INVESTIGATING THE AGE OF A PENNINE LANDSLIP

by

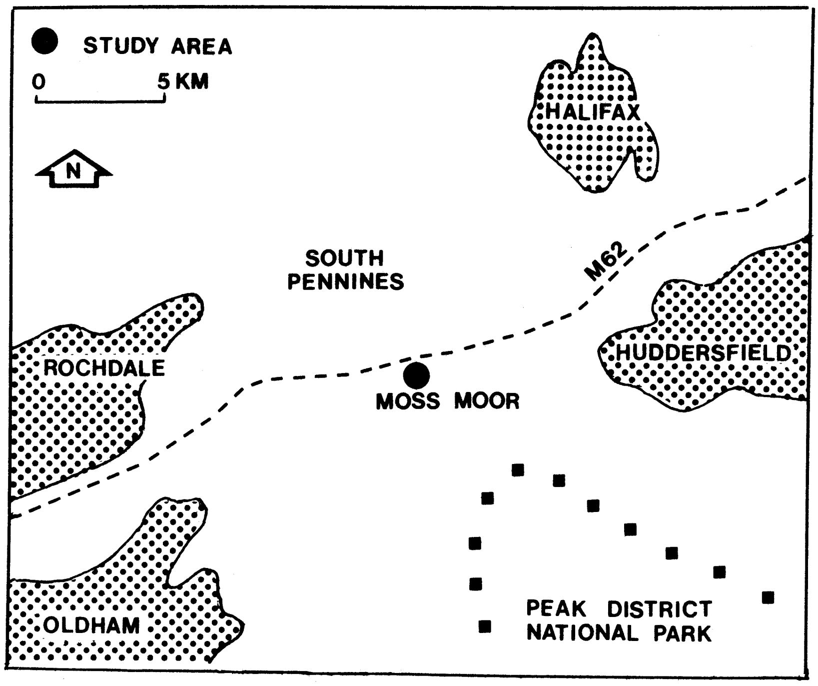
Roderick Muller

Introduction

Slope instability has produced both ancient and recent landslips of considerable areal extent within the Pennines. In studying slips of substantial age the time of occurrence has largely been a matter of inference. Until the advent of pollen analysis there were few methods by which these processes of past millenia could be dated with reasonable accuracy. The problem concerning the age of landslips cannot be severed from the causes generating them and for this reason some questions pertinent to the factors of displacement are considered in this study of a landslip at Buckstones Moss, West Yorkshire.

"The hills are shadows, and they flow
From form to form, and nothing stands;
They melt like mist, the solid lands
Like clouds they shape themselves and go."

Lord Tennyson



Text-fig.1. Location of Moss Moor.

Buckstones Moss (SE 005139) is an isolated upland region and a constituent part of Moss Moor, text-fig. 1, situated 16 km due west of Huddersfield. The area of landslipping (SE 014143) is unnamed and for the sake of convenience is termed the Buckstones Landslip. Buckstones Moss attains a height of 473 m and comprises an escarpment with a dip 9° to the NNW. The gentle arching of the Pennines with its many minor anticlines and synclines has given rise to a complex series of cuestas often referred to as "edges". Here the edge is formed by the massive Midgley Grit and the dip-slope has been dissected by the headwaters

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of the River Ryburn, a tributary to the River Calder. The result of this erosion has been the production of a large cuesta stretching in a shallow, concave arc for 3.2 km along the northern margin of the moss, and backed by the gritstone erosion-scarp of Moss Moor. Generally speaking, this Moor rests on the softer shales, mudstones, flags and fireclays of the Millstone Grit Group (Upper Carboniferous), while the scarp is of a more massive nature (Wray *et al.*, 1953). The slipped mass extends along the cuesta for almost 1 km., but only the westernmost sector is described in this paper.

