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PEDOGENESIS DURING THE LATER PREHISTORIC PERIOD IN BRITAIN

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Introduction

Soils are complex natural bodies evolving in response to the interaction of environmental factors. The soil forming factors are climate, organisms (including man), parent material, relief and the passage of time. Five important trends in soil development during the postglacial period in the British Isles can be seen:- 1) podzolisation, 2) clay movement, 3) gleying, 4) peat formation and 5) erosion. The causal factors relating to these trends have been the subject of considerable debate. The soil classification used in this paper is that of Avery (1980).

1) Podzolisation

The horizon sequence of a podzol shows that iron, aluminium and organic matter have been removed from the top of the mineral soil (E horizon) and, at least partially, deposited in the B. How the compounds are mobilised in the E and then immobilised in the B has been the focus of considerable research, much of which has been summarised by Petersen (1976) and reviewed more recently by De Coninck (1980).

All podzols are acid and the podzolisation process includes leaching of all basic compounds, such as carbonates, and most adsorbed mono and divalent metal ions from the soil. The time required to leach decreases with the buffer capacity of the soil, so podzols are primarily formed on light-textured parent materials.

Formation of water-soluble complexes is a pre-requisite for podzolisation and these are produced during decomposition of plant residues in the soil and are also present in leaf leachates of certain species. As long as the soil has a fairly high pH and high content of adsorbed divalent cations (mainly Ca), podzolisation will not take place.

Soils which are susceptible are sandy with little Ca, Al or Fe and become acid easily. In such soils water-soluble organic compounds take up only small amounts of Al and Fe in the place where they are formed and, in humid climates, will leach downwards taking up more Al and Fe. They probably only remain soluble while they have enough negatively charged functional groups and uptake of Al and Fe presumably leads to neutralisation of this charge; after a certain amount of metal has been taken up, precipitation occurs because of the reduced charge. Precipitation of organic compounds in the B is incomplete and a fraction of the organic matter may be leached entirely out of the profile, removing some metals as well. The organic compounds dissolved in the leaching water may be subject to biological attack. Petersen (1976) considers this is not responsible for the regular precipitation pattern observed in podzols but Ball (1975) has suggested that Fe and Al are progressively deposited in the Bh or Bs horizons because microbial and fungal activities destroy the organic part of the complex.

It may well be that a cool climate favours some of the causes of podzolisation, eg accumulation of mor-type humus through reduced breakdown of organic matter and possibly also a vegetation likely to promote podzolisation. However, many podzols in the tropics have thick bleached horizons, so high temperature itself does not prevent or impede podzolisation.

Stagnopodzols may develop where the formation of an iron pan leads to waterlogging in the E horizon and subsequent peat formation. Alternatively a change in climate or land use many lead to the formation of a compact surface accumulation of organic remains which cause mobilisation of Fe under wet, acid conditions and development of an iron pan in what was originally an acid brown earth or brown podzolic soil.

2) Clay movement

The development of a B horizon enriched in clay occurs through washing of particles suspended in the soil solution into the lower parts of the soil. In well-developed argillic horizons clayskins may be seen with a hand lens, or even the naked eye. Following removal of calcium carbonate, bases are leached from exchange positions resulting in increased acidity. As the depth of leached soil increases and the flocculating effect of Ca ions is reduced, gradual movement of clay particles begins. These are washed from the A and Eb horizons into the Bt, where clay particles are deposited on and lie parallel to ped faces. The Bt develops strong medium prismatic or blocky structure, in contrast with the weaker blocky structure of the Eb and A horizons. The clay particles are washed down pores and cracks in the soil, particularly after a period of summer drying when shrinkage cracks are most evident, and consequently the continental climate of mainland Europe encourages formation of these soils but they are relatively weakly developed in Britain.

3) Gleying

Gleying occurs when water saturates a soil, filling all the pore spaces and driving out the air. Any remaining oxygen is soon used by the microbial population and anaerobic conditions are established. At the same time the soil water contains the decomposition products of organic matter and in the presence of these, and the reducing conditions brought about by the absence of oxygen, iron compounds are chemically reduced from the ferric to the ferrous state, in which iron is very much more soluble and is removed from the soil, leaving behind the colourless minerals. This gives gley soils their characteristic grey colour, with yellow, brown or red mottles if seasonal oxidation occurs preferentially, eg in root channels. Surface water gley soils have grey and/or ochreous mottles due to anaerobic conditions of waterlogging caused by slow permeability of the soil, high rainfall, lateral flushes or some combination of these. Ground-water gley soils have grey colours and/or ochreous mottles due to anaerobic conditions of waterlogging caused by a high ground water table.

