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ENVIRONMENTAL ARCHAEOLOGY OF THE PECKFORTON HILLS

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THE PROBLEM. Bickerton Hill, western Cheshire, sustains the prehistoric hillfort site of Maiden Castle, which has been the focus of archaeological study by the Department of Prehistoric Archaeology, the University of Liverpool, in recent years. The hillfort was quite obviously constructed at the cost of substantial human labor, and another prehistoric hillfort was built on the Peckforton Hills at the present location of Beeston Castle. Archaeological knowledge of possible settlements in the area, related to these constructions, is lacking - with the possible exception of an earthwork located on a low sandy ridge immediately east of Peckforton Mere. Finds of Bronze Age or Iron Age artefacts which could be reflections of the prior existence of such settlements are also lacking from the lowlands surrounding the Peckforton Hills. Yet the soils of the area are sandy, as the result of weathering of the Peckforton Hills sandstone strata, and the topography below the colluvial slopes of the hills is gently rolling. The combination of easily tilled soils, available well-drained housing sites, flowing streams concentrating runoff from the hills and supported by springs issuing from the sandstone, and open water meres, not to mention the hilltop fortifications themselves, strongly suggests a landscape suited for residency by a significantly large human population during the Bronze and Iron ages.

The Conservation Section in the Planning Department of the Cheshire [illegible] the character of Bronze and Iron Age settlement patterns in the Peckforton Hills area, and to resolve the question of whether prehistoric sites in general actually did not occur on the Cheshire Plain or whether deficiencies in the techniques and methods of prehistoric archaeology account for our present inability to identify them. It was thus considered reasonable to sponsor a research programme designed to produce relevant information through studies generally classified under the term Environmental Archaeology: the study of the environmental setting in which prior populations existed and exerted influence upon their local landscapes. Given the possible earthwork site on its eastern margin, the focus of this research was centered on Peckforton Mere.

A wide variety of techniques adapted from the physical and natural sciences are employed for various purposes in environmental archaeology. Most are designed to identify the occurrence of changes in ecological or climatic conditions. Such changes are then interpreted by reference to their potential to encourage or discourage certain patterns of economic activity, or as effects of human activities which modified the landscape through exploitation of certain resources. Normally, the natural science technology most specifically appropriate to the character of the problem under investigation and the nature of the source of available paleoenvironmental data is employed. In this study, a distinctive approach was used. Here two natural science techniques were employed, and one was used to control the application of the second.

One of the more powerful and flexible tools used in environmental archaeological research is pollen analysis. Pollen produced by the vegetation of a basin of deposition (here, the land surface across which water flows before coming to relative rest in Peckforton Mere) settles out of suspension with other water-transported particles in the lowest part of the basin. Through time, the pollen of successive periods accumulates in stratigraphically superimposed layers. Coring the deposit provides sequentially ordered samples of sediments whose pollen may be extracted, which is then identified and analyzed statistically. If no modification of the vegetation occurred during the period of time represented by the samples, no statistically significant modification of the pollen record will be observed in the samples. Changes in the kinds and relative frequencies of pollen as one proceeds from the youngest samples to older ones, however, are recognizable as functions of factors which affected the vegetation of that basin of deposition over time. Such human activities as land clearence or changes in agricultural technology affect vegetation patterns, and thus may be recorded as modifications of pollen record sequences.

Palynological investigations had been undertaken prior to the initiation of the Peckforton Mere research by S. N. Twigger and W. Priestly, when undergraduates in the Department of Geography, University of Liverpool. Their dissertations of 1982 involved analysis of pollen from sediment cores recovered from near-shore deposits at Bar Mere. Their research had sought indications of human modification of vegetation patterns during the Bronze and Iron Ages in the Bickerton Hill area, but were successful only to a degree. In part, this was because those studies were designed to address the problem of the relationship of the Bar Mere pollen sequence to other British pollen sequences. However, the Bar Mere work documented the occurrence of depositional units dating between 3000 b.c. and 1200 b.c., thus demonstrating the existence of both Neolithic and Bronze Age pollen records. Pre- and post- 1200 b.c. pollen records yielded evidence of human modification of local vegetation patterns whereas those dating to the Bronze Age did not.

But the Bar Mere palynological research was not definitive as a means of demonstrating that human activity had no effect on Bronze Age vegetation patterns in the catchment area. It suggested that such human activity as may have occurred did not effect vegetation in the same ways as it was affected during earlier and later periods. But those studies were not designed to resolve the issue beyond that point. The effect of human activity during the Neolithic was identified as resulting in a reduction of the number of forest trees in the Bar Mere catchment area, and further reduction of forest in the immediate environs of the mere occurred after 1200 b.c. But Bar Mere is the basin of deposition for a catchment area of about sixteen square kilometers. Lack of definitive evidence for human modification of vegetation patterns during the 3000-1200 b.c. period might be explicable as the result of lack of human occupation or exploitation. Yet it could also be explained as the result of a reduction in intensity of land use or the implementation of a distinctive argicultural technology during this period. Actually, the Bar Mere palynological record does not totally lack evidence of possible intermittent phases of land clearance during the 3000-1200 b.c. period. However, the evidence is sufficiently weak that it may be interpreted as the result of random variations in the pollen rain.

Peckforton Mere is the basin of deposition for a very much smaller catchment area than Bar Mere, and as a result we could expect that if subjected to pollen study the [illegible] populations on local vegetation would be more pronounced. However, some independent means was required to control palynological investigations at Peckforton Mere and link the [illegible] in the two catchment area sizes could result in quite distinctive pollen sequence records. The most secure independent link between the two meres is absolute time. Identification of one or more segments of the pollen sequence at Peckforton Mere that correspond to the pollen records of one or more specific dates at Bar Mere would allow comparisons to be drawn. Such comparison would advise if similarities in the pollen records were the result of contemporaneity and if differences were the result of distinctions in vegetation of the two meres at the same points in time.

