowed more light to reach the forest floor. This apparently allowed the Potentilla and Rosaceae to increase and Melampyrum pratense (Cow wheat) and the light-demanding Fraxinus to become established. As this interference diminished the forest once again closed in. Ulmus partly recovered and all the herbaceous plants decreased. Pollen analysis might well show that the boundary between peat C and D is a stratigraphic representation of the Primary Elm Decline but no comparable boundary was found elsewhere.

During the Sub-Boreal increased amounts of Calluna, Cyperaceae and Sphagnum, and the appearance of Ericales, suggest that bog conditions were spreading and in many places tree regeneration was not possible but only in the latter half of this period is there any suggestion of human interference. At 304 cm pollen analysis shows a decrease in Quercus, Corylus and Ulmus and an increase in Betula and Fraxinus. At the same level there is an increase in Gramineae and Pteridium and a reappearance of Rumex. This could possibly mark the recovery stages after a temporary "Landnam" clearance, most of the smaller herbs having already disappeared as Pteridium and the pioneer trees, Betula and Fraxinus, increased. Clearly a number of intermediate samples would need to be analysed before this could be confirmed but Neolithic remains have been found not far away. Certainly Quercus, Corylus and Ulmus would all be slower to recover after such a clearance. Actually Ulmus never regained its former position which was occupied henchforth by Fraxinus. This thus marks a secondary elm decline.

Further analysis (272 cm) of this Sub-Boreal peat shows that the recovery of the forest after this possible clearance was only partial and, in all probability, it was interupted by the arrival of Bronze Age people who are known to have been in the vicinity. It would seem that they felled trees but, rather surprisingly, these appear to have been mainly Alnus and Fraxinus. Although the latter is associated with a good soil the former is a tree of wet places and it must be assumed that the settlers had selected a sheltered hollow in preference to a site which was drier but more exposed. Pinus also decreased at that time and numbers remained low until relatively recent times. The increase in Plantago, Pteridium and weed species, and the appearance for the first time of cereals, show that, having cleared the trees, these people cultivated the land for which purpose they no doubt used the primitive plough and other implements which they are known to habe had.

Once again human interference decreased possibly because the site which had been chosen proved unsuitable, because Iron Age people came into the area, or, more likely, because of deteriorating climatic conditions. Whatever the reason it would appear that by now (256 cm) bog conditions were widespread with Calluna giving way to Sphagnum as the main peat-forming plant and Quercus to Alnus as the most plentiful tree. The increasing wetness, which these changes suggest, is confirmed by a change in stratigraphy (260 cm) which, it has already been proposed, represents the Sub-Boreal (pollen zone VII b)/ Sub-Atlantic (VIII) boundary and roughly separates the Bronze Age from the Iron Age.

Not far above this horizon further pollen analysis shows (224 cm) what appears to have been another clearance. Plantago, Rumex, Pteridium, Gramineae, Ranunculaceae and Rosaceae all increased and Chenopodiaceae, Cruciferae and Filipendula appeared. These are all plants of more open habitats including those associated with husbandry and cultivation. That extensive deforestation began at about this time is indicated by an increase in the more light-demanding Betula which thereafter is consistently well represented. It is thought that this clearance, coming soon after the beginning of the Sub-Atlantic period, was Romano-British although the exact events leading to it will probably ever remain a mystery. Similar clearances were observed at the Bollihope Common and Steward Shield Meadow sites but there they were revealed by the analysis of pollen from near the base of the deposit which apparently began to form around the Sub-Boreal/Sub-Atlantic boundary. Probably prior to that time rainfall at those lower altitudes had been insufficient to initiate peat growth.

It seems possible that after this 1st century clearance most of the trees left in the immediate vicinity were in the Rookhope Burn since the stratigraphy seems to indicate that by then the Rookhope Head blanket bog was already well developed. In fact the large amount of Calluna, Cyperaceae and Sphagnum together with Ericales and Empetrum suggest that the bog had much the same size and appearance as it has today. During the years which followed, from the Roman occupation until perhaps the 17th century, there appears to have been a slow decrease in all those species which, at the time of the clearance, had increased. It is thought that this may have resulted from a gradual reduction in the intensity of cultivation. Tree numbers remain low throughout that period partly because of the increased size of the bog which was too wet to support them and partly because the rest of the area was probably unfenced and extensively grazed not only by domesticated animals but also by large herds of wild deer which are believed to have lived in the area until relatively recent times. Regeneration of trees was thus discouraged.

After a considerable time a sharp increase in Gramineae, Plantago, Rumex, Pteridium and weed species again occurred (80 cm) and this is represented by two overlapping peaks in the pollen diagrams. Two more or less coincident developments are believed to be responsible. Firstly, from the early 17th century and particularly for the next 150 years, great areas of land were enclosed for permanent pasture, and for cultivation, with the consequent felling of trees many of which would no doubt also have been used for farm buildings, fences and woodland industry. Quercus and Alnus mainly suffered but the more open habitat seems to have favoured the shorter-lived and more quickly established Betula. Later, as many of these areas became unprofitable, they were abandoned, a situation particularly favouring Fraxinus which greatly increased. Secondly, from about the same time, lead mining in the area began to increase, slowly at first but rapidly later, reaching a peak when agriculture had begun to decline. During that time most of the trees appear to have been exploited, no doubt partly as a constructional material and partly as a fuel for smelting, coal being scarce in the area. Probably timber which was straight and strong was most useful and this is why Alnus and Corylus mainly suffered at that time. Many trees would also have been felled merely to allow mining operations to proceed. The increase in Pinus which occurred during this period is thought to indicate the establishment of plantations since the depleted woodlands were no longer able to provide all the timber needed. The 1889 edition of the 6" O.S. map of the area shows quite extensive plantations around Allenheads and similar ones may well have been established very much earlier.

