Gwaun Nant Ddu.

A study of an ancient lake site.

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Summary.

Gwaun Nant Ddu is at present a large bog 1400 ft, (420m.) by 650ft. (200m.) and up to at least 43ft. (13m) at the deepest point. It has the characteristics of a lake formed behind a glacial moraine. This sediment has been sampled near one “shore” by taking a core 52” (1.32m) and sampling by taking contiguous 1” (2.54cm.) samples, extracting the pollens (and other things such as protozoa shells, fungal spores etc) and examining under a microscope. The sample was taken to penetrate into the sediment as well as the surface vegetation. In addition to a wide range of pollens typical of now-lost environments there was volcanic fall-out typical of Hekla (or similar) and, in the surface layer, industrial fall-out of fused siliceous particles typical to those produced by high temperature furnaces such as blast furnaces. These undoubtedly came from the early iron industry along the Heads of the valleys area.

Index.

Introduction.

An ancient lake site at 1600ft. (490 metres) in the Brecon Beacons National Park. (SO 087154).

This report will be compiled in such a way as to present the evidence in the most logical fashion. In practice it was not at all like this but involved much back-tracking, re-evaluation and re-testing.

The exercise started as I realise that the area was highly unusual, an awareness which increased as I passed it on many occasions when I walked the area.

Perhaps, strangely, it was not the most obvious feature of the site, that is its large, almost flat area which first caught my attention but that of a small cave (about 12" high by 18" wide - photo I.1) at surface level on the southern side where, after a spell of heavy rain, water was exiting at a substantial rate. I subsequently showed this feature to Bill Gascoigne who who had considerable experience of caves and cave hydrology – much of which he had carried out for Welsh Water – and he recognised that the water was entering a bedding plane and probably emerged in the side of the west end of the Dyffryn Crawnon. The general location of the site is shown in Figure I.1 which taken from the 1:25,00 Ordnance Survey map of the area of the western end of the Dyffryn Crawnon where it is seen enclosed by two streams which merge to become the Nant Ddu.

The second thing which captured my attention was the well known pathway from Pontsticill to Talybont on Usk which passed immediately to the west of the area and on part of which I observed the almost perfect preservation of the metalled surface (Photo. 1.2).

Sitting on the Gwaun Danydarren and reflecting on the area in general it was apparent that there was an extensive flat area (subsequently measured at nearly a quarter of a mile (400m) long and up to 200yards (200m) wide), one end of which was adjacent to the track and the other (eastern) end reaching a cutting dropping into the steep sided Nant Ddu gorge leading to the Dyffryn Crawnon, which can be seen in Photo.I.3 taken from Clo Cadno (SO 113 163). At this point I became seized of the notion that the area might just possibly be that of an ancient lake.

That observation was the start of several years of work which although clearly only scratching the surface (both metaphorically and actually) has, I feel, been sufficient to justify that idea.

It is advised that for a fuller understanding of the area that copies of the Ordnance Survey 1:25,000 maps are obtained. While not essential, those particularly interested in the geology of the area will find the British Geological Survey Abergavenny Sheet No. 232, Solid and Drift Edition, valuable. The hand-drawn sketch maps in this report have included the National Grid so that they can be directly related to the Ordnance Survey maps. In general, six figure references have been used for positions on the open mountain as they were taken with a Magellan GPS of limited precision. Where greater precision was possible eight figure reference are given.

For this version – available on the internet from www.karlmartin.co.uk - the number of illustrations has been drastically reduced but many more are available for those who might be sufficiently interested if they contact me. For similar reasons, appendices are referred to but are not included. These contain more detailed information on individual topics.

Chapter 1.

The water supply for the lake at Gwaun Nant Ddu.

The water supply during the formative and the mature stages of the lake was almost certainly much greater than that seen today as is evidenced by the deep gorge descending into the Dyffryn Crawnon (Photo. 1.10) and by the very considerable size of the lake which, based on the survey covered in Chapter 3, approximates to 1200x400x20ft.= 9.6 million - say 10 million cubic feet (400x200x10m =800,000 cu m). Whether the water flow was high for a lengthy period of time or very high for a shorter period associated with ice melt is not certain but the Old Red Sandstone of the gorge is soft and friable and the capping of Quartz Conglomerate, which seems to form the lake bed although hard, is thin and, once undercut, would easily collapse.

Today a small stream enters the lake from the western end cutting through the track, but only at a time of the heaviest rainfall, and a few small non-constant springs issue near the lake surface level from Bryn Cefnog to the north. Examination of the catchment area, which is now largely covered with blanket bog of up to 6 feet (2m) depth, clearly shows the reason for the failure as, not only is the surface below the peat eroded and fissured, and hence porous, but the lowest line of the catchment area, which is scoured bare in places to show the rounded pebbles of what might have been the once vigorous stream, is interrupted in two places by very large sinkholes (at SO 083 152 and SO 082 149) into which the available water now flows to be lost underground (Photo.1.1 – others in Appendix 1).

The degree of dissolution of the limestone by the peat acids would seem to have been greatly underestimated if recent work is confirmed. Samples of freshly broken dolomite chippings, carefully washed and weighed, were suspended, in a fine nylon bag, in the stream running into the sinkhole at SO 083 152 from February 1995 to August 1998. The pH was measured at 5.5, which is extremely acid and it is well known in the water industry that such peaty water is "aggressive" and needs neutralising by means of lime or limestone beds before passing into the supply system. The weight loss of the sample over the period was 26.76% or 7.6% per year and the chips were visually eroded (Photos. 1.2a and 1.2b) with large quantities of siliceous particles released. This feature can often be seen as an outwash of silver sand from the edge of a bed of blanket peat such as shown in Photo. 1.3. While the effects on massive rock, with a smaller exposed surface, is likely to be less it would seem clear that the dissolution rates are far higher than has been thought with obvious implications for the dating of features such as sinkholes and the structures sometimes found affected by them. It also suggests that , the porosity of the underlying rock will increase with time due to opening up of the natural fissures by such dissolution. It seems to me that a more detailed study is justified. Some further work on this matter was subsequently carried out and is reported in Chapther 4 of "Assorted Archaeology", available on the web-site or from the library at Tredegar of the RCAHMW.

Both of these sinkholes appear to have a moraine bar on the downstream side and might have formed largish pools. This would have added attraction of the area to early occupants. The present rising of the stream is at around SO 082 147 but may once have been uphill of this in the vicinity of a stone scatter. The very extensive quarrying on the high ground above must have had a considerable effect on the water flows in more recent times. It might be observed that this quarry is much larger than it appears to be from a ground view and it is the most visible single feature on a recent satellite photograph of South Wales. Another source, which today swings to the north as the start of the Nant Ychain running down Cwm Callan, may once have joined the Nant Ddu. It is also possible that the ice cap sat on this elevated area to the north and west of the lake site for some period of time and directed the melt water towards the Dyffryn Crawnon which might also help to account for the size of the gorge.