The peripheral upland areas, which were never glaciated throughout the Würm/Weichsel stage (Raistrick 1933, 1934), reveal but few exposures of the underlying solid geology except were stream courses have become deeply entrenched. Invariably there is a considerable development of rotted and kaolinised grit debris, and isolated pillars or collections of weathered grit are characteristic of the moors as first noted by Hull (1869). The frequency of their occurrence is in itself confirmatory evidence of the unglaciated nature of these moorlands, and detached blocks have been transported by subsequent landslips and solifluction movements (Bairstow 1902). Interestingly, it was near Buckstones Moss that Hull incorrectly interpreted the fragmented blocks as erratics. This litter of grit is clearly reflected in such a place name as "Buck-stones" perceptively noted by Crossland (1902).

Existent relationships between landslips, free-faces, tors, shattered blocks, and solifluction deposits emphasise the probability that such features within the Pennines may be a by-product of a much larger scheme of slope evolution before the present climatic regime (Bass 1954, 1956; Loundsbury 1963; Linton 1964). Landslips are frequent wherever a prominent scarp of grit overlies a thick mass of shale, and the possibility that some of them were formed either in Pleistocene times or during a succeeding phase gave genesis to this investigation.

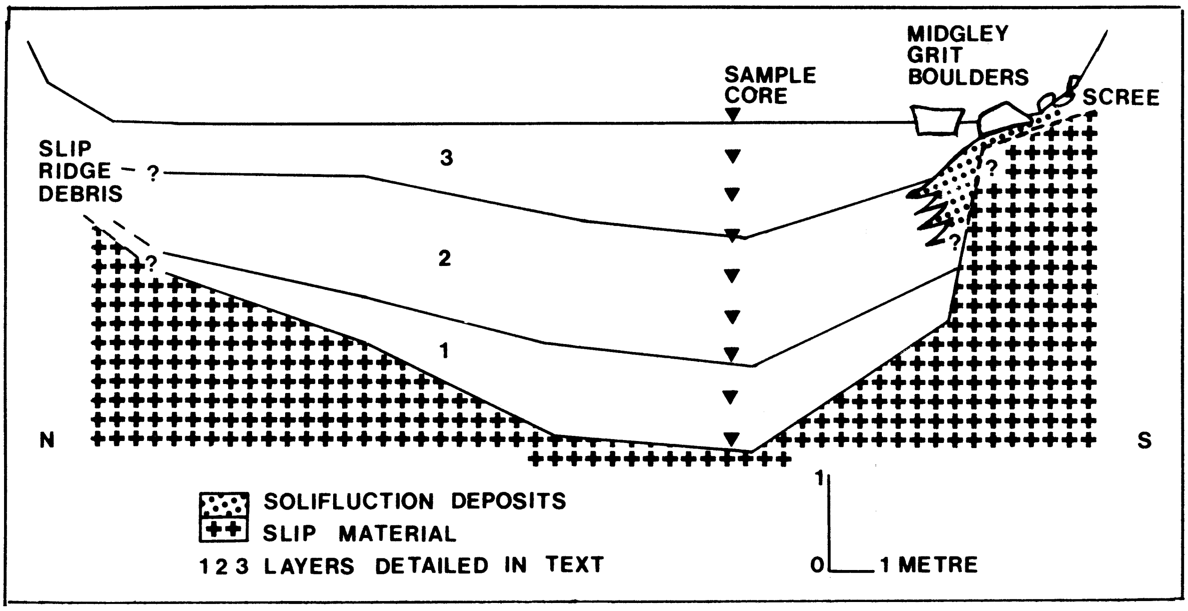
Only brief reports have appeared regarding the age of ancient landslips, and few special researches employing the techniques of pollen analysis have been devoted to this problem (Morariu 1964; Franks and Johnson 1964; Johnson 1965).

Pollen grains may be identified significantly from the Jurassic System onward, but their value is more spectacular when establishing environments and relative dates for the Quaternary. Pollen analysis (palynology) is based on the principle that wind pollinated vegetation produces pollen in considerable quantities, and that the annual pollen 'rain' is added to the accumulation of stratified sediments especially in bogs and lake beds. Pollen is robust and, if the sediments are poorly aerated or acidic, may be preserved quite well. Shape is diagnostic of the species which produced it, and the laminae of sediments thus hold a chronological and environmental record for a region. The retrieval of samples must be done without contamination and a careful record made of levels. Chemical treatment of each sample is undertaken in the laboratory to rid it of extraneous material. Identification and counting of pollen grains for each level leads to the construction of a pollen diagram which can be subdivided according to acknowledged pollen zones. The late and post-glacial periods of the Quaternary have been divided into 8 major zones, and using radioactive methods now have absolute dates. An insight into climate, vegetation, prehistoric settlement, environment and processes is thus provided. Pollen analyses are published in numerous books and journals, but a wider description of principles and applications may be had by referring to Davis (1963), Faegri and Iversen (1964), Crabtree (1968), and Pennington (1969).