4) Peat Formation

Peat is formed through accummulation, under anaerobic conditions, of slightly humified but recognisable plant remains and is therefore encouraged in conditions of very poor soil drainage. In moorland areas leaching of soils led to increased acidity and development of mor humus at the soil surface, followed by formation of less humified peat as soil drainage deteriorated; consequently moor peat is acid. Fen peat accumulates under the influence of calcareous ground water and largely consists of the remains of aquatic plants such as reed and sedge; it is neutral or mildly alkaline (pH). Raised bogs occur in sites where an acid peat sustained from the nutrient supplies of the rainwater overlies a peat formed in a declivity of the landscape.

5) Erosion

Soil particles can move by three processes: they may be blown away, washed away or the whole soil may slide or slump down a hill-side. Wind erosion can in a short time remove as much material as a more prolonged period of water erosion but water running over the soil surface is a more frequent cause of erosion in most parts of the world. Removal of trees and other natural vegetation interrupts the biogeochemical cycling of elements required for vegetative growth and results in quite profound changes in the soil (including loss of organic matter and bases), making it more prone to erosion, by reduction in structural stability and lack of permanent root system to bind the soil together.

Cultivation leads to soil movement even on the slightest slope, and further damage to soil structure may be caused by animals trampling and puddling the ground, thus increasing the probability of erosion. The material removed may accumulate to considerable depths in adjacent valleys, as shown in Martin Bell's paper.

Post-glacial Soil Development in the British Isles.

The history of soil development in the British Isles has been discussed in detail by Limbrey (1975) and Evans (1975) and summarised by Bridges (1978) and more recently by Simmons and Tooley (1981). It is becoming increasingly clear that the main trends occurred at vastly different times in various areas.

Estimates of time required for soil processes to occur vary considerably, for instance at least 3000 years were required for the formation of a podzol Ah horizon in southern Norway (Matthews, 1980); 250 years for a podzol to develop from acid brown earth in Denmark (Andersen, 1979) and less than 100 years for a podzol to develop on coastal sand dunes in Australia (Paton et al, 1976). Other examples are given by Ellis (1980), Jauhiainen (1972, 1972a) and Ugolini (1966). The Australian example, in particular, suggests that the speed of pedological processes, especially in disturbed systems, may have been under-estimated.

At about 7,500 BP Britain was finally isolated from Europe and during the stable period from 7,500 to 5,000 BP much of the British Isles was covered with mixed deciduous forest, dominated by oak, and had a relatively warm and oceanic climate. It has been suggested that brown soils predominated (eg Bridges, 1978), although there are examples of podzolisation without man's influence during this period (eg Valentine, 1973). The forest may not have closed where soils had the lowest base reserves and climate was most severe (Limbrey, 1975) and these areas succumbed soonest to soil degradation and have provided evidence of mesolithic activity, eg in the Pennines and on Dartmoor. It is generally accepted that Mesolithic man, at least locally, drastically modified his environment, probably mainly through the use of fire to increase the grazing and browsing potential of the forest and thereby increase numbers of herbivores. In particular, the pollen analytical work of Dimbleby (eg Dimbleby 1962) and Simmons (1964, 1969) has shown forest clearance associated with mesolithic activity and pointed to the existence of podzols in some areas by this time, and possible instigation of soil erosion, particularly on coarse textured parent materials.

Some clay eluviation occurred during this period, such as in the profile developed in the loess of Pegwell Bay, Kent (Weir et al, 1971) as in loess areas in Germany (Kwaad and Mücher, 1977). Blanket bog formation increased at the onset of the Atlantic period. Mesolithic flints are frequently found at the base of the Pennine and Dartmoor peats, associated with remains of birch, which may have failed due to grazing pressure or fire. Peat formation could have resulted from opening of the forest, not necessarily linked with a climatic change (Limbrey, 1975).