In addition to the greatly reduced inflow of water there are at least five "leakages" from the southern margin seemingly along the plane between the Quartz Conglomerate layer and the Castel Coch limestone and at least one, the one which first drew my attention to the area, is substantial. Four others are shown in appendix 2.

Almost certainly associated with this leakage is a tufa deposit of at least tens of cubic metres on the southern flank of the steep gully down which the Nant Ddu falls (SO 089 154) (Photo 1.4). This could be of considerable interest because of the possibility that calcareous material, usually lost in a highly acidic peat environment, might have been preserved.

Apart from these problems, which have clearly developed after the lake had a considerable period of maturity, the land is believed originally to have been covered with a substantial layer of topsoil bearing far more vegetation, of a much greater diversity, than is found today and this must have provided much greater stability of the water budget.

Chapter 2. The formation of the lake.

The first instinct of some who, when the area was drawn to their attention, was to attribute the feature to a collapse of ground due to dissolution of the underlying limestone. Very large collapses are possible, indeed the Clydach Gorge was believed to have formed in such a fashion. I was not very convinced of this because I knew, from walking up the steep gorge to the east, that any limestone layer beneath the lake had to be very thin as I had observed sandstone to within at least the upper, grass covered, part of the gorge.

The answer lay in consulting the British Geological Survey map of the area (Abergavenny Sheet 232 Solid and Drift Edition) which showed clearly that, although the Castel Coch limestone lay to its north and south, the putative lake lay partially on the Quartz Conglomerate layer and partly on the Plateau Beds, both lying on the Upper Old Red Sandstone of the Devonian. A composite map derived from the 1:25,000 OS map and the geological map (Figure 2.1) shows the relationship of the geological feature to the contours, the old trackways and to the position of the lake site. Neither of these older Devonian rocks are subject to dissolution and so the collapse theory became untenable.

The Quartz Conglomerates are tough and form the characteristic table-top cap to much of the Brecon Beacons and this feature almost certainly had a part to play in the formation of the lake bed which, from results to date appear to have been glacial in origin, the hard rock layer giving rise to the flat or slightly dished area later to become the lake bed and an end moraine forming a dam across the eastern end.

It is postulated that the last glaciation withdrew up the Dyffryn Crawnon, depositing moraines at the upper end of the valley, and finally rested on the lip of the valley, which is approximately 250m higher, at its present position for a sufficiently lengthy period to accumulate a considerable deposit.

Chapter 3. The topography of the lake.

1) The surface features.

The first measurements made were to establish its present size. This was done by means of pegs, the distances were measured with long tape measures and the bearings made with a prismatic bearing compass. The results of this are shown as the solid outline in Figure 3.1.

2) Measuring the depth of the deposit.

Using the surveying pegs as datums it was decided to attempt to measure the depths of the longitudinal axis and three transverse sections. The position of these sections was chosen, hopefully, to give an indication of the shape of the underlying lake bed, in particular a) a "V" shaped cross section which might be interpreted as an extension of the gorge, b) a flat bed co-incident with the underlying hard rocks or c) a depth greater at an intermediate point than at the end, as might be found in a cirque.

Initial soundings were made (in the spring of 1992) with a 2 ft. long "ground prodder" which I had made many years ago when I was searching for lost trackways in another area. This showed clearly that the depth of smooth peaty deposit, before one entered grit or gravel, increased in a regular fashion as I moved towards the east from the immediate edge of the trackway. Measurements with a longer rod showed, typically, a depth of just over 30" at 40 foot (12.1m.) from the edge of the track (marked with a peg for future reference) and 44" at 70 feet (13.3m.). This increase of depth with distance from the track was regular and was consistent with that of a lake shore.

Although this was interesting enough it was far from conclusive and it was clear that far longer sounding rods were needed and that I would also need some help to manipulate them. The work remained in limbo, due to other work in progress, until early in 1994 when I eventually made a set of steel rods, which could joined by means of threaded couplings, which could be extended to 30 feet (10m). I was able to take this step because of the enthusiastic participation of Ken Palmer without whom I would have been unable to carry all the equipment to the area let alone use it. In the event we found that the greatest depth we could probe was about 24 feet (7.3m.), by which point our combined strength was inadequate to proceed further, withdrawing the rods against their weight and an apparently thixotropic clinging of the wet peat being the main problem. Nevertheless, the profiles we have derived seem to give sensible results and fair grounds for making the assumption that the maximum depth of the area could well be in the region of 30 feet (10m) or possibly more.

In practice we have, so far, taken soundings from the trackway toward the eastern end to a distance of 340 feet (approx 100m), at which point we ran out of strength at a depth of 18 feet (5.5m), and a distance of 200 feet (61m) from a peg inserted near the eastern end, immediately before the surface slumps to the stream-bed, in a westerly direction, i.e. towards the trackway, where we reached bottom at 24 feet (7.3m) (Fig. 3.2).

We attempted three transverse sections, two of which we were able to complete and which give sensible profiles (Figure 3.3, Transverse sections 1 and 3), but the third, central, one was impossible to complete as we ran out of strength at 24 feet (7.3m) while only approximately one third of the way from each side. The profile of this section (Figure 3.3, transverse section 2), while incomplete, does give further grounds for believing that the depth equals, and might even exceed, 30 feet (10m).

In order to establish true profiles of the deposits and the lake bed, accurate levels were measured using a "Dumpy" level based on the master western peg. The results of the measurements are incorporated in Figure 3.2 and all depth measurements have been made from the actual surface shown as a dotted line. The true level, which would be that of a lake, is shown broken in Figure 3.2.

Some points on this "shore-line" were pegged and fluorescent orange tape was stretched between them to mark it and, although the photographs are not of the best and it was impossible to avoid a slight sagging of the tape over the long stretch across the eastern end of the lake site where the Nant Ddu drops into the Dyffryn Crawnon, that the volume of water might well have been considerably greater than the original estimates. (Photographs in Appendix 3).

3) Depth measurements using resistivity measurements.

Because of the problems met when attempting physical methods of measuring the depth of the deposits, discussion of the problem with colleagues led to the involvement of Mr. Peter Armitage who had a great deal of experience of geological surveying. Because of his contacts he was able to borrow a ABEM TERRAMETER Type 1370v from Dr. Peter Styals of Liverpool University Earth Sciences Department.

Measurements were made during the summer of 1995 using the apparatus in "drilling" mode. The results were disappointing as it became clear that the high water table gave demonstrably incorrect results.
More details of this work can be found in Appendix 4.

Chapter 4. The lifetime of the lake and its ending.