The chronometric technique normally employed for this purpose is radio-carbon dating. Radio-carbon dating, however, is both expensive and time-consuming [illegible] In addition, the project's sponsors sought resolution of the research as quickly as possible. Magnetic measurements were selected as an expedient means of identifying the temporal limits of the Peckforton Mere evidence. Not only is it a cheaper and faster means of dating lacustrine deposits, but it offered additional advantages.

A variety of different measurements of the magnetic properties of lacustrine sediments can be performed which, singly and in combination, serve as the data base for different sorts of inferences. familiar with the use of magnetic measurements for the "archaeomagnetic" dating of fired clay objects, such as hearth linings, which involves measurement of the magnetic declination of samples. Magnetic inclination has also varied over time, however, and this allows dating of such unoriented materials as ceramic fragments. Samples of lacustrine sediments may also be dated through magnetic measurements, since their natural remnant magnetic (NRM) fields have a tendency to become fixed at the time the sediment particles come to rest at the mud-water interface of the lake bottom and are buried beneath younger materials. In addition, measurements of the isothermal remnant magnetization (IRM) of lacustrine sediment samples may be obtained. Stated simply, the IRM of a sediment sample is the amount of magnetic field the sample can be induced to retain beyond what it naturally contains. This is a function of the amount of magnetic mineral particles incorporated in the sample whose magnetic orientation was not established by the earth's magnetic field at the time of deposition, and which thus are randomly oriented as a group. Essentially, the amount of randomly oriented magnetic particles is a function of the volume of magnetic particles in the sample. If the source of the magnetic mineral particles has remained constant over time, an increase in their numbers per unit volume per unit of time is most probably due to an increase in the intensity of erosion bringing sediment particles into the lake.

Yet another form of magnetic measurement, coercivity of IRM, provides an index of the relative proportions of the two commonest forms of magnetic minerals. One of these is the principal mineral of iron-bearing rock, rock flour and subsoils. The other is commonly abundant only in soils formed on parent materials containing the first. If the coercivity measurement remains stable through time, it suggests the source of eroded sediment has remained the same. If it varies, it suggests modification in the relative input of topsoil and subsoil particles to the lake bottom. Analyses of sequential samples can thus identify horizons of topsoil erosion in contrast to horizons of subsoil erosion.

Twigger's Bar Mere study involved magnetic susceptibility measurements in addition to pollen analysis, and a limited examination of magnetic coercivity as well. Magnetic susceptibility is roughly proportional to IRM if there is a reasonable similarity in the magnetic mineral assemblages. Since both Bar Mere and Peckforton Mere sediments are derived from the same sandstone sources, IRM and susceptibility can be considered comparable indices of erosional intensity. Twigger's results advised us of the probable existence of at least one episode of intensified erosion during the 3000-1200 b.c. period. Magnetic measurements cannot identify the cause of any erosional or non-erosional episode, so the existence of one or more such episodes during post-Neolithic time neither proved nor disproved the existence of human settlements duri [illegible] In the Neolithic samples, however, an increase in magnetic susceptibility and subsoil-derived magnetic minerals corresponded to palynological evidence of forest clearance. The correspondence suggests that forest clearance by the Neolithic populations caused erosion to intensify for a time.

Magnetic measurements of samples from Peckforton Mere, then, offered prospect for dating associated pollen records, for identification of horizons or intensified erosion in the Peckforton Mere catchment area, and for identification of horizons of increase or decrease in the relative proportions of topsoil and subsoil magnetic minerals eroding from the catchment area. Pollen studies previously undertaken at Bar Mere identified at least one way in which local vegetation patterns might be palynologically indexed, and magnetic susceptibility measurements at Bar Mere identified at least one Bronze Age episode of erosion which might have been the result of human activity. But our decision to undertake palynological study of the Peckforton Mere deposits relative to the controls provided by magnetic measurements and the information obtained from Bar Mere was not without a significant element of risk. As the catchment areas of the two basins of deposition are not similar in all respects, the pollen records of Bar Mere and Peckforton Mere could well have been so different that variations occurring in the two sequences might not allow correlation.

There was also a significant probability that the magnetic measurements which could be obtained from the samples would not fulfill their intended purpose. The equipment available for use was not that which has been designed to recover sediment samples controlled for the relationship of the sample to the earth's present magnetic field. It could be adapted in a way that might compensate but only a field trial could determine if it would work successfully.

If it failed, the magnetic declination measurements obtained might be valueless for dating. As magnetic inclination measurement is a risky dating technique when unsupported by other methods, basing the future of the Peckforton research effort on the success of magnetic measurement studies could prove a fatal flaw in the research programme.

This meant some means of determining the probable value of magnetic measurement studies in the research was necessary before major and costly investment had been made in the pollen analysis of the Peckforton Mere sediments. A decade ago, magnetic measurements of sediment samples could only be performed under elaborate laboratory conditions. Within the past three years, however, the required equipment has been miniaturized from room-size to bench top-size, and within the past six months it has been miniaturized to portable range. Only two such portable devices for magnetic measurements

one is owned by the Department of Geography at the University of Liverpool and was available for our use in July 1982. This device allowed recovery of natural remnant magnetism (NRM) and isothermal remnant magnetism (IRM) measurements of sediment samples in the field immediately upon their collection from the mere deposits. This provided a rapid means of monitoring the value of magnetic measurements, and Provided flexibility to modify the project research design on the spot or abandon the project altogether if necessary in response to a continuous flow of information.

As it turned out, no field modification was required and the research proceeded towards positive results. Had any particular stage of the research produced information seriously diverging from expectations and project needs, alternative techniques or methods could have been applied or the research abandoned. The Peckforton Mere study, then, should be recognized as applied to a specific problem.

RESULTS AND DISCUSSION. Field magnetic measurements of the Peckforton Mere sediments demonstrated that replicate samples of the same strata yielded comparable data and that sequentially ordered samples yielded data patterns. This suggested that more refined analyses would successfully provide estimates of the true antiquity of at least some associated pollen records. Even if they did not, patterns in the data array would support an indirect dating argument. This was sufficient to justify continuing the coring and sampling of the Peckforton Mere deposits to the limits of available time and equipment. In all, 111 samples suitable for NRM and pollen study and 84 samples suitable for IRM measurements were collected. They represent a depositional sequence of 4.60 meters, recovered below a superficial water stratum 1.30 meters in depth.