Substantial forest clearance coincides with the elm decline, possibly connected with established and expanding communities. There was still a general forest cover, varying in constitution, over the British Isles and the height of the tree-line is not known. Peat formation led to development of mires in the lowlands and, also, fens and bogs, and soil erosion occurred in the uplands, with widespread downwash of soils in the Lake District (Pennington, 1975). Clay movement seems to have occurred in soils as a direct result of forest clearance and agriculture (Evans, 1975), possibly initiated in the Mesolithic and intensified in the Neolithic (Limbrey, 1975), leading to a certain amount of hill wash. Although a favourable climate for clay illuviation is one having a wet and dry season, evidence for the change to a more continental climate is elusive. Limbrey (1975) has suggested that the possible dry summers of the sub-Boreal may have contributed to the illuvial horizons of the argillic brown soils but implies that their initiation resulted from the activities of Neolithic cultivators, as stated by Evans (1975), or even Mesolithic man. In the Ardennes in Luxembourg and Belgium, soils with an argillic horizon are thought to have developed during the sub-Boreal and it is suggested that the clay migration and swelling and shrinking phenomena must have occurred in a climate drier and possibly warmer than today (Langohr and Van Vliet, 1979), although it appears that formation came to an end because of human intereference in the Sub-Atlantic period, as in the loess areas of Dutch south Limburg, not because of climatic change (Kwaad and Mücher, 1977).

The area of podzols continued to expand during the Neolithic period with the depletion and decline of more marginal soils, associated with increased forest clearance.

Vegetation at the start of the Bronze Age was largely forest but much reduced in some places, particularly at high altitude. The Chalk Downs had been cleared by the beginning of the Bronze Age and large scale clearance of uplands, such as Dartmoor, led to permanent replacement of woodland by heath and bog communities, although at lowland and valley sites clearance was restricted to grassy enclosures (temporary) in the forest. Dimbleby (1962) pointed to rapid pedogensis in the Bronze Age with the example of a thin iron pan podzol from an unbleached soil on the North Yorks Moors during this period. Decline in soil fertility coincided with soil erosion and Tinsley (1981) suggests this is the direct consequence of the introduction of metal technology (ie more efficient tools).

Environmental deterioration was particularly marked in marginal upland woodlands, where exploitation probably reached a peak in the Bronze Age, but as climate worsened towards the end of the Sub-Boreal and upland settlement retreated, woodland failed to regenerate and heath and bog spread over the grazing lands. In contrast much of lowland Britain, apart from the chalk, was subject to only temporary clearance during the Bronze Age.

In the Iron Age the climate was much wetter and there was considerably less forest in many parts of the country (Turner, 1981) and further soil deterioration, including gleying and peat formation, occurred. Mixed farming was carried out on light calcareous soils in South East England and mainly pastoral farming in the north and west. The timing of forest clearance (no doubt aided by the availability of more sophisticated iron tools) varied from region to region but was itensified on Dartmoor, although Iron Age occupation was concentrated on the edge, with continued peat development (Simmons, 1964) as on Exmoor. Podzolisation of soils and the spread of heath also continued.

It has been suggested, however, that in many moorland areas soils reached their present form late in their land use history (Limbrey, 1975; Bridges, 1978), intensification of podzol horizon differentiation, build up of peat and thin iron pan formation correlated with changes in vegetation consequent on intense grazing of the uplands by sheep (Limbrey, 1975). Certainly in south Wales Ericaceous vegetation associated with the development of organic horizons can be dated to the Middle Ages, but in other areas such as Dartmoor, the basic outline of soil distribution appears to have been established by the beginning of the Iron Age.

Soil Studies at Archaeological Sites

Archaeological excavations may provide the opportunity to study soils which have been sealed. The buried soil itself gives evidence of the stage of soil development reached at the time of burial and comparison with modern soil profiles can indicate subsequent pedogenesis. Evidence of the past landscape derived from pedological studies is considerably strengthened when linked with pollen or molluscan analysis, examination of macroscopic plant remains, etc. Post-burial changes, particularly resulting from variations in the soil drainage regime, are often found, even in well-sealed profiles, but these do not preclude drawing valid conclusions about the history of the land. Examples of archaeological soil studies at later prehistoric sites carried out by the author are described below.

1) <u>Trefignath, Anglesey</u>

A Neolithic burial chamber of segmented cist type has recently been excavated by Dr C Smith at Trefignath, Anglesey. The site is 1½ miles south south east of Holyhead and the soils have been mapped by Roberts (1958) as low base status brown earths of the Rocky Gaerwen series, developed on glacial drift derived from pre-Cambrian schists of the Mona complex. Surface soil pH is usually around 5, the soils are low in phosphorus and potassium and well-drained. The normal phase can carry arable crops or pasture and agriculturally these are the most important soils on Anglesey (Roberts, 1958). These soils were also important in prehistoric times when the most densely populated areas were on light to medium-textured soils (Grimes, 1945). The rocky phase is shallow, with frequent rock outcrops, so farms and fields are smaller (Ball, 1963).