The nature of the pollens and the micro-flora and fauna found in the uppermost levels of the deposits suggest that the water level must have been similar to that of the existing ground surface at the western end for most of its history, perhaps until comparatively recently. Comparative, that is, to what must have been a very long life to have allowed the formation of such a considerable depth of deposit. On the other hand, the surface level could not have been much higher, at least not for around the last 1500 years because of the presence of the track from Pontsticill to Pen Rhiw calc which runs past its western end (Photo I.2). The age of the track is unknown but the presence of the "Ogham stone" as SO 072 132 (Photo 4.1) attests to its use in the period between 300 AD and 600 AD.

It is clear from the evidence of the water budget already discussed that problems arose at some time in its history but analysis of the deposits suggest a long period as an active lake and also that very little change has taken place in at least the recent past. It is pure speculation at this stage, in the absence of radiocarbon dating, that major changes in the hydrology took place because of environmental changes associated with human exploitation of the environment and/or with known major episodes of climatic deterioration such as Hekla 1, 2, and 3. Both of these factors are believed to be have influenced the stripping of the top-soil and the blanket bog formation but it is probable, that once the peat formed, the high levels of acidity thereby caused (measurements have shown the pH of water at the base of the blanket peat to be below 5.5 and sometimes 5.0) greatly accelerated changes . Once the normal surface water flows ceased the leaching of the limestone, as the water now percolated downwards continually opening up fresh channels and widening existing ones beneath the surface, became an irreversible process and the lake became a fossil. Because of this it is possible that its present condition has been unchanged for perhaps millennia.

It is also clear from the measurements made that the moraine barrier has been breached so that the present stream bed is at around 5m (15ft.) below the one-time surface level. Whether this has been a slow process, one accelerated by loss of tree and shrub cover, which might have bound the soil, or is a fairly recent feature caused by human activity is difficult to decide but there is a track crossing from north to south across the eastern stream-bed. This track, which is shown on the 1:25,000 and on the 6" OS maps, is of unknown use but may be associated with the considerable limestone extraction which has taken place in this area and passage of pack animals through the running stream could have rapidly deepened its bed

Some insight into the fauna of the area in the area in post-glacial times can be gained from the contents of a bone cave at SO 089 138 (another is reported at SO 100 151) where the bones of many mammals such as pine marten, wild boar, deer (uncertain which type), and ancient ox (undefined) can be found. Unfortunately various people have removed bone at one time or another but I do not believe that a proper study has been made. What information I have is in Appendix 12 or Chapter 3 of "Assorted Archaeology".

Chapter 5. Evidence of human habitation in the immediate area.

The general area of the Llangynidr moors show many signs of human activity from Mesolithic to the present day. If this site was once a lake then it could have been of considerable economic and cultural importance and it would be reasonable to expect some signs of human activity.

The first stages of a search for signs of occupation have been started by the simple process walking the area and looking for visible traces. This process has only recently started and the main problems are those caused by natural events such as the climatic deterioration at around the end of the Bronze Age i.e. loss of considerable depths of topsoil, the formation of up to about 6 feet of blanket bog and the many sink-holes which have formed between this time and the present.

Features which have been found are as follows:

1) A cairn with a central cist at approx. SO 082 152.

2) A cairn with central cist on the high ground to the south of the lake site at approx. SO 088 153 n.b. Note the lake site in the background and the northern part (marked on the 1:25,000 O.S. map) of the trackway which crosses the exit end of the lake site.

3) Possible fallen standing stones on each of the prominent points of Gwaun Nant Ddu at approx. SO 088 153 and SO 089 153.

4) Enclosure at SO 090 135.

5) The trackway to the west of the lake site which is very well constructed, as a surface exposure revealed (Figure 5.1), and of some considerable antiquity, as evidenced by the Ogham stone on the track at SO 072 132 (Photo 4.1), proves that the area was adjacent to an old transport system.

6) A flint bladelet of Mesolithic appearance and other flint fragments have been found in a small area some 20m to the west of the track. Some of the fragments were burned but whether this denotes habitation or was caused by natural fire is unknown. The fragment shown in Photo 5.1 has

been described by Elizabeth Walker as "The group contains a bladelet of Mesolithic appearance with the parallel facets on the ventral surface suggestive of its manufacture from a prepared core. There are also three broken flake fragments and a heavily damaged piece which might be natural." Since then further fragments, to date (May 2006) nearly 60 fragments mainly of flint but some of chert, all of which show signs of human action have been found within a few metres of the same area, which is about 20 metres west of the trackway. These have all not been expertly assessed and while none were as well formed as that illustrated in Photo.5.1 others were clearly worn cores and struck flakes. It seems certain that the flint was derived from small pebbles, some heavily corticated, which were deposited locally by the last glaciation .

7) Possible burials of unknown age at SO 076 147.

8) There are many other features in the area which might be man-made but these await expert inspection.

Chapter 6. Microscopic examination of the sediments.

Having considerable past experience in microscopy and, still having a very good instrument in my possession, I determined to take a core sample and see whether it might be possible to find some clues as to its origin and history. I knew that identification of pollens, algal and protozoan remains, phytoliths etc. were widely used in this field and felt that it would be an interesting project.

This work can be conveniently divided into three parts:

1) Taking a core sample.

2) Extracting the pollens and other identifiable remains from the sample.

3) Identifying and interpreting the results.

1) Taking a core sample.

When I started taking a core I had no idea just how deep the sediments were but it was clear that any sample taken had to include both the clay and gravel at the bottom and the layer immediately below the surface grass. As an initial experiment I used a 4 foot length of aluminium down-pipe in which I cut teeth at the lower end and a hole for a transverse steel bar at the upper. I found that this device cut a core quite readily and I only had to add a push rod with which to eject the sample and I could make a start. The cores were ejected into a longitudinally hinged container for transport. Samples were subsequently taken by pushing 1" (2.5cm) sample tubes into the core, each tube immediately adjacent to the next intended to give, ideally, a continuous inch by inch sample along the length of the core - this is the reason why the results were initially taken in inches rather than centimetres. I should make the point here that this method of sampling is not the best as it is possible to get longitudinal contamination - this effect I minimised by scraping away the surface layer in a direction at right angles to that of the core axis before taking the samples.

The first core was the subject of a great deal of experimentation as I had to learn how to extract, stain, mount, identify and photograph the pollens and other features which I was finding and it was not for nearly two years until I felt sufficiently confident to take another core and attempt to analyse it. The full depth of the peat deposits was still unknown at this time but I improved the sampling as far as I was able by making a 6 foot corer with which I was able to take a 52" (1.32m) sample, ensuring that the corer penetrated some inches into the clay bed and also included the topmost layers including the surface vegetation, at a distance of 40 feet (12m) in an easterly direction from a "master" peg in proximity to the edge of the track on the western edge of the site. How representative the results from this are will depend upon the pattern of sedimentation i.e. like that of Longitudinal Section (6.1a) or of Longitudinal Section (6.1b) which illustrates two possible sedimentation patterns. The answer to this will have to wait until deep cores can be taken. Recognition that the core would, because of its proximity to the western shore and subject to inwash and its truncation, be unrepresentative of a full core I have not attempted to produce traditional pollen diagrams but contented myself with more general observations.