NRM analysis of the magnetic declination values of the samples indicated that the means employed to adapt equipment to maintain a specific orientation relative to the earth's magnetic field had not proved effective. Therefore, magnetic dating of the pollen record would have to depend upon inclination measurements values and indirect argument. Fortunately, three statistically strong patterns were identifiable in the magne[illegible] n [illegible]. The most prominent occurred very late in the depositional sequence and could be correlated with a period of magnetic inclination variation occurring in the 18th century. This was preceded by a period of reduced magnetic inclination, which was in turn preceded by a weaker episode of increase near the base of the sequence which could be correlated with a magnetic episode occurring during the centuries of Roman occupation of Britain.

The probable accuracy of the 18th century age estimate could be tested independently by two other magnetic measurements. It was critical to do so, for if an 18th century date for the younger episode of increased intensity could be confirmed, a Roman period date for the older one was only unlikely if the depositional sequence had been interrupted. There was no physical stratigraphic evidence that such an interruption had occurred. The 16th-19th century agricultural history of Cheshire records an increase in land use, and land use patterns had subsequently been modified as the result of improvements in agricultural technology. If IRM measurements suggested an increase in the rate of erosion for the same depositional stratum as the episode of increased magnetic inclination, an 18th century date would be more probable than any other date. Further, if a significant relative decrease in the proportion of topsoil-derived magnetic minerals occurred subsequent to the deposition of that stratum the probable cause would be the introduction of deep ploughing and other 19th century agricultural technology. In fact, this was the case. In addition, the physical stratigraphy of the depositional sequence supports the dating argument. The increase in magnetic intensity values is initiated towards the end of an interval of deposition of unlaminated highly organic gytta and persists through the initial phases of deposition of laminated organic and inorganic sediments. Above the point of the magnetic intensity maximum, the laminated deposit is succeeded by a loosely structured and highly inorganic deposition episode which continues to the mud-water interface.

The IRM measurements supported a series of other inferences as well. Those of principal relevance were the inference that both the

Roman period and an earlier period had also been times of increased erosion, and a rather long episode of gradual erosive intensification had occurred prior to the 18th century erosion peak.

after ~~during~~ the period of gradual intensification of erosion the proportional relationship of topsoil to subsoil minerals shifted sign. If human agricultural practices were responsible for the land erosion surrounding Peckforton Mere, the IRM data suggested a minor peak of Roman period agricultural activity followed by a period of low agricultural land use, followed by a long period of gradually increasing land use leading up to an 18th century horizon of peak agricultural activity. Sometime during the period of increasing land use the vast bulk of the area's topsoil had been destroyed.

Since the temporal controls provided by the magnetic measurements suggested the Peckforton Mere cores did not sample Bronze or Iron Age deposits, Peckforton Mere pollen records of that antiquity could not be observed. But pollen study of Peckforton samples remained relevant to resolution of the problems posed by our sponsors. First, it was relevant to produce a body of palynological data which would allow us to evaluate whether or not the erosion evidenced by magnetic measurements was anthropogenic. Second, it was not unlikely that some means of correlating the post-1200 b.c. pollen records of Bar Mere and the records from Peckforton Mere could be identified, and this would allow the Peckforton Mere record to be used as control data for interpretation of the 3000-1200 b.c. pollen data previously recovered from Bar Mere.

Funding allowed for the extraction, observation and counting of 32 pollen samples out of the 111 that had been collected at Peckforton Mere. To accomplish the sorts of statistical operations thought to be necessary to control interpretation of the Bronze Age pollen record from Bar Mere, the Peckforton samples had to be clustered into populations incorporating not less than 5 samples. To explore the relationship between the palynological record and the magnetic evidence of erosion, at least one of these populations had to correspond to the horizon of maximal IRM values and one had to correspond stratigraphically to the horizon of minimal values. To determine if the Roman period erosion was caused by man, a population had to be identified which would stratigraphically correspond to that set of magnetic measurements. The peak IRM values occurred over a very short section of the depositional sequence, so could be encompassed by a 5 sample population of pollen records. The Roman period values, however, extended over a longer section and required an 11 sample population, as was true of the minimal IRM values section. As these demands accounted for 27 of the 32 samples we had opportunity to analyze, it was also possible to analyze five samples from a short core section in which magnetic measurements indicated erosion at a moderate order of magnitude.

The palynological records expressed the probable anthropogenic character of the erosional episodes in a variety of ways. First, each of the four populations contains a statistically real proportion of pollen of cultivated taxa (cereals, flax and hemp), which constitutes evidence for a continuous use of the Peckforton Mere catchment area landscape for agriculture since Roman times. Second, the pollen record documents a continuous and persistent reduction through time in the proportion of tree and shrub taxa, suggesting forest clearance activity. Third, the proportion of <u>Plantago</u> pollen, a weedy genus adapted to the disturbed soils of cultivated fields, corresponds to the level of erosional intensity indicated magnetically. Fourth, the proportion of grass pollen varies historically in the same directions as *Plantago* pollen. The inference consistent with all these data is that land clearance activity was continuous in the Peckforton Mere catchment area throughout the depositional interval sampled, as was cultivation of various crop plants. During the period of minimal erosion, both activities were least intensive. The probable 16th century date for the period of peak erosional activity is palynologically indicated by the occurrence of pollen of trees utilized as ornamentals from that time onwards(*Platanus*, *Juglans*). These pollen types do not occur in earlier pollen populations.

At this juncture, the Peckforton Mere study had produced information which could be interpreted for reconstruction of land use and erosional history since the Roman Period, while Twigger's Bar Mere study had produced information which could be interpreted to similar effect for the period from about 3000 to 1200 b.c. The millenium of crucial interest, during which Bronze Age and Iron Age populations might have occupied the area, was not definitively represented in the Bar Mere record. Post-1200 b.c. deposits had been laid down and sampled, and their pollen record was known. What was not internally evident, however, was the amount of time they represented.