As far as the Buckstones Landslip is concerned, some minor rockfalls, due to physical weathering, occur along the main scarp of Moss Moor Edge, but there is no evidence to suggest the recent splitting-off of massive debris from the scarp. Apart from the gritstone scarp, the whole area of slipping is completely covered by moorland vegetation, and the undulating topography of the landslip rubble has been superimposed by a drainage system of intermittent peat-moor streams. Furthermore, auger probes on some of the slip ridges encountered a stiff clay material to 14 cm in depth and this, together with the related features, indicates the passage of considerable time. Thus, a recent historical age is out of the question for it becomes immediately apparent in the field that, morphologically, the landslip is not a recent feature.

Along the whole interior section of the slip, and that part nearest the scarp face, are to be found both large and small depressions. Within the larger depressions correspondingly large and small hollows can be located which have, since the time of movement, been infilled with water and a miscellany of material. A suitable site for the collection of pollen samples was found near the western end of the slipped material.

The site is an oval-shaped basin with a level, vegetated floor of *Eriophorum* sp., *Juncus* sp., and *Empetrum* sp., and bordered on its periphery (and therefore completely isolated from subsequent drainage erosion) by ridges of slipped material from the abutting middle scarps to the south. The floor of the depression measures 50 m x 15 m. Towards the eastern section there exists an all-season pond with the dimensions of 13 m x 8 m and a depth of at least 3 m. Due to a vigorous hydrosere the pond is now diminishing in size. Within the depression there is evidence of the progressive stages of infill to the aquatic environment and thus, at an earlier stage in the evolution of the basin, the pond would have extended over a far greater area. A transect was taken across the depression and the data obtained from 7 probes provided the information for text-fig. 2.



Text-fig.2. The Landslip Depression.

From this illustration it will be seen that throughout the history of its infilling the basin has become markedly stratified, except against the precipitous southern slopes where what appears to be downwash from the scarp slopes together with rockfall boulders of Midgley Grit interrupt the succession to a slight degree. Deposits for pollen analysis were taken from a Hiller (sampler) boring 85 cm from the transect, and an identical succession to the other transects was obtained at this point. The greatest depth was in fact met by the auger at this boring where an impenetrable substratum was reached at 335 cm.

Obviously the period between the occurrence of the Buckstones Landslip and the initiation of the pond and *Sphagnum*-*Eriophorum* spp. marsh within the depression represents a somewhat variable element and one which could reflect in the dating. Nevertheless, a pollen analysis of the deposit within this hollow might offer a more absolute age to the landslip since it is clear that the depression itself could only have been produced *after* the slip movement and, consequently, an *upper date* for the displacement can be obtained. Since an upper date to the landslip was the objective the basal sediments were of prime interest and, once a depth of 300 cm had been exceeded, Hiller samples were taken every 5 cm.