If this chronology is correct then from the 17th century cereal counts seem high, particularly since the point (+17) from which the samples were taken is about 750 m to the north and 1,100 m to the east of the nearest land suitable for cultivation. It may well be that, because the Rookhope Head site is high and exposed, much of the pollen received has travelled a considerable distance as was the case for a large bog described by Tauber (1967). If this is so then the analysis may well be reflecting the vegetational pattern of a wide area against a background of moorland plants. Nevertheless, whether the vegetational pattern is local or regional, it would seem to be consistently pastoral rather than arable. Turner (1964) explained that when total Plantago grains are expressed as a percentage of the sum of Plantago, Compositae, cereals, Cruciferae and Chenopodiaceae grains a high value is considered to indicate pastoral farming and a low one arable farming; only at two levels at Rookhope Head does the value fall below 65%.

Because of the large time interval represented by samples 16 cm apart it is felt that considerable caution must be exercised in the interpretation of the pollen diagrams, and the analysis of many intermediate samples is needed to test the validity of several of the conjectures made in this study.

CONCLUSIONS

1. Peat began to accumulate on the site at about 4,100 B.C. at more or less the same time as it started to form on topographically similar Pennine sites but considerably earlier than on sites at lower altitudes in Upper Weardale.

2. The deepest peat is not on the highest ground showing that topography and altitude operate together in controlling the speed of accumulation which has been most rapid since about 500 B.C.

3. Pollen analysis reveals three major clearances in the area; possibly the first is Romano-British (1st century), the second is connected with the enclosures (from early 17th century), and the third is associated with lead mining (mainly late 18th and most of 19th century).

4. There can be little doubt, in view of all the evidence in the area, that lead mining has played a major role in setting the present day vegetational pattern.