The Bar Mere core had been collected from near-shore deposits at a position which may be a part of the Bar Mere basin that became infilled and stabilized some millenia or centuries ago. Stratigraphic information collected by Priestley in 1982 suggested this was the case, but is inconclusive. If the rate of deposition in the lake at the point of collection of the Bar Mere core was stable subsequent to ca.3000 b.c., the 1.36 meters of post-1200 b.c. deposition could have been completed by approximately 400 b.c. However, there is no internal evidence that this occurred, and the near-shore position of the core could suggest that the deposition rate was not stable but reduced as the basin was infilled. Basically, then, two opposing general models of post-1200 b.c. deposition at the point of the Bar Mere core exist which can be neither confirmed nor denied from available information. One is that the Bar Mere record is truncated at some time subsequent to 1200 b.c. and prior to the present; probably prior to the Roman Period and possibly in the first millenium b.c. The other is that the entireity of the past 3200 years is represented in the post-1200 b.c. deposits sampled by the Bar Mere core.

If the latter model is accurate, correspondences which exist between the Peckforton and Bar Mere post-1200 b.c. pollen records can be granted the status of biostratigraphic correlations representing temporally equivalent modifications of vegetation in the catchment areas of the two meres. If the former model is accurate, such correspondences might represent the similar modifications of vegetation. But this would not be demonstrably probable, and would necessarily represent vegetation changes occurring at different times. At this point in the research a simple choice became obvious. The effort could proceed conservatively, assuming the former model to be accurate, or proceed liberally, assuming the latter was accurate. Proceeding along conservative lines of research would offer no opportunity to collect information pertinent to the question of Bronze and Iron Age settlements in the area, as it would assume no data was available for that time period.

Proceeding along liberal lines of research would grant potential to obtain information pertinent to that question. But it would not guarantee that potential would be realized, since there was no assurance that correspondences would exist between the post-1200 b.c. pollen records from Bar Mere and the post-Roman Period pollen records from Peckforton Mere. It seemed practical and advisable to follow the liberal course, since neither is intrinsically more scientific than the other. At best, the wisdom of accepting the assumption would be supported by future research designed for the purpose and the potential to collect information relevant to project needs would be realized. At worst, the wisdom of accepting the assumption would not be supported in future and the sponsors would be in the same position as would be the case if the conservative course had been followed.

The problem of identifying palynological correspondences between the Peckforton Mere and Bar Mere pollen sequences was complicated by three factors. All of the post-1200 b.c. pollen records from Bar Mere contain significantly higher arboreal pollen to non-arboreal pollen ratios (AP:NAP) than is the case for the records from Peckforton Mere; all contain significantly lower proportions of grass pollen; and none contain a record of pollen of cultigens. This could be the result of a variety of native differences between the two catchment areas, e.g. the distinctions in catchment area size. However, it could be because the history of modification of the vegetation was distinctive in the two catchment areas. That is, the Peckforton Mere district might have been continuously and persistently cleared and cultivated since Roman times while the Bar Mere district not so used.

The pollen sequence variations which are the historic result of continuous clearance and cultivation in the Peckforton Mere record are identifiable by the trends evidenced in successive populations. Among arboreal taxa, continuous trends of increase occur in the alder, ash and lime pollen frequency values, and among non-arboreal taxa continuous trends of decrease occur in sorrel, Oxyria and Filipendula. The statistical constraint imposed upon the pollen frequency values of other taxa by these trends can be released by eliminating them from the pollen sum upon which frequency values are calculated. Their elimination from the pollen sums of both the Peckforton Mere and the Bar Mere pollen records would not affect analysis if the history of land use upon vegetation is similarly expressed taxonomically in both cases.

This would be the case even if the proportional expression of that history is different in the pollen records of the two districts. In the Peckforton Mere situation, the proportional increase in alder pollen frequency through time is 43.7:59.4 and the proportional increase in ash is C.3:2.2. Thus the alder frequency increased by roughly 1.4 times while the ash frequency underwent a roughly seven-fold increase. The opposite sort of relationship may have occurred in the Bar Mere situation. But exclusion of both taxa from the pollen sum negates the total effect, if any, both taxa have in constraining other taxa frequency values.

If the historical trends evident in the Peckforton Mere district pollen record are similar to those affecting the Bar Mere record, the two sequences will appear more comparable than otherwise once the constraint imposed on other taxa by that trend is totally released.

Other constraining factors, however, also exist which affect the correspondence of the two pollen sequences. The most obvious is that the

Peckforton Mere sequence contains pollen taxa which do not occur in the Bar Mere post-1200 b.c. record. The second is that because the two meres contain different volumes of water and their two basins have distinctive underwater topographies, and because Peckforton Mere was sampled near the basin center while Bar Mere was sampled near its shore, the potential for distinctions in frequency values for pollen of aquatic taxa is quite high. To increase the correspondence of the two pollen sequences, these constraints must be released by excluding the aquatic taxa, as well as any pollen taxon which does not occur in the Bar Mere post-1200 b.c. pollen record, from the pollen sum.

This means of data manipulation can establish comparability of the two pollen sequences only if the history of land clearance was actually similar in both districts, since the manipulation is nothing more than a mathematical way of emphasizing the evidence of continuous land clearance which occurs in the Peckforton pollen sequence. If a similar historical pattern is not evidenced in the Bar Mere pollen records, the two pollen sequences will remain distinct. This should be most evident in the trends for oak, birch and grass pollen values since these are the principal statistically significant unconstrained pollen taxa. There is, however, a strong probability that the two sequences would not yield correspondent results even if a pattern of continuous land clearance

occurred in both districts. Only six pollen records are available from Bar Mere for the post-1200 b.c. period. Given the assumption discussed above and its stratigraphic position, the youngest Bar Mere pollen record cannot be as old as any of the Pekeforton Mere pollen records and the oldest is very likely to have been deposited prior to the Roman period. Thus, at best, we have 5 individual pollen records from Bar Mere to compare against 4 populations of pollen records from Peckforton Mere. There is no way to know if any one of the Bar Mere records is truly representative of a population of pollen records deposited at that time interval. More important, none of the few Bar Mere records need date to the periods represented by any of the Peckforton Mere pollen sample populations. Thus even if we assume that the individual Bar Mere pollen records are statistically representative of pollen record populations, lack of correspondence between the Bar Mere and Peckforton Mere data could be due to temporal differences among the particular records we have available for comparison. In effect, there are three reasons why palynological trends occurring in the two cores might not be comparable: distinctions in the vegetation history of the two catchment areas, distinctions in the temporal periods represented in the two cases, and distinctions resulting from lack of representativeness of one or more of the Bar Mere pollen records. And, of course, more than one of these reasons may apply.