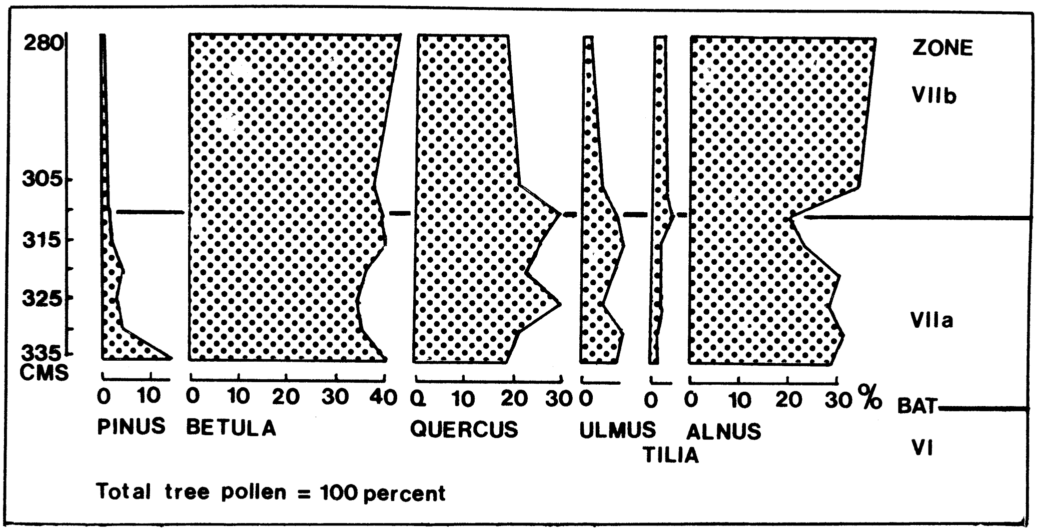
The succession at the site, although showing variations in stratification over short vertical distances, can be subdivided into three main stratified layers, (table 1), but it is the basal layer which is, in the context of this report, of most importance. This layer consists of an amorphous and highly humified dark-brown peat with some occasional *Sphagnum*, overlying a coarse or gritty sandstone.

Table 1 - Succession of deposits at the Buckstones Site

Depth (cm)	Description	Layer
000-103	Alternating layers of highly humified and fairly humified *Eriophorum* peat with abundant *Sphagnum*	3
103-123	Fairly humified *Sphagnum* peat with abundant *Eriophorum* rootlets	
123-182	Less humified peat with less *Eriophorum*	
182-229	*Sphagnum* peat not highly humified	2
229-252	Fresh *Sphagnum* peat	
252-335	Amorphous highly humified peat	1
335- ?	Mineral substratum	

One should consider at this point that a time-lag in deposition would have been present, although in terms of the pollen diagram and dating attempt this would probably be very small. A time-lag in deposition could have been caused by the existence of the local acidic rocks, for an abundance of H+ ions would ensure acidic water within the depression so that only siliceous micro-organisms and acid-tolerant plants would have thrived at the onset. Thus the basin, with no base-seeking plants such as sedges and some weeds, would have seen only slow accumulation. One may broadly conclude that this is an *Eriophorum*–*Sphagnum* bog since the mass of peat has been produced by an abundance, if not dominance, of such vegetation. The lowermost layers of the peat were not dominated in such a manner, thus according with the widespread observation that bog *Sphagnum* and *Eriophorum* do not grow directly on a mineral base.

Since the prime interest of the investigation was to obtain an upper age for the onset of deposition, and thus an upper age for the landslip, the methods used were far from the refined techniques employed in specialist pollen analysis. It was hoped that an answer to the main problem could be achieved by using the simplest methods on a number of samples. No attempts have been made to discuss the results in relation to the general forest history of the region or the vegetational colonization of displaced rubble. The arboreal pollen curves are shown in text-fig. 3 and provide a framework to which we may attach our conclusions as to the phases of local ecology, since tree data alone can form a link in the general sequence of events in post-glacial time. These events are further expressed in pollen zonation schemes as outlined by table 2.



Text-fig.3. Pollen frequencies.

Table 2. Post-glacial climatic periods

Climate		Zone	Period	Date (B.C.)
Cool and wet	Oceanic	VIII	Sub-Atlantic	
				c. 500
Warm and dry	Continental	VIIb	Sub-Boreal	
				c.3000
Warm and wet	Oceanic	VIIa	Atlantic	
				c.5500
Warmer than before and dry		VI, V	Boreal	
				c.7600
Sub-Arctic		IV	Pre-Boreal	
				c.8300
	Late Glacial	III	Younger Dryas	

(Sources: Godwin 1956; Pennington 1969) (Radiocarbon dates)