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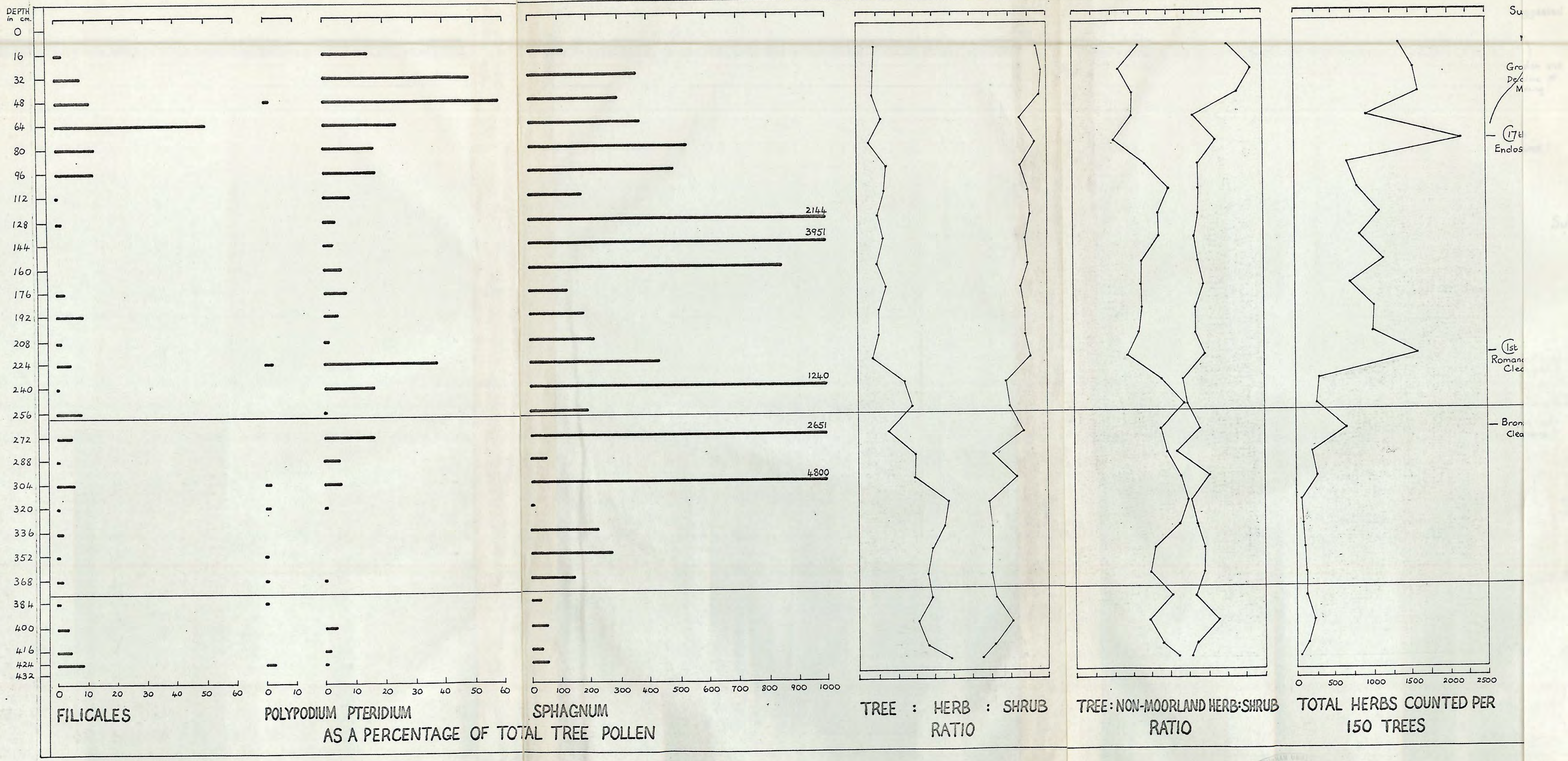