2) Extracting the pollens and other identifiable remains from the sample.

A great deal of research both practical and into the available literature was undertaken on the preliminary core and "Textbook of Pollen Analysis" by Faegri and Iversen, "An Illustrated Guide to Pollen Analysis" by Moore and Webb and "Handbook of Palaeontological Techniques" by Kummel and Raup were particularly valuable. From these books and other sources a standardised extraction method was developed as close as possible to the normal method but with periods of settling rather than using a centrifuge. The technique used for all the samples is as follows.

a) Sample size.

This was quite difficult as weights would only be relevant if all samples were carefully desiccated and volumes were also difficult with such compressible material. Eventually I decided, particularly as my approach was to be mainly qualitative, to use a reasonably carefully measured scoopful which approximated to 1 cubic centimetre.

b) Extraction method.

The samples were dispersed, with gentle stirring, in a boiling tube with 30 ml. of 10% KOH and raised to, and held at, boiling point, in a water bath, in a closed, but not pressurised, vessel for 1 hour. After this time the tubes were removed and allowed to cool to around 50°C and filtered through a 100µ nylon filter washing with a minimum volume of de-mineralised water. The 100µ plus sample retained by the filter was further washed and stored in a sample tube for examination with a stereo microscope while the 100µ filter-passing sample was subjected to four decantations at 2 hour intervals using de-mineralised water. Each sample was then treated with 2ml. of commercial hypochlorite solution with the addition of a few drops of 10% HCl and after 2 hours decanted four more times. The clear liquor was removed and the sample transferred to a small sample tube to which was added 6 drops of 1% Safranin and 3 drops of 1% Fast Green to dye vegetable and animal material respectively. This was a satisfactory level of stain for reasonably thick-walled pollens but larger thin-walled grains sometimes needed more.

It is a matter of reference that the liquor resulting from the digestion of the samples varied considerably from sample to sample in colour intensity, from pale straw to very dense dark red, and in turbidity, and attempts have been made to measure these features against arbitrary standards made by using caramelised sugar extract for the colour comparators and kaolin suspension for turbidity.

It was, of course, impossible in a semi-domestic situation to use HF to remove siliceous material and, although the presence of such material often made the use of phase-contrast difficult, if not impossible, it did have the advantage that such material as thin, siliceous protozoan shells, cysts and a previously un-reported airborne Industrial Revolution material could be observed.

3) Microscope slide preparation.

Small amounts of the stained extract were dropped onto carefully cleaned microscope slides with a fine pipette and spread into a smear. After air drying at around 40°C in a shallow oven for the minimum possible time, so that desiccation was minimised, a mountant was used and cover slips placed. In the trial stages five mountants were tested:

a) Farrants Medium - this was soon abandoned as it had no particular virtue in this context although it was good for use with fresh algal material.

b) Canada Balsam - This was an effective permanent mountant but was abandoned as it took too long to harden, the sample required undesirable dehydration and, more important, because the refractive index was too high for good contrast with siliceous material.

c) Water Glass - this was very effective but messy and only really useful after ringing.

d) Silicone oil - This was a natural choice as it has been widely adopted for pollen analysis but it was abandoned for two reasons. First, I was not looking solely for pollen but for siliceous material and the mountants high Refractive Index was not helpful and secondly I found it impossible to use unringed slides with immersion oil without getting into a complete mess.

e) Glycerine Jelly - This ended up as the mountant of choice for several reasons.

1) The specimen could be mounted while it was still damp thus reducing trapped air bubbles and minimising distortion.

2) The process was speedy and large numbers of slides could easily be prepared allowing a better appreciation of the features of each sample.

3) The Refractive Index was more satisfactory for the non-pollen features.

4) The slides did not need ringing before use could be made of Oil Immersion objectives.

Initially each slide was prepared with two cover slips to increase the viewed area but later slides were made using rectangular cover slips of 22x50mm.

4) Slide Examination

A Cooke,Troughton and Simms research polarising microscope was used, with phase contrast when it was felt to be useful. The microscope was normally used with binocular viewing but a monocular body tube was used for photo-micrography or, with the in-built Bertrand lens, for centring the Phase Contrast optics.

Consistent use has been made of the vernier scales on the mechanical stage and all the observations made in the notebooks and the photographs taken of selected features have the co-ordinates recorded as well as the slide reference. This allows any previously recorded feature to be found again although the precision is not perfect on earlier slides due to a re-alignment of the microscope optics necessitated by the phase contract condenser and objectives.

The normal examination procedure is to scan each cover slip on the slide laterally, advancing the slide vertically at the end of each traverse so that there is a definite degree of overlap. Scanning is done with a 10X objective which, with a 10X eyepiece and a binocular head factor of 1.7X, gives a magnification of 170X. Any interesting features are more closely examined with a 40X objective (680X) and occasionally with 100X Oil Immersion objective (1700X). This latter magnification is high for broad spectrum light but the optics are very good and extra features can be discerned. All magnifications have been checked by correlating a stage micrometer with an eyepiece graticule.

5) Photo micrography

The original camera for this microscope was a quarter-plate reflex which, together with a diaphragm shutter, gave impeccable results but it lacked convenience and was far too costly. All the work done in this investigation has been undertaken using single-lens reflex 35mm cameras mounted on a bellows and, after many trials, satisfactory results have been obtained even at the higher magnifications. The perfection of the photographic technique took some time and it was found that the shutter/mirror system can cause perturbation of the camera during exposure. Some cameras, such as Pentax, causing little and others, such as Praktica, being quite unacceptable results. This problem was eliminated by using the camera with an open shutter and controlling the exposure by interposing a diaphragm shutter in the light source. This method gives excellent results and some of the earlier photographs have been re-taken with this improved method.

Each specimen was photographed initially under low power - that is with a 10X objective, 10X eyepiece and a monocular microscope body with no factor but with a camera bellows extension of 150mm (this I refer to as 10:10:150). This gave an overview of a reasonably representative area of the slide and such an area of each slide was photographed and mounted as strip giving a very vivid impression of the changes from sample to sample in the levels of mineral material, charcoal and pollen through the core. This is mounted as Appendix 5 and is usefully examined with Appendix 6 which contains a summary of the results of closer examination of each sample. Closer examination of the pollens and other features were made using other objectives, normally 40x with 100x Oil Immersion on occasion. A bellow extension of 150mm was used as a standard but occasionally other bellows extensions were used. The description of the conditions used was recorded as e.g. 40:10:100

meaning - 40x objective, 10x eyepiece and 100mm bellows extension etc.

Colour film has been used in conjunction with the cross-dying of the specimen but the use of blue filters and monochrome film to maximise resolution might be considered for siliceous and other mineral materials.