Given this state of affairs, it was encouraging when the data manipulation was undertaken that a number of trends which occurred in the two sequences did, in fact, correspond. The proportion of grass pollen, for example, declines significantly and subsequently it persistently increases to roughly its earlier level. There are differences between the two sequences. The principal one is that a trend of increase and subsequent decline in Ericaceae pollen in the Peckforton series is represented in the Bar Mere series by an increase in Tubuliflorae and Plantago values. But the character of those trends which agree suggests that they reflect broadly-scaled ecosystem changes, while the character of non-correspondent trends suggests they reflect highly localized ecosystem changes. Considering the probability that the two series might lack any patterns of correspondence at all, it appears the data manipulation produced the observed results because the historical sequence of vegetation modification in the two districts was roughly equivalent. Despite differences in their size, the overall trend in both catchment areas between 1200 b.c. and the 18th century seems to have been a decrease in the relative frequency of trees to herbaceous vegetation. In both sequences, there seems also to have been a period of time when this trend was slowed to the extent that birch was able to increase its proportional representation relative to ash and lime while shrubby vegetation (heath in the Peckforton case and Tubiliflorae in the Bar Mere case) was able to increase its proportional representation vis-a-vis grass. An anthropogenic cause can be inferred for these vegetation modifications in the Peckforton case. It seems very probable that land clearance was similarly responsible for post-1200 b.c. vegetation change in the Bar Mere catchment area.

The same sort of data manipulation can be applied to the 1200-3000 b.c. record from Bar Mere to identify earlier vegetation pattern changes. This is relevant, as the Bar Mere pollen study undertaken by Twigger documents a land clearance episode preceding 3000 b.c. Our concern was not vegetation pattern modifications over the 3000-1200 b.c. period which were effects of that episode, but identification of other vegetation changes, particularly any which were induced by man.

When the data manipulation was performed on the 300-1200 b.c., data from Bar Mere, three sequential data patterns could be recognized. The earliest occurs in Twigger's Pollen Zone 3, which began about 3000 b.c. In these pollen records, oak pollen values range roughly between 70 and 80 per cent of the AP record, and the grass pollen frequency ranges from 0 to roughly 9 per cent of the total pollen sum and averages 2.48 per cent. In the subsequent data pattern, which occurs in Twigger's Pollen Zones 4 and 5, oak pollen frequency is reduced to a range roughly between 60 and 75 per cent (mean = 68.72) and the mean grass value is increased to 7.83 per cent. But the standard deviations around both means are wider than is the case for the earlier pattern. Compared to the first pattern, the time represented by the second sees not only a reduced proportion of oak and an increase in grass but sharp and successive swings upwards and downwards in the frequency values for both taxa such that oak frequency reductions are matched by grass frequency increases. In the first pattern, oak frequency reductions are smaller in scale and matched by birch or birch/Tubuliflorae frequency value increases. The third pattern is reflected in only the latest sample from Twigger's Pollen Zone 5, which presumably dates about 1200 b.c., but occurs in the two subsequent records from Twigger's Pollen Zone 6. Here, oak pollen frequency values fall in the 40 to 50 per cent range. In this pattern, decline in oak frequency is compensated by an increase in the frequency of Plantago pollen.

The slope of the overall declining trend curve for oak pollen indicates something not represented in the post-1200 b.c. record, where the oak frequency value is stable over most of a roughly 2000 year interval. It suggests a continuous reduction in the amount of the Bar Mere catchment landscape supporting oak forest until a time preceding 1200 b.c. by perhaps a century or two, after which no further significant decline occurred before the 18th century. In its earliest phase, however, birch and elm, and then birch alone, replaced the oak lost, so the proportion of wooded to unwooded land in the district remained essentially stable. In a second phase of forest reduction, fluctuating conditions of vegetation change occurred, with episodes of intensified oak decline. In the earliest of these episodes, loss of oak cover was compensated by the sort of increase in birch which had occurred previously. In a later episode, the oak decline was accompanied by a decline in birch but both were compensated by an increase in the coverage of elm.

Generally, then, the pattern of continuing oak woodland reduction between 3000 b.c. and the few centuries just preceding 1200 b.c. is not identifiable as a continuing decline in the proportion of forested land. An episode is evident during the second phase of forest reduction when the amount of forested area is sharply reduced, and there may have been other episodes of this sort which are not recorded as a result of wide sampling interval. While such episodes could be reasonably interpreted as anthropogenic, the general pattern is somewhat more consistent with a climatic-induced than a human-induced interpretation. Therefore, only one episode of vegetation modification resulting from human activity is evident between 3000 b.c. and the few centuring preceding 1200 b.c. Even if a number of such episodes actually occurred, it would be reasonable to suggest that they date to the period after 2000 b.c.

Given the correspondence between the Peckforton and Bar Mere pollen sequences dating later than 1200 b.c., it is also possible to utilize relationships which exist between pollen and magnetic measurements data at Peckforton Mere to control assessment of erosion intensity in the Bar Mere catchment area during the 3000-1200 b.c. period. The most robust statistical method to use for this purpose is identification of a multivariate correlation between clusters of magnetic measurements and correspondent pollen spectrum data, as this allows simultaneous consideration of the entire set of such statistically significant mathematical relationships as may exist linking the two data sets.