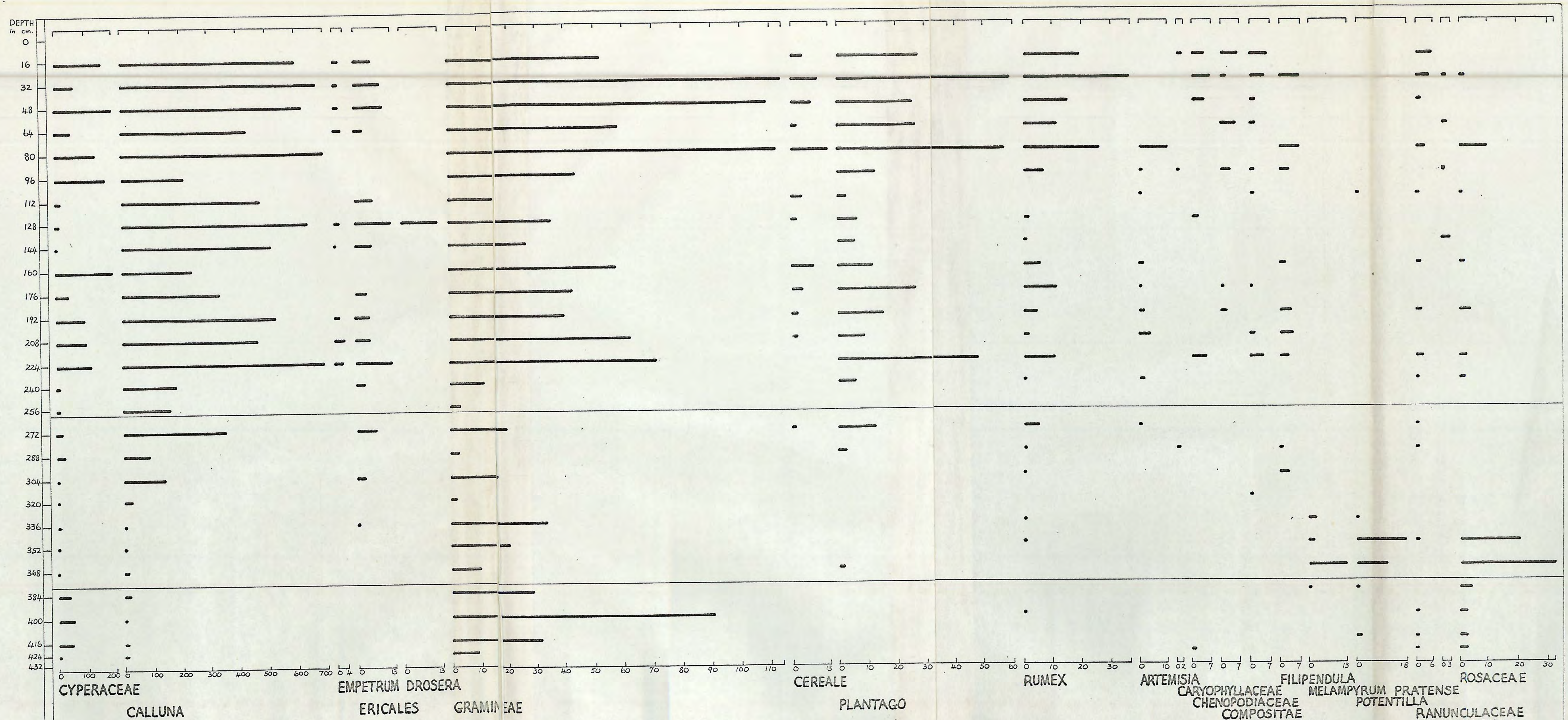
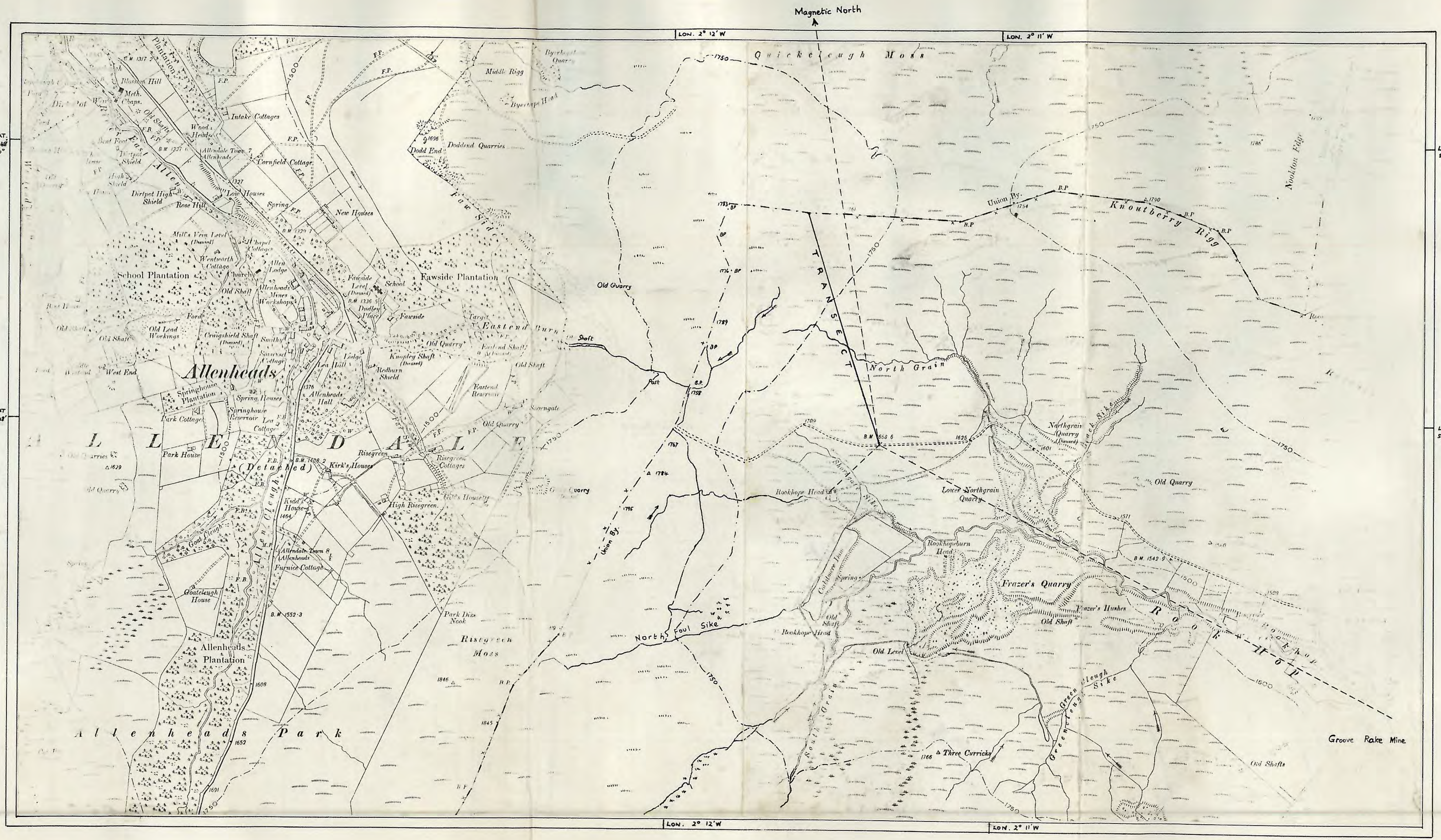
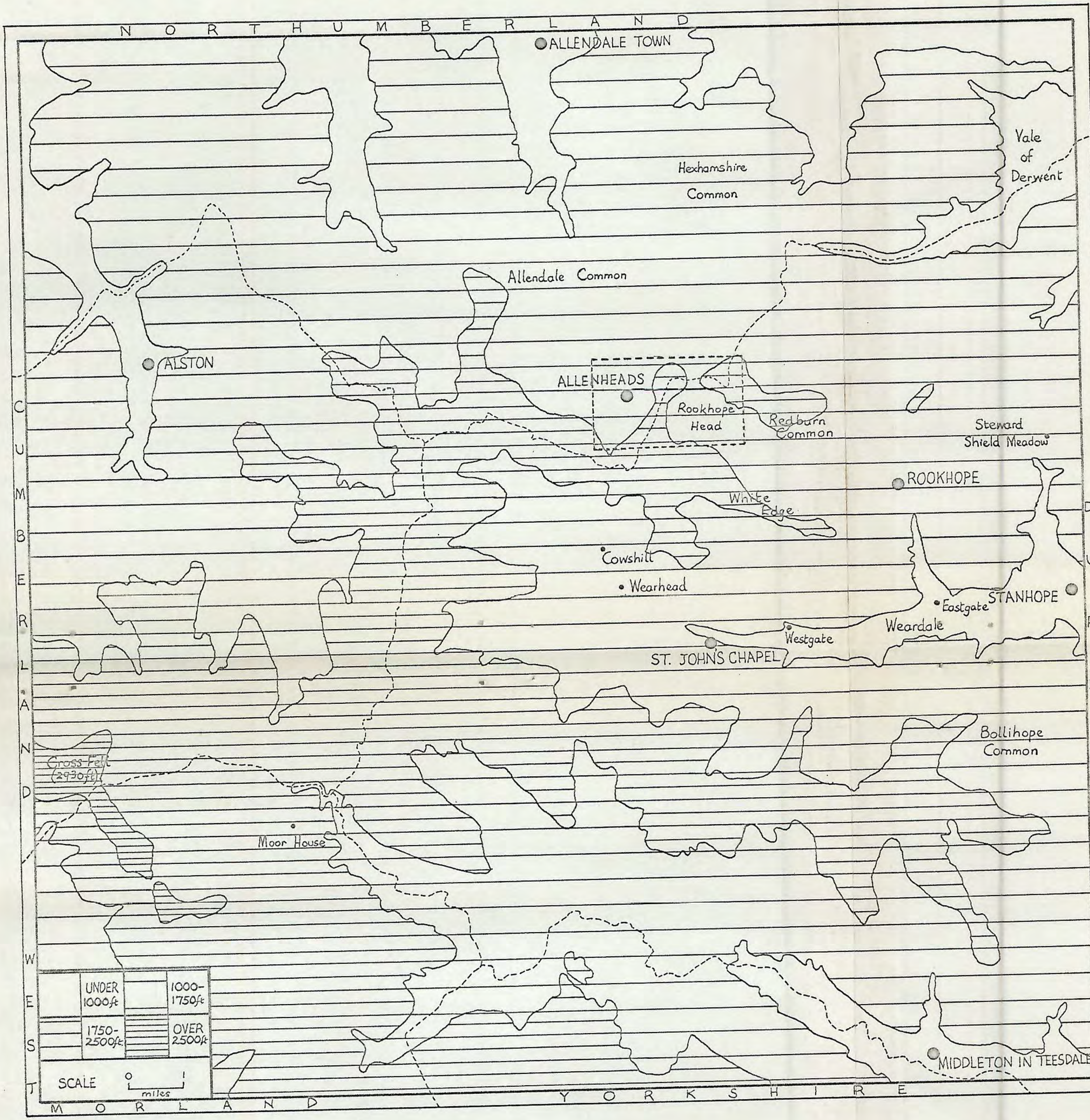