6) Results from examining the slides.

In order to get an impression of the variation, if any, of the character of the sediment at different depths an initial test was made on samples take 4" apart numbering from the lowermost to the one nearest the surface. These samples were numbered from A1 (Core A) at the bottom to A14 at the top. Even a cursory examination showed that there were considerable differences through the column and a full set of samples were prepared as slides. The numbering sequence was based on the original 4" sampling and became e.g. A1, A1.1, A1.2, A1.3. A2, A2.1.... and so on. Where the core had become broken during extraction a note was taken and a blank result entered thus maintaining the proper sequence. In the graphical illustrations this identification is supplemented by a scale in inches from the bottom (0") to the top (52").

The original set of low power photographs of typical areas of each slide (10:10:150), mounted so that they were arranged in order in a hinged sequence with blank cards for missing samples (Appendix 5), clearly that there was considerable differences in

a) The amount of pollen.
b) The amount of mineral material.
c) The amount of carbonaceous material.
d) An apparent difference in the types of pollen.
e) Micro-organisms.

Obviously at this degree of magnification only general impressions could be gained but the differences were very marked and further investigation seemed justified. This was carried out with use of 10x and 40x objectives, as necessary, using the scanning technique described but before going further a few words on pollen analysis is needed.

Pollen analysis has become a very precise and mature discipline and I do not claim sufficient expertise to subject these specimens to a full critical examination - I hope somebody so qualified will undertake this. Having said that, some pollens have pretty distinctive features i.e.

Lime (Pry), Elm etc. although many such as Dandelion, Autumnal Hawkbit and Smooth Hawksbeard can be easily confused. Nevertheless, allowing for this I believe that the results are reasonably valid and useful. The identifications were made with three aids

a) The use of books such as those mentioned earlier.

b) Definitive sample slides such as those from Phillip Harris to accompany Moore and Webbs book plus others from suppliers such as Northern Biological Supplies. These were closely studied and photographs taken of most.

c) Slides of pollen taken from plants clearly identified by means of floras.

The problem was not made easier by the fact that the pollens extracted from the core had deteriorated to some extent and were often very distorted.

Pollen was not the only matter of interest and equal consideration was given to fragments of algae, protozoa, microfauna etc. and again identification could be no more than partial but the use of such books as the guides of the Natural Environmental Research Council enabled at least some identifications to be made.

To help make sense of the quite considerable amount of data piling up a hinged sequence of file cards was prepared with a card for each specimen taken through the core (Appendix 6) i.e. matching the similarly presented set of photographs (Appendix 5). On these cards the types of pollen identified, an assessment of the amount of pollen and all the other data such as the amount of sediment, the presence of carbonaceous material, colour, turbidity etc. was also recorded thus allowing an overview of the results.

In addition to the pollens identified with reasonable accuracy there were others which were distinct but unknown and in the composite graphs (Fig. 6.2) I have only attempted to show the range of types and an assessment of the levels with substantial error bars. Nevertheless these graphs correspond quite closely with the visual appearance of the photographs in appendix 5. I have also indicated in Figure 6.3, together with the sizes of Gramminea pollen, those samples in which water lily pollen were found and, interestingly, it was found from 14" above the lowest level to immediately below the surface grass which would seem to indicate that the lake had a long life and that there was a reasonable depth of water present over at least some of the area until relatively recent times. Typical specimens are shown in Photos. 6.1 to 6.6. Some illustrations of other common and readily identifiable pollens are shown in Appendix 7. These are just a few of many which illustrate the past presence, at various times, a rich and varied wooded landscape and one which showed a wide range of the weeds associated with cultivation i.e. Coltsfoot, Thistles, Plantains etc.

If weeds of cultivation are to be found then so too might be cultivated grammineae and while this is a specialised field, which can give experts problems even with the aid of a Scanning Electron Microscopy, I studied each sample carefully for grammineae and measured the size of the largest. I feel that grains of around 50µ (even allowing for the use of glycerine jelly), if also associated with weeds of cultivation, might reasonably considered to be confirmatory

The results of careful examination of all the specimens is shown in Fig. 6.2 and although the well known caution "absence of evidence is not evidence of absence" they were all checked by making extra slides, for example A5 was checked four times with the same result. Because of this and because of the changes found in the types and quantities of other pollens plus other changes yet to be discussed there seems to be a genuine case for assuming considerable environmental changes have taken place over the period in which the deposits were laid down.

Changes in the mineral content of the sample.

When the samples were digested in KOH there were distinct differences in the amount of fine mineral material remaining. A measure was made of this quantity by means of measuring the height of the mineral deposit in the sample tube. The tubes were nominally 4" long by just over 1/2" internal diameter and, as all the samples were in identical tubes, the height of the deposit could be taken as directly proportional to the quantity. Bearing in mind my earlier Caveat, concerning the relative crudity of determining the quantity of sample for processing, the results could be taken as reasonably valid provided that the differences in height were substantial. The results are plotted in Fig. 6.2 and they are sufficiently different to be taken as meaningful. These results agree with visual examination and with the photographic series in appendix 5. It can be seen that there is a high mineral deposit in the lowest sediments followed by a long period of low deposition which is ended by a massive influx of silt after which low deposition becomes, once again the normal. As we will see when we examine all the results other changes are associated with this event.

Variation in carbonaceous fragments.

The phrase "carbonaceous fragments" has been used because it is not always easy to distinguish between well-defined fragments of charcoal resulting from burning and other very dark material remaining after digestion in KOH. What is certain is that variations are considerable, for example there are virtually no such particles in A1, A1.1, A1.2, A2, A2.1, or A2.2. A few are to be found in A2.3 and quite large amounts in A3 diminishing again to low levels in A3.2. Other lows and highs are to be found and it is presumed that the regions with high levels of carbon are associated with burning. To what extent such episodes are as a result of natural events, such as the massive burning of many mountain areas such as we saw in 1976, or to man-made events is unknown. Examination of the 100µ plus fragment, not yet undertaken, may help to decide the nature of the burnt material but for the present I prefer to allow the matter to remain qualitative and to make no attempt to impose a spurious precision. Again, the series of photographs in Appendix 5 is pretty representational.

Having said that it might be relevant that the high carbon levels of A2.3 and A3 coincide with a major increase in the quantity and range of flora and to the first observations of approximately 50µ grammineae. Clearly more work needs to be done when a full core is available. The graph shown in the composite Figure 6.1 is based on visual assessment, with no attempt to differentiate on particle size.

Protozoan and phytoplanctonic remains.

Also included in this category I have included the frequently found fragments of small crustacea, plant phytoliths, etc. Once again a proper appraisal of this material is in the province of an expert but at least I can demonstrate their presence. It may be a valuable spin off from my simple digestion process that the fine siliceous material is still very clear. Some, particularly some phytoliths, show very clear detail with phase contrast but as I have limited expertise in identification I have taken few photographs. For most purposes the best compromise conditions for examining a large amount of material with reasonable thoroughness was to use Kohler illumination and to keep the sub-stage iris carefully optimised at every change of objective.