Natural soil profiles were compared with buried soils beneath the mound (Keeley, 1977; 1979). Pollen analysis of buried soil profiles and a peat core taken from a nearby bog was carried out by James Greig (University of Birmingham). The buried soils showed evidence of post-depositional iron and manganese movement.

Pollen analysis of samples from the bog indicated the presence of trees, particularly Oak (and Alder carr round the peat bog), in the early Neolithic although the environment was essentially open and very grassy (Greig, pers. comm. 1981). Soil pollen from the period immediately preceding construction of the earliest burial chamber and cairn (charcoal on the old ground surface has been dated to 5050 ∓ 70 b p) showed more trees were present than in later periods but substantial clearance had occurred by this time. The next phase showed little change in the soil pollen record, although more cereal pollen occurred, and the buried soil appeared to have an undisturbed Ah horizon, consistent with a soil under grassland. By the final phase of building there was much less tree pollen and the buried soil appeared to have been disturbed prior to mound construction.

To summarise, therefore, buried soils showed marked similarities with modern soils and pollen analysis confirmed that the monument was built in an environment of open grassland with occasional trees, not unlike the present landscape.

2) Gwernvale, Powys

During 1977 and 1978 excavations of a Neolithic Severn-Cotswold chambered tomb were carried out by Mr B Britnell at Gwernvale, Crickhowell, Powys. The site is on the north side of the Usk valley, to the west of Crickhowell, on a kame terrace of sand and gravel. The buried soil was a freely drained brown earth showing considerable disturbance but no direct evidence for cultivation, such as plough marks (Keeley, 1978; 1980). The Ap horizon contained carbonised plant remains and one sample produced examples of a very primitive form of Emmer wheat, two grains of six-rowed hulled barley and wild edibles including hazelnut, blackberry and rosehip (Hillman, pers. comm. 1981). Pollen preservation was very poor (mean soil pH was 7.2 in distilled water).

The evidence indicated that Emmer was cultivated locally and habitation was nearby. The modern soils are under grass but are essentially similar to the buried soils, which would have been suitable for cultivation - possibly droughty in dry years but better than the valley soils, which are still prone to flooding today.

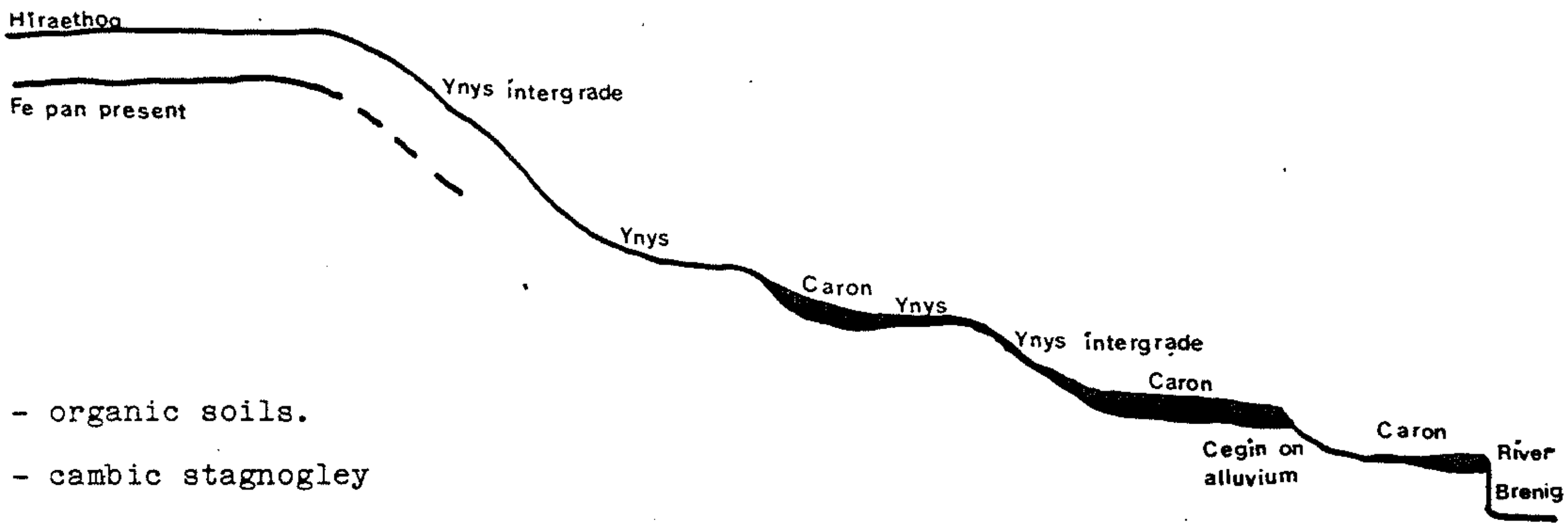
3) Brenig Valley, Clwyd.

A programme of archaeological excavations was carried out, in advance of flooding for a reservoir, in the Brenig Valley (Denbigh moors) beginning in 1973 (Lynch et al, 1974) and completed in 1974 (Lynch, 1975; summary Lynch, 1977). In addition to vegetation surveys of the general moorland area (Bonner 1971). and monuments (Palmer, 1974), a survey of modern and buried soils was carried out (Keeley, 1977a). The focus of the excavations was a major group of Early Bronze Age burial mounds, including 7 large barrows, 2 Ring Cairns and a platform Cairn.

Soils in the area are developed on drift derived from Silurian shales and siltstones and the main series have been described by Ball (1960) and Rudeforth (1970). Distribution is related to topography and drainage in a catenary fashion, as shown in Figure 1.

Pollen analysis was carried out on samples from buried soils and turves from the mounds (Hibbert, 1977), in addition to studies of peat deposits (results not yet

Figure 1. Catenary soil sequence - Brenig Valley, Denbigh Moors.



Key.

Caron - organic soils.

Cegin - cambic stagnogley

Hiraethog - iron pan stagnopodzol

Manod - typical brown podzolic soils

Ynys - cambic stagnohumic gley

Ynys intergrade - intergrade between Hiraethog and Ynys series available). The state of pollen preservation varied but in general about 10% of the total dry land pollen was from trees and, therefore, it appeared that there was no extensive development of forest in the area when the monuments were constructed. The highest representation was of Alder and some birch, with low values of Oak, Lime and Elm, probably through long range transportation, eg from the Clwyd valley (Hibbert, 1977). The local habitat gave high values for hazel and other herbaceous pollen; values were especially high for grasses and sedge and large quantities of heather pollen came from some sites. Cereal pollen occurred in small quantities at all sites and was abundant in the soil buried beneath one of the ring cairns, associated with Beaker occupation (1550 ± 70 BC). Peat from a later occupation of this site contained pollen indicating wetter conditions and less local agricultural activity.

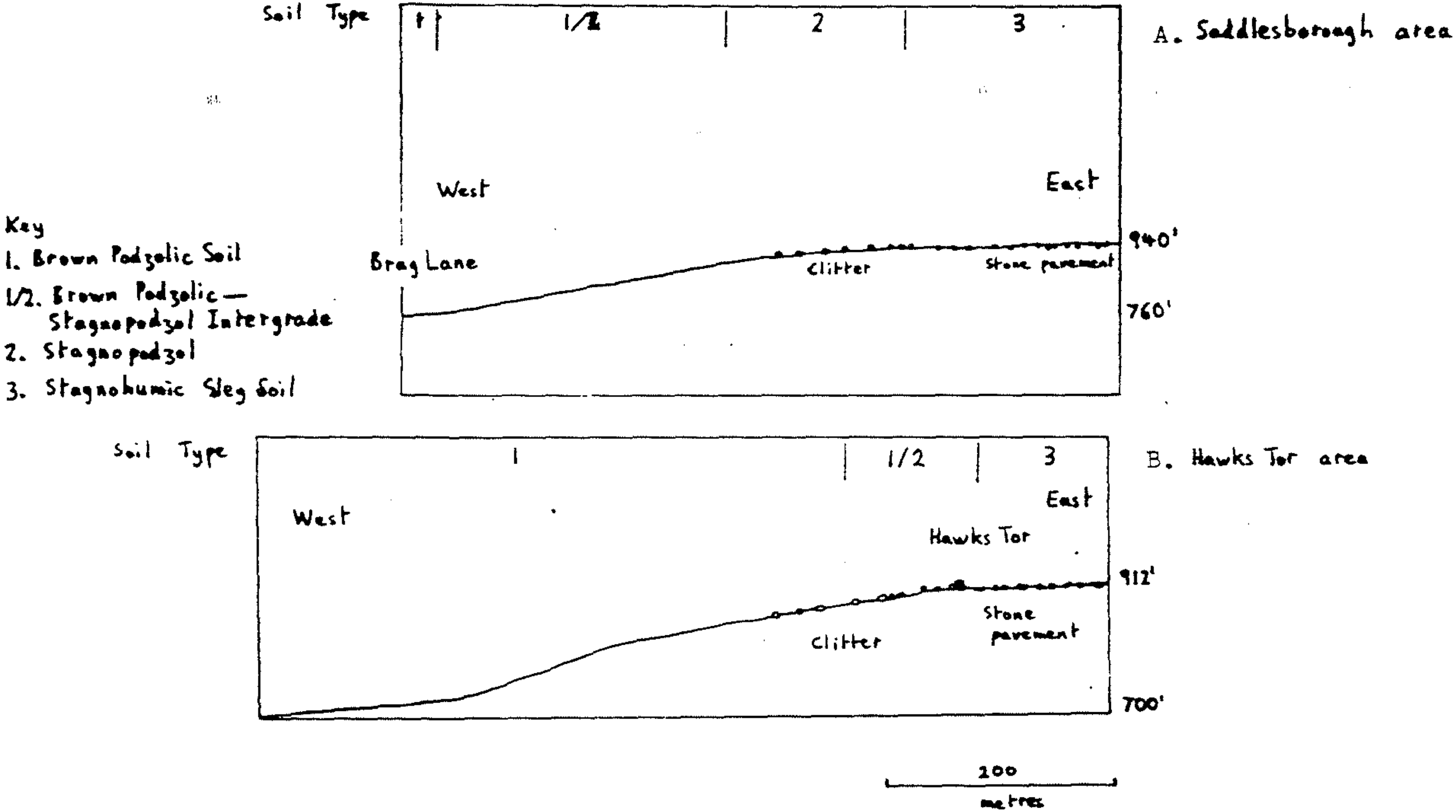
Buried soils were examined beneath several of the monuments and all had been affected by post-burial Fe and Mn movement to some degree and a few were truncated. Most of the buried soils were iron pan stagnopodzols similar to the modern Hiraethog series, although peaty surface horizons were less developed and the soils appeared to be generally better drained than at present.

It appears, therefore, that the environment of the Denbigh Moors at the time of erection of the monuments was an open landscape of grass/sedge moor with hazel locally abundant on the steeper, better drained soils. Alder was present in waterlogged sites around the main watercourses and birch was generally distributed. Some local cereal cultivation occurred but the main emphasis was no doubt on pastoral farming in this area. The soils were essentially similar to those of today, although somewhat better drained, and pollen evidence indicates increasing wetness, presumably coinciding with deterioration in climate towards the end of the Sub-Boreal.

4) Shaugh Moor, Dartmoor, Devon

Since early 1976 the DOE Central Excavation Unit has been involved in extensive archaeological surveys and excavation of prehistoric monuments and field systems in the area of Shaugh Moor, on the southern edge of Dartmoor. The prehistoric land boundaries, including the Shaugh Moor system, have been discussed by Fleming (1978) and Wainwright et al (1979) and Wainwright and Smith (1980) have described progress of the project to date. In 1976 a general environmental survey was carried out (Keeley, 1976), including a vegetation survey (Wilkins, 1977) and a soil survey (Keeley and Macphail, 1979, 1981).

Sections across Shaugh Moor. Figure 2.



The soils of Dartmoor have been described (Clayden and Manley, 1964) and surveyed in part. (Clayden, 1964; Harrod et al, 1976). Simmons (1962) showed that much of the area of Moretonhampstead (typical brown podzolic) and Hexworthy (iron pan stagnopodzols) soils were formerly forested. In the Shaugh Moor area soil distribution was related to slope in a catenary fashion, similar to other moorland areas of Devon (Harrod et al, 1976) as shown in Figure 2. Brown podzolic soils occurred at lower altitudes, being "improved" at the lowest elevations of the moor, while stagnohumic gleys and stagnopodzols occurred on plateaux tops, which had a reltiavely low density of prehistoric settlement. No substantial accumulation of soil was found upslope of prehistoric field boundaries, implying that the fields were used for pastoral rather than arable farming. Soil build-up was noted in the lower part of some huts and behind enclosure walls, which could have resulted from cultivation or disturbance by animals and man and subsequent erosion. It has been suggested that the high density of Bronze Age settlement in the Shaugh Moor area may have been due to tin working (Price, 197(

Buried and unburied soils associated with an enclosure and hut circules were examined (Keeley and Macphail, 1979) and found to show considerable variation, with both stagnopodzol and related gley types present, all formed in granite head. The settlement may have been founded by 1500 bc, by 1200 bc it was probably enclosed by a stone wall, and long-term use of the houses was a feature of the site. Some settlement of unknown intensity persisted until about 600 bc (Wainwright and Smith, 1980).

There was no real difference in degree of degradation between the buried soils and those in the surrounding area, except for slightly more intensive eluviation of the Eag horizon in soils with a contemporary peat cover. Soil variation appeared to be natural and often related to differences in parent material. Some soils contained weakly formed palaeoargillic horizons and fragipans relating to earlier phases of soil formation - probably brown earth types prior to degradation and the change to a moorland environment.

Buried soils were examined below the Saddlesborough reave - a low linear mound of turf-covered stone with occasional projecting orthostats. The first phase of construction is dated to around 1590 $\pm$ 80 bc; the second to around 1390 $\pm$ 90 bc. The buried soil below the upper part of the reave was a humic iron pan stagnopodzol, further downslope a stagnohumic gley with a mor humus surface was found and below the lower section of the reave the buried soil was a stagnohumic gley with about 15cms. of peat at its surface. Preliminary results of soil pollen analysis indicate an open grassland environment at the time the boundary was constructed (Balaam, pers. comm. 1981). Degraded stagnohumic podzols were found below the Wotter reave and a soil with a peaty top was also found beneath another boundary forming part of the parallel reave system.

Pollen analysis of peat deposits from several sites in the area has been carried out by S Beckett (Smith et al, forthcoming). After the elm decline (about 5000 b.p.) the environment was open with scattered woodland. There was some woodland regeneration after the Neolithic, as found by Simmons (1964). In the Bronze Age there was greatly increased clearance activity and predominantly pastoral farming. The main development of heath occurred after the Bronze Age.

Evidence from Shaugh Moor fits in well with the picture of early soil degradation on coarse parent materials and conforms to the suggestion of Staines (1972), that the basic outline of soil distribution found today on Dartmoor was established by the beginning of the Iron Age.

Summary and Conclusions

During the Mesolithic period on coarse parent materials where the forest cover was thinner or, at the highest altitudes, may not have closed at all, man's activities led to soil degradation including podzolisation, peat formation and soil erosion. In lowland areas in southern parts of the country where loess was present in the soils, clay eluviation occurred, probably because these areas were exploited by Mesolithic people, as in the loess belts of Europe (Cornwall 1958).

At the beginning of the Neolithic period clay movement intensified, mainly as a result of forest clearance and agriculture but possibly enhanced by a climate in which summers were drier than in preceding or subsequent periods. Peat formation and podzolisation continued during this period and some soil erosion occured, particularly in parts of the uplands. By the beginning of the Bronze Age the Chalk Downs had been cleared and heath and bog communities with their associated podzolised, gleyed and peaty soils, had permanetly replaced woodland in some upland areas. Soil and pollen studies at Trefignath indicate an open grassland environment, with occasional trees, in this part of Anglesey during the Neolithic period; studies at Gwernvale provide evidence of local cereal cultivation in that part of south Wales. Both sites are on light textured soils.

The Bronze Age was a period of maximum exploitation of uplands resulting in rapid pedogenesis, decline in soil fertility and soil erosion. Woodland failed to regenerate in these areas, particularly where parent materials were coarse textured and heath and bog spread over the grazing lands. Over much of lowland Britain, apart from the chalk, however pedogenesis was not greatly influenced by Man during the Bronze Age. Examples from the Denbigh Moors and Dartmoor confirm the extent of soil degradation in these upland areas.

The climate was much wetter in the Iron Age and extensive forest clearance was carried out, with associated soil deterioration and the spread of heath.

It is difficult to link changes in soils during the later prehistoric period directly to climatic change and, therefore, pedogenesis must be considered in terms of all the soil forming factors.

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