DEPTH in cm.
0
16
32
48
64
80
96
112
128
144
160
176
192
208
224
240
256
272
288
304
320
336
352
368
384
400
416
424
432
2144
3951
1240
2651
4800
0 10 20 30 40 50 60
FILICALES
0 10
0 10 20 30 40 50 60
POLYPODIUM PTERIDIUM
0 100 200 300 400 500 600 700 800 900 1000
SPHAGNUM
AS A PERCENTAGE OF TOTAL TREE POLLEN
TREE : HERB : SHRUB
RATIO
TREE: NON-MOORLAND HERB: SHRUB
RATIO
0 500 1000 1500 2000 2500
TOTAL HERBS COUNTED PER
150 TREES
Su
Gro
De
M
17th
Enclos
1st
Romanc
Clea
Bron
Clea



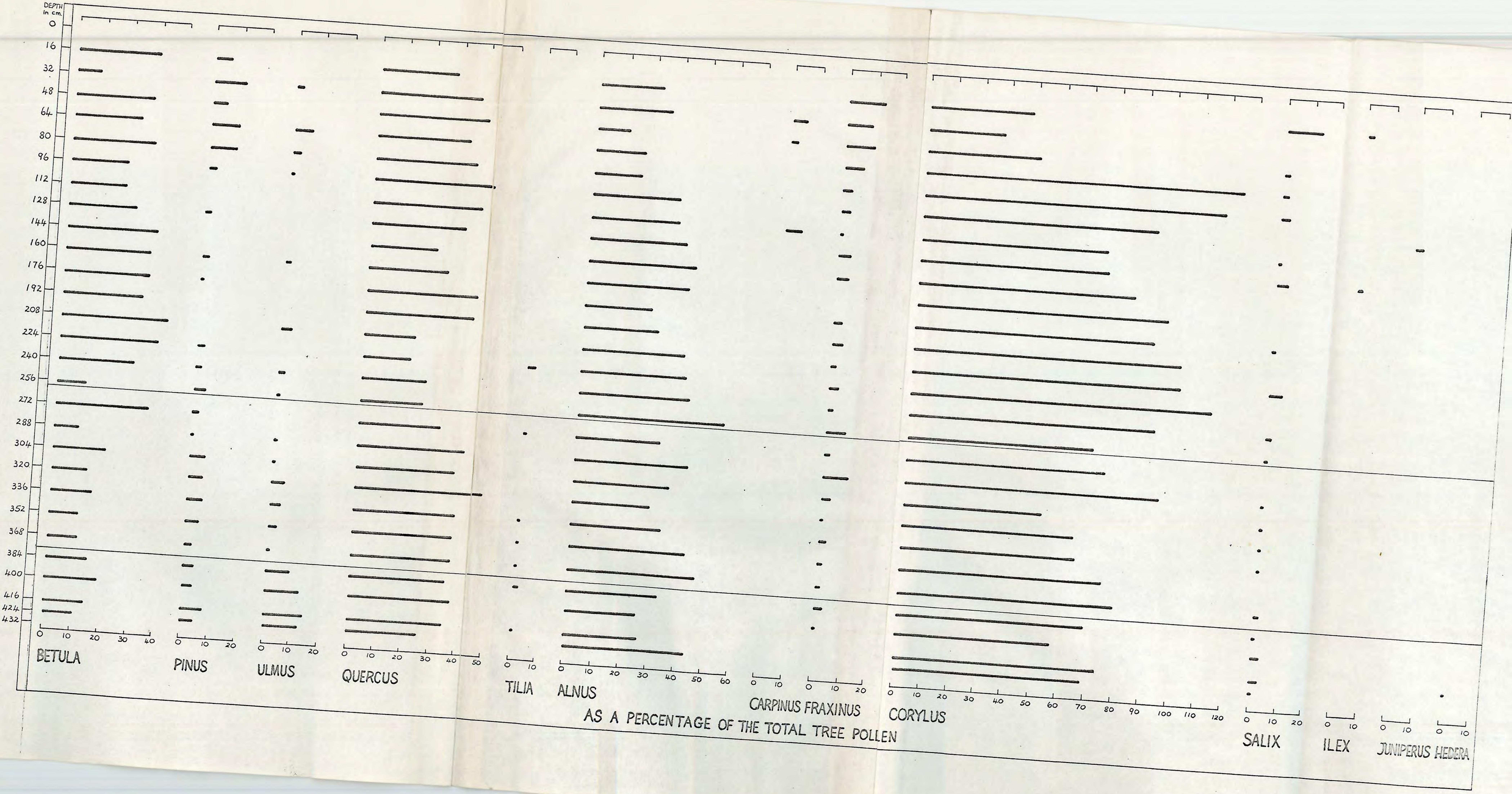
AS A PERCENTAGE OF THE TOTAL TREE POLLEN