Some fragments can be found in all the samples but the first well-defined one is that of a small colony of actinastrum (Photo. 6.16), found in ponds, lakes and slow rivers in sample A2. Also in A2 was a well defined Diflugia teste (diflugia is common in lake sediments). What is remarkable is the profusion of protozoan remains in sample A8 including a fine specimen of prorodon, an active feeder on other protozoa and algae, other well defined protozoa shells and, possibly equally significant, many cysts, which might indicate a change to unfavourable climatic conditions. Evidence for such a change at this point has been shown in the high level of mineral deposition in sample A7.3, immediately preceding it, and in the changes in pollen quantity and diversity. A full set of photographs can be found in Appendix 8.

Fall-out associated with the Industrial Revolution.

Sample A14, the one from immediately below the turf, contained extraordinary mineral particles which had very clearly been molten. In addition to smooth molten surfaces many contained gassy bubbles, some were hollow shells with the shell itself comprising a glassy foam. They were found in single and in composite forms and were very common. See Photo. 6.7.

On consideration it became pretty obvious that they were air-borne particles discharged from the furnaces some of the earliest of which operated in early 19th century only a couple of miles away, the nearest probably being the ones in Dukestown. Since the first furnaces iron furnaces of various types were to be found within a radius of a few miles until recent times (See Figure 6.4).

I am not aware of such particles being reported previously and although a great deal of work will be needed to characterise the types and the geographical dispersion of the fall-out it has the potential, even at this stage, of providing a dating level for the period of time from the late 18th. century until recent times. Similar particles are still falling today as shown in Photos 6.8 and many more in Appendix 9.

This information has now been reported in "Industrial Archaeology News", 94, (Autumn 1995).

Notes to accompany the composite graph.

1) Graph showing the level of charcoal.

a) This is a visual assessment derived from examination of the series of low magnification (10:10:150) photographs of typical areas of the slides. See Appendix 5.

b) It does not include particles which did not pass the 100µ sieve.

c) Note the error bars and also that the size and possible morphology of the particles has been ignored in this graph.

2) Graphs of pollen quantity and range of types.

a) The range of types is not precise as many grains could not be accurately identified (e.g. Taraxacum, Hieraciums, Leontodon and Cepis) because of insufficient expertise, poor preservation or presentation of the grains and the use of optical microscopy only. The scale of 0 to 40 is divided into broad ranges and reflects the numbers of reasonably well identified plants. Although there is this admitted lack of precision and fairly generous error bars the very considerable variation throughout the core is clear. The inverse relationship of high silt with low pollen is noted but not surprising as a substantial silt deposit may take only a short period of time.

b) The amount of pollen present approximately, but by no means exactly, corresponds the range of types.

c) Sample A10.1 is anomalous and remains so despite re-checking.

3) Graph of mineral content.

a) This graph derives from extracting the mineral content from a weighed quantity of dry core sample and is a reasonably accurate measurement and not an estimate.

b) The deepest samples were from the clay bed of the lake and contained very few pollen grains which were poorly preserved. The sudden explosion in pollen types and quantity at A2.3 is very dramatic.

c) The massive intrusion of mineral matter between A7 and A7.3 is almost entirely of fine material, mainly silt, and contains many particles of an unusual nature which might be air-borne.

d) It should be noted that this mineral intrusion might be due to a major environmental event, particularly when considered with the pollen changes and a great increase in siliceous protozoa shells and especially of cysts but that it must also be taken into account that the sample core was taken from the western edge of the lake near where the main stream entered and this core might not be fully representative of the full sequence which might be found nearer the lake centre. As there is approximately 10m of peat deposit which will need sampling at no more than 1cm. intervals it was beyond the scope of this exercise.

4) Water Lily (Nymphaea Alba).

This has been identified at A4.2, A4.3, A5.1, A5.2, A6, A6.1, A6.2, A6.3, A8.2, A10.1, A11, A11.1, A12, A12.2, A13.1, and A14. As A14 is immediately beneath the surface vegetation this would suggest a long period as an active lake.

5) Grammineae of 50µ or more.

Grammineae of a size compatible with cultivated cereals have been found in A3, A3.1, A3.2, A4.2, A4.3, A5.1, A5.2, A6, A6.1, A10.1, A12.2 and A13.1. Other grains of 40µ or more have been found in further samples (see separate graph). What is more surprising is that there are some samples in which no specimens have been found, despite making several extra slides and despite the fact that the immediately adjacent samples contain them e.g. A5 and A6.2.

Perhaps equally interesting is that there are ranges of samples in which no grammineae, larger than those associated with some grasses, were found.

These observations might not be borne out by further, more comprehensive, work but seem to fit in with the other pollen work to indicate changes in land use.

Distinct differences in the detailed features of some of these large grains might have significance to the expert.

Chapter 7. Possible volcanic fall-out.

Unusual mineral fragments centred on A8.

The presence of mineral grains and flakes of unusual appearance was noted in several of the samples but in A8 there were a large number which fell into two main categories although some were intermediate. The first category comprised flakes measuring in the range of 30 to 50µ and a few microns thick sometimes tapering to sub-micron. These flakes often had elongated bubbles indicating attenuation while in a plastic state and, equally often, striated or rippled surfaces. The fragility of these fragments might well indicate an airborne origin. The other type of unusual grain seemed to comprise black, possible carbonaceous material, held in a clear matrix. The intermediate type comprise rather larger flake i.e. mainly around 50µ and a few micron thick which were full of small bubbles and black particles. The impression gained from some which had reddish discolorations was that heat had been involved in their formation or that they had been exposed to heat.

The two types might have differing origins certainly a great deal of lime burning has been carried out in this area for very many years but the fragility and the once-molten state of the fine flakes, together with the depth at which they were found (24" or 60cm) does lead to the speculation that they are of aerial origin. Indeed some of the particles are of such baroque shapes that it would be difficult to imagine any other form of transport. Such an origin can, of course, be quite prosaic such as the Saharan dust which often falls today but it would also be quite consistent with volcanic fall-out possibly, but not exclusively, from Hekla. If true this would be of exceptional value for dating the core although there were 4 events associated with Hekla - Hekla 1 at 1104AD, Hekla 2 at 850AD (with some uncertainty), Hekla 3 at 1159bc and Hekla 4 at 2310bc - but it is with Hekla 3 that the Bronze age environmental deterioration is associated. This will be discussed more fully later.