However, there is no way to guarantee that a multivariate correlation coefficient established for the Peckforton Mere data would be applicable to the Bar Mere record, as relatively minor distinctions in the character of the two catchment areas might strongly influence the relative strengths of particular elements of the multivariate correlation. It is both simpler and more expedient to identify qualitative distinctions in the relationship between the specific magnetic measurement most directly linked to erosion intensity and a limited set of palynological data. A qualitative approach may overlook real correspondences which exist as well as identify correspondences which are not statistically valid. But it is the appropriate way to proceed in this study.

The Peckforton Mere IRM measurements for which correspondent pollen data are available are divisible into four populations indicating as many degrees of erosional intensity. Recognizing that such a data spread might be too broad, the measurements were re-grouped into three clusters representing low, moderate and high values of erosional intensity separated by orders of magnitude. Only 21 of the available 32 measurements could be used, but this gave a better probability that the qualitative variations in correspondent pollen records would be statistically meaningful. The low IRM measurements (N=9) ranged between 10 and 20 (mean=13.9), the moderate measurements (N=5) ranged between 100 and 200 (mean=159.0) and the high measurements (N=7) ranged between 1000 and 2000 (mean=1415.7). Correspondent pollen sample clusters were treated as populations. To reduce constraints emphasizing distinctions between the Peckforton and Bar Mere pollen sequences, the taxa and pollen sum utilized in this analysis was the one previously used to identify correspondences in vegetation pattern modifications during the post-1200 b.c. period.

The resulting data identified qualitative distinctions in the pollen record which correspond to directional changes in intensity of erosion, as monitored by directional changes in IRM measurements. For example, change from the palynological population representing low levels of erosional intensity to that measuring moderate levels was shown by an increase in oak and Umbelliferae pollen and a decrease in the pollen frequencies of elm, Chenopodiaceae, Polygonum, Tubuliflorae and Ericaceae. Alternatively, change from the palynological population representing moderate levels of erosion intensity to that expressing high levels was expressed by an increase in frequency values for grass, Plantago, Caryophyllaceae, Chenopodiaceae, Polygonum and Tubuliflorae pollen and a decrease in the pollen of oak, birch and Umbelliferae.

Applying this standard to the Bar Mere pollen sequence, the three pollen records of Pollen Zone 3 illustrate no relative variation and thus ostensibly represent erosion at a similar level of intensity. The sample from the base of Pollen Zone 4, however, varies from those of Pollen Zone 3 by an increase in oak, grass and Caryophyllaceae values and a decrease in those of birch and elm. The closest approximation to this pattern in the Peckforton series is that corresponding to a transition from low to moderate levels of erosional intensity. Magnetic susceptibility measurements of the Bar Mere core independently index an increase in erosion intensity at the base of Pollen Zone 4.

In the subsequent sample from Pollen Zone 4 at Bar Mere, the pollen frequency values for elm and Tubuliflorae increase and those for oak, birch and grass decline. The closest approximation for this pattern in the Peckforton series is that corresponding to a change from moderate to low levels of erosional intensity. In the two subsequent samples, also from Pollen Zone 4, the variations suggest return to low levels of erosional intensity followed by a change to moderate levels. The two youngest samples from Pollen Zone 4 yield records distinct from those below, indicating that yet another change in the level of erosional intensity occurred before the end of Pollen Zone 4. The pattern of modification, however, does not occur in the control data, suggesting a change in erosional intensity that is less than one order of magnitude.

Variations amongst the three Bar Mere pollen records of Pollen Zone 5, which ends ca. 1200 b.c., correspond best to patterns of variation in the Peckforton series which express successive changes from high to moderate to high levels of erosion intensity. There is no pattern of variation between the youngest sample of Pollen Zone 5 in the Bar Mere sequence and the subsequent samples of Pollen Zone 6. All of the Pollen Zone 6 (post-1200 b.c.) records, then, like the youngest sample from Pollen Zone 5, appear to express the occurrence of high levels of erosion intensity.

Taken at face value, these patterns of variation in the Bar Mere pollen record suggest a complex erosional history during the 3000-1200 b.c. period. Twigger used magnetic susceptibility measurements to suggest that the period immediately before 3000 b.c. in the Bar Mere catchment area was one in which the level of erosion rose. As the period is palynologically distinguished by a decline in the proportion of elm pollen, he argued that Neolithic forest clearance selectivity acting on elm was responsible for both effects. The pollen analysis performed here suggests that in the first interval of time subsequent to

3000 b.c. for which data is available, erosional intensity remained at the same level as that Twigger identified for the Neolithic. With the inception of Pollen Zone 4, however, a series of intervals of oscillation between episodes of moderate and low levels of erosional activity occurred. During the interval of time represented by Pollen Zone 5, which ends ca. 1200 b.c., similar oscillations occurred except that episodes of moderate and high levels of erosional intensity were involved.

What is of concern, however, is not erosional history during the 3000-1200 b.c. period *per se*, but the identification of episodes of increased erosional intensity which are likely to be a function of human behaviour. Twigger argued that the general character of Pollen Zone 6 suggested a pattern of continuous cultivation activity in the Bar Mere catchment area subsequent to 1200 b.c. The grounds for this were not the occurrence of pollen of domesticated taxa (which is the basis for the same conclusion for the Roman to 16th century period at Peckforton Mere) but the occurrence of increased frequency values for a cluster of herbaceous taxa (grass, *Plantago* and *Chenopodium*) which would have thrived as weeds on cultivated land. It is instructive to view the results of the present analysis from this perspective, as there are striking qualitative differences in the representations of these taxa in the records of intervals of time which seem to have distinctive erosional histories. *Plantago* and grass pollen only co-occur in one of the three Pollen Zone 3 records, and that is the earliest. They do not co-occur in any of the five Pollen Zone 4 records. They do co-occur in the two Pollen Zone 5 records assessed as indicative of high levels of erosional intensity, however, and in the three succeeding Pollen Zone 6 records. Taken in context, this data pattern suggests that some of the modifications in level of erosional intensity indicated for the 3000-1200 b.c. period were caused by man and others were not. Human cultivation of a significant fraction of the Bar Mere catchment area seems indicated by the record dating about 3000 b.c., but erosion rates seem not to have been increased by this practice. During the period of deposition of the Pollen Zone 4 samples, the level of erosional intensity fluctuated but cultivation is not indicated as a causal factor and the patterns of vegetation modification reconstructed suggest that climatic variation was taking place. The fluctuations in erosional intensity occurring during the period of deposition of Pollen Zone 5, on the other hand, seem to be correlated with palynological expressions of both land clearance and cultivation.