Magnetic North
LON. 2° 12' W
LON. 2° 11' W
LAT. 54° 48' 30"
LAT. 54° 48'
Quickcleugh Moss
Knoutberry Rigg
Nookton Edge
Union By.
TRANSECT
North Grain
Old Quarry
Middle Rigg
Byerhope Head
Doddend Quarries
Dodd End
Intake Cottages
Cornfield Cottage
New Houses
Low Houses
Rose Hill
Dirtpot High Shield
School Plantation
Fawside Plantation
Allenheads
Allenheads Hall
Eastend Burn
Eastend Reservoir
Old Shaft
Old Lead Workings
Craigshield Shaft
West End
Springhouse Plantation
Spring Houses
Springhouse Reservoir
Park Cottage
Park House
A L L E N D A L E
(Detached)
Kirk's Houses
Risegreen
Risegreen Cottages
High Risegreen
Goatcleugh House
Furnace Cottage
Allenheads Plantation
Allenheads Park
Park Dike Nook
Risegreen Moss
North Foul Sike
Rookhope Head
Northgrain Quarry
Lower Northgrain Quarry
Rookhopeburn Head
Frazer's Quarry
Frazer's Hushes
Old Level
South Grain
Three Curricks
Greencleugh Sike
Rookhope
Groove Rake Mine
Old Shafts