This aspect of the core analysis has proved to be the most difficult. It started by the observation that many of the mineral particles found associated with the influx between A6.3 and A8 were of unusual shapes, in particular my attention was drawn to the large (50µ), very thin (1µ or even less) particles which, although present elsewhere in the core were common here. While still considering this I discovered the extraordinary particle shown in Photo 7.1: this was so fragile and complex that it could only have been airborne, landing directly into the water. Around the same time Current Archaeology number 134 for May/July arrived and an article by Mike Baillie "Using Tephra to date the past" was illustrated with a particle of similar appearance although no size was given.

At this time further work on this was shelved while the pollen sequence was completed although I was now looking for anomalous particles as well and, although only a few even approaching the complexity of the one first discover was found, although Photos. 7.2 and 7.3 were similar, it was clear that there were many others with difficult to explain characteristic. It should be remembered that all samples were stained with Safranin and Fast Green and checked for bi-refringence under crossed polars.

There seem to be four type of particle and some can be found, in varying quantity, at all levels of the core but there is a considerable degree of variation and the most extraordinary ones (Class 4) seem to be centred on either side of the high silt peak around A6.3 to A8, 22" (56cm.) to 28" (71cm.) from the bottom of the core. There is some difficulty in finding these fragments on the intermediate samples, that is A7 to A7.3, due to the large amount of fine siliceous matter.

Class 1.

These particles are in the range of 20 to 50µ and are solid, with the exception of occasional small gas bubbles, often glassy, opaque black or red appearance and sometimes show signs of fusion. They are often highly eccentric in shape – Photo. 7.4.

Their size and weight probably indicate a local origin (unless winds of extraordinary strength were involved) i.e. produced by high temperature combustion processes such as domestic fires, charcoal burning, lime burning or resulting from slash and burn firings. The irregular shapes could be due, in some cases, to differential dissolution by the humic acids and by carbonic acid of clay/limestone mixtures which are found in the Lower Limestone shales.

It is too early to be definite about this but most of the photographs were taken from samples from the lowest levels of the core i.e. from 1" (2.5cm.) to 10" (25cm.) from the bottom but similar ones could be found in other regions. The two particles from A7.2 would seem undoubtedly to have been molten and are similar to those found connected with industrial fall-out in the uppermost layer. It is possible that they are due to contamination of the core during sampling but no others were found in any of the other samples either above or below.

Class 2.

The fragments typical of this group comprise very thin, parts can be sub-micron, shards and can be found, in varying quantities, at all levels. These, as far as I can see, are similar to those illustrated in a photograph supplied by Dr. Lascelles of the Dept. of Soil Science at Bangor University. Typical specimens are 1 micron or less thick and 20 microns to 30 microns across. More interesting are specimens with a thin three-dimensional shape which could only have been formed from a molten glassy material. The specimen in Photo 7.6 has been formed from a colourless source material, a larger specimen of which type can be seen in Photo. 7.8 which was taken from a sample of Hekla 4 fall-out from Sluggan Bog, as supplied by Professor Baillie, while that in Photo 7.7 of apparently similar material, was found at Gwaun Nant Ddu. Other similar three-dimensional shapes are formed from apparently clear material. More are shown in Appendices 10 and 11.

Class 3.

These are possibly variants of Class 3 but have been distinguished because, although of similar thickness, they are of larger surface area, 50 by 50µ being common, are frequently filled with bubbles and often with interesting surface features. Both the bubbles and the surface features have the appearance that the material suffered extension while in the plastic state. Two of the most convincing specimens are shown in Photos 7.9 and 7.10 both of which show, by the deformation of the gas bubbles, orientation when in a semi-plastic state with 7.10 bearing a close resemblance a specimen of Hekla 4b fall-out illustrated in Photo 7.14.

Class 4.

These particles are of such a nature and found in such baroque shapes that they would appear to have been formed from the molten state and to have suffered, in a few cases, little mechanical damage although the majority of the illustrations are fragments which appear to have broken from the larger ones. To date the largest and most complex fragments have only been found in the part of the core which lies on either side of the major incursion of silt i.e. in the samples from 22" (56cm.) and 28" (71cm.) but smaller pieces have been found at other levels, particularly below.

The highly silted region will be searched but the amount of mineral material makes it difficult. It is also possible that larger fragments would not be able to stand the increased mechanical action of high water flow with the entrained material. Some typical examples of the particles in this class are shown in Photos 7.1. 7.2, 7.3, 7.11 and 7.12. Those are most difficult to explain except by resort to a molten phase in their formation are those, very rare, particles such is illustrated in Photo 7.13 which are bomb shaped and, under crossed polars exhibit spherulites with radial crystallisation. Professor Baillie in his book “Exodus to Arthur” has suggested meteoric or cometary incidents capable of giving fall-out, but I am not able to pass any judgement on this.

I was not able to find any indisputable fall-out of the “ropy” type from Sluggan Bog found by Professor Baillie although some others with bubbles and apparently crystalline inclusions were very similar.

Further photographs are in Appendices 10 and 11.

To give some better precision on dating the sediments in general, and these strange particles in particular, would need recourse to equipment I lack i.e. S.E.M, Electron Microprobe and radiocarbon dating of surrounding peat but I shall continue to look for more samples, to form an opinion as to the distribution through the core and to use Phase Contrast to seek structural detail. If the suspected volcanic origin of these particles were confirmed it would give rise to interesting speculations about the wind directions and speeds pertaining at the time.

Some idea of the relationship of South Wales to Iceland and to the wider area from which volcanic fall-out could easily have come is shown in Photos. 7.15 and 7.16, but major events can spread their particles around the world.

Control Samples.

In order to see just how unusual these strange particles really are and whether modern material could produce artifacts (I had just moved to a new well-insulated house) and bearing in mind that I had already found that fall-out from modern furnaces of hollow glassy particles of up to 40 microns were ubiquitous, “control” slides were prepared of:

a) Blank slides mounted as usual with glycerine jelly but with no specimen.

b) Aqueous extract of Rock Wool insulation batt.

c) Aqueous extract of fibreglass attic insulation.

d) Expanded polystyrene dust.

e) Local fall-out from sample jars left exposed to rainfall for some months.

f) Aqueous extract of garden soil.

Samples b), c) and d) were prepared as possible sources of the highly baroque particles, the polystyrene indeed gave very convincing ones but, of course, being highly bi-refringent were easily discerned. The rock wool samples all retained some of the aspects of a fibrous glassy nature and could not have given false results but the fibreglass did contain many particles which, while not highly baroque, were of complex shapes which would have drawn attention to themselves if they appeared in a slide prepared from the core. It is not entirely clear whether they are derived from the fibreglass per se or whether they have become entrapped from the atmosphere as the fibreglass has been exposed for 8 years while the rock wool was new.

What is clear is that many particles of highly irregular shape found in the peat samples were also to be found occasionally in blank slides mounted in glycerine jelly with no specimen and much more commonly in recently collected local fall-out and in extracts of garden soil. In addition both latter samples {e) and f)} commonly contained the quite common industrial type fall-out and it is quite possible that both of these specimens contained examples of modern volcanic activity from such sources as Mount St. Helens, Pinatubo, Montserrat etc. This means that only a restricted type of particle could be used to identify volcanic dust and that only if the concentration in a particular layer of peat was high could such particles as might be found be associated with any change in the nature of the sample.