CONCLUSIONS. The object of this study was to apply techniques of environmental archaeology which would illuminate two questions. First, can an explanation be offered for the apparent lack of archaeological evidence in the Peckforton Hills area? Second, did prehistoric sites exist and did their occupants interact with the physical environment in identifiable fashions? Resolving the first of these problems requires recognition of the ways archaeological evidence is produced. The forms of archaeological evidence which most definitively establish the location, form and character of prehistoric sites are aspects of past material cultures. Remains of material culture are produced by the abandonment and subsequent disintegration of residences, other constructions and artefacts. The nature of the materials used in artefacts and constructions influences both the type of evidence which will survive for archaeological analysis and the degree of integrity of association which will persist amongst the individual remains of material culture. But physical and cultural events which occur subsequent to the abandonment of a site also play roles in the survival and integrity of evidence. Resettlement at the location of a prior settlement and consequent new construction, for example, will normally result in a significant loss of evidence of the prior settlement.

Magnetic measurements and pollen analysis suggest that a combination of physical and cultural events are responsible for the apparent lack of archaeological evidence in the Peckforton and Bar Mere catchment areas. The primary physical force involved seems to be the erosion-induced transportation of sediments from topographically higher to topographically lower positions. Magnetic measurements data suggest that variations in the intensity of erosion have occurred through time. When moderate and high rates of erosional intensity occurred, their principal affect would have been degradation of upper and middle elevational range landscape surfaces with the coincident burial of surfaces located in topographic depressions.

The palynological record associated with magnetic measurements evidence of post-Roman episodes of erosional intensification strongly suggests cultural behaviour was at least partially responsible for this situation. During those episodes, at least, forest clearance and the use of agricultural technology which would expose more sediment to erosive forces seems to have occurred. Such behaviour would have been directed towards the low hills and ridges of the catchment basins and their adjacent gentle slopes. These middle elevation topographic ranges constitute the bulk of the land of the area, and that which is most suitable for residence by agricultural populations. What seems indicated, then, is that the agricultural activities of post-Roman populations caused, or at least exacerbated, destruction of the landscape surfaces upon which many prehistoric settlements may have been placed, and simultaneously caused, or at least hastened, burial of lower elevation landscape surfaces upon which others may have been placed or upon which transported material culture remains may have come to rest. The period of most intensive erosion, the 18th century, seems to be the horizon of time in which destruction and burial reached an archaeologically critical point, for significantly more subsoil magnetic minerals appear in the record at that time. Whether centuries of persistent agricultural activity had already stripped the bulk of topsoil from the farmed districts before the 18th century, or the introduction of deep ploughing technology exposed subsoil deposits to the force of erosion at that time is uncertain. But either the new technology or the accretive effect of continuous farming, or both, would have caused loss of archaeological evidence of prehistoric settlements in these catchment areas at middle elevational ranges, and buried such evidence in topographic depressions, which might have escaped earlier destruction or burial.

Our present inability to locate prehistoric sites in the area, then, is principally explained by these investigations as the result of physical forces and cultural events which have degraded and transported the material culture evidence archaeologists have been looking for. In part, it is also explained by our present technical inability to locate such evidence systematically where it has been deeply buried. The accuracy of this conclusion is not dependent upon assumptions which were made in the course of the project to allow work to proceed, for the paleomagnetic and palynological records datable to the 18th century provide adequate basis for the conclusion separately as well as in combination. What remains problematical is not the likelihood of the destruction and burial of the archaeological record by these means, but whether the bulk of such destruction occurred in the 18th century or before.

Resolving the second of the problems relevant to the research project has required accepting certain assumptions as well as applying techniques of pollen analysis which are unusual and lack quantitative rigor. The conclusion derived, then, is clearly and admittedly problematical. Its greatest support is that it is consistent with the expectations of a model of Bronze Age and Iron Age cultural events generated independently of the archaeological record of the area.

This study analyzes patterned variations in the pollen records from Bar Mere in three ways. One yields interpretations of the character of the catchment area's forests; the second identifies changes in the level of erosional intensity through time; and the third identifies episodes of cultivation activity. In combination, taken together with the interpretations of forest history and land use provided by Twigger's study of the Bar Mere data and the interpretations of pollen and magnetic measurements data from Peckforton Mere, a complex landscape history for the Peckforton Hills district has been reconstructed.

Prior to 3000 b.c. alder woods apparently grew along the margins, stream banks and moister valley floors of the area below oak forest on the middle and upper elevational ranges. The soil surface of the oak forest was not stable, but only low levels of erosional intensity occurred. The major impact of Neolithic man on this pattern was a continuous selective reduction in the frequency of elm in the area's forests. Some evidence of cultivation activity occurs in the record about 3000 b.c. but it is not persistent and does not suggest the presence of a significant agricultural population. During the period of time represented by Twigger's Pollen Zone 4, erosional intensity fluctuated between moderate and low levels. The period witnessed a general reduction in the frequency of oak trees in the oak forest, but this seems to have been compensated by an increase in the frequency of birch and shrubs to the effect that the extent of oak forest declined only slightly. There is no palynological evidence of cultivation cctivity, and the episode can be interpreted as one of climatic instability in an unoccupied area.