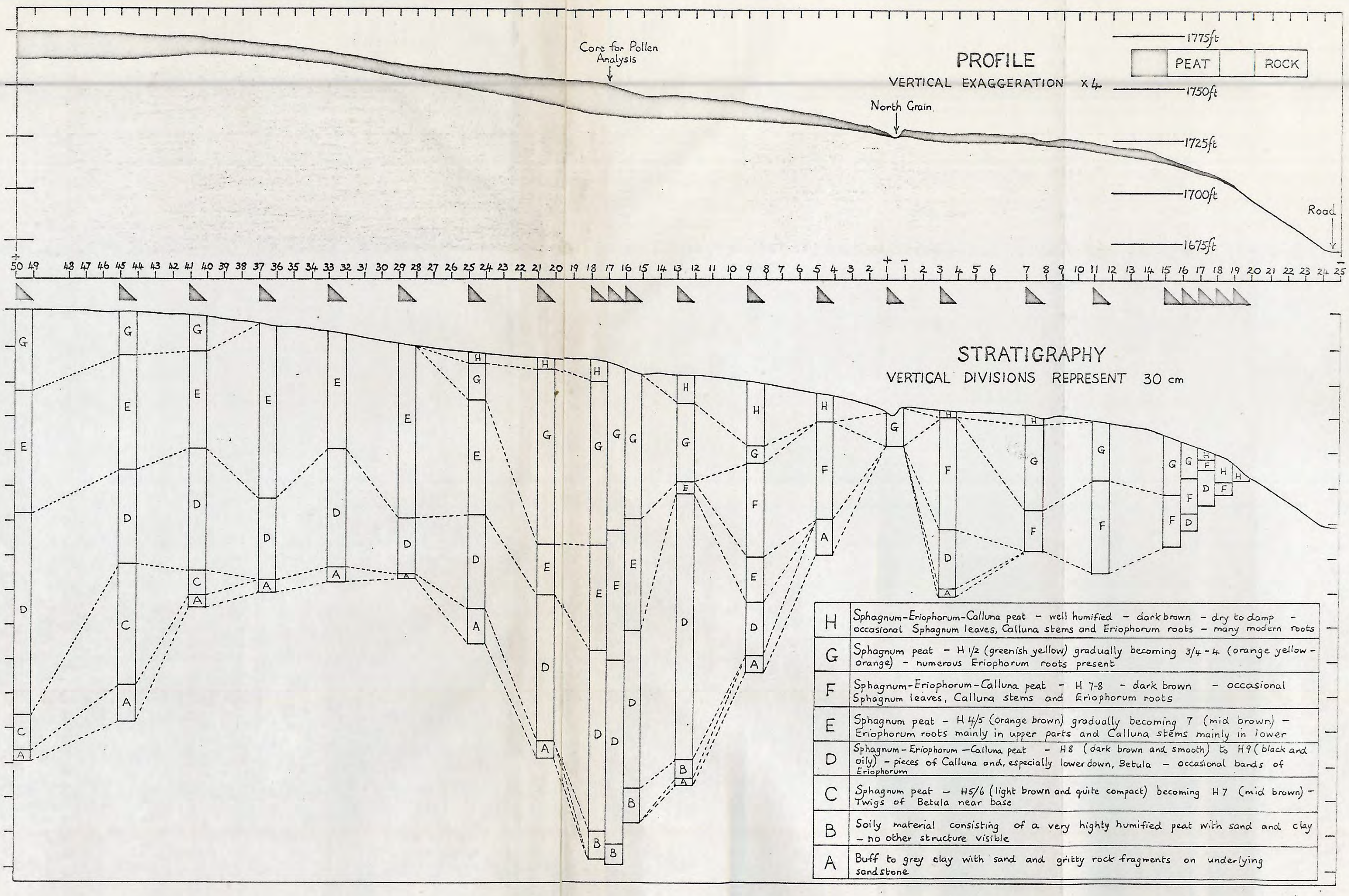
NORTHUMBERLAND
ALLENDALE TOWN
Hexhamshire Common
Vale of Derwent
Allendale Common
ALSTON
ALLENHEADS
Rookhope Head
Redburn Common
Steward Shield Meadow
ROOKHOPE
White Edge
Cowshill
Wearhead
Eastgate
STANHOPE
Weardale
Westgate
ST. JOHNS CHAPEL
CUMBERLAND
DURHAM
Bollihope Common
Cross Fell (2930ft)
Moor House
MIDDLETON IN TEESDALE
WESTMORLAND
YORKSHIRE
UNDER 1000ft
1000-1750ft
1750-2500ft
OVER 2500ft
SCALE
0
1
miles



DEPTH in cm.
0
16
32
48
64
80
96
112
128
144
160
176
192
208
224
240
256
272
288
304
320
336
352
368
384
400
416
424
432
BETULA
PINUS
ULMUS
QUERCUS
TILIA
ALNUS
CARPINUS FRAXINUS
CORYLUS
SALIX
ILEX
JUNIPERUS HEDERA
AS A PERCENTAGE OF THE TOTAL TREE POLLEN