This raises the question of how high is "high"?. The common-sense answer must be high (but still presently unquantified) in relation to the rest of the siliceous material. In the extreme case such as that pertaining in typically the vicinity of Pinatubo, all the mineral material would comprise tephra but regions sufficiently distant to have only a small rain of volcanic dust might still be affected by climatic change which could be continental or even global. It is also clear that air-borne particles either from volcanic sources of from e.g. Saharan dust storms might comprise a much greater part of mineral matter extracted from peat than from a region of high silt in-wash from soil surfaces as might be found at stream entry points.

To complicate things even further the sample I took was but a short distance from the western shore and hence near the main stream bringing water into the lake from the catchment area and so might give the impression of a much more serious event than was really the case.

Nevertheless, taking into account the evidence for changes in the pollen and the charcoal, together with the increase in the remains of protozoa and the large number of cysts, it seems clear that some climatic change did take place.

Discussion.

The examination of the core samples show that there are very considerable changes in :

a) The quantity of pollen,

b) The range of plants represented,

c) The amount of charcoal present,

d) The mineral content,

e) The presence of unusual mineral particles.

In order to attempt an understanding of the way in which these features inter-relate a), b), c) and d) have been drawn as a composite graph on the common base of location on the core (Figure 6.2). From this composite graph and reference to the photographic and data strips in Appendices 5 and 6, and the laboratory notebooks, the following conclusions can be drawn with the reservations previously made that this is a single core sample and is unlikely to give more than an insight to that which a rigorous examination of the full core length would reveal. Other information regarding cereal grains and the presence of Nymphaea, both of which give valuable information regarding the local environment at the time, are shown in Figure 6.3.

It would seem that the lowest samples, derived from the clay at the bottom show a high mineral content with the grains tending towards the sharp and angular. There are very few pollens and these are difficult to identify but are probably tetrads and inaperturates i.e. heathers and sedges. Some simple algae such as Tintinidium and Actinastrum are to be found. This situation continues until A2.3 where the mineral content almost vanishes and there is a sudden change to a very high level of pollens of a very great range of types. Sedges and reeds are common but so also are a wide range of trees, shrubs and herbaceous plants typical of an open woodland environment. The land was occupied as is testified by the presence of grammineae of up to 50µ and many weeds of cultivation. Charcoal particles can be found but at a low level.

The sudden change in character from A2.2 to A2.3 which has evidence of human occupancy of the land, is most probably explained by the position of the core sample near the western end where the fresh influx of water might well have continually or intermittently removed peat deposits until the influx was moderated by a reduction in flow of by increased vegetation exerting a protective effect.

At A3 a peak in the charcoal occurs, possibly due to human impact on the environment, as cereal grains of 50µ with their associated weeds of cultivation might suggest, a situation which continues to A6.2 before a change takes place with an increase in grains of under 40µ with a thicker exine and the loss of the larger ones previously found. Otherwise trees such as alder, pine , hazel, willow, blackthorn and lime are still common as are the herbs and shrubs of open woodland and the first elm was found. This general condition pertains with some fluctuations but a general decline in both the quantity and the range of pollens until A6.3 where both are low. The generally increasing proportion of heathers, polypodia, triletes, ficales together with the most common trees in A6.3 being alder, birch, hazel and elm together with the absence of cereal pollens, although the weeds associated with their cultivation are still common, suggest a cold and wet climate.

Between A6.3 and A8 a major change takes place with a large deposit of fine mineral matter, peaking at A 7.3, associated with which are:

a) An increase in charcoal up to a peak at A7.2 after which it falls off sharply to a very low level at A8.

b) An increase in the range of pollens at A7.2 which continues to A8 after which it diminishes to a low level.

c) An increase in the quantity of pollen to a peak at A7.3 after which it falls to a low level.

d) After A6.2 no large grammineae are found until much later at A12.2.

e) No nymphaea are found between A6.3 and A10.1 with the single exception of one at A8.2.

f) The sudden large increase on protozoan remains including many cysts at A7.3 coinciding with the peak in mineral matter.

g) At A7 the unusual mineral particles, discussed more fully in Chapter 7, starts reaching a peak at A7.1 where they make up an appreciable, but unquantified, proportion of the total mineral matter. The unusual particles seem to start at A7 with a predominance of flakes and end in the same way at A8 but at the peak at A7.1 the greatest proportion comprises particles with complex three-dimensional shapes.

The combination of such a wide range of effects suggests that the cause was general rather than local although it is accepted that a heavy in-wash of silt would also cause a similar in-wash of any accumulated volcanic fall-out and would give anomalous pollen results, a centimetre of peat is likely to contain far more than a centimetre of silt. However the in-wash event itself suggests either that the climatic event was extraordinary or that there was a large area of exposed soil vulnerable to heavy rainfall or both. The disappearance of cultivated cereal grains might suggest that an exposed land, which had shown a general reduction in the range and the quantities of pollens since A3.2, was challenged with a sudden and severe deterioration in the climate.

After A8 the amount of pollen is low and is what there is are represented by those associated with a cold and wet environment trees being mainly represented by alder and hazel, but with some birch, elm, pine and lime, while the most common pollens are of mosses, sedges, heathers, ferns, and reeds. Weeds of cultivation are still common but grammineae of 50µ are not found until A10.1 where there seems to be a full recovery in both the quantity and in the range of pollen types. This sudden improvement at A10.1 is echoed in a charcoal peak and seems to indicate a pretty full recovery in the local environment.

This recovery at A10.1 is short lived and is followed immediately by a collapse back to the conditions which pertained between A8 and A10 but the fall-back is followed by a steady improvement to a fresh high level of both quantity and range of pollens by A12.1 which continues until A12.3 after which both diminish more or less steadily to the top of the core.

It seems clear that within the known limitations resulting from the location of the core sample and the limited number of samples taken along the core that considerable changes in the local environment have been shown and it is frustrating to know that a few radio carbon datings and an examination of some of the possible volcanic fall-out particles with a scanning electron microprobe would clarify things considerably. Despite this I believe that there is sufficient evidence of a long term undisturbed record of the past in this site to justify a full-length core or cores to be taken and analysed more exhaustively. There is also a pressing need for radio carbon dating to give a time scale to the sequence.

If, as I believe, that the lake had a long period of active life, as it must have done to build up such deep deposit, and if it has been in its present ”fossil” state for very many years then this site presents us with a “Time Capsule” of the environment over a long period of time of the distant past. Possible this might be from the time of its first formation at the end of the last glaciation until some time after the formation of the blanket peat which, because of its raised acidity levels, rapidly caused an irrevocable change to its water budget.