Human occupation and use of the Bar Mere catchment area is indicated at the inception of Pollen Zone 5 by evidence suggesting oak forest reduction, cultivation and an order of magnitude increase in the level of erosional intensity. Dating is uncertain but has been estimated as ca. 2000 b.c. At least one episode of forest recovery and reduction in erosion rate is indicated during the succeeding half millenium, but further oak forest reduction, cultivation activity and an increase in erosion are indicated about 1500 b.c. Further reduction in the extent of the oak forest is not evident in the record from that date to Roman times, but the level of erosional intensity remained high and evidence of continuous cultivation occurs. By the Roman Period, the level of erosional intensity was reduced and some oak woodland regeneration seems already to have occurred.

The evidence of this study, then, leads to the conclusion that Bronze and Iron Age agricultural settlements were common in the Peckforton Hills area. During the first half millenium of this occupation, one or more episodes of abandonment or population reduction may have occurred. But by 1500 b.c. a significant amount of oak forest clearance had made much land suitable for crop production. The level of agricultural activity indicated for the Bronze Age seems to have been higher than that which occurred during the Roman Period and was probably not again reached before Elizabethan times. High levels of erosional intensity throughout the Bronze and Iron Ages would have acted continuously to degrade and transport the surface of the land that was most intensively cultivated. This probably had little effect upon agricultural productivity since the deposit so transported was highly organic topsoil. But it would have resulted in a process of obliteration of material culture evidence of the settlements of the Bronze and Iron Age populations soon after their abandonment. The reconstruction thus suggests that the bulk of archaeological evidence of Bronze and Iron Age occupancy of the area was probably already damaged, dispersed and buried by Roman times, and subsequent agricultural activity has caused it to be buried further.

SUMMARY. The Conservation Department of the Cheshire County Council sponsored a programme of environmental archaeology research in 1982 which addressed two questions: (a) did Bronze and Iron Age sites related to the hillfort sites of Maiden Castle and Beeston Castle once occur in the Peckforton Hills district, and (b) can an explanation be offered for the apparent lack of archaeological evidence of their existence? Environmental archaeology employs methods and techniques for reconstructing and dating changes in paleoenvironments. It is applicable to these problems, for if settlements were common, their occupants are likely to have affected the regional environment in ways which could be identified by study of the pollen and magnetic minerals deposited in lake sediments at the time.

An earlier study of sediment samples collected from Bar Mere had been performed, but was not designed to provide answers to the two questions of interest to the sponsors of this research. It suggested that Neolithic land use practices could be detected by pollen analysis and magnetic measurements, however, and that if related techniques were applied to deposits of Bronze Age and Iron Age date, evidence of forest clearance and cultivation would document the existence of agricultural settlements in the area at those times. This research programme sought recovery of such deposits and evidence at Peckforton Mere.

Magnetic measurements of sediment samples from Peckforton Mere identified periods of time when the rate of erosion in the Peckforton Mere catchment area was significantly increased, and dated them to the 18th century and the period of Roman occupation of Britain. Associated pollen records indicate the cause of these erosional episodes was coincident intensification of agricultural activity. The Peckforton Mere deposits were not as old as the Bronze or Iron Age. They displayed palynological data patterns, however, which allow recognition of Bronze Age and Iron Age pollen records in the Bar Mere sediment samples.

The most recent deposits that have been examined from Bar Mere, those which produce the pollen records of Pollen Zone 6, can only be dated as younger than 1200 b.c. on the basis of internal evidence. They might represent the entirety of post-1200 b.c. time or only a fraction of that period. This research programme operated on the assumption that the Pollen Zone 6 palynological record extends from 1200 b.c. through the 18th century AD, and sought to test that assumption by determining if palynological trends occurring in the Roman and post-Roman pollen records from Peckforton Mere also occurred in the post-1200 b.c. deposit at Bar Mere. The results of the test suggested this was indeed the case. Thus the Bar Mere pollen sequence appears to incorporate evidence of paleoenvironmental conditions which occurred during the Bronze and Iron Ages as well as during Neolithic and post-Roman times.

Re-analysis of the Bar Mere pollen sequence employed a method suggested by patterning which occurs in the Peckforton Mere pollen sequence. The re-analysis indicates that between 3000 b.c. and approximately 2000 b.c. the number of oak trees in the oak forest of the Peckforton Hills district diminished, but the amount of forested land was not reduced and cultivation seems not to have been a widespread practice. From about 2000 b.c. to roughly 1500 b.c. episodes of forest clearance and cultivation and episodes of forest recovery are indicated. Between about 1500 and 1200 b.c. the pollen record suggests major oak forest clearance took place. From 1200 b.c. until shortly before the Roman occupation of Britain, additional forest reduction seems not to have occurred but cultivation took place and soil erosion preceeded at a high rate.

The re-analysis thus provides evidence that the Peckforton Hills district was occupied during the Bronze and Iron Ages by people whose land use practices cleared a significant amount of oak forest from the landscape and replaced it with cropland and pastures. This supports the conclusion that agricultural settlements existed in the area when the Maiden Castle and Beeston Castle hillforts were constructed.

The Peckforton Mere pollen sequence suggests that additional forest clearance and plant cultivation has continued since Roman times.

In addition, magnetic measurements of the Peckforton deposits indicate a moderate increase in erosion took place during the Roman period and a very large increase in erosional intensity occurred in the 16th-19th centuries. This last is associated with evidence of increased subsoil erosion, and has been interpreted as a consequence of agricultural intensification in the 18th century. The conclusion drawn from this evidence is that the landscape surfaces of the portions of the Peckforton Hills district which were locations of Bronze and Iron Age agricultural settlements have been degraded or deeply buried, depending on their topographic positions. During episodes of high erosion rates, probably induced by agricultural intensification, the material culture remains of earlier settlements located on the slopes, low hills and ridges of the area were degraded and transported to dry valley floors and streams and mere margins. There they were buried by the sediments transported by subsequent erosion. Sites which escaped such destruction and burial previously did not escape that process in the 18th century.

The study thus suggests that archaeological evidence of prehistoric sites in the Packforton Hills district is lacking because it has been removed from its original position by a combination of cultural events and physical forces, and it has subsequently been buried too deeply for systematic recovery by existing techniques of archaeological surveys.