HEIGHT OF TELESCOPE EYE-PIECE ABOVE GROUND LEVEL (m)	STAKES		GRATICULE READINGS ON CALIBRATED POLE			DISTANCE		CHANGE IN GROUND LEVEL	
	FROM	TO	MIDDLE (m)	TOP (m)	BOTTOM (m)	ACCUMULATIVE (m)	BETWEEN ADJACENT STAKES (m)	ACCUMULATIVE (m)	BETWEEN ADJACENT STAKES (cm)
1·46	+50	+49	1·42	–	–	10	10	+0·04	+4
		+48	1·43	–	–	30	20	+0·03	−1
		+47	1·44	–	–	40	10	+0·02	−1
		+46	1·65	–	–	50	10	−0·19	−21
		+45	1·72	–	–	60	10	−0·26	−7
		+44	1·83	–	–	70	10	−0·37	−11
1·18	+44	+43	1·39	–	–	10	10	−0·21	−21
		+42	1·42	–	–	20	10	−0·24	−3
		+41	1·62	–	–	30	10	−0·44	−20
		+40	1·73	–	–	40	10	−0·55	−11
		+39	1·89	–	–	50	10	−0·71	−16
1·30	+39	+38	1·60	–	–	10	10	−0·30	−30
		+37	1·84	–	–	20	10	−0·54	−24
		+36	2·13	–	–	30	10	−0·83	−29
		+35	2·45	–	–	40	10	−1·15	−32
		+34	2·66	–	–	50	10	−1·36	−21
		+33	3·08	–	–	60	10	−1·78	−42
1·36	+33	+32	1·94	–	–	10	10	−0·58	−58
		+31	2·22	–	–	20	10	−0·86	−28
		+30	2·70	–	–	30	10	−1·34	−48
		+29	3·00	–	–	40	10	−1·64	−30
		+28	3·20	–	–	50	10	−1·84	−20
		+27	3·59	–	–	60	10	−2·23	−39
1·42	+27	+26	1·68	–	–	10	10	−0·26	−26
		+25	1·88	–	–	20	10	−0·46	−20
		+24	2·03	–	–	30	10	−0·61	−15
		+23	2·16	–	–	40	10	−0·74	−13
		+22	2·27	–	–	50	10	−0·85	−11
		+21	2·37	–	–	60	10	−0·95	−10
1·41	+21	+20	1·52	–	–	10	10	−0·11	−11
		+19	1·71	–	–	20	10	−0·34	−19
		+18	2·00	–	–	30	10	−0·59	−29
		+17	2·32	–	–	40	10	−0·91	−32
		+16	3·10	–	–	50	10	−1·69	−78
		+15	3·60	–	–	60	10	−2·19	−50
1·37	+15	+14	1·33	–	–	10	10	+0·04	+4
		+13	1·31	–	–	20	10	+0·06	+2
		+12	1·54	–	–	30	10	−0·17	−23
		+11	1·73	–	–	40	10	−0·36	−19
		+10	2·07	–	–	50	10	−0·70	−34
		+9	2·39	–	–	60	10	−1·02	−32
1·30	+9	+8	1·70	–	–	10	10	−0·40	−40
		+7	2·06	–	–	20	10	−0·76	−36
		+6	2·56	–	–	30	10	−1·26	−50
		+5	2·89	–	–	40	10	−1·59	−33
		+4	3·58	–	–	50	10	−2·28	−69
1·34	+4	+3	2·19	–	–	10	10	−0·85	−85
		+2	2·61	–	–	20	10	−1·27	−42
		+1	3·63	–	–	30	10	−2·29	−102
		−1	3·05	3·27	2·76	40 (81)	10 (51)	−1·71	+58
1·35	−1	−2	1·60	1·67	1·57	10 (10)	10 (10)	−0·25	−25
		−3	1·77	1·84	1·60	20 (24)	10 (14)	−0·42	−17
		−4	1·81	1·99	1·63	30 (36)	10 (12)	−0·46	−4
		−5	1·81	2·04	1·62	40 (42)	10 (6)	−0·46	0
		−6	1·93	2·20	1·68	50 (52)	10 (10)	−0·58	−12
		−7	2·22	2·65	1·82	70 (83)	20 (31)	−0·87	−29
1·33	−7	−8	1·95	2·00	1·89	10 (11)	10 (11)	−0·62	−62
		−9	1·61	1·72	1·48	20 (24)	10 (13)	−0·28	+34
		−10	1·97	2·13	1·80	30 (33)	10 (9)	−0·64	−36
		−11	2·22	2·40	1·95	40 (45)	10 (12)	−0·89	−25
1·39	−11	−12	1·76	–	–	10	10	−0·33	−37
		−13	1·94	–	–	20	10	−0·55	−18
		−14	2·40	–	–	30	10	−1·01	−46
		−15	3·30	–	–	40	10	−1·91	−90
1·39	−15	−16	2·32	–	–	10	10	−0·93	−93
		−17	3·25	–	–	20	10	−1·86	−93
		−18	4·44	–	–	30	10	−3·05	−119
1·52	−18	−19	2·98	–	–	10	10	−1·46	−146
1·46	−19	−20	3·57	–	–	10	10	−2·11	−211
1·49	−20	−21	3·42	–	–	10	10	−1·93	−193
1·51	−21	−22	3·53	–	–	10	10	−2·02	−202
1·51	−22	−23	3·44	–	–	10	10	−1·93	−193
1·42	−23	−24	3·75	–	–	10	10	−2·33	−233
		−25	4·17	–	–	20	10	−2·75	−42
	+50	−25				760 (819)		−32·16	

Note: Numbers in brackets are those based on information collected while levelling and later found to be unacceptable – see page 18.



PROFILE
VERTICAL EXAGGERATION x4
PEAT
ROCK
1775ft
1750ft
1725ft
1700ft
1675ft
Core for Pollen Analysis
North Grain
Road
STRATIGRAPHY
VERTICAL DIVISIONS REPRESENT 30 cm
H Sphagnum-Eriophorum-Calluna peat - well humified - dark brown - dry to damp - occasional Sphagnum leaves, Calluna stems and Eriophorum roots - many modern roots
G Sphagnum peat - H 1/2 (greenish yellow) gradually becoming 3/4-4 (orange yellow-orange) - numerous Eriophorum roots present
F Sphagnum-Eriophorum-Calluna peat - H 7-8 - dark brown - occasional Sphagnum leaves, Calluna stems and Eriophorum roots
E Sphagnum peat - H 4/5 (orange brown) gradually becoming 7 (mid brown) - Eriophorum roots mainly in upper parts and Calluna stems mainly in lower
D Sphagnum-Eriophorum-Calluna peat - H8 (dark brown and smooth) to H9 (black and oily) - pieces of Calluna and, especially lower down, Betula - occasional bands of Eriophorum
C Sphagnum peat - H5/6 (light brown and quite compact) becoming H7 (mid brown) - Twigs of Betula near base
B Soily material consisting of a very highly humified peat with sand and clay - no other structure visible
A Buff to grey clay with sand and gritty rock fragments on underlying sandstone