With reference to text-fig. 3, certain points can be noted concerning the tree pollen curves. *Pinus* (pine) shows a fall from possibly high Boreal values to a more or less steady and low level around 3% through zone VIIa. *Betula* (birch) shows its characteristic reversion to higher values beginning above the transition zone with maximum values around 35% appearing quite consistently from the Boreal-Atlantic Transition through to zone VIIb. *Quercus* (oak) shows a rise from this supposed Boreal-Atlantic Transition with two peaks: one of which occurs in mid-zone VIIa; the other at the transition with zone VIIb. A familiar decrease towards the upper part of the diagram is noticeable. *Ulmus* (elm) has low values and never exceeds 8%. The "elm decline" which marks the boundary between VIIa and VIIb is clearly discernible. *Tilia* (lime) is recorded low down in the succession and may indicate that the Boreal-Atlantic Transition has not quite been fully reached. A gradual increase to a maximum around the "elm decline" is evident. *Alnus* (alder) reaches a characteristic maximum following the elm horizon. Changes are apparent around the Boreal-Atlantic Transition (B.A.T.) and at the elm horizon, but the time-scale is much compressed and fluctuations in the pollen curves should be regarded as slow swings.

If we accept that the landslip took place after the Boreal-Atlantic Transition then it is possible to suggest that the displacement took place somewhere around 5500 BC. Although radiocarbon dates have eroded some confidence in the age of this transition, students of Holocene history generally take the boundary between the Boreal and Atlantic periods as *circa* 5500 BC. Bearing in mind the delay in deposition, and the short basal hiatus caused by acidic rocks, it is reasonable to assume a similar date for the Buckstones Landslip.

The zonation scheme used herein is based on the traditional "Blytt-Sernander boundaries' as applied in some form by most palynologists. Analysis of the Buckstones site is thus based on well established documentation of vegetational change and boundary criteria for this latitude and altitude. Recent work with 14C has generated problems in assigning 'traditional' dates to boundaries. There now exists sufficient evidence to show some discrepancies between published dates and 14C measurements. The provision of a reliable calibration curve for 14C together with research into regional, topographic, climatic and edaphic influences on vegetational change are still being undertaken. Consequently, all the dates recorded in this paper are interim suggestions based on published palaeoecological evidence. For a discussion of these and related problem see: Smith & Pilcher (1973).

Post-glacial variations in climate raise several interesting points: The role played by water in the mechanics of landslips has already been noted (Sharpe 1938; Terzaghi 1950; Gifford 1952; Young 1972), but it is rather intriguing to realise that during the very termination of the Boreal Period, and throughout the Atlantic Period, climate became markedly maritime. Indeed, various workers have noted the marked climatic shift at this point in time caused by the continuing eustatic rise in ocean levels and the creation of both the North Sea and Baltic Sea (Willett 1950; Godwin *et al.* 1958; Zeuner 1958; Manley 1959; Lamb 1966). This more oceanic clime, coupled with a suggested more southerly track of depressions, would have provided an increase to precipitation amounts and triggered a general rise in ground-water levels. Conway (1954) has shown how, in the Pennines, this increase in both rainfall and ground-water allowed the expansion of 'blanket' peats at the expense of established wet alder and birch woods. Perhaps this increase in available water is the very ingredient we are looking for as a major participatory factor in slope failure at Buckstones around 5500 BC.

The relationships between significant processes and prevailing climate are discussed in length by Stoddart (1969). It could be an interesting exercise to perform pollen analyses upon many more Pennine landslips because if the conditions for displacement seem to be of a similar nature can there be any reason for not suggesting a peak of slip activity on the post-glacial time-scale? This proposition could be most attractive, particularly when one visits and considers the morphological characteristics of the numerous and ancient Pennine slips. Unfortunately the idea of any further analyses is beyond the scope of this study, but if reference is made to palynological investigation of a landslip in Derbyshire a highly interesting correlation is found (Franks & Johnson 1964; Johnson 1965). It has been shown of the Charlesworth Landslip (SK 015915) that it has very similar features to that of Buckstones, and the onset of deposition within a slip-zone depression has been dated at 5200 BC. This is a close date to that of 5500 BC for Buckstones. Dare we, from only two approximations, infer a peak of Pennine landslipping? The answer, however tempting, remains to be established.

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Roderick Muller
49, Constable Drive
Marple Bridge
Stockport
Cheshire, SK6